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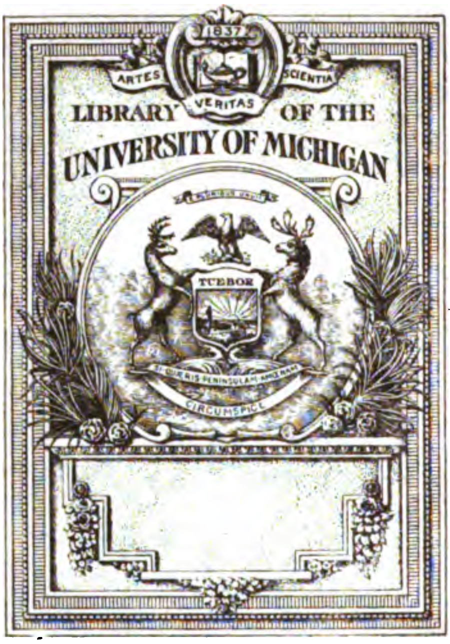

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AN

ELEMENTARY TREATISE

ON

MINERALOGY AND GEOLOGY,

BEING AN

INTRODUCTION TO THE STUDY OF THESE SCIENCES,

AND DESIGNED

FOR THE USE OF PUPILS,—FOR PERSONS, ATTENDING LECTURES
ON THESE SUBJECTS,—AND AS A COMPANION FOR
TRAVELLERS

IN

THE UNITED STATES OF AMERICA.

ILLUSTRATED BY SIX PLATES.

BY PARKER CLEAVELAND,

PROFESSOR OF MATHEMATICS AND NATURAL PHILOSOPHY, AND LECTURER ON
CHEMISTRY AND MINERALOGY, IN BOWDOIN COLLEGE, MEMBER OF THE
AMERICAN ACADEMY, AND CORRESPONDING MEMBER OF THE
LINNÆAN SOCIETY OF NEW ENGLAND.

..............................itum est in viscera terræ:
Quasque recondiderat, Stygiisque admoverat umbris,
Effodiuntur opes.................. Ovid.

BOSTON:
PUBLISHED BY CUMMINGS AND HILLIARD, NO. 1, CORNHILL,

PRINTED BY HILLIARD AND METCALF, AT THE UNIVERSITY PRESS,
CAMBRIDGE, N. ENGLAND.
1816.

DISTRICT OF MAINE.

Be it remembered, that on the eighth day of November, A. D. 1816, in the forty first year of the Independence of the United States of America, Parker Cleaveland, of the said District hath deposited in this office the title of a book, the right whereof he claims as author, in the words following, to wit;

"An Elementary Treatise on Mineralogy and Geology; being an Introduction to the Study of these Sciences, and designed for the use of Pupils—for persons attending Lectures on these subjects—and as a companion for travellers in the United States of America. Illustrated by six Plates. By Parker Cleaveland, Professor of Mathematics and Natural Philosophy, and Lecturer on Chemistry and Mineralogy, in Bowdoin College, member of the American Academy, and Corresponding member of the Linnæan society of New England.

……………………itum est in viscera terræ:
Quasque recondiderat, Stygiisque admoverat umbris,
Effodiuntur opes………… Ovid."

In conformity to the act of the Congress of the United States, entitled, "An act for the encouragement of learning, by securing the copies of maps, charts, and books, to the authors and proprietors of such copies, during the times therein mentioned;" and also to an act, entitled "An act supplementary to an act, entitled an act for the encouragement of learning, by securing the copies of maps, charts, and books, to the authors and proprietors of such copies during the times therein mentioned; and extending the benefits thereof to the arts of designing, engraving, and etching historical and other prints."

HENRY SEWALL, { *Clerk of the District Court of Maine.*

TO

BENJAMIN VAUGHAN, LL. D.

FELLOW OF THE ROYAL SOCIETY OF EDINBURGH, OF THE AMER.
PHILOS. SOCIETY, OF THE AMER. ACADEMY, AND OF THE
MASS. MED. SOCIETY, ETC.

SIR,

You will not, I trust, be displeased, and the Public, I am assured, will not be surprised, that I should embrace this favorable opportunity of addressing you, as the patron of general literature, and more especially of Natural Science.

It is, indeed, an *elementary treatise only*, which is here offered to your notice. But it is no small encouragement to those, who are anxious to promote the progress of Mineralogy and Geology, to know, that these branches of knowledge receive the patronage and attention of such, as have, like yourself, devoted a large portion of life to the cultivation and improvement of deeper and more abstruse sciences.

Accept, Dear Sir, for your friendship, both to myself, and the College, with which I am connected, these sincere expressions of gratitude and respect,

from your much obliged
and humble servant,
PARKER CLEAVELAND.

Bowdoin College,
Nov. 8, 1816.

7-12-37

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Systematic works on Mineralogy, which have been more or less used in preparing this volume.

Elements of Mineralogy. By Richard Kirwan, 2 vols. 2d edit. London, 1794.

Traité de Minéralogie. Par le citoyen Hauy, 5 tomes, Paris, 1801.

Traité Elémentaire de Minéralogie, suivant les principes du Professeur Werner. Par A. J. M. Brochant, 2 tomes, Paris, 1800, 1803.

System of Mineralogy. By Robert Jameson, 3 vols. Edinburgh, 1804, 1805, 1808.

Tableau Méthodique des Espèces minérales. Par J. A. H. Lucas, Paris, 1806.

Traité Elémentaire de Minéralogie, avec des applications aux arts ; ouvrage destiné a l'enseignement dans les Lycées Nationaux. Par Alexandre Brongniart, 2 tomes, Paris, 1807.

Tableau Comparatif des resultats de la crystallographie et de l'analyse chimique, relativement à la classification des Mineraux. Par M. l'Abbé Hauy. Paris, 1809.

Abbreviations, sometimes used in this volume.

Kirw.	Kirwan.	Brong.	Brongniart.
Broch.	Brochant.	Wern.	Werner.
Jam.	Jameson.		

Introd. Introduction.
Spec. grav. Specific gravity.
Geolog. sit. Geological situation.

PREFACE.

The subjects of Mineralogy and Geology have but recently received any considerable degree of attention in this country. Even at the present time, these interesting studies, and often profitable pursuits, are confined to a number comparatively small.—It is, however, undoubtedly true, that the progress of Mineralogy has been much retarded by the want of suitable means of becoming acquainted with the elements of this study.

All, who are engaged in mineralogical pursuits, perceive the need of an introductory or *elementary* treatise in the English language, neither *too brief*, nor *too much extended*. Such a work is peculiarly important for all persons, while attending lectures on mineralogy and geology. Indeed, being a *portable* volume, it is convenient for those, who, while travelling, are inclined to devote an occasional attention to these subjects, with a view either to increase their knowledge, or relieve the tediousness of the journey.

But, to supply that, which is so obviously wanted, or, in other words, to furnish a suitable elementary work on mineralogy and geology is an undertaking, attended with some peculiar difficulties. These difficulties arise from the nature of the subject, and from the diversity of opinions, which already exist on these subjects.—It is, therefore, proper for the writer here to state his general views and plan.

Minerals may be divided into species and arranged according to their *external characters* alone, or according to their *true composition*, as far as that is known. Hence have arisen two, distinct, mineralogical *schools*; viz. the German, which regards Professor Werner, of Freyberg, in Saxony, as its founder—and the French, which looks chiefly to the Abbe HAUY, as its author.

In the system of Werner, minerals are divided into species and arranged, according to the external characters. In the system of Haüy, the true composition of minerals is considered the basis of arrangement, although the *crystalline* characters are, in fact, principally employed—with the belief, however, that arrangements, founded on the crystalline characters and true composition, are never at variance. In the *description* of minerals, Werner depends almost entirely on an accurate enumeration of *all* the external characters. Haüy, on the other hand, employs only the most important of the external and chemical characters, relying chiefly, however, on the crystalline form and structure, where these can be observed.—Hence it results, that, in many cases, Werner attaches to certain differences of external character a degree of importance, which Haüy does not admit;—hence also the number of species, in the arrangement of Werner, is much greater than in that of Haüy.

It has already been remarked, that minerals may be divided into species and arranged according to their external characters, or according to their chemical or true composition, as far as that is known. It is, in fact, these two methods, which, in comparison, ought to be opposed to each other. The crystallographical method of Haüy is only a modification of the chemical method, which it acknowledges as its basis; but it can never be of universal application, for some minerals are destitute both of crystalline structure and form.

In regard to the systematic works on mineralogy, which have proceeded from the *German* and *French* schools, they undoubtedly possess peculiar excellencies, with some peculiar defects intermixed. The German school seems to be most distinguished by *a technical and minutely descriptive language;* and the French, by the use of *accurate and scientific principles in the classification or arrangement of minerals.*

Many of the writers of the two schools appear to have indulged an undue attachment to their favorite and peculiar system, and have hereby been prevented from receiving mutual benefit; the one being unwilling to adopt what is really excellent in the other.—But it is believed, that the more valuable parts of the two systems may be incorporated, or, in other words, that the peculiar, descriptive language of the one may, in a certain degree, be united to the accurate and scientific arrangement of the other.

This union of descriptive language and scientific arrangement has been effected with good success by BRONGNIART in his system of mineralogy—an elementary work, which seems better adapted both to interest and instruct, than any, which has hitherto appeared. The author of this volume has, therefore, adopted the *general* plan of Brongniart, the more important parts of whose work are, of course, incorporated with this.

It is respectfully requested by the writer, that those persons, who, like himself, may have received their first ideas on mineralogical subjects from the writers of the German school, would carefully and candidly examine Chap. iii of the Introduction on the *systematic arrangement of minerals;* and that they would particularly attend to the *distinction,* which is made in Articles 176, 197, and 198 of the same Introduction, between those properties of minerals, which may be used as the *basis of arrangement,* and those, which may be safely employed in *description* only.

In the Introduction, all the external characters of minerals are enumerated, and accompanied, when necessary, by explanatory remarks. The very interesting and important subject of crystallography is also explained with as much minuteness, as is consistent with the nature of an elementary work.

But, as the limits, assigned to this volume, would not permit a particular notice of all the secondary forms of crystals, I have endeavored to give those general views of the primitive form and structure of the crystals under each species, which may enable the student to refer the various secondary forms to their proper nucleus. In addition to this, the most common secondary forms, and sometimes those, which are most rare, or most complex in their structure, are particularly described, and often explained by the assistance of diagrams.—It is extremely important to possess correct, general ideas of the form and structure of the *perfect* crystals of each species; for, without such knowledge, it would often be impossible to recognise those forms, which are incomplete, or irregular in regard to the number or extent of their faces, &c.

In the list of Localities, subjoined to each species, I have intermixed brief, geological notices, whenever it was practicable.—Of foreign localities some of the most important only are selected.

In regard to *American* localities, several difficulties have attended this *first* attempt to collect them; and, although I have many acknowledgments to make to those mineralogists, who have kindly assisted me in the collection, the list is still incomplete. But I have reason to place great confidence in the accuracy of those, which are given; for most of them have been furnished expressly for this volume. Bruce's Mineralogical Journal, v. i; a paper by S. Godon in the Memoirs of the American Academy, v. iii; and another by Dr. Adam Seybert, of Philadelphia, in the Medical Museum, v. v. are almost the only printed authorities, which I have employed,

Among those gentlemen, to whom I am under obligations for lists of localities and geological notices, not before published, are Drs. H. H. Hayden and E. Debutts, and R. Gilmor, esq. of Baltimore—Messrs. C. I. Wister and S. W. Conrad, of Philadelphia—Prof. Bruce and Col. G. Gibbs of New York—Professor Hall, of Middlebury College, Vt.—and Professor Silliman, of Yale College, Connecticut. These authorities are generally cited, when used.—To Dr.

Hayden and Professor Silliman I am under peculiar obligations.

The names of the species, subspecies, and varieties are, in most cases, accompanied by *notes*, containing the synonyma of Werner, Haüy, Kirwan, Jameson, Brochant, and Brongniart. Wherever the German names of Werner differ from those, found in Jameson's Mineralogy, they are copied from the Tableau comparatif, &c. of Haüy, who took them from a late edition of Karsten's Mineralogical Method. It should be remarked, that, when synonyma from any of the aforementioned authors are wanting in a note, it is not to be inferred, that those authors have not mentioned that particular mineral.

In preparing this volume, the author has made indiscriminate use of whatever appeared to him most important in the more recent systematic works on mineralogy; among which are those of Kirwan, Haüy, Brochant, Jameson, Lucas, and Brongniart. The titles and editions of these works have already been mentioned, p. iv. The foregoing authors are seldom cited, except in regard to some facts, which are uncommon, or whose existence, as universal facts, is still doubtful. —Whenever the Tableau comparatif of Haüy differs from his Traité de Minéralogie, in consequence of additions, corrections in the measure of angles, &c. &c. the Tableau has been uniformly employed. Hence, in most cases, where the name of Haüy is annexed to an assertion, the reference is to the Tableau comparatif.

The works of Humboldt, Spallanzani, and other modern travellers, various Reviews, and literary Journals have also furnished something toward this volume. In many cases, however, to abridge as much as possible, I have barely mentioned the author's *name*, without the title of his work, although I am sensible, that some inconvenience attends this practice.

Some authors, whose works I have not seen, are cited on the authority of Brongniart, Edinburgh Review &c. The analyses of Kirwan are, in general, those, which were published in Nicholson's Journal.

To pursue, with pleasure and advantage, the studies of mineralogy and geology, some previous knowledge of natural philosophy and conchology is important; but an acquaintance with the general principles and *nomenclature* of chemistry is a necessary prerequisite.

This preliminary knowledge of chemistry is, indeed, easily attainable; but, for the convenience of those, to whom the nomenclature of chemistry may not be familiar, a *vocabulary* of chemical terms is subjoined to this volume.

It will be seen by the reader, that the United States have furnished not only some new varieties, belonging to species already known, but also a few species of minerals entirely new. The rocks of this country seem also to offer some aggregates, not heretofore named or described.

An acquaintance with simple minerals, or with Mineralogy in the more limited sense of this word, is a necessary prerequisite to the study of Geology. To the student, therefore, who has acquired this preliminary knowledge only, we may apply the lively remark of Haüy in the Preliminary Discourse of his Mineralogy;—'il n'a pas encore vu la nature, mais il a reçu des yeux pour la voir.'

CONTENTS.

This table relates only to the contents of the Introduction to the study of Mineralogy, extending from p. 1 to 87, and the Introduction to the study of Geology, from p. 586 to 597. For other and more particular contents, see the general *Index*, at the close of the volume.

INTRODUCTION TO THE STUDY OF MINERALOGY.

INTRODUCTION TO THE STUDY OF GEOLOGY.

INTRODUCTION

TO

THE STUDY OF MINERALOGY.

CHAPTER I.

DEFINITIONS AND PRELIMINARY OBSERVATIONS.

1. The extensive field and the numerous objects, which Natural History presents for our observation, render systematic arrangement and division of labor absolutely necessary. By these means each individual is enabled to direct his attention to some particular class of bodies, with advantage to himself and the public; and to pursue his favorite path in natural science without that confusion and perplexity, which the multiplicity of objects would otherwise produce.

2. Natural bodies may with great propriety be divided into two extensive classes; organic and inorganic.

3. *Organic bodies* have a peculiar structure, which consists in the possession of certain organs, on the proper action of which they depend for increase and perfection. This class embraces animals and vegetables; the former of which is distinguished from the latter by possessing the power of voluntary motion.

4. *Inorganic bodies*, on the contrary, possess neither life, nor the power of voluntary motion; they are entirely destitute of organic structure, and suffer change from the influence of external agents only. In this class we find minerals, and adopt the following definition.

5. *Minerals* are those bodies, which are destitute of organization, and which *naturally* exist within the earth, or at its surface.*

6. *Mineralogy* is that science, which has for its object a knowledge of the properties and relations of minerals, and enables us to distinguish, arrange, and describe them.

7. The writers of the Wernerian school usually divide mineralogy into the following five branches.

---

* The term *fossil* is usually appropriated to those organic substances, which have become penetrated by earthy or metallic particles; thus we say fossil shells, fossil bones, fossil wood, &c. Sometimes however the alteration, which these bodies have undergone in the mineral kingdom, is very slight. But the consideration of fossils belongs more particularly to geology.

Oryctognosy (ορυκτος γνωσις), which consists in the description of minerals, the determination of their nomenclature, and the systematic arrangement of their different species. It coincides very nearly with mineralogy in its modern acceptation.

Chemical mineralogy, which describes the chemical properties, and ascertains the constituent parts of minerals.

Geognosy (γη γνωσις), which investigates the structure, position, and relative situation of minerals, as they exist in the earth; and indeed every thing, which regards the mineralogical constitution of the crust of this globe.

Geographical mineralogy, which informs us what minerals are found in any particular section of the globe, and in what manner they there exist. It bears the same relation to a portion of the earth, that geognosy does to the whole.

Economical mineralogy, which considers minerals with reference to their various uses in the arts, medicine, &c.

The two branches, which have just been defined under the names of oryctognosy and geognosy, involve some important distinctions, and require further elucidation. But the names themselves, having been unnecessarily introduced into the English language from German writers, will, in this treatise, yield precedence to the terms *Mineralogy* and *Geology*.

8. The distinction between the two branches, of which we have just spoken, is intimately connected with a division of minerals into two kinds; simple or homogeneous, and compound or heterogeneous. The words simple and compound do not here relate to chemical composition, but merely to the different appearances, which these two classes of minerals respectively exhibit to the eye.

9. *Simple minerals* appear uniform and homogeneous in all their parts. They do in fact usually contain several different elementary principles; but these are so intimately combined and similarly blended in every part, as to exhibit the aforementioned uniformity of appearance.

10. *Compound minerals*, on the other hand, more or less evidently discover to the eye, that they are composed of two or more simple minerals, which either merely adhere to each other; or, as is sometimes the case, one appears imbedded in the other. Compound minerals are frequently called *aggregates* or *rocks*.

11. Now it is the *simple minerals* only, with which *mineralogy*, in the present acceptation of this term, is concerned. It is only this portion of minerals, which it undertakes to describe and arrange. The description of *compound minerals* or aggregates, including their mutual relations, &c. constitutes the science of *geology*.

12. We shall conclude this chapter with a few observations on the connexion of mineralogy with other sciences; its rank, as a distinct branch of science; and the utility of mineralogical and geological researches.

13. It is not unfrequently necessary to call in the united aid of philosophy, chemistry, and mineralogy to obtain a complete investigation of the properties of a single mineral. In the examination of the same body they differ from each other by observing that body from different points of view, and by taking cognizance respectively of different sets of properties. The two last of these sciences, however, are the most intimately connected.

It is but a few years since mineralogy could with any propriety claim the rank of a science; and for this claim she is principally indebted to the discoveries of chemistry. But, as if elated by her own rapid progress, she has, in several instances, refused to acknowledge the assistance, derived from chemistry. The truth is, both sciences necessarily concur to furnish us with the knowledge and description of minerals.

A chemist may ascertain the ingredients, which enter into the composition of a given mineral; but he cannot inform us what he has analyzed, nor describe the subject of his experiments, without the assistance of mineralogy. On the other hand, a mineralogist may detail every external character of a mineral; he may give it a name, and describe some of its relations to other minerals; but he cannot inform us what it contains, nor indeed designate some of its most essential and important characters without the aid of chemistry. Their connexion will more strikingly appear in a subsequent chapter on the classification of minerals.

It is further to be remarked, that no inconsiderable share of chemical knowledge is a necessary prerequisite to render mineralogical pursuits either pleasant or advantageous.

14. From a superficial view of minerals in their natural depositories, at or near the surface of the earth, it would hardly be expected, that they could constitute the object of a distinct branch of science. Nothing appears further removed from the influence of established principles and regular arrangement, than the mineral kingdom, when observed in a cursory manner. But a closer inspection and more comprehensive view of the subject will convince us, that this portion of the works of nature is by no means destitute of the impress of the Deity. Indications of the same wisdom, power, and benevolence, which appear in the animal and vegetable kingdoms, are also clearly discernible in the mineral.

To be convinced, that the mineral kingdom affords suitable objects for scientific research, we need but glance our eyes on those singular properties of phosphorescence, electricity, magnetism, and double refraction, which some minerals possess, and more especially on that striking modification of the laws of affinity, which results in the production of those regular, beautiful, geometrical solids, called crystals.

But whatever progress may hitherto have been made in mineralogical pursuits, every new advance has opened a wider and more interesting prospect. The science is still in its infancy, and in many of its paths can proceed only with a faltering and uncertain step.

15. The general view of mineralogy, which we have already given, will offer to the minds of many sufficient inducements to the cultivation of this branch of knowledge. It may also be remarked, that several arts and manufactures depend on mineralogy for their existence; and that improvements and discoveries in the latter cannot fail of extending their beneficial effects to the aforementioned employments. In fine the study of mineralogy, whether it be viewed as tending to increase individual wealth, to improve and multiply arts and manufactures, and thus promote the public good; or as affording a pleasant subject for scientific research, recommends itself to the attention of the citizen and scholar.

CHAPTER II.

PROPERTIES OF MINERALS.

16. The description of minerals and their arrangement in systematic order must result from an investigation of their properties. These properties consist in certain relations, which minerals bear to our senses, or to other objects. Some of them are discoverable by mere inspection, or, at most, require some simple experiment to be made upon the mineral to ascertain its hardness, structure, &c. but without producing any important change in its natural state; while others cannot be observed without a partial, or complete decomposition of the mineral. All these properties, when employed for the purpose of discriminating minerals, are usually called characters. We hence have a twofold division of the properties or characters of minerals into *physical* and *chemical*. Of the various characters, which these two divisions comprehend, the most important will be described in the present chapter.

SECTION 1.

Crystallography.

17. Of the physical properties of minerals no one is so important in itself, and extensive in its influence and application, as that, by which crystals or regular solids are produced. To investigate and describe these solids is the object of crystallography, and constitutes without doubt the most interesting branch of mineralogical research.

Crystallization and Crystals.

18. Crystallization, in the most limited extent of the term, is that process, by which the particles of bodies unite in such manner, as to produce determinate and regular solids. But it is equally true, that those minerals, which possess a foliated or fibrous structure, are the products of crystallization under circumstances, which have rendered the process more or less imperfect, and prevented the appearance of distinct and regular forms.

Let a quantity of muriate of soda (common salt) be dissolved in water, and permit the solution to evaporate by a moderate heat; the particles of the salt will separate from the water, unite, and form little cubes, which float on the surface, till their increased weight causes them to fall through the liquid. These cubes are called *crystals*. Other substances, when permitted to crystallize, also exhibit regular solids, but of a different form. Thus the emerald presents the form of a hexaedral prism, and the garnet that of a dodecaedron with rhombic faces.

19. The ancients believed crystallized quartz (rock crystal) to be water, congealed by exposure to intense cold; and accordingly applied to it the term κρυσταλλος, which signified ice. Hence the etymology of the word crystal. Now, as a beautiful regularity of form is one of the most striking properties of crystallized quartz, the name crystal has been extended to all mineral and other inorganic substances, which exhibit themselves under the form of regular, geometrical solids.

20. A crystal may therefore be defined an inorganic body, which, by the operation of affinity, has assumed the form of a regular solid, terminated by a certain number of plane and polished faces. The corresponding faces of all crystals, which possess the same variety of form and belong to the same substance, are inclined to each other in angles of a constant quantity. This constancy of angles remains even in those cases, where the faces themselves, from some accidental causes, have changed their dimensions or number of sides. Transparency, though many crystals possess it in a greater or less degree, is not a necessary property. But plane surfaces, bounded by right lines, are so essential to the crystalline form, that their absence decidedly indicates imperfection in the process of crystallization. The lustre and smoothness of the faces may also be diminished by accidental causes.

21. The property of crystallizing is by no means confined to a small number of bodies. Nearly all the different species of simple minerals, and some inorganic bodies of vegetable and even animal origin, such as sugar, camphor, and spermaceti have been seen in a crystallized state. Most of the aforementioned substances are also capa-

ble of exhibiting a variety of forms. It is exceedingly probable, that many other natural bodies, not hitherto observed in the state of crystals, would, under favorable circumstances, undergo a similar process.

22. The limits, prescribed to this introduction, will not permit many remarks on crystallization, as a chemical process. It will be recollected, that affinity is of two kinds, *homogeneous* and *heterogeneous*; the former of which unites particles of the *same kind*; the latter, particles of *different kinds*. Now it is evident, that the production of a crystal essentially depends on the action of homogeneous affinity.

Solution in some fluid, as water or caloric, is a necessary prerequisite to crystallization. By solution the particles of the body to be crystallized are reduced to a state of minute division, separated from each other, and permitted to move in the solvent with perfect freedom. As solution takes place by the action of heterogeneous affinity, it is evident, that so long, as this continues to act with undiminished force on the particles of the dissolved body, no crystallization can be effected. It is therefore necessary to diminish the force of heterogeneous affinity, and cause the dissolved particles to approach each other, still permitting them to move freely and moderately among themselves. This may sometimes be effected by simple cooling, as in the case of metals; but to crystallize other substances, as most of the salts, slow evaporation and subsequent cooling are necessary.

It is obvious from the preceding remarks, that, to produce perfect crystals, the solvent should be free from external agitation, and sufficient in quantity to permit the particles to move, and to arrange themselves in the requisite order without disturbance. But, when these conditions are not complied with, an imperfect crystal, or only a fibrous or foliated mass is produced. Indeed from the frequent absence of some of the requisite conditions, large and perfect crystals are somewhat uncommon. The effects of a disturbed crystallization will be subsequently noticed.

23. It is evident, that the geometrical forms, which crystals exhibit, must depend on regularity of form in the particles, which compose these crystals, and on a determinate arrangement of these particles, at the moment of combination. The particles, of which we now speak, and which are undoubtedly the same, into which the body is reduced by solution, are called *integrant particles*. But we know that mere solution does not produce decomposition. Hence there are in bodies two kinds of particles; integrant and elementary.

24. *Integrant* particles are the smallest particles, into which a body can be reduced without destroying its nature; that is, without decomposing it.

25. *Elementary* or constituent particles are the final results of

chemical analysis. They are the elements, of which integrant particles are composed. Thus, while the latter remain invariable in the same body, the elementary particles must vary with the progress of chemistry.

Let a portion of the natural compound of sulphur and iron, called sulphuret of iron or pyrites, be as minutely divided, as is possible, without producing decomposition, and we shall obtain the integrant particles; each particle, although invisible and excessively small, will be perfectly similar in its composition to the original mass, and will be really a portion of pyrites. But, if the same mass of sulphuret of iron be decomposed, we shall have its elementary particles, consisting of sulphur and iron. Possibly the sulphur and iron may both prove to be compounds; but this will not affect the integrant particles of sulphuret of iron.

In bodies really simple the integrant and elementary particles are evidently the same. It is also undoubtedly true, that the elementary particles of bodies must possess a regularity of form, which is constant in the same simple substance.

26. From the preceding observations it must be obvious, that a mineral is an assemblage of similar particles; and that it is formed, and increases in size merely by the juxtaposition of these similar, integrant particles. It depends on no interior mechanism, like organic bodies, for its growth; but is enlarged in its dimensions by the application of successive layers of particles.

27. Both theory and observation induce us to believe, that the integrant particles of the same substance possess the *same form* and *dimensions*. Now it is obvious, that, if these similar particles always combined in the *same manner*, all the crystals of any given substance would exhibit the *same form*. This however is far from being the case. It is true, indeed, there are many bodies, which have a determinate form, under which each of them most frequently appears. Thus muriate of soda usually presents a cube; the emerald, a hexaedral prism.

28. But the same species of minerals often presents itself under very different forms, equally regular and well defined. Sulphuret of lead (galena) appears at one time in the form of a cube, at another in that of an octaedron. Carbonate of lime can exhibit a rhomb, a hexaedral prism, and a dodecaedron with triangular or pentagonal faces. Indeed most bodies have several different forms, under which they occasionally appear.

29. Frequently the different solids, which the same substance produces, have no apparent resemblance. But, as all the particles of the same substance have the same form, it is undeniable, that this

striking difference of form, observable in the crystals of any one substance, must depend entirely on a *difference of arrangement* in the integrant particles. Thus the cubic particles of the sulphuret of iron can so arrange themselves, as to produce sometimes a cube, sometimes an octaedron, and sometimes a solid, contained under twenty triangular faces.

30. Again, different substances sometimes crystallize under the same form. Fluate of lime, muriate of soda, and the sulphurets of iron and lead all occasionally appear in cubes.

But, notwithstanding this variety and apparent confusion, every thing is regulated by established laws. The different crystalline forms which any one substance is permitted to assume, are limited to a certain number; and the most dissimilar varieties, belonging to the same substance, do in a certain sense originate from one common point, which is the primitive form.

31. In illustrating the theory of crystallization, it will be necessary to describe the primitive forms of crystals and the methods of obtaining them; to ascertain the forms of integrant particles; to show in what manner secondary forms are constructed on the primitive, and to investigate the laws of their formation.

Primitive forms.

32. Every substance, when crystallized, has a particular form, which it actually exhibits, or on which, as a basis, all the other varieties of existing forms, which belong to that substance, depend. Thus, if we examine the various crystals of the carbonate of lime, we shall find them either in the form of a rhomb, under given angles constantly the same, or containing within them a similar rhomb, as a *nucleus*. This rhomb may be extracted from the crystal, which contains it, by a certain operation, and is called the *primitive form* of the crystals of carbonate of lime. All the other forms, which this substance presents, are called *secondary forms*.

33. It is on the primitive, as a substratum, that the various secondary forms are constructed by different arrangements of the integrant particles. Sometimes the primitive form is entirely concealed within the secondary, while, in other cases, some of its original faces are still visible; but its angles, edges, or bases are modified by additional faces.

34. The primitive form is found to be invariable, and to give a constant measure of its angles in all the crystals of the same substance. Thus all the secondary forms of the garnet are reducible to a dodecaedron, whose sides are rhombs, inclined to each other at an angle of 120°, which is its primitive form. If the fluate of lime do not pre-

sent a regular octaedron, whatever form it actually exhibits may be reduced to an octaedron, for that is its primitive form.

The same nucleus is often extracted from secondary forms, which differ exceedingly from the primitive and from each other. Of the truth of this remark the crystals of carbonate of lime furnish striking instances. Some substances are almost always found under some one of their secondary forms, and seldom or never exhibit their primitive, as a natural crystal.

Nature of mechanical Division.

35. The primitive forms of crystals can be ascertained only by *mechanical division*. This process, sometimes called *cleavage* by lapidaries, consists in separating thin layers or slices from the sides, edges, or angles of a crystallized substance in a given direction. Many crystallized substances are very obviously composed of thin plates or laminæ, which by careful operation may be separated from each other, without presenting the appearance of a fracture. The planes, in which these laminæ are applied to each other, are called the *natural joints* of a crystal or crystallized mass. It is at these joints only, in the direction of the laminæ, that mechanical division can be effected.

In some minerals the natural joints are very obvious, while in others they are nearly or quite imperceptible; even in the same crystal the joints in one direction are often much more easily perceived, than in another. In examining many crystals it is necessary to employ the bright light of a candle, by the reflection of which from the faces of the laminæ the direction of the joints may be discovered.

36. This division is best effected by applying a thin, sharp instrument of steel to the natural joints of the mineral, and causing it to enter by a very delicate percussion. Sometimes, indeed, a gentle and well directed percussion is sufficient without an instrument of steel, especially when an edge or solid angle is to be removed. But, in other cases, it is necessary to heat the mineral red hot, and plunge it into cold water, which produces fissures in the direction of the natural joints.

37. The faces of the crystal or nucleus, obtained by mechanical division, as well as those of the separated laminæ, are plane and smooth, possessing a greater or less degree of polish; and are thus easily distinguished from the surfaces, which a common fracture produces, and which never exhibit all the aforementioned properties.

38. Many crystals are not susceptible of this kind of dissection This frequently arises from too great brittleness; sometimes from other causes, but in no instance from any thing, which appears incon-

sistent with the general theory of the structure of crystals. But, when the primitive form cannot be obtained by mechanical division, it may often be inferred with considerable probability from the secondary forms by calculation. The striæ or channels, sometimes observed on crystals, may often assist in the determination of the primitive forms.

38. The nature of mechanical division will be best illustrated by an example.

Let *a b c d e f g h* (Pl. I, fig. 1.) be a hexaedral prism of carbonate of lime. Let a knife be applied to one of the sides of the prism, suppose *t u f g*, in the direction of the line *s r*, not far from the edge *t u*, and parallel to it; let the knife be so inclined, as to make an angle of 45° with the face of the crystal. By gentle blows with a hammer a segment will be separated from this edge of the crystal, leaving on the prism a smooth, polished, trapezoidal face *m v r s*, inclined both to the base and the side of the prism in an angle of 135°. If a similar attempt be made on the next edge *u d*, it will not succeed; either no impression will be made on the crystal, or a mere fracture will be produced.

Proceed to the third edge *d c*, and from this may be removed a segment altogether similar to the one removed from the edge *t u;* the trapezoidal face, remaining on the crystal, will be equally smooth, and inclined both to the base and side of the prism in the same angle of 135°. Pass to the fourth edge *c b*, which is parallel to the first edge *t u*, but no separation can be effected. Apply the instrument, as before directed, to the fifth edge *b a*, parallel to *u d*, and here another segment is obtained, leaving a smooth surface. Attempt a division on the sixth edge *a t*, and nothing but a fracture will be produced.

Proceed now to the other end of the prism. Let the first attempt be made to remove the edge *g f*, parallel to the edge *t u*, first operated upon at the other extremity of the prism. Nothing can be here obtained, but a fracture. Repeat the attempt on the next edge *f e*, parallel to the edge *u d*, which, at the other extremity, refused to be separated. A trapezoidal face *i l o p*, entirely similar to the preceding faces, obtained by division, will here be produced. Pass round the prism; the alternate edges *n y* and *h g* will submit to a division, while the other edges *e n* and *y h* will be found refractory.

From an examination of the prism, thus far dissected, it appears, that only the alternate edges at each end yield to a division; viz. the first, third, and fifth edges, at one extremity, and the second, fourth, and sixth edges, at the other extremity, counting from the side, whose edge was first separated. It further appears, that the edges, which, at one end of the prism, are capable of being removed by mechanical division, correspond to those, which, at the other end, prove refractory. The section *i l o p* is parallel to the section, supposed to be made on the edge *a b;* and the four remaining sections are also parallel, taken two and two.

Mechanical division, thus far effected, has converted the prism into a solid, contained under fourteen faces. The remainder of each side of the prism is a pentagon; the remaining surface of each base is a triangle; and, by the removal of the edges, six new trapezoidal faces are produced.

Let the division be continued by sections, parallel to those already made. It is evident, that the bases of the prism must gradually diminish, till they entirely disappear, and a new solid (Pl. I, fig. 2.) is obtained. This solid is a dodecaedron, exhibiting twelve pentagonal faces. Six of these faces, of which *s r i* O *w* is one, are remaining portions of the original sides of the prism; and the other six, of which A I *r s* E is one, have resulted from the division.

Continue the removal of laminæ from the crystal in directions parallel to the preceding. The six pentagons, which, in the last figure, terminated the solid, remain the same; but the lateral pentagons gradually diminish in length, till they are converted into triangles. The solid is still a dodecaedron (Pl. I, fig. 3.), but it is now bounded by six pentagons and six triangles; see the faces A I *r s* E, &c. and *s r* O, &c.

One step more will close the process. Continue to separate layers from the crystal, as before, till the six lateral triangles vanish. No part of the surface of the original solid is now visible. Instead of a prism, we have a *rhomb* A B E K (Pl. I, fig. 4.), bounded by six equal and plane rhombs. This rhomb is the *primitive form* of crystallized carbonate of lime. All the other varieties of form, belonging to this substance, though exceedingly numerous and different from each other, yield, by mechanical division, a nucleus, perfectly similar to the preceding, both in form and the measure of its angles.*

39: In the same manner, if the eight solid angles *a c d b*, &c. (Pl. I, fig. 5.) of a cubic crystal of fluate of lime be removed by a knife, placed parallel to the diagonals of the faces, and inclined at an angle

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* The reader will find the preceding example of mechanical division strikingly illustrated, by preparing a six-sided prism of soft wood, or, what is still better, of a potatoe, and dividing it in the manner already described for obtaining a rhombic nucleus. Indeed the structure of crystals should always be studied with the assistance of models, some of which should be composed of separable parts to illustrate the interior arrangement of the laminæ. See Traité de Minéralogie par le C^{en}. *Haüy;* also Elements of Crystallography, after the method of Haüy, by *Fredrick Accum.*

of about 54$\frac{1}{2}$°, the same number of polished, triangular faces, of which *e f g* is one, will be produced. By continuing to remove laminæ, parallel to the first section, the sides of the cube entirely disappear; and an octaedron *e i f g h* (Pl. I, fig. 6.) with triangular faces is obtained, as the primitive form.

40. The primitive form is always divisible in directions parallel to all its sides. But such a division can only diminish its size; it can never change its form. A cube, however frequently divided by sections of equal laminæ, parallel to its sides, would remain a cube. Hence we have a good distinction between primitive and secondary forms. The latter are never divisible in directions, parallel to *all* their sides; whereas *primitive* forms are *always divisible in directions, parallel to all their sides*, and frequently also in other directions.

41. The number of primitive forms at present known is six; viz. a *parallelopiped*, including the cube, rhomb, and all other solids, contained under six faces, which are parallel, when taken two and two; a regular *tetraedron*; an *octaedron* with triangular faces; a regular *hexaedral prism*; a *dodecaedron*, whose faces are *rhombs*; and a *dodecaedron*, whose faces are *isosceles triangles*.

42. Were there as many different primitive forms, as there are distinct species of minerals, we should be enabled very easily to distinguish different substances by this character alone. Still however the aforementioned six solids, by a variation in their angles, dimensions, &c. are capable of furnishing a very considerable number of distinct, primitive forms. Thus the rhomb may vary in its angles in different species, as in the carbonate of lime and the tourmaline; the two pyramids, which compose the octaedron, may vary in the shape of their bases; and in the prismatic forms the base may be a square, rhomb, &c. and the ratio between the sides of the base and the height of the prism may vary indefinitely.

43. Some of the primitive forms, however, are common to several different substances. Muriate of soda and the sulphurets of lead and iron have a cube; fluate of lime, the spinelle, diamond, and the red oxide of copper, &c. have a regular octaedron.

Further it should be remembered, that the same form is sometimes primitive in one substance and secondary in another. Thus the cube, just mentioned as the primitive form of the sulphuret of lead, is one of the secondary forms of the fluate of lime.

Forms of the integrant Particles.

44. Mechanical division is not limited to the discovery of primitive forms only. These forms are still capable of division, and the ultimate result is the form of an integrant particle. We have already

remarked (40), that the primitive form is always divisible in directions parallel to all its sides. But, if divided in this manner, it is evident its form would not be changed; and could we reduce it so minutely, that any further division would involve a decomposition in substances not really simple, we should then have obtained an integrant particle; but its form would be precisely the same, as that of the primitive crystal.

45. But, if the primitive form be also divisible in any direction or directions, *not parallel* to any of its sides, it may evidently be resolved into solids, whose forms are different from that of the primitive. This is in fact the case with some of the primitive forms. Take, for example, the primitive form of the staurotide, which is a right prism (Pl. I, fig. 7.), whose bases *a b c d* and *l m n o* are rhombs. If this be divided by a plane, passing through *d b* and *o m*, the shorter diagonals of the bases, we shall obtain two triangular prisms, which may be further divided in directions, parallel to their sides, but in no other. We must therefore conclude, that all the integrant particles of the staurotide possess the form of a triangular prism.

46. Even in cases, where the primitive form permits no division, except in directions parallel to its sides, the integrant particles will sometimes be found to possess a form, unlike that of the primitive. The phosphate of lime furnishes an example. Its primitive form is a regular hexaedral prism. Let *a b c d e f* (Pl. I, fig. 8.) be one of the bases of this prism. If a division be made by removing laminæ in directions, parallel to the three alternate sides *a b*, *c d*, *e f* only, the solid will be reduced to a triangular prism *g h i*, which, being incapable of division, except in directions parallel to its sides, is the form of an integrant particle of the phosphate of lime. In the figure, the lines of division are extended over the whole base, for the purpose of rendering it obvious to the eye, that the hexaedral prism is an aggregate of a certain number of integrant particles in the form of triangular prisms.

47. Only three forms of integrant particles have hitherto been discovered. They are the three most simple, geometrical solids, viz. a *tetrædron*; a *triangular prism*; and a *parallelopiped*, including all solids of six sides, parallel two and two.

48. It is not to be understood, that integrant particles can be actually obtained by mechanical division. These particles are infinitely small in reference to our senses; we can neither perceive them, nor even name their real magnitude. But it is certain, that, however small, they must have some form; and it is believed, that their true form may be ascertained by the methods already described.

49. From these three forms of integrant particles proceed, by different modes of combination, the aforementioned six primitive forms

of crystals (41). The preceding examples of the staurotide and phosphate of lime show how two different forms, a right prism with rhombic bases, and a regular hexaedral prism, may be composed of integrant particles, having the form of triangular prisms.

50. It has been already remarked (27), that all the integrant particles of the same substance undoubtedly possess the same form and dimensions. Now, as integrant particles have but three forms, it would seem, that the same form must be common to many different substances. It is true, that, in some instances, different minerals have integrant particles of precisely the same form in all respects. Both muriate of soda and sulphuret of lead have a cube.

But it appears from the results of mechanical division, combined with calculation, that, in a large number of the different species of minerals, each species has integrant particles, whose form is peculiar to itself. It may then be asked, how can it be said, that the number of forms is only three. The varieties however, which these three forms are capable of producing, will be obvious, if we consider how many modifications the angles of the same form may undergo, and the various proportions, which may be made to exist between the dimensions of different faces of solids, bearing the same name. Thus the rhomb may vary indefinitely in its angles; the base of the four-sided prism may be a square, or a rhomb, the latter of which may also exhibit a great variety of angles; the base of the triangular prism may be isosceles or equilateral; and the ratio between the sides of the base and the height of the prism may serve to distinguish particles, which in other respects possess the same form.

51. This constancy of form in the integrant particles of the same substance is a character of very considerable consequence in the examination of minerals. It often enables us to recognise a mineral, which, by accidental causes, may have its usual characters very much altered or disguised. For amidst the various coloring matters and other accidental ingredients, which are often found in different individuals of the same substance, its integrant particles and the nucleus of its crystals retain the same form.

Structure of secondary Forms.

52. Having pointed out the method of analyzing crystals by mechanical division, we are now to examine their synthesis; or to inquire in what manner the integrant particles arrange themselves around the nucleus to produce secondary forms. These forms may be supposed to arise from the successive application of laminæ of integrant particles to the faces of the primitive crystal. These laminæ form a decreasing series, beginning with the layer first applied to the

nucleus; and each succeeding layer is somewhat less in extent, than that, which immediately precedes it. This decrement of the laminæ is produced by successively abstracting one range or more of integrant particles from the sides or angles of each layer. These abstractions may be made on all the sides at once, or on all the angles, or only on some one or more of them.

The planes, in which these laminæ of superposition are applied to each other, are always parallel to the faces of the nucleus, and constitute, as we have seen (35), the natural joints of the crystal. It seems then, that the integrant particles first combine to produce the primitive form, and are then so arranged around this nucleus, as to produce the secondary forms.

53. It is important to remark, that even in those crystals, whose integrant particles are tetraedrons or triangular prisms, these particles are so arranged in the interior of the crystal, that, if taken in groups of two, four, six, or eight, they constitute parallelopipeds; so that in fact in every secondary form, the decrements may be supposed to be effected by abstracting ranges of little parallelopipeds. Thus it is obvious (Pl. I, fig. 8.), that any two contiguous triangles compose a rhomb, which may be viewed as the base of a parallelopiped.

54. There are four kinds of decrements, sometimes called laws of decrements.

Decrements on the edges; in this case the ranges of particles are abstracted from the edges of the laminæ in directions, parallel to the edges of the nucleus.

Decrements on the angles; here the abstraction of particles is made from the angles of the laminæ, parallel to the diagonals of the faces of the nucleus.

Intermediate decrements; these are made parallel to lines, intermediate between the diagonals and edges of the nucleus.

Mixed decrements; these take place, when the number of ranges subtracted is greater than unity, and, at the same time, the height or thickness of each layer is greater than the height or thickness of a single integrant particle; thus the decrement may be made by two ranges of particles in breadth, and three ranges in height.

Of these four laws the first and second are by far the most common.

55. The structure of secondary forms in best explained by one or two examples.

Let the cube *a b c o l f g* (Pl. I; fig. 9.) be the given nucleus, on which a secondary form is to be constructed, according to the first law of decrement. Let this cube be composed of 4913 cubic particles. Each face of the primitive, as *a b c o*, will exhibit 289 of these small cubes, and of course each side of this face will present 17 cubic particles. Let L, M, N, O, P, R, S, T (Pl. I, fig. 10.) be laminæ, composed of cubic particles, each cube being equal to one of those, contained in the nucleus. Each of these laminæ is successively diminished by the abstraction of one row of particles from all its sides; so that the number of particles, contained in each side, forms the decreasing series 15, 13, 11, 9, 7, 5, 3, 1. In this series the common difference is two, because one range of particles is taken from each side of each lamina; there will of course be eight laminæ, the last being a single cube only.

Let the lamina L (fig. 10.) be applied to the face *a b c o* of the primitive form (fig. 9.), so that the letters *r*, *s*, *t*, *u*, at the angles of this lamina, shall correspond with the same letters on the face of the nucleus. The sides of this lamina will be parallel to the edges *a b*, *b c*, &c. of the cube; but the lamina itself will evidently be less, than the face, on which it is deposited, by one row of particles on each side.

In a similar manner let the other laminæ be successively applied over each other, with their edges parallel to those of the first lamina. This series of layers, terminating with a single cube, will evidently form a four-sided pyramid *a b c d* (Pl. I, fig. 11.) with triangular faces. By a similar process five other equal and similar pyramids may be raised on the remaining five faces of the primitive cube. This will give a solid, bounded by twenty four triangular faces. Now each of these faces is equally inclined to the face of the nucleus, because the rate of decrement is the same in all the pyramids. Consequently, any two of these triangular faces, as *d b c* and *e b c*, belonging to two contiguous pyramids, lie in the *same plane;* and, uniting at their bases, form the *rhomb b d c e*. But, as there are twenty four triangular faces, thus united two and two, the secondary form will be a dodecaedron, bounded by twelve rhombs.

It must also be obvious, that if the six solid angles *d*, *e*, *h*, &c. of the dodecaedron be removed by mechanical division, a cubic nucleus will remain.

56. In the crystal, which we have just constructed, it will be perceived, that the decrements form re-entering angles, and the edges of the laminæ projecting angles, so that the sides of the pyramids do in fact resemble the steps of a stair. But in the real crystal, which we suppose to have the same structure, the faces appear perfectly plane and smooth. This apparent difficulty however will instantly vanish, when we consider, that the real cubes, which compose the crystal, are infinitely small in reference to our senses, and consequently the abstraction of one or two rows of particles is imperceptible. Hence the smoothness and uniform appearance of the new faces.

The effects however of these decrements are not always invisible.

It is not very uncommon to find the faces of secondary crystals, exhibiting striæ or little channels in the direction of the decrement, as on some trapezoidal garnets. This circumstance, although arising from imperfection in the process of crystallization, forms a striking proof in favor of the theory we are now illustrating, and sometimes may assist to determine the form and position of the nucleus. Some caution however is requisite in employing this character, for it is possible, that striæ may appear on secondary forms in directions, which do not correspond to those of the decrements, and indeed they may sometimes be observed on the primitive form.

57. The new faces on this dodecaedron are usually somewhat less brilliant, than those of the primitive cube. The reason of this will appear, when we reflect, that in the primitive we look directly upon *the faces* of the integrant cubes; whereas in the secondary form we view *the edges* of the same cubes; for the faces of this dodecaedron are really composed of an infinite number of edges of laminæ.

58. When the process of crystallization ceases before this dodecaedron is completed, the secondary form presents eighteen faces, of which six are squares and parallel to the sides of the primitive cube, and the remaining twelve are hexagons, parallel to the sides of the secondary dodecaedron. Or the crystal may be described as a cube, truncated on all its edges.

59. In the preceding example the rate of decrement was supposed to be one row of particles from the four sides of each of the successive laminæ. But, instead of one row, there may be two, three, or more rows of particles, subtracted from the sides of each layer. In these cases it is evident the altitude of the pyramids would be diminished, and the several pairs of contiguous, triangular faces would not lie in the same plane. The solid thus produced would consequently have twenty four triangular faces.

60. The decrements, of which we have hitherto spoken, are supposed to affect only *the breadth* of the laminæ, while their height or thickness remains the same, that is, equal to the height of one of the integrant cubes. But there are cases also, in which *the height* or thickness of each lamina of superposition may be equal to the height of two or more ranges of particles, while *the breadth* is diminished by one range only. The former of these is called a decrement in *height*; the latter, a decrement in *breadth*.

Sometimes these two decrements combine in the same crystal. Sulphuret of iron exhibits a dodecaedron with pentagonal faces, derived from a cubic nucleus by decrements both in height and breadth. On two opposite sides of each pyramid the decrements are made by two rows of particles in height and one row in breadth, and on the striking difference of form, observable in the crystals of any one substance, must depend entirely on a *difference of arrangement* in the integrant particles. Thus the cubic particles of the sulphuret of iron can so arrange themselves, as to produce sometimes a cube, sometimes an octaedron, and sometimes a solid, contained under twenty triangular faces.

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38. Many crystals are not susceptible of this kind of dissection This frequently arises from too great brittleness; sometimes from other causes, but in no instance from any thing, which appears incon-

65. To assign the causes of the preceding modifications, or even of secondary forms in general, is, in the present state of our knowledge, impossible. No doubt some of them may be found in the nature of the solvent, and its various densities, &c. The presence of foreign ingredients, or even an undue proportion of one of the principles of the crystallizing body, may have considerable influence on the arrangement of the particles. It is certain, however, that the causes of a particular secondary form are often quite extensive. For it is frequently the case, that secondary crystals of any given substance, taken from the same vein or repository, or even from the same range of mountains, have the same form; while crystals of the same substance, taken from another place, exhibit a secondary form of a different kind, but uniform in that particular repository.

66. We cannot indeed demonstrate that secondary forms are actually produced in the manner, which the theory supposes.* It is however no inconsiderable argument in its favor, that all calculations, founded on it, give results perfectly conformable to observed facts. The quantity of an angle, obtained by calculation, is verified by actual measurement on the crystal. The theory can determine what forms it is possible for the same body to assume; and of course enables us to say of any particular form, it does, or it does not belong to a given substance; or that this substance can or cannot assume a given form. We are hereby furnished with some important assistance in the discrimination of crystallized minerals, viz. an appeal to the forms and structure of their crystals. In fine, this theory is in fact a very interesting application of the principles of geometry to the analysis and synthesis of various solids. It shows us, that a crystalline structure is to minerals in some degree what organization is to vegetables.

67. The theory, we have just considered, does indeed extend only to the *structure* of the crystal, which is to be considered, as an aggregate of similar particles, having a determinate arrangement; it presumes not to explain the mode of formation.

It may however be remarked, that it is not necessary to suppose, that the primitive form always reaches the size of that, which we extract by mechanical division, before the application of the laminæ of superposition. Indeed we find very minute crystals equally perfect

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* It can hardly be necessary to state, that mineralogy is indebted to the Abbé Haüy, of Paris, for the system of crystallography here given; more especially for the actual discovery of primitive forms, the details, which relate to secondary forms, and the application of this theory to a great proportion of the crystals hitherto observed. Bergman and Romé de Lisle had previously drawn some of the outlines.

in their structure with those of the same kind, that are larger. Is it not then possible, that the secondary form may be often completed soon after the commencement of crystallization, and afterwards increase without changing its form?

Goniometer.

68. It has already been remarked (20), that crystals, which possess the same form, and belong to the *same substance*, give a constant measure of their angles; it is hence true, that crystals of the same form, but belonging to *different substances*, may, in most instances, be distinguished by the measure of their angles, which, though constant in the same substance, is different in different substances, even when possessing the same form. It must then be a matter of great importance to ascertain with accuracy the quantity of any required angle. The importance of such measurements will be more striking, when we consider, that the same substance sometimes presents crystals, which fall under the same general name, but which are produced by different decrements, and differ in the measure of their angles, by which alone, however, they must be discriminated. Thus the carbonate of lime yields different secondary forms, which come under the name of a rhomb. Indeed different forms sometimes so nearly resemble each other, that they can hardly be distinguished by the eye, as in the case of a very obtuse rhomb and a cube.

69. This accurate measurement of crystals is, in a great degree, effected by a very simple instrument, called a *goniometer* (*Γωνια Μετρον*), and invented by M. Carangeau. It consists of a brass semicircle *a b d* (Pl. II, fig. 12, A.), graduated into 180°. A thin plate of brass extends from *d* to *a*. The centre *c* of this brass plate is made the centre of motion of two steel arms *g d* and *k i*, which, at the extremities *g* and *k*, are reduced to a point, that they may more conveniently be applied to a crystal; and, for the same reason, both arms are made to slide on the pin, which confines them at the centre. By being thus enabled to shorten the arms at pleasure, the inconvenience, arising from the gangue or adjoining crystals, may be avoided; sometimes also the brass plate extends only from *d* to the centre, and the quadrant *a b* is made to fold back occasionally, on *b d*, that it may not interfere with adjoining crystals.

Now, if the two inner edges of the steel arms, near the points *g* and *k* be carefully applied to the planes of two contiguous faces of a crystal, the arms being held perpendicular to the edge, formed by these two faces, we shall evidently obtain the angle, which the two aforementioned faces make with each other; for it is equal to its vertical angle, and measured by the arc, contained between the two arms, at their extremities *i* and *d*.

The arms of the goniometer are sometimes distinct from the semicircle, as in Pl. II, fig. 12, B. The measurement is effected in the manner already described; and the arms are then applied to the semicircle to ascertain the angle. This mode is convenient in very acute angles.

The goniometer, invented by Dr. Wollaston, appears to be capable of great accuracy in its measurements. It may be called an optical goniometer; for the angle is determined by rays of light, reflected from those two faces of the crystal, which contain the angle. It consists of a vertical wheel or circle with a graduated circumference. The axis of this wheel is perforated in a horizontal direction, and through this perforation passes a moveable axis, to which the crystal is attached. When the position of the crystal is so adjusted by this moveable axis, that *one of the sides*, containing the angle to be measured, *reflects its light to the eye*, the circle is turned, till the *other side* is brought into the same position; and hence the inclination of these two faces is measured by the arc, through which the zero or index of the vertical circle has passed.

This goniometer must be peculiarly useful in cases, where the side of the crystal, or the surface of the fracture is imperfect; for the most minute portions of those laminæ, which are parallel to each other, though not in the same plane, reflect the light at the same moment.

70. Hitherto in our remarks on crystallization we have supposed the results to be perfect crystals. But the numerous and frequent imperfections, which crystals exhibit, clearly indicate a very considerable degree of disturbance in the process of their formation. This disturbed crystallization is productive of various modifications in the shapes of crystals, or even entirely prevents the appearance of the crystalline form. Sometimes this disturbance manifests itself by giving an undue extension to some of the faces, while others are scarcely perceptible; so that the crystal sometimes appears to have been compressed in certain directions. Sometimes the edges are rounded and the angles blunted; while, in other instances, the faces of the crystal present a convex or concave surface.

In cases, where the crystalline form has entirely disappeared, a *fibrous* or *lamellar* structure of the mass may still indicate, that the mineral has been formed by a very disturbed crystallization. The particular names, by which those crystallized substances, which present no regular form, are designated, will be given in the section on external characters, under the article *imitative* forms (105).

Description of Crystals.

71. For the purpose of describing and distinguishing minerals

crystallography furnishes two kinds of characters. One is derived from the actual forms of crystals; the other from the internal structure, and may obviously be extended to laminated masses, not possessed of regular forms.

As the actual forms of well defined crystals furnish important characters, we shall now attend to the modes of describing them.

72. Crystals may be described, either by the assistance of a diagram, or by employing certain well defined terms, capable of conveying an adequate idea of the solid intended. The use of a diagram is attended with many obvious advantages. It enables us to refer with ease to a particular angle or side. Indeed when the form is very complex, mere description is tedious, even when sufficiently intelligible; whereas a figure conveys at once a correct, general idea of the form of the crystal. In all cases, however, the exact quantity of the most important angles should be mentioned; or of so many of them, at least, as may be necessary to prevent mistake.*

73. If a crystal exhibit the form of any geometrical solid, known by a particular name, as a cube, or a regular tetraedron, or octaedron, it is easily described; it is sufficient to name it. But, when a definite idea of the form of a crystal cannot thus be conveyed, some other method must be employed. And probably no mode is attended by so many advantages, as that, in which a clear, short, and technical description of the form, including accurate measures of the most important angles, is combined with a diagram.

74. For accurate definitions of *the terms*, now generally employed in the description of crystals, mineralogists are much indebted to the celebrated Werner. This mode of description is founded on certain assumed principles, and essentially consists in supposing the crystal to possess what is called a *predominant* form; and that this predominant form has undergone certain alterations, till it has acquired the actual form, intended to be described.†

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* Some mineralogists designate the angles of crystals, as right, acute, or obtuse, and qualify the two last by some general terms, expressive of the degree of obliquity. But it appears from previous remarks (68), that this can assist but little in discriminating forms, which much resemble each other. Two crystals may exhibit in certain parts *very obtuse angles*, and yet these angles may uniformly differ by a certain quantity, insensible to the eye.

† It is important to premise, that this method of describing the forms of of crystals is, in general, entirely artificial; that the assumption of certain predominant forms has no relation whatever to the primitive form, or the manner, in which crystals are actually formed; and that the alterations, supposed to be made in these predominant forms, are not real; for a crystal, viewed as a whole, always increases during the period of its formation, whereas this

By the *predominant form* of a crystal is intended that geometrical form, to which the given crystal most approximates. Thus the solid (Pl. II, fig. 13.) most resembles a cube; but it has lost a segment from each of its solid angles, and from each of its edges; or each edge and each solid angle is said to be replaced by one face. The solid (Pl. II, fig. 17.) most resembles a prism; but its extremities exhibit pyramids. In the two preceding examples a cube and four-sided prism are respectively the predominant forms. The appearance of a crystal may be still more removed from that of the predominant form by further alterations.

75. The number of predominant forms may be reduced to six; an *icosaedron* with triangular faces; a *dodecaedron* with pentagonal faces; a *hexaedron*, or solid with six equal faces; a *prism*; a *pyramid*; and a *table*, by which is intended a very short prism. In describing these solids and their various modifications, the faces, edges, and solid angles must receive attention.

76. Many solids admit a distinction both of their faces and edges into *lateral* and *terminal*.

In crystals of a prismatic form the *lateral faces* are the sides of the prism, as M, M (Pl. II, fig. 14.); and the *lateral edges* are those formed by the meeting of any two lateral faces, as the edge *a b* in the same figure.

The *terminal faces* of prismatic crystals are their bases, sometimes called the upper and lower base, as P, P in fig. 14; and the *terminal edges* surround the bases or terminal faces, as *a c*, *c d* in the figure last mentioned.

If the crystal have a *tabular* form (Pl. II, fig. 15.), P is a lateral face, and *a b* a lateral edge. And in the same crystal M, M are terminal faces, and *c d* a terminal edge.*

A pyramid is said to have a *base*, and *lateral* faces; and its lateral edges all meet at the vertex. An octaedron is sometimes considered a double four-sided pyramid, having a common base at the junction of the two pyramids. The vertices of a double pyramid are also called its *summits*; and a rhomb is sometimes viewed, as a double three-sided pyramid, whose summits are the two opposite, solid an-

method supposes certain subtractions to be made from the magnitude, which the crystal once possessed.

* This mode of distinguishing the faces and edges of *tabular* crystals is altogether unnecessary. A table, as just observed, is only a very short prism; and its several parts may be denominated in the same manner, as those of a longer prism. This distinction between lateral and terminal faces does not extend to the two first named predominant forms.

gles, which are formed by three equal plane angles. So also the pyramidal terminations of a prism are called its summits.

When all the faces of a prismatic crystal are not equal, they are sometimes alternately wide and narrow; and sometimes two opposite faces are equally wide or narrow.

77. We are now to notice the several alterations, to which the predominant form may be subjected. These are three; *truncation*, *bevelment*, and *acumination* or *termination*. By each of these supposed alterations new faces are produced on the crystal; and their inclination to the contiguous faces may be measured by a goniometer.

78. *Truncation.* This alteration supposes a segment to be cut off or separated from the predominant form. A truncation may be applied either to an edge or a solid angle of a crystal, and will evidently leave a face more or less large in place of the edge or angle, as *a*, *a* and *b*, *b* (Pl. II, fig. 13.), where each edge and each solid angle of the cube is replaced by one small face. A truncation is said to be oblique, when the new face does not make equal angles with all the contiguous faces.

79. *Bevelment.* A bevelment may be applied to a lateral or terminal edge, or even to a terminal face, or a solid angle. It supposes the removal of two contiguous segments from the edges, angles, or terminal faces of the predominant form, thereby producing two new faces, as r, r (Pl. II, fig. 16.), inclined to each other at a certain angle and forming *an edge;* in this figure the cube is bevelled on all its edges. This new edge is sometimes situated obliquely, when referred to the edge or face, on which the bevelment is made. When a terminal face is bevelled, the two planes may stand either on the lateral faces or lateral edges. A second bevelment is sometimes applied to the edge, produced by the first, thereby forming four new faces, instead of two.

The degree of alteration, produced in the predominant form by truncation or bevelment, may be expressed in a general manner by saying *slightly* or *deeply* truncated or bevelled.

80. *Acumination or termination.* When three or more new faces are produced in the manner aforementioned, and these all unite in one point or line, a termination or acumination is said to exist. This alteration may be applied to a terminal face, as in the pyramidal termination *a d b c* (Pl. II, fig. 17.); or to a solid angle, as *a*, *a*, *a* (fig. 18.), where each solid angle of the cube is terminated by three faces. The faces of a termination, which is applied to a terminal face, may correspond to the lateral faces or the lateral edges of the predominant form; and the edges, produced by these terminating

faces, are called the lateral edges of the termination. Sometimes two opposite faces of a pyramidal termination are so much wider than the others, that the pyramid terminates in an *edge*, instead of a point, and is said to be *cuneiform*.

81. When a crystal is supposed to stand on one of its bases, or to have its axis vertical, or indeed to rest in any other given position, its faces and edges may be conveniently designated, as horizontal, vertical, or oblique.

82. *Grouping of crystals.* Two or more crystals are often found attached to each other in groups more or less regular. In a few cases, indeed, these groups have much regularity in their structure and appearance. Sometimes they are composed of two crystals, which partially penetrate each other, or simply adhere by two faces similarly situated on both crystals. Sometimes two prisms intersect each other at constant angles, either right or oblique.

Other groups exhibit the appearance of *two halves* of the same crystal, so applied to each other, that, while one half is supposed to remain at rest, the other half, without being separated from the former, seems to have performed some part of a revolution in the common plane of intersection.

In some cases that half, which is supposed to revolve, seems to have passed through only one sixth of the circumference of a circle; in others it has described a semicircle, so that its position is inverted in regard to that half, which remains fixed. To this inversion of one half the Abbé Haüy has given the name hémitropie (hemitropy), which is designed to indicate, that one segment of the crystal has *turned* through *half* the circumference of a circle; and the crystal, thus produced, he designates by the epithet *hémitrope.* Such crystals are also called double or twin crystals.

These hemitrope or twin crystals, as well as those, which penetrate or intersect each other, may almost always be easily recognised by the *re-entering angle* or *angles*, which they present; for such angles never appear on simple crystals. Those parts of the crystal directly opposite to these re-entering angles will, of course, exhibit projecting edges or angles. In Pl. II, fig. 19. is an octaedral crystal of spinelle, which is supposed to be bisected in the plane of the dotted hexaedron, which appears in the interior. If, while the lower half remains fixed, the upper half be supposed to revolve in the aforementioned plane, through one sixth of a circle, the crystal (fig. 20.) will be produced. Feldspar and oxide of tin exhibit hemitrope crystals, as will be seen under those articles. In some minerals more than two single crystals are regularly grouped.

Most frequently, however, groups of crystals are quite irregular. In this case, they are described, as far as practicable, by comparing them to some known body, which they resemble. Thus these groups may be *fascicular*, like a bundle of rods, or *scopiform*, like a broom, being in both cases composed of small crystals diverging from a centre; they may also resemble a *rose* or a *sheaf*. Sometimes the crystals aggregate in rows, and constitute *acicular* or *columnar* groups. In fine the groups may be *globular*, *pyramidal*, &c.

All these various adhesions of crystals must arise from a greater or less degree of disturbance in the process of their formation.

83. *Size of crystals.* As the size of crystals may vary from that of several inches in some of their dimensions, till their form becomes indeterminable without the aid of a microscope, it is of some consequence, that their general size should be stated.

Nomenclature of Crystals.

84. The importance of a systematic nomenclature in any branch of science is extremely obvious; and chemistry has already presented a striking instance of the truth of this remark. It must also be evident, that numerous advantages would result from a similar nomenclature in crystallography; especially when we consider the immense variety of crystalline forms, which the mineral kingdom presents, and the importance of being able, without the labor of description, to designate any particular variety of form by some *name* or *epithet*, which may indicate the form itself, or the general structure, or some peculiarity of form or structure. The attempt, of which an account is now to be given, has been made by the celebrated Haüy.

The *original names* will be employed with an explanation annexed, and, in many cases, a reference to figures; for the analogy of our language does not appear to justify a literal translation of many of the terms of this nomenclature.* Indeed mineralogy already presents many uncouth and barbarous terms *unnecessarily* introduced into the English language by a literal translation of words belonging to foreign languages.

It may, however, be remarked, that many of the terms of this nomenclature may be easily understood without a knowledge of the French language, and may with great propriety be adopted, as English words, by a slight alteration of the orthography.

85. *Primitif* or *Primitive*, added to the name of the species, always denotes the primitive form of the crystals of that species. Thus zircon primitif.

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* See Elements of Crystallography, after the Method of Haüy, by *Fredrick Accum.* London; 1813.

86. The secondary forms of crystals may be considered under six different points of view.

I. Secondary forms, considered in regard to the modifications, produced in the primitive form, by a combination of the faces of the latter with those, which result from the laws of decrement.

Thus a crystal may be called

Pyramidé, when the primitive form is a prism, and, in the secondary form, is terminated at each extremity by a pyramid, having as many faces, as the prism has sides.

Prismé, when the primitive form is composed of two pyramids united base to base, and, in the secondary form, these pyramids are separated, and a prism is interposed. Thus zircon prismé; (Pl. III, fig. 34).

Semi-prismé, as in the preceding, except that the interposed prism has only half as many sides, as there are edges at the common base of the two pyramids.

Basé, when the primitive form is a rhomb, or is composed of two pyramids united base to base, and, in the secondary form, the summits of the rhomb or double pyramid are truncated by faces perpendicular to the axis of the crystal.

Epointé, when all the solid angles of the primitive form are truncated, each by one face. Thus strontiane sulfatée (sulphate of strontian) epointée; (Pl. III, fig. 6).

Bisépointé, *triépointé*, *quadriépointé*, when each solid angle of the primitive form is replaced by two, or three, or four faces. Thus analcime triépointée; (Pl. IV, fig. 21).

Emarginé, when all the edges of the primitive form are truncated, each by one face.

Bisémarginé, *triémarginé*, when each edge of the primitive form is replaced by two, or three faces.

Périhexaèdre, when the primitive form is a prism of four sides, and, in the secondary form, is converted into a prism of six sides by the decrements; or, in other words, is truncated on two of its lateral edges.

Périoctaèdre, *péridécaèdre*, *péridodécaèdre*, when, as in the preceding, a four-sided prism is converted into a prism of eight, or ten, or twelve sides. The term péridodécaèdre is also employed, when the primitive form is a regular six-sided prism, and, in the secondary form, has each of its lateral edges truncated by one face.

Raccourci (shortened), when the primitive form is a prism, whose bases are rhombs, and, in the secondary form, each of the two lateral edges, contiguous to the *longer* diagonals of the bases, is truncated by one face; in consequence of which the crystal appears diminished in length.

Rétréci (narrowed), when the primitive form is the same as in the preceding, but, in the secondary form, each of the two lateral edges, contiguous to the *shorter* diagonals of the bases, is truncated; in consequence of which the crystal appears diminished in breadth. Thus baryte sulfatée (sulphate of barytes) rétrécie; (Pl. III, fig. 2).

87. *II. Secondary forms, considered by themselves, and merely as geometrical forms.*

A crystal may be called

Cubique, when it exhibits a cube, as a secondary form.

Cuboïde, when the form differs very little from a cube. Thus chaux carbonatée (carbonate of lime) cuboïde; (Pl. III, fig. 15).

Tétraèdre, when the crystal presents a regular tetraedron, as a secondary form.

Octaèdre, when it presents an octaedron, as a secondary form.

Prismatique, when the form is a right or oblique prism, whose sides are inclined to each other at an angle of 120°.

Dodécaèdre, when the surface of the crystal presents twelve triangular, quadrangular, or pentagonal faces, all equal and similar, or whose plane angles possess only two different measures. Thus zircon dodécaèdre; (Pl. III, fig. 35); also cuivre gris (gray copper) dodécaèdre; (Pl. IV, fig. 40).

Icosaèdre, when the crystal is bounded by twenty triangles, of which twelve are isosceles and eight equilateral. Thus fer sulfuré (sulphuret of iron) icosaèdre; (Pl. V, fig. 7).

Trapézoïdal, when the surface is composed of twenty four trapeziums, all equal and similar. Thus grenat (garnet) trapézoïdal; (Pl. IV, fig. 14).

Triacontaèdre, when the crystal is bounded by thirty rhombs. Thus fer sulfuré (sulphuret of iron) triacontaèdre; (Pl. V, fig. 8).

Ennéacontaèdre, when the surface presents ninety faces.

Birhomboïdal, when the surface is composed of twelve rhombic faces, which, being taken six and six and prolonged in idea, till they intercept each other, would form two different rhombs.

Trirhomboïdal, when, as in the preceding, three different rhombs would be formed. Thus chabasie trirhomboïdale; (Pl. IV, fig. 22).

Biforme, when the crystal embraces a combination of two remarkable forms, as the cube, rhomb, octaedron, dodecaedron with rhombic faces, &c.

Triforme, when, as in the preceding, three forms are concerned. Thus cobalt arsenical triforme; (Pl. V, fig. 24).

Cubo-octaèdre, when the crystal presents a combination of the two forms, indicated by the name, viz. a cube and octaedron.

Cubo-dodécaèdre, *cubo-tétraèdre*, when, as in the preceding, the forms are a cube and dodecaedron, or a cube and tetraedron. Thus fer sulfurè (sulphuret of iron) cubo-dodécaèdre; (Pl. V, fig. 6).

Trapézien, when the lateral planes are composed of trapeziums, situated in two ranges between the two bases. Thus baryte sulfatée (sulphate of barytes) trapézienne; (Pl. III, fig. 3).

Ditétraèdre, when the form is a tetraedral prism with diedral summits. Thus fer arsenical (arsenical iron) ditétraèdre; (Pl. V, fig. 4).

Dihexaèdre, *dioctaèdre*, when the form is a hexaedral prism with triedral summits, or an octaedral prism with tetraedral summits. Thus topaze dioctaèdre; (Pl. III, fig. 25).

Didécaèdre, *didodécaèdre*, when the crystal is a decaedral prism with pentaedral summits; or a dodecaedral prism with hexaedral summits. Thus diopside didodécaèdre; (Pl. IV, fig. 26).

Trihexaèdre, when the surface exhibits three ranges of faces, placed one above the other, each range containing six faces.

Tétrahexaèdre, *pentahexaèdre*, *eptahexaèdre*, *trioctaèdre*, *tridodécaèdre*, when, as in the preceding, the crystal presents certain ranges of a given number of faces, as indicated by the several names respectively.

Bigéminé, when the crystal exhibits a combination of four forms, which, taken two and two, are of the same kind.

Amphihéxaèdre, when the faces of the crystal, counted in two different directions, give two hexaedral outlines, or are found to be six in number.

Sexdécimal, when a prism, or the middle part of a crystal, has six faces, and the two summits, taken together, ten faces; or the reverse. Thus feldspath sexdécimal; (Pl. IV, fig. 7).

Quadridécimal, *octodécimal*, *sexduodécimal*, *octoduodécimal*, *déciduodécimal*, *octosexdécimal*, *sexoctonal*, &c, when, as in the preceding, a prism or the middle part of a crystal, and the two summits have the number of faces, indicated by the several names respectively. Thus feldspath quadridécimal; (Pl. IV, fig. 6); also corindon (corundum) octoduodécimal; (Pl. III, fig. 29); also plomb carbonaté (carbonate of lead) sexoctonal; (Pl. V, fig. 15).

Péripolygone, when a prism has a great number of sides.

Surcomposé, when the form is very complex. Thus fer sulfurè (sulphuret of iron) surcomposé; (Pl. V, fig. 10).

Antiennéaèdre, when there are nine faces on two opposite parts of the crystal. This form appears in a variety of the tourmaline, in which each summit has nine faces, and the prism twelve sides; whereas the prism usually has nine sides.

Prosennéaèdre, when there are nine faces on two adjacent parts of the crystal. This form also belongs to a variety of the tourmaline, in which the prism has nine sides and one of the summits nine faces.

Récurrent, when the faces of the crystal, being counted in annular ranges from one extremity to the other, furnish two different numbers, which succeed each other several times, as 4, 8, 4, 8, 4.

Equidifférent, when a different number of faces is presented by the prism and by each summit; and these three numbers form a series in arithmetical progression, as 6, 4, 2. Thus amphibole (hornblende) equidifférent; (Pl. IV, fig. 30).

Convergent, when the series of numbers, taken as in the preceding variety, is rapidly convergent, as 15, 9, 3.

Impair, when a different number of faces is presented by the prism and by each summit; but the three numbers follow no law of progression. Thus tourmaline impaire; (Pl. IV, fig. 3).

Hypéroxyde (acute to excess), which is a name given to a variety of carbonate of lime, embracing a combination of two acute rhombs, of which however one is much more acute, than the other; (Pl. III, fig. 21).

Sphéroïdal, when it is bounded by several convex faces, as one variety of the diamond, which has forty eight convex faces; (Pl. IV, fig. 34).

Plan-convexe, when, as in a variety of the diamond, some of the faces are plane, and others curved.

88. *III. Secondary forms, considered in regard to certain faces or edges, remarkable by their position, or relative situation.*

Thus a crystal may be called

Alterne, when on two parts, an upper and lower part, it presents faces, which alternate among themselves, but which correspond with each other, when the two parts are compared.

Bisalterne, when, as in the preceding case, the alternation takes place not only between the faces on the same part, but also between those on the two parts.

Bibisalterne, when there is on both parts two sets of bisalterne faces. Thus mercure sulfuré (sulphuret of mercury) bibisalterne; (Pl. IV, fig. 39).

Annulaire, when a hexaedral prism has six, or an octaedral prism eight marginal faces, disposed in a ring about each base; or when these prisms are truncated on all their terminal edges.

Monostique, when a prism of a given number of sides has on the margin of each base a range of faces of a different number from that of the sides; these faces may be all marginal, or some may be marginal and others may replace the solid angles; or they may be viewed as truncations of the terminal edges and solid angles. Thus topaze monostique; (Pl. III, fig. 26); also epidote monostique; (Pl. IV, fig. 16).

Distique, when, instead of one range, as in the preceding variety, there are two ranges of faces about each base.

Subdistique, when two of the faces, disposed in the same range about each base, are surmounted by two additional faces, which seem to constitute the beginning of a second range.

Plagièdre, when a crystal has faces situated obliquely, or in a slanting direction.

Dissimilaire, when two ranges of faces, situated one above the other towards each summit, have a want of symmetry. Thus epidote dissimilaire; (Pl. IV, fig. 17).

Encadré, when a crystal has faces, which form a kind of *frame* about the faces of a more simple form, already existing in the same species.

Prominule, when a crystal has edges, which contain a very obtuse angle, and of course project but little.

Zonaire, when the crystal has about its middle part a range of faces, which form a kind of zone.

Apophane (manifest), when certain faces or certain edges present some useful indication for discovering the position of the nucleus, which it would otherwise be difficult to determine.

Emoussé (blunted), when there are faces, which intercept and apparently blunt certain edges or angles, which, without these faces, would be more projecting than the other edges or angles.

Contracté, a name applied to a dodecaedral variety of the carbonate of lime, in which the bases of the terminating pentagons suffer a kind of contraction, in consequence of the inclination of the lateral faces.

Dilaté, a name applied to another variety of the dodecaedral carbonate of lime, in which the bases of the pentagons, which terminate the crystal, suffer a kind of dilation, in consequence of the inclination of the lateral faces; (Pl. III. fig. 20).

Acutangle, a term employed to designate a hexaedral prism of carbonate of lime, which has its solid angles truncated by very acute-angled triangles.

Defective, a name particularly applied to a variety of the borate of magnesia, in which four of the solid angles of the primitive cube are truncated, each by one face, while the opposite solid angles remain untouched.

Surabondante, a name applied to another variety of the borate of magnesia, in which each of the solid angles of the cube, which were untouched in the preceding variety, is terminated by four faces; (Pl. III, fig. 24).

89. *IV. Secondary forms, considered in regard to the laws of decrement, on which they depend.**

A crystal may be called

Unitaire, when its form is produced by a single decrement of one range of particles. Thus feldspath unitaire; (Pl. IV, fig. 5).

Bisunitaire, triunitaire, quadriunitaire, when there are two, or three, or four decrements by one range of particles. Thus epidote bisunitaire; (Pl. IV, fig. 15); also pyroxene (augite) triunitaire; (Pl. IV, fig. 28).

Binaire, when the secondary form depends on one decrement by two ranges of particles.

Bibinaire, tribinaire, when it depends on two, or three decrements, each by two ranges of particles, according to the names respectively. Thus chaux carbonatée (carbonate of lime) bibinaire; (Pl. III, fig. 18).

Ternaire, biternaire, when the secondary form is produced by one, or two decrements, each by three ranges of particles, according to the names respectively.

Unibinaire, when there are two decrements, the one by one range, and the other by two ranges of particles. Thus staurotide unibinaire; (Pl. III, fig. 30).

Uniternaire, when one of the two decrements is by one range of particles, and the other by three ranges. Thus titane siliceo-calcaire uniternaire; (Pl. V, fig. 35).

Binoternaire, when, of the two decrements, one is by two and the other by three ranges of particles. Thus fer oligiste (specular oxide of iron) binoternaire; (Pl. V, fig. 11).

Equivalent, when the exponent or index of one decrement is equal to the sum of the exponents of the other decrements. Thus chaux sulfatée (sulphate of lime) équivalente; (Pl. III, fig. 11).

Soustractif, when the exponent, which relates to one decrement,

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* By the term *exponent*, employed in this division, is intended the number, which indicates how many ranges of particles are subtracted in the several decrements. In mixed decrements the exponent is a fraction, of which both terms are greater than unity; the numerator expresses the decrement in breadth, and the denominator the decrement in height.

is less by unity, than the sum of the exponents of the other decrements.

Additif, when the exponent of one decrement exceeds by unity the sum of the exponents of the other decrements.

Progressif, when the exponents form a series of numbers in arithmetical progression, as 1, 2, 3. Thus fer oligiste (specular oxide of iron) progressif; (Pl. V, fig. 13).

Disjoint, when the decrements differ much from each other, as from 1 to 4 or 6.

Partiel, when some part of the primitive form remains without decrements, while other parts, similarly situated, undergo them. Thus cobalt gris (gray cobalt) partiel; (Pl. V, fig. 25).

Soudouble, when the exponent of one decrement is half the sum of the other exponents. Thus axinite soudouble; (Pl. IV, fig. 11).

Soutriple, *souquadruple*, when the exponent of one decrement is only one third, or one fourth the sum of the other exponents.

Doublant, when one of the exponents is twice repeated in a series, which would otherwise be regular.

Triplant, *quadruplant*, when one of the exponents is three, or four times repeated in a series, which would otherwise be regular.

Identique, when the exponents of two simple decrements are equal to the terms of the fraction, which express a third and mixed decrement in the same crystal.

Isonome (equality of laws), when the exponents, which mark the decrements on the edges, are equal; and also those, which denote the decrements on the angles. Thus cuivre sulfaté (sulphate of copper) isonome; (Pl. V, fig. 3).

Mixte, when the form results from a single mixed decrement.

Pantogène (originating from all its parts), when every edge and every solid angle undergoes a decrement. Thus baryte sulfatée (sulphate of barytes) pantogène; (Pl. III, fig. 4).

Bifère, when each edge and each solid angle suffers two decrements.

Entouré, when there are decrements on all the edges and on all the solid angles about the base of a prismatic nucleus.

Opposite, when one decrement is made by one range of particles, and another decrement is intermediate.

Synoptique, when the laws of decrement in any given crystal offer a kind of synopsis of the laws, which operate in the formation of all the other secondary crystals of that species, or at least the greater part of them.

Rétrograde, which is a name applied to a variety of the carbonate of lime, whose form depends chiefly on two mixed decrements; and the faces thence resulting seem to retrograde, that is, they appear to be thrown backward toward that side of the axis, which is most removed from that face, where the decrements commence.

Ascendant, when all the laws of decrement have an ascending direction, setting out from the angles or lower edges of a rhombic nucleus.

90. *V. Secondary forms, considered in regard to certain geometrical properties, which they present.*

Thus a crystal may be called

Isogone (equality of angles), when the faces, which exist on certain parts, differently situated, form among themselves equal angles. Thus tourmaline isogone; (Pl. IV, fig. 2).

Anamorphique (inverted form), when the crystal cannot be placed in its most natural position, without apparently inverting that of the nucleus. Thus stilbite anamorphique; (Pl. IV, fig. 20).

Rhombifère, when certain faces of the crystal are true rhombs, although, from the manner, in which they are connected with the contiguous faces, they do not, at first view, appear to be regular figures. Thus quartz rhombifère; (Pl. III, fig 36).

Equiaxe, when the secondary form is a rhomb, whose axis is equal to that of the primitive form, which is also a rhomb. Thus chaux carbonatée (carbonate of lime) equiaxe; (Pl. III, fig. 13).

Inverse, when the secondary form is a rhomb, whose *edges* contain angles equal to the plane angles of the primitive form, which is itself a rhomb, and whose *plane angles* are equal to those, contained by the edges of the primitive rhomb. Thus chaux carbonatée (carbonate of lime) inverse; (Pl. III, fig. 14).

Métastatique (a transfer), when the secondary crystal has some of its plane angles and some of those, formed by the inclination of its faces, equal to certain angles of the nucleus, which are thus in a certain sense transferred to the secondary form. Thus chaux carbonatée (carbonate of lime) métastatique; (Pl. III, fig. 16).

Contrastant, which is a name applied to a very *acute* rhomb of carbonate of lime, whose angles, when compared with those of the variety *equiaxe*, undergo an inversion, similar to that described in the variety *inverse;* in consequence of which certain parts of the crystal are made to resemble a very *obtuse* rhomb, thus producing a kind of contrast in the same crystal.

Persistant, a name applied to a variety of carbonate of lime, in which certain faces are intercepted by the contiguous faces in such manner, that they preserve the same measures of their angles, which they would have had without being thus intercepted; these angles may however have different relative positions.

Analogique, when the form presents many remarkable analogies. Thus chaux carbonatée (carbonate of lime) analogique; (Pl. III, fig. 22).

Paradoxale, when the structure presents singular and unexpected results.

Complexe, when the structure is rendered complicate by uncommon decrements; as when some are mixed and others intermediate.

91. *VI. Secondary forms, considered in regard to certain peculiar properties.*

Thus a crystal may be called

Transposé, when it is composed of two halves of an octaedron, or of two portions of some other crystal, of which one seems to have turned upon the other through a space equal to one sixth of the circumference of a circle. Thus zinc sufuré (sulphuret of zinc) transposé; (Pl. V, fig. 23).

Hémi-trope, when it is composed of two halves of the same crystal, of which one half seems to be inverted in regard to the other; see art. 82. Thus feldspath hémi-trope; (Pl. IV, fig. 8).

Rectangulaire, a name applied to that variety of the staurotide, composed of two prisms, which cross at right angles.

Obliquangle, a name applied to another variety of the staurotide, in which the two prisms cross at an angle of 60°. (Pl. III, fig. 31).

Sexradiée, a name applied to that variety of the staurotide, composed of three prisms, which cross in such manner, as to exhibit the six radii of a regular hexagon.

Cruciforme, a name applied to a variety of the harmotome, composed of two prisms, intersecting each other, and producing a kind of cross. (Pl. IV, fig. 23).

Triglyphe, when the striæ on the surface of the crystal, being viewed on three faces, which unite about the same solid angle, have three different directions, all perpendicular to each other. Thus fer sulfuré (sulphuret of iron) triglyphe; (Pl. V, fig. 5).

Géniculé, when the crystal consists of two prisms, which unite at one extremity, so as to form a kind of knee. Thus titane oxidé (red oxide of titanium) géniculé; (Pl. V, fig. 31).

SECTION 2.

Physical or External Characters,

92. The properties of minerals are somewhat numerous, and fall under the cognizance of two distinct branches of science; hence the

twofold division, already mentioned (16), into physical and chemical properties or characters. But, as the *physical* characters of minerals may be ascertained by mere inspection, combined in some instances with a simple experiment, they have generally received the name of *external* characters; to describe which is the object of this section.

93. Whenever those properties, which are named in the description of bodies, exist in different degrees in different substances, it becomes peculiarly important, that the language employed should be accurate. Now this is remarkably the case in regard to the external characters of minerals. The same character, when viewed in different minerals, often presents very nice grades of distinction. Even different individuals of the same species not unfrequently possess the same property in various degrees. These remarks will be sufficiently illustrated by referring to the numerous degrees of hardness, lustre, &c. and more especially to the almost innumerable varieties of color, observable in the mineral kingdom.

It must hence be obvious, that great precision and accuracy of language are absolutely necessary in describing minerals by their external characters. Each term must be well defined, and carefully employed, so that it may always convey the same definite idea.

94. For the appropriate language, now generally employed to express the external characters of minerals, we are indebted to the celebrated *Werner*, Professor of Mineralogy, at Freyberg, in Upper Saxony. In the following arrangement of these characters, no other principle is regarded, than to pass from those, which may be observed by mere inspection, to others, requiring more or less of experiment.

Color.
Changeable colors.
Lustre.
Transparency.
Refraction.
Form.
Surface.
Unctuosity.
Coldness.
Smell.
Taste.
Adhesion to tongue.
Soil.
Streak.
Distinct concretions.
Flexibility.
Sound.
Cohesion.
Hardness.
Fracture.
Frangibility.
Shape of fragments.
Tenacity.
Magnetism.
Electricity.
Phosphorescence.
Specific gravity.

1. *Color.*

95. This property, although one of the most striking, is by no means the most characteristic. Its real importance, however, will be best ascertained by examining its sources.

First, in many minerals the coloring matter is both accidental and variable; and arises from the presence of metallic oxides, particularly those of iron and manganese. Now these oxides may exist in different proportions, or with different degrees of oxidation; either of which would produce a variation in the color, or at least in the shade of the color of different varieties, belonging to the same species. Hence zircon may be gray, green, blue, red, yellow, or brown; quartz may be white, gray, brown, yellow, green, red, &c. and all these colors are further diversified by various shades. Now in these and similar cases it is evident, that but little reliance can be placed on color alone. It may indeed be true, that most minerals usually exhibit some one or two of the colors belonging to them; it may even be true, that some minerals present but one color, yet this one may assume a variety of shades. It is hence obvious, that, when the color depends on some accidental ingredient, it can only increase the probability, that the mineral under examination belongs to this or the other species. The preceding remarks apply to the colors, which appear on most of the *earthy compounds* and of the *earthy* and *alkaline salts.* The coloring matter may actually be extracted from some saline minerals, and every other property remain the same.

But, secondly, the color sometimes depends on the nature of the mineral, and is produced by light reflected from its essential, component parts. Here it is a character of very considerable value. This is the case with most of the ores of the *metals*, and with some *combustibles.*

96. We shall now notice the varieties of color, and the terms employed in describing them.

Fundamental colors. Of the various colors eight are assumed, as fundamental. These are snow *white;* ash *gray*, the color of wood-ashes; velvet *black;* Berlin or Prussian *blue;* emerald *green;* lemon *yellow;* carmine *red*, a high red, like that of vermillion; and chesnut *brown.* All other colors are considered, as intermixtures of two or more of these; and are expressed by combining the names of the two principal colors, of which the intermixture is supposed to consist, as *greenish white*, or by referring to some well known substance, whose color is nearly uniform, as *blood red.* When a color is compounded of any two colors, which have received distinct names, and seems to be intermediate between them, it is described by saying, that the predominant color *inclines* to or *passes* into the other, according as it exhibits less or more of that other color.

*Varieties of white.** Snow white; reddish white; yellowish

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* In the explanations, annexed to many of the varieties of color, the additional shade is supposed to be mingled with the fundamental color, unless the contrary be expressed.

white; *silver* white, which has a slight tinge of yellow with a metallic lustre; grayish white; greenish white; *milk* white, which has a slight tinge of blue; *tin* white, which is nearly the preceding with a metallic lustre.

Varieties of gray. *Lead* gray, which has a slight tinge of dark blue with a metallic lustre; bluish gray; *smoke* gray, which has a shade of brown; *pearl* gray, which has a very slight tinge of violet blue; greenish gray; yellowish gray; ash gray; *steel* gray, which has a shade of blue and a metallic lustre.

Varieties of black. Grayish black; *iron* black, which is a dark grayish black with a metallic lustre; velvet black; *pitch* black, which contains a little brown; *raven* black, in which a shade of green is perceptible; bluish black.

Varieties of blue. *Indigo* blue, which is very dark; Berlin or Prussian blue; *azure* blue, which is dark with a slight tinge of red; *violet* blue, which has a strong tinge of red; *plum* blue, which is a dark reddish blue; *lavender* blue, which contains a little reddish gray; *smalt* blue, which is azure blue, rendered pale by an intermixture of white; *sky* blue, which is pale, with a tinge of green.

Varieties of green. *Verdigris* green, which has a shade of blue; *sea* green, which is paler than the preceding; *mountain* green, which is pale and grayish; emerald green; *apple* green, which has a tinge of white; *grass* green, which is lively, but has a strong tinge of yellow; blackish green; *leek* green, which is dark and contains a little brown; *pistachio* green, which has a shade of brownish yellow; *asparagus* green, which is paler, than the preceding; *olive* green, which is a pale grass green, with a strong shade of brown; *oil* green, which is paler and has more yellow than pistachio green; *canary* or *siskin* green, which is a pale yellowish green.

Varieties of yellow. *Sulphur* yellow, which is pale and has a shade of green; *brass* yellow, which is the preceding, with a shade of gray and a metallic lustre; *straw* yellow, which is sulphur yellow, containing much white; *bronze* yellow, which is brass yellow, mingled with gray; *wax* yellow, which has a shade of reddish brown; *honey* yellow, which is sulphur yellow, tinged with brown; lemon yellow; *gold* yellow, which differs from the preceding by its metallic lustre only; *ochre* yellow, which has a strong shade of brown; *wine* yellow, which has a shade of brownish red; *isabella* yellow, which is brownish yellow, with a slight tinge of red; *orange* yellow, which has a shade of red.

Varieties of red. *Aurora* red, which has a strong shade of yellow; *hyacinth* red, which is tinged with brownish yellow; *brick* red.

which is paler, than the preceding; *scarlet* red, which has a very slight tinge of yellow; *blood* red, which is nearly a pure red, but tinged with a little dark brown; *flesh* red, which is paler, than the preceding; *copper* red, which is nearly flesh red with a tinge of yellow and a metallic lustre; carmine red; *cochineal* red, which has a shade of bluish gray; *crimson* red, which has a strong shade of blue; *columbine* red, which is darker, than the preceding; *rose* red, which resembles cochineal red, but is pale; *peach blossom* red, which is a pale reddish white, with a slight tinge of blue; *cherry* red, which is crimson red with a strong shade of dark brown; *brownish* red, which is a blood red, shaded with brown.

Varieties of brown. Reddish brown; *clove* brown, which is dark with a very slight tinge of red; *hair* brown, which is the preceding with a shade of gray; *broccoli* brown, which is hair brown with a tinge of blue; chesnut brown; yellowish brown; *pinchbeck* brown, which is the preceding with a metallic lustre; *wood* brown, which results from a mixture of yellowish brown with a large portion of gray; *liver* brown, which has a shade of gray; blackish brown.

The various intensities of the same color are denoted by the terms *dark* or *deep*, *light* or *pale*.

It is always to be understood, unless the contrary be expressed, that the color of a mineral is observed on the *interior* surface, exhibited by a fracture *recently made*, and that the mineral is in an *unaltered* state.

When minerals are perfectly clear and transparent, having no perceptible color, they are said to be *limpid*, or colorless.

97. *Arrangement of colors.* Some minerals present two or more colors differently arranged. The collocation of these colors is expressed by the terms *dotted*, *veined*, *clouded*, *striped*, or *zoned*, &c.

98. *Turnished colors.* The surface of a mineral often exhibits very different colors from those, which appear in the interior, and is said to be tarnished. This tarnish usually arises from the action of moisture or air on some metallic matter, contained in the mineral, or investing its surface. When more than one color is present, the tarnish is described by referring to some well known appearance, which it more or less resembles, as the neck of a dove, the tail of a peacock, the rainbow, tempered steel, &c. hence it is denominated *columbine*, *pavonine*, *irised*, &c. These tarnishes are frequent on some of the ores of copper and iron; and the alteration of color sometimes extends to a considerable depth.

2. *Changeable colors, or chatoyement, or play of colors; irised colors.*

99. The appearances, denoted by the above terms, are altogether distinct from a tarnish, although the latter may sometimes appear irised. They are exhibited by minerals in their purest state, and depend on a peculiar incidence and reflection of light. We notice both *changeable* and *irised* colors in the same article, because they are often produced in a similar manner; and for the former, which is the most beautiful, we have mentioned the French term *chatoyement*, because it is expressive, and because there is no word in English, by which it may be translated. This term alludes to those mutable and shining colors, which appear in the *eye* of a *cat*, when observed in the dark; similar appearances may be seen on certain varieties of silk.

A mineral is said to exhibit changeable colors, or a *chatoyement*, when *different collections* of colors alternately appear and disappear, according to the varying position of the mineral, in regard to the incident light. This is a striking property in that variety of quartz, called *cat's eye*, in the precious opal, and particularly in some varieties of feldspar.

In other cases most of the colors of the iris or rainbow appear; and, although moveable, do *not change*, but present the same appearance, on whatever part of the mineral they may be observed. Crystallized quartz and carbonate of lime exhibit this property.

The preceding colors may exist near the surface, or rise from the interior; and are sometimes confined to two opposite parts of a crystal.

The exhibition of changeable and irised colors, when the latter is not merely a tarnish, appears in most cases to be produced by light, reflected from the sides of numerous and very minute fissures, which traverse certain minerals. These fissures sometimes proceed from a partial decomposition and slight separation of the laminæ, in which case the fissures will all lie in the direction of the natural joints of the mineral; in other cases the mineral is traversed by fissures in all directions, as in the precious opal.

In some instances these peculiar appearances seem to arise from irregularity in the relative position of some of the integrant particles, or even from the total absence of some of these particles; little cavities are hereby produced, from whose sides the light is variously reflected, and, during its passage to the eye, becomes refracted.

According to Bournon, when these little cavities are near the surface and lie in the same plane, a *pearly* light is reflected.

3. *Lustre.*

100. The lustre of a mineral depends on its disposition to reflect light more or less copiously. It must of course be variously modified by the shape, position, and density of the integrant particles. The lustre of the *internal surface*, discovered by breaking the mineral, is always intended, unless external lustre be expressly mentioned. We perceive not only different *degrees*, but different *kinds* of lustre. The degree of lustre is distinguished by the following terms; *splendent*, when perceptible in full day light at a great distance, as in highly polished metals; *shining*, when it is weak at a considerable distance, but strong, when the object is near the eye, as in most crystals; *glistening*, which is not perceptible, unless near, as in some silks; *glimmering*, when only a few shining points appear, even when the mineral is held very near to the eye.

The kind of lustre is made known by comparing it with that of some familiar objects. Hence it may be *vitreous*, *waxy*, *resinous*, *pearly*, *adamantine*, or *metallic*. Minerals, having no lustre, are said to be *dull*.

4. *Transparency.*

101. This well known property needs no definition. According to the quantity of light transmitted, the transparency will be variable; and its different degrees are denoted by the following terms;* *transparent*, when objects may be distinctly perceived through the mineral; *semitransparent*, when objects may be perceived, but not distinctly; *translucent*, when light evidently passes, but objects cannot be distinguished; *translucent at the edges*, when light passes through the edge only. If no light pass through any part of a mineral, it is said to be *opaque*.

Some minerals, nearly or quite opaque, become more or less transparent by being plunged in water, and are said to be *hydrophanous*. This phenomenon depends on the imbibition of water, and will be more fully explained.

5. *Refraction.*

102. It is well known, that, when a ray of light passes obliquely from one medium to another of different density, it is refracted, or bent from its original direction. Still the image of any object, seen through a refracting medium, usually appears single. There are,

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* Some writers denote the different degrees of transparency and lustre by the numbers 4, 3, 2, 1, the number 4 indicating the highest degree in each character.

however, some transparent minerals, which have the remarkable property of causing objects to appear double; that is, they present two images of any object, seen through them. In this case it is evident, that the ray must be divided into two portions after entering the refracting medium, and that each portion presents an image of the object.

As this property depends on the nature of the mineral, and not on any accidental circumstances, it must be a distinctive character of very considerable value. Different opinions have been given on the cause of this phenomenon; it has indeed exercised the abilities of Huyghens and Newton, nor is it by any means certain, that it is yet well understood.

We have room only for some general remarks on this character, and to point out the mode of observing it.

This property was first observed in that variety of carbonate of lime, sometimes called Iceland spar; and few minerals exhibit it in so striking a manner. Let a black line be drawn on white paper, and viewed through two opposite and parallel surfaces of a rhombic crystal or fragment of the aforementioned substance so placed, that the *longer* diagonals of the two opposite faces shall be parallel to the line on the paper. Two distinct and separate lines will appear, the one being somewhat *above* the other. If now this rhomb be made to revolve, the two images or lines will approach each other, till they coincide in the direction of their length, but in such manner, that the extremity of one image extends a little beyond that of the other. This coincidence takes place, when the *shorter* diagonals of the aforesaid faces become parallel to the given line. The experiment is in some respects more striking, when a circle is employed, instead of a line.

It appears probable, that all substances, possessed of this property, have a limit, at which the two images coincide. The quantity of the refraction is measured by the angle, contained between the two portions of the divided ray.

In some minerals the double refraction is very great, and easily observed. Often however it cannot be perceived without difficulty; the two images are very near, and apparently touch or penetrate each other, and are scarcely distinguishable, except at their borders. It is often necessary to view the object through two sides of a crystal, which are naturally inclined to each other, or so cut by a lapidary. Thus to observe double refraction in crystallized quartz, the ray to be refracted must be made to pass through one side of the prism, and the opposite face of the pyramid, which terminates the prism.

The distance between the two images is, in general, proportional to the quantity of the angle, contained between the two inclined faces; and, when other things are equal, it is proportional to the thickness of the medium.

This character may frequently be observed by holding the mineral near the eye, and looking through it at a pin, held by the point, at some distance on the opposite side, the face being directed toward a window. If the pin be successively placed in various positions, there will be one, in which two images of the pin will be seen, parallel to each other, and usually irised.

Or it may be observed in the following manner. Make a very small puncture in a card or piece of pasteboard; and, having closely applied the card to that side of the crystal most distant from the eye, look through the crystal and the puncture at a candle, placed at some distance from the eye in a dark room. The two images are quite distinct.

It seems hardly necessary to suggest the important use, to which this character may be applied. As it can be noticed with equal ease after a mineral has been deprived of its native appearance by a lapidary, it may enable us to discriminate minerals, in which other characters cannot be observed.

6. *Form.*

103. This is a very important character in the description of minerals. The varieties of form may be included under three general divisions, viz. *regular*, *imitative*, and *indeterminate* or *amorphous*.

104. *Regular forms.* These all arise from a crystallization, which is attended with but little or no disturbance; and have already received sufficient attention in the first section of this chapter.

105. *Imitative forms.* The form of a mineral is said to be *imitative*, when it is not regular, and, at the same time, has sufficient resemblance to any other body to be denominated by the name of that body. These forms are either the results of a very disturbed crystallization; or they may be mere *concretions*, formed under circumstances, which have entirely prevented the appearance of a crystalline form or structure. The following are the most common; viz. *lenticular*, resembling a convex lens—this form may be conceived to arise in some cases from the disappearance of the edges and angles of a crystal, thereby producing a convexity of surface; *cylindrical*—sometimes produced by the rounding of the edges of a prism; *acicular*, like a needle—minerals, possessing this form, are sometimes in very minute prisms, and sometimes in very small pyramids much

elongated; *filiform* or *capillary*, resembling a thread or a hair; *stalactical*, resembling an icicle—stalactites are generally produced by the filtration of water, containing earthy, saline, or metallic particles, through the pores or crevices of other minerals—sometimes also they are formed on the floors of caverns by the dropping water, and in this case are often called *stalagmites*;* *tubular*, which is more or less cylindrical and hollow; *dentiform*, like teeth, presenting short and often crooked cones; *coralloidal*, resembling a branch of coral; *dendritic*, branching like a tree or shrub; *reticulated*, like a net; *nodular*, in small lumps; *globular*—this form may sometimes arise from a crystal, whose edges and angles are rounded, or it may be produced by an aggregation of prismatic crystals or fibres; *botryoidal*, like a bunch of grapes; *reniform* or *mammillary*, in the form of a kidney—it presents elevations, resembling segments of a sphere, but the eminences are more flat than in the botryoidal form; *tuberous*—it presents elevations less regular, than the preceding, and separated by intermediate depressions; *cellular*—the cells have various forms and are separated from each other by thin plates or laminæ—they are often produced by the impression of crystals, and present regular forms, as cubic, hexangular, &c; *perforated*, when a mineral exhibits numerous round holes, like a sieve; *corroded*, presenting numerous cavities, as if eaten by a worm; *vesicular*, having cavities, which resemble bubbles of air in ice; *ramous* or *entangled*, composed of slender branches of filaments, intermingled in various directions; *specular*, having the even, polished surface of a mirror; also in *leaves*, *plates*, *scales*, or *membranes*.

106. *Incrustations.* These are deposites, made in the form of a crust, sometimes on other minerals, and frequently on the surface of bodies, belonging to the vegetable kingdom; sometimes also they invest the sides of cavities, situated in the interior of certain bodies. The latter appearance may often be observed in tubes, through which water, containing calcareous particles, has been running for a long time. Sometimes the crust is left empty by the removal of the body, whose form it has taken. This may happen, when crystals of carbonate of lime are incrusted by quartz. Incrustations are most frequently calcareous or siliceous, and their structure is sometimes a little crystalline.

107. *Geode.* This is an incrustation, whose form is, in general, nearly spherical. Its interior is sometimes empty, and, in this case, the sides of the cavity are often lined with crystals. Sometimes it

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* For a particular account of the manner, in which stalactites and stalagmites are formed, see the species carbonate of lime.

contains a solid, moveable nucleus; and is sometimes filled with an earthy matter different from the envelope.

108. *Guhr.* This is a loose, earthy deposit from water, and may be siliceous, calcareous, &c.

109. *Pseudomorphous bodies.* These bodies have received their present form in cavities, which true crystals, or some other substances, either animal or vegetable, had once occupied. When the form has been taken from cavities, once occupied by crystals, it is by no means difficult to distinguish the pseudomorphous or false from the true crystal. The edges and angles of the former are seldom well defined; their surfaces are frequently rough and unpolished; and they never submit to mechanical division in any direction. Quartz and steatite furnish crystals of this kind.

Sometimes the form has been derived from the interior of a shell, and is a true model of the animal, which once occupied it; and sometimes it is a faithful imitation of the trunks and branches of vegetables. It hence appears, that many petrifactions are strictly pseudomorphous bodies.

In some cases it is probable, that the particles of the pseudomorphous body have found the cavity entirely empty; in others they have perhaps entered, as the original substance has gradually disappeared.

110. *Indeterminate* or *amorphous forms.* When the form of a mineral is neither regular nor imitative, it is called indeterminate, or the mineral is said to be *amorphous.*

If a mineral form a part of an aggregate or compound rock, and its different portions be less than a hazel nut, it is said to be *disseminated* in the aggregate; but, if it exist in portions not less than a hazel nut, it is said to occur *massive.*

The term *massive* is also employed to denote those varieties of certain minerals, which, though indeed crystallized, do not present a regular form, but occur in masses more or less large, having a crystalline structure. Whenever used in this treatise, it is to be understood in the latter sense.

When a mineral occurs in loose, detached portions, it may be in *grains*, or in *angular* or *rounded* fragments.

7. *Surface.*

111. By this is intended the *external* surface of minerals, and also that of their distinct concretions, when separated. The internal surface, or that brought to view by a fracture, will be noticed under a distinct article. The most common varieties of external surface are the following; viz.

uneven, presenting small and irregular elevations and depressions; *granulated*, when the little elevations on the surface are rounded, like shagreen; *rough*, when the asperity is discoverable by feeling, rather than by sight; *smooth*; *drusy*, when the surface is covered with minute crystals, often somewhat grouped; *striated*, when it is marked with small channels or furrows.

The last variety of surface is far more important, as a character, than any of the others; for these striæ, as we have already remarked (56), when found on secondary crystals, not unfrequently indicate the direction of the laminæ, applied to the primitive form.

The direction of the striæ is to be noticed in description. Thus in reference to the face of a crystal, the striæ may pass longitudinally, transversely, or diagonally, all on the same face being supposed parallel. In some substances, not regularly crystallized, the striæ are irregular.

8. *Unctuosity.*

112. Certain minerals, when the finger is passed over their surface, or applied to their powder, feel as if they were coated with some unctuous or greasy substance. The sensation is, in general, easily distinguished from that, which is excited by mere smoothness of surface. It is often an important character in discriminating minerals; and its existence in a mineral, when reduced to powder, is to be particularly noticed. Most minerals, however, especially when in powder, feel *dry* or *meager*.

9. *Coldness.*

113. Little use can be made of this character. It has been remarked, that siliceous minerals feel colder than those, which are calcareous, both possessing the same temperature; and that combustibles feel less cold than most other minerals.

10. *Smell.*

114. This character can be observed in but few minerals. When, however, it does exist, it generally indicates the nature of the mineral, or, at least, of some of its principal ingredients. The odor of a mineral may be *bituminous*; *sulphureous*; *alliaceous*, like that of garlic; *empyreumatical*, like that of burnt substances; *earthy* or *argillaceous*, like that of moistened clay; *bitter*; or *fetid*, like that of sulphuretted hidrogen gas.

In some cases the odor is constantly exhaled. In other instances it is necessary to develop it by very slightly moistening the mineral, as with the breath; or by friction; or by the application of heat.

11. *Taste.*

115. This property supposes at least a partial solubility of the mineral in water or saliva, and belongs to a part of those bodies, called *salts*. The terms, employed in describing the different tastes, are those in common use. Thus the taste may be *saline; astringent; sweetish; cool; bitter;* or *urinous*. Sometimes the taste, excited by the first impression on the tongue, is a little different from that, which soon follows; hence a kind of compound taste results.

12. *Adhesion to the tongue or lip.*

116. The adhesion of a mineral to the tongue or lip depends on its disposition to imbibe moisture. In some instances, when the tongue is too moist for the experiment, the adhesion to the lip is still very sensible. Its degree may be noted by the terms strong; moderate; slight, &c. Aluminous or argillaceous substances furnish striking examples of this property.

In some cases, where little or no alumine is present, this adhesion appears to arise from a partial decomposition of the mineral, which, by losing its water or some other ingredient, becomes filled with minute pores; and these pores absorb moisture on the principle of capillary tubes. Such is probably the cause of the adhesion sometimes observed in calcedony, flint, and other siliceous substances. This explanation is confirmed by the fact, that, when the same bodies are reduced to powder, they lose their absorbent power, and do not adhere to the tongue.

13. *Soil or Stain.*

117. Some minerals, when rubbed on white paper or other light colored substances, leave a trace, more or less distinct. In some cases merely a *soil* or stain is produced; in other cases a trace is left sufficiently definite for the purpose of writing. It should be observed, whether the color of the trace be *similar* to that of the mineral; or *dissimilar*.

14. *Streak.*

118. By the streak of a mineral is understood the appearance, which arises from scratching it with a hard, sharp instrument, as the point of a knife. The streak is said to be *similar*, when its color, or rather that of the *powder* produced, is the same with the color of the mineral; and *dissimilar*, when its color varies from that of the mineral.

The lustre of the streak may also be compared with that of the mineral.

This character, though very simple and easily observed, is often of very considerable value. It is well known, that many minerals, when reduced to powder, present a different color from that, which they exhibit in portions of any sensible magnitude. It is also known, that the same mineral, though presenting different colors in its natural state, may, when reduced to a fine powder, uniformly exhibit but one color. This is certainly the case with a number of minerals. Hence in description, the color of the powder, obtained by *trituration*, should be mentioned; especially if the color belong to the nature of the mineral, and is not dependant on any accidental ingredient. The powder, produced by scraping the mineral, is perhaps never so fine, as that obtained by trituration.

15. *Distinct concretions.*

119. Some minerals appear to be composed of certain distinct portions, more or less large, united to each other by the intervention of a very *delicate seam*, but with a less force than that, which unites the minuter particles of each concretion. Hence these distinct concretions are usually separable at the aforementioned seams without producing a *fracture* in the more strict sense of that term. When, however, their union is so strong as to prevent a separation from each other, their form may be discovered, either by the directions of the seams, or by the different relative positions of the concretions themselves. Each concretion may be said to be bounded by *its own surface*, as distinguished from the surfaces produced, when a real fracture is made.

The shape of the concretions may be referred to one of the three following kinds; viz.
granular—these may be round, or angular, large, coarse, small, or fine; *lamellar*—these may be straight or curved, thick or thin;—*columnar*—these may be large or small, straight or curved, parallel, diverging, or promiscuous, and sometimes cuneiform.

In some minerals this character might with propriety be described, as presenting a particular kind of *structure*.

16. *Flexibility.*

120. This well known property is easily observed. Very few minerals possess it naturally. It is to be particularly noticed, whether the flexibility be accompanied with elasticity, that is, whether the mineral have the power of restoring itself to its former position, after being bent.

Some minerals by the gradual application of heat may be rendered flexible; while others lose this property by exposure to heat, and regain it, when moistened. See further remarks on this character under the article, granular limestone.

17. *Sound.*

121. To discover the existence of this property, which is rare, the mineral must be *struck* or *bent*. Some minerals, when struck, give a *clear* and almost metallic sound, which dwells for a moment on the ear; others, when bent, give repeated and almost constant cracks.

The production of these sounds depends much on the tabular form of the mineral. Thus the Chinese employ small and thin *tables* of certain minerals, as bells or musical instruments.

18. *Cohesion.*

122. According to the various degrees, in which this property exists, minerals are described as *solid*; *friable* or *earthy*; or *fluid*.

19. *Hardness.*

123. This property, although liable to a little variation in minerals of the same species, from partial decomposition or the presence of some accidental ingredient, still constitutes an important character. It may often of itself discriminate minerals, that occur together and much resemble each other. It is evident, however, that it is only the relative hardness, which can be described.

Hardness is that property in a body, which enables it to resist, more or less, the impression of another body; and must depend on the strength of cohesion between the integrant particles. In saying this, however, a careful distinction must be made between the cohesion of integrant particles, and that aggregation of *small grains*, by which the larger masses of many minerals are formed. With the *cohesion of these grains* the real hardness is often very little connected. This is evident in the case of certain sandstones, the grains of which are sufficiently hard to scratch steel, although the mass itself will not strike fire with steel, in consequence of its *friability*.

Different modes of observing the hardness of bodies have been employed. One method depends on the application of a file or a knife, and the property, which some minerals possess of giving sparks with steel.

Thus a body is said to be

extremely hard, when it receives no impression from a file; *very hard*, when a file produces but little effect; *hard*, when it yields to a file without difficulty, but still strikes fire with steel; *semihard*, when it does not give fire with steel, and yields a little to a knife;

soft, when it is easily cut by a knife, but receives no impression from the finger nail; *very soft*, when it is easily impressed by the finger nail.

It must be evident, however, from the preceding remarks on the friability of certain sandstones, that a greater or less power of giving fire with steel cannot accurately indicate the hardness. It is also true, that, in cutting or scraping a mineral with a sharp instrument of steel, the apparent hardness will in part depend on the greater or less degree of cohesion between the *grains* or minute parts, of which the body is composed.

124. It is perhaps a more definite method of ascertaining the different degrees of hardness to determine in what order minerals impress or *scratch each other*; and in this way the hardness of a mineral in the state of grains or a powder may be discovered. According to this method minerals must be arranged under several divisions. Thus the first division may comprehend all minerals, capable of scratching crystallized quartz, a substance possessing a very uniform degree of hardness. The different substances, which compose this division, are to be so arranged, as far as practicable, that each preceding substance may be understood to scratch that, which follows it. The second division may exhibit a similar arrangement of those minerals, which are inferior in hardness to the preceding, but still capable of scratching some particular kind of glass.*

Crystallized carbonate of lime may form the basis of a third division; and the last division may contain those minerals, properly arranged, which are inferior in hardness to carbonate of lime.

20. *Fracture; and structure, as indicated by the fracture.*

125. To denote that character of a mineral, which is derived from its structure, many writers have employed the term *fracture*; meaning thereby the appearance of the *surface*, produced by a fracture. Indeed the terms fracture and structure are sometimes indiscriminately used. But, although the fracture in many instances discovers the structure of the mineral, there are several epithets, employed to describe certain fractures, which cannot with propriety be applied to the structure. We have therefore placed both terms at the head of this article, and shall endeavor to point out the appropriate use of each.

126. The structure of a mineral undoubtedly depends on the

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* In some cases after rubbing a mineral on glass, it is important to wipe the glass with a wet cloth, to determine whether the trace, which may be perceived, do not arise from particles of the mineral, adhering to the glass.

shape, size, and arrangement of the *minute parts*, of which it is composed. These minute parts may have the shape of little plates or *laminæ;* or they may resemble *fibres;* or they may be in *grains* of no determinate form. The size of these laminæ, fibres, and grains may vary indefinitely, and their arrangement may be more or less regular.

Now it is evident, that any mineral, composed of fibres, arranged in a given order, may be said to have a certain *structure*, which actually exists in it, whether the mineral be broken, or remain entire. In this example we should say the *structure is fibrous.* If this mineral be broken, the fibres will appear, forming the two separated surfaces; but the *fracture* has not *produced* the fibres.

Let us now suppose another mineral to be broken, and, as is frequently the case, let the surface of the fragments exhibit little *splinters*, projecting above the surface, but adhering to the mineral by one of their extremities. It would be hardly correct to say, that this mineral has a *splintery structure;* these splinters did not preexist in the mineral; they were *produced* by the fracture, that is, the given mineral has a *splintery fracture.* Still however every mineral must have some structure; and the disposition of any substance to exhibit splinters on the surface of its fracture must ultimately depend on its structure, whatever that may be.

In the former of the two supposed cases we may indeed say, that the fracture is fibrous, meaning the surface, produced by the fracture, though in truth the fibres belong to the structure. But in the latter of these cases, although the splintery appearance of the fracture depends on the structure, we cannot with propriety substitute the word structure in the place of fracture, and say that *the structure is splintery.*

We shall now describe the various fractures and structures, observed in minerals.

127. *Splintery fracture.* The fracture is called splintery, when the surface, produced by breaking a mineral, is nearly even, but exhibits little splinters or scales, somewhat thicker at one extremity than the other, and still adhering to the surface by their thicker extremities. That part of the splinter or scale, which projects above the surface of the mineral, becomes very thin at its extreme edges, and hence permits a little light to pass. By this light the splinters become visible, and may be distinguished as *coarse* or *fine.*

Even fracture. This scarcely needs a remark. The surface produced is nearly plane, having no perceptible inequalities.

Conchoidal fracture. A fracture is said to be conchoidal, when its surface exhibits concave depressions, and convex elevations, as if it had been impressed by a *shell.* These cavities and elevations may be *perfectly* or *imperfectly* conchoidal; they may be *large* or *very small;* and the cavities may be *deep* or *flat.* Some varieties of this fracture are with great propriety said to be *undulated.* When the cavities are imperfect and small, this fracture gradually passes into the following.

Uneven fracture. This exists, when the surface, produced by the fracture, exhibits numerous inequalities. The elevations on this surface are usually sharp or angular, somewhat abrupt, and irregularly arranged. According to their size, the fracture is said to be *coarse* or *fine grained* uneven. It passes into the following.

Earthy fracture. The surface of this fracture is rough, the elevations and depressions being very minute. Minerals, which present this fracture, have probably been formed by precipitation from some fluid, in which they were minutely divided and suspended, rather than dissolved. Dry or indurated clay often exhibits this fracture.

Hackly fracture. This is peculiar to metals. It is not easily distinguished by the eye, but may be discovered by attempting to pass the finger over its surface, from which very fine and sharp points seem to project and impede the progress of the finger.

No one of the preceding fractures clearly indicates the structure.

128. *Fibrous structure; or fracture.* This fracture obviously brings to view the structure of the mineral (126). It presents a surface, composed of fine threads or fibres. Sometimes these fibres are too minute and delicate to permit a measurement of their breadth; indeed they are sometimes so very minute and closely applied to each other, that the mineral appears compact, except in being marked with very delicate striæ. From this extreme, their breadth gradually increases, till it becomes capable of being measured, and is sometimes so great, that this fracture may be viewed, as passing into the foliated. Their comparative breadths or sizes may, however, be sufficiently distinguished by the terms *broad* or *narrow*, *coarse* or *fine*, or *capillary.** Their direction may be *straight* or *curved.* Their

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* The fracture here described is often divided into two kinds. When the fibres are too small to be measured, it is called a fibrous fracture; and when they become broader, the fracture is said to be *radiated.* The distinction however does not appear to be important, nor useful. They are equally *fibres* in both cases, and their comparative breadths may be sufficiently indicated by the terms already mentioned. If greater accuracy be requisite in regard to the broader fibres, their average breadth may be estimated or actually measured.

relative position may be *parallel* or *diverging*; and in the latter case the fibres may be *radiated*, diverging on all sides from a common centre, or *fascicular*, like a bundle of rods confined at one extremity, or *promiscuous*.

The broader fibres are frequently separable from each other, and often terminate in a crystal, which causes them to appear pointed. Indeed minerals, having a fibrous structure, are always the result of a disturbed crystallization.

129. *Foliated* or *laminated structure*; or *fracture*.* This fracture discovers the structure. It appears in minerals, composed of thin plates or laminæ. When such minerals are broken, the fracture exhibits laminæ, having smooth, shining or polished surfaces, like the surface of a crystal. In fact, minerals, having a foliated fracture, are the result of crystallization; and, when they are divided or separated in the direction of their laminæ, it can hardly be called a fracture; it is really a mechanical division of a crystallized substance (37).

Several particulars are to be noticed in regard to this fracture. The *magnitude* of the laminæ may vary from very large to very small. In some cases a single plate extends through the whole mass; in others the plates appear like very minute scales, not easily discernible, except by the reflection of light from their polished surfaces. The *direction* of the laminæ may be *straight*; *curved*; *undulated*; or *indeterminate*, that is, lying irregularly in various directions. Sometimes a number of plates unite in the same point, like the petals of a flower.

The most important circumstance, connected with this fracture, is the *direction* or directions, in which it can be made; or in other words, the directions of the *natural joints* of the mineral, for it is at these only, that a cleavage or mechanical division can be effected (35). In some minerals there is but one direction, in which their component laminæ can be so separated, as to exhibit a smooth, shining surface. Other minerals may be divided in two, three, or more directions. But in all cases, where the mineral can be thus divided in two or more directions, it is exceedingly important, that the angles, which the laminæ form with each other, should be accurately measured. This measurement renders mechanical division even in

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* The terms foliated—laminated—lamellar or lamellated are all employed to express this structure. The first may be viewed as the most general, and as indicating nothing in regard to the size of the foliæ or laminæ. The second is usually applied to minerals, composed of large laminæ; and the third to those, whose laminæ are small.

masses, which have not a crystalline form, an important character in determining the nature of the mineral.

The fracture, of which we are speaking, is said to be *perfectly* or *imperfectly* foliated, according as the plates separate with more or less ease, and exhibit a surface more or less smooth and polished. Sometimes the foliæ appear only on certain parts of the surface, and cause it to glimmer.

130. *Slaty structure*; or *fracture*. Minerals, which exhibit this fracture, are composed of somewhat thick and extensive layers; but the surfaces of the layers are not smooth and polished, as in minerals, having a foliated fracture. They split only in one direction. In fine, this fracture appears in substances not crystallized, whereas the foliated belongs to minerals more or less perfectly crystallized.

When minerals appear to be composed of different layers, which do not, however, easily separate from each other, their structure is rather stratified, than slaty.

131. *Granular structure; or fracture.* When a mineral is composed of grains, either large or small, but still visible to the eye, as in sandstone, its structure may be called granular. Such minerals are sometimes described as composed of granular, distinct concretions (119). When the grains become invisible to the eye in consequence of their minuteness, the mineral is said to have a *compact texture*; such is that of jasper.

132. In minerals not crystallized the fracture may be made in any direction, provided natural seams be avoided. In minerals of a prismatic form, it should be stated, whether the fracture be longitudinal or transverse; for these are often different. Thus a prismatic crystal of hornblende may be mechanically divided in the direction of its axis, that is, its *longitudinal* fracture is foliated; whereas its transverse or cross fracture is uneven.

21. *Frangibility.*

133. This property can be described only in general terms; or by comparing one mineral with another in this respect. Thus a body may be *very tough*; *tough*; *moderately tough*; *brittle* or *very brittle*.*

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* Much confusion arises from the distinction, which some writers make between *brittle* and *fragile*. By opposing brittle to ductile, and tough to fragile, they have been led to say, that certain bodies were *brittle*, but *not fragile*. If these distinctions are necessary in the description of a mineral, terms less ambiguous ought to be employed.

22. *Shape of the fragments.*

134. When a mineral of a moderate size receives a heavy blow, it usually separates into a number of fragments, which are commonly very irregular in their shape. Sometimes, however, these fragments exhibit a form more or less regular; and, when the substance is crystallized, the particular form results from the arrangement of the laminæ, which compose the mineral. Such fragments may be cubic, rhombic, trapezoidal, tetraedral, &c. Even fragments somewhat irregular may sometimes be designated as *cuneiform*, *splintery*, *tabular*, &c. The sharpness or bluntness of the edges of irregular fragments, and the comparative lustre of different faces of regular fragments may also be noticed.

23. *Tenacity.*

135. It is in consequence of possessing this property, that certain substances permit themselves to be drawn into wire, or flattened under a hammer; in the former case the substance is *ductile;* in the latter, *malleable*. A mineral is sometimes said to be *ductile* also, when it may be moulded between the fingers, or cut into slices. It is called *sectile*, when, being cut with a knife, the separated particles do not fly away, but remain on the mass.

24. *Magnetism.*

136. It is well known, that two north or two south poles of a magnetic needle repel each other, when brought near; and, on the contrary, that a north and south pole attract each other in a similar situation. Hence any mineral, which, being alternately presented to the two poles of a magnetic needle, attracts the one and repels the other, is said to be magnetic, or to possess polarity.

If a small needle of pure iron be alternately presented to the two poles of a magnet, it will be attracted by both poles; because the magnet produces in that end of the iron needle, which is nearest to itself, a polarity contrary to its own. On removing the iron, however, its magnetism disappears.

Hence to determine whether a given mineral possess magnetic polarity, it is often necessary to employ a needle, which has a very feeble magnetic power; for, if the power of the needle be in a great degree superior to that of the mineral presented, each extremity of the needle may produce in the mineral a polarity, *contrary* to its own, and consequently *attraction only* will appear at both poles.

Although the property of magnetism belongs only to nickel, cobalt, and iron, and not indeed to all the ores of iron, yet, from the frequent intermixture of magnetic iron in other minerals, there is very often occasion to notice this property. A delicate needle is superior to a magnetic bar for detecting the existence of magnetism.

25. *Electricity.*

137. It will be recollected, that there are two kinds of electricity, which are called positive and negative, or vitreous and resinous, according as they are produced by exciting smooth glass, or any resinous substance. It will also be recollected, that, when two bodies possess the same kind of electricity, whether positive or negative, they repel each other; but, if one possess positive electricity and the other negative, they attract each other.

A considerable number of minerals may be rendered electric by friction with the hand or woollen cloth; and, when thus excited, they are capable of attracting light bodies, or of moving a delicate electrometer.

138. Among the minerals, which are capable of exhibiting electric properties, there are a few, which acquire electricity by being *heated*, either by simple exposure to a fire, or by immersion in hot water. But those minerals, which are excited by heat, acquire, at the same time, both positive and negative electricity; but so separated, that, on whatever part of the mineral the positive may appear, the negative will be found on the part diametrically opposite. Thus if positive electricity appear on one side, or at one extremity of a crystal, negative electricity will exist on the opposite side, or at the other extremity. And it is very remarkable, that, in crystallized minerals, excitable by heat, the opposite parts of the crystal, on which the two electricities appear, are almost always different from each other in their configuration, or number of sides, although similarly situated in reference to the crystal itself. Thus if it be a prismatic crystal of tourmaline, and if the two electricities appear at the two extremities or summits of the prism, these two summits will differ from each other in the number or situation of their sides.* Most frequently that part of the crystal, which possesses positive electricity, presents the greater number of faces. On the contrary, it is usually the case, that, when a crystal does not become electric by heat, the opposite parts are similar. Some-

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* The different configuration of the opposite parts of a crystal, exhibiting the two kinds of electricity, has been supposed to be a uniform fact. But more extensive observations seem to show, that it is not always the case. Some tourmalines from Pegu and Ceylon, which give both electricities, appear to have both summits perfectly regular and similar. Another exception appears in the dodecaedral crystals of the borate of magnesia. (BOURNON.)

times certain angles or faces possess positive electricity, while the opposite angles or faces exhibit negative.

139. It may be stated as a general fact, with very few exceptions, that stones and salts, possessing a considerable degree of purity, and having their surfaces *polished*, acquire positive electricity; but, if their surfaces are not smooth and polished, they may acquire negative electricity, as is the case with rough glass.

Combustibles, the diamond excepted, become negatively electric by friction. The diamond, whether polished or unpolished, always becomes positive.

Ores are usually conductors of electricity, with the exception of some metallic salts, which become positive by friction.

140. For observing the electricity of minerals the electrometer (Pl. I, fig. 12.) is the most convenient instrument. In this figure *a b* is a needle of copper, terminated at each extremity by a small ball, and moving very easily on a pivot at the centre. At *c* the instrument has a metallic base. If a mineral, which has been excited, either by friction or heat, be presented near to one of the balls, the needle turns, whether the electricity be positive or negative; and the force of the electricity may be estimated by the distance, at which the needle begins to move.

To determine which kind of electricity a mineral possesses, the needle must previously be electrified, either positively or negatively; which may be done in the following manner. Let the instrument be insulated by placing it on *d*, a plate of glass or resin. Having excited a tube of glass, or a stick of sealing wax, place one finger on the metallic base *c* of the electrometer, and then bring the excited glass or sealing wax *e* within a small distance of one of the balls of the needle. When the needle is sufficiently electrified, first withdraw the finger, and then remove the glass or sealing wax. If now an excited mineral be presented to the needle, they will repel or attract each other, according as they possess the same or opposite kinds of electricity. But, as the electricity of the needle is known, that of the mineral may be determined.

To ascertain the electric poles, or those parts of a crystal, which possess contrary electricities, let a thread of silk about one fourth of an inch in length be connected to one extremity of a rod of sealing wax, which must then be excited. To this thread of silk, which of course is negative, let the sides, angles, or summits of the mineral under examination be successively presented; and the attraction or repulsion observed will indicate those parts of the crystal, where the two electricities reside.

141. Sealing wax, when rubbed by most minerals, becomes negative. There are, however, a few minerals, of which the sulphuret of molybdena is one, which, being rubbed on sealing wax, communicate to it positive electricity. In these experiments both the wax and mineral should possess smooth surfaces of considerable extent.

142. The power of *conducting* electricity, possessed by some minerals, may enable us to detect the existence of metallic matter; for this purpose the mineral must be insulated and connected with an electrified conductor. It must however be remembered, that carbon is also a good conductor of the electric fluid.

The power of acquiring electricity by *heat*, the comparative facility, with which minerals become excited by friction, and the comparative strength of their electricities, often constitute important characters for determining the nature of minerals, even when cut and polished. Thus chrysoberyl may be distinguished from adularia by the great facility, with which the former is excited.

26. *Phosphorescence.*

143. A body is said to phosphoresce, when it shines with a feeble light, unattended by any sensible heat. Some minerals exhibit this property, when rubbed against each other, or when scratched by any other hard body; and a few phosphoresce even when brushed by a feather. Others must be reduced to a coarse powder, and projected, in a darkened room, on a shovel or other body, heated but very little below redness. Sulphuret of zinc may be examined, as an example of phosphorescence by friction, and the fluate or phosphate of lime, by heat. Some minerals phosphoresce, when melted by the blowpipe. This appearance is considered by Vauquelin, as indicating the presence of lime.

This property does not appear to be essential to those minerals, in which it exists; for in those species, which most uniformly phosphoresce, there are certain varieties, which refuse to yield this light. Thus the variety of phosphate of lime, called asparagus stone, does not phosphoresce; and certain dark blue fluates of lime from Cumberland, England, yield no light whatever. (*Bournon.*)

The color of the light is variable, being green, blue, yellow, reddish, &c. and may even change during the experiment according to the degree of heat or some other circumstance.*

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* In a paper, communicated to the National Institute of France in 1810, by *M. Dessaignes*, it is asserted, that, when bodies phosphoresce by an increase of temperature, the color of the light is always *blue*, unless altered by the presence of iron.

144. In general, phosphorescence more frequently appears in minerals possessing color, than in those, which are limpid or colorless. And perhaps the most interesting circumstance, attending this property of minerals, is the connexion between the phosphorescence and the color of the mineral; particularly when the former is developed by the action of heat. In this case, as the light diminishes, the color gradually disappears; and, when the color has entirely departed, the phosphorescence ceases. (*Bournon.*)

To secure a proper degree of heat in these experiments, it is perhaps best to heat a shovel, till it becomes red; and, having entered a dark room, let the mineral, in a state of powder, be projected on the shovel immediately after the redness disappears.

The time, during which equal quantities of different minerals continue to phosphoresce, is variable. Thus phosphate of lime loses its color and phosphorescence much sooner than fluate of lime.

27. *Specific gravity.*

145. The specific gravity of a body is its weight, compared with that of another body of the same magnitude. Thus, if a cubic foot of water weigh 1000 ounces, and a cubic foot of iron 7000 ounces, their comparative weights or specific gravities are as 1000 : 7000, or as 100 : 700, or as 10 : 70, or as 1 : 7.

It is well known, that, when a body is immersed in water, it is in some degree supported by the water, and consequently loses part of its weight. This loss of weight is also known to be precisely equal to the weight of a quantity of water, of the same magnitude, as that of the body immersed. If then we weigh a body in air, we have its absolute weight; if we weigh the same body in water, we have the absolute weight of a bulk of water equal to that body; for it is equal to the weight, which that body loses in water. We hence have the absolute weight of two different bodies of equal bulk; and the ratio of these weights is the ratio of their specific gravities.

For convenience, however, the weight of a given bulk of some substance must be assumed, as a standard or unit, with which to compare the weight of the same bulk of all other bodies. In this case one number is always sufficient to express the specific gravity of a body, because the standard unit is understood.

For the purpose of a standard, distilled water is usually employed, a cubic foot of which weighs 1000 avoirdupois ounces. This, we have already seen, may be called 1000, or 100, or 10, or 1, adding decimals as far, as necessary. If we assume 1, as the standard, the following proportion will give the specific gravity of all bodies heavier than water;—as the weight, which a body loses in water, is to its absolute weight, so is 1 to the spec. grav. required. If the mineral be lighter than water, add the weight, which is necessary to make it sink in water, to its weight in air, and then say, as this sum is to its weight in air, so is 1 to the spec. gravity.

146. On the preceding principles is founded the method of taking specific gravities by the instrument, commonly called *Nicholson's Portable Balance* (Pl. II, fig. 21).

The body of this instrument is a hollow cylinder of tinned iron, of which each extremity *a* and *b* terminates in a cone. From the vertex of the upper cone a small stem of brass *a c* rises perpendicularly, bearing on its upper extremity a small tin cup *d*. From the vertex of the lower cone is suspended a similar cup *e*, attached to a cone of lead underneath it, as a ballast. Both the cups may be removed, when the balance is not in use.

When this instrument is placed in a vessel of water, a portion of the cylinder ought to swim above the surface of the water. The tin cup *d* is then to be loaded with weights, till the instrument sinks so far, that the surface of the water may exactly coincide with a mark near *f* on the brass stem. The quantity, necessary to make the instrument sink thus far may be marked on the cup, as a given quantity for future use. Suppose this quantity to be 600 grains, which may be called the *balance weight*, and will serve for taking the specific gravity of any substance, whose absolute weight is not greater than that of the balance weight.

To ascertain the specific gravity of a mineral, place it alone in the upper cup, and add weights, till the mark on the stem coincides with the surface of the water; and suppose this to be 210 grains. Subtract the 210 grains from the balance weight of 600 grains; and the remaining 390 grains is the absolute weight of the mineral in air. Let the mineral be now removed to the lower cup; but, as it weighs less in water, than in air, the mark on the stem will rise a little above the surface of the water. Additional weights must now be placed in the upper cup, till the mark on the stem again coincides with the surface of the water. Suppose this to be 80 grains, which will of course be the weight of a quantity of water precisely equal in bulk to the mineral. We now have the absolute weights of equal bulks of water and of the mineral; then say, as 80 : 390 :: 1.000 : 4.875, the spec. gravity.

If the mineral under examination be lighter, than water, it must be confined, when weighed in the lower cup; and the weight of whatever confines it is to be regarded, as belonging to that of the instrument. In other respects the process is the same, as the preceding. But, as the mineral is lighter than water, it is evident the second term of the proportion will be less than the first.

If the mineral very sensibly absorb water, which fact may be discovered by the gradual sinking of the instrument, after the specimen is placed in the lower cup, although no additional weight is put into the upper cup, the weight of the water imbibed must be ascertained by again weighing the mineral in air; and is then to be added to the first term of the proportion.

Some minerals are rapidly dissolved in water. In such cases some other fluid, as oil of turpentine, may be employed; or the water may be previously saturated with a portion of the same salt, whose specific gravity is to be taken.*

147. The spec. gravity of minerals, belonging to the same species, often varies a little, either from the accidental mixture of coloring matter or other foreign ingredients, or from a more or less intimate combination of the component parts. But, notwithstanding these variations, the character drawn from the spec. gravity is exceedingly useful. For by taking the mean spec. grav. of several specimens of the same species in a state of as great purity, as can be procured, something like a standard of spec. grav. for every species may be obtained. In crystallized minerals, not obviously impure, the variation from the mean, will probably be within the limits of one fiftieth above or below. In substances not crystallized it must be greater, especially in certain species of ores.

SECTION III.

Chemical Characters.

148. The characters to be described in this section are called *chemical*, because it is the business of chemistry to discover and examine them. They are all to be ascertained by experiments, which produce a partial decomposition of the mineral, or a separation of its integrant particles. In most cases these characters are exceed-

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* The preceding experiments are supposed to be made with distilled water at the temperature of about 62° Fahr. But, when common water, at a different temperature, is employed, the true spec. grav. of the mineral in distilled water, at the proper temperature, must be determined by calculation; for the method of which, reference may be made to treatises on hydrostatics.

But in those cases, where the greatest precision is not requisite, rain water, at a temperature near to 62°, will give results sufficiently accurate.

Fluid minerals are few in number and rare. For methods of obtaining their specific gravity, reference may be made, as above.

ingly important; more especially when the properties, on which they depend, belong to the nature of the mineral, unaffected by any accidental circumstance. Their number is indeed considerable, though but very few are commonly employed; and these depend on very simple experiments, easily performed, and requiring very little apparatus. A complete analysis of the mineral is not included in the characters, of which we now speak.

1. *Fusibility.*

149. When the fusibility of a mineral is mentioned, it is always to be understood, that the flame is supported by atmospheric air, unless the contrary be expressed. For, when oxigen gas is employed, many minerals, usually called infusible, are easily melted.

In order to derive the greatest benefit from the fusibility of minerals, as a distinctive character, the precise temperature, at which they melt, when in a state of purity, as well as the results of their fusion, ought to be known. The most common method of ascertaining the temperature is by *Wedgewood's Pyrometer;* but this instrument, not always uniform in its results, involves the use of a forge, which it may not always be convenient to employ; it is also difficult to inspect the process on account of the great heat.

150. The most convenient and useful method of examining the fusibility of minerals is by the blowpipe. It is true we do not here discover the temperatures, at which fusion takes place; we have, however, the advantage, not only of inspecting the different products of fusion, but also of observing the manner of fusion, that is, the various appearances, which minerals present, while melting. Even these appearances are often very characteristic, and greatly assist in determining the nature of the mineral.

The blowpipe is an instrument too well known to require a minute description. The tube should be composed of two different materials, as metal and wood, or metal and ivory, to prevent the communication of heat to the fingers and mouth. The flame, which is directed by the blowpipe towards the mineral, assumes the form of a cone, whose sides, however, are not very well defined. But within this flame appears a second conical flame, well defined, and of a blue color; and it is at the vertex of this second cone, that the greatest heat exists. In many cases it is expedient to heat the mineral at the vertex of the outer cone, before it is exposed to the intense heat of the blue flame.

151. Much depends on the size of the fragment to be melted, and on that of its support. It is essential, that the fragment should be

extremely small, never exceeding a grain of pepper; otherwise a part of it will be without the focus of heat, and may prevent a complete fusion by cooling that part, which is within the focus.

Various methods, depending on the nature of the mineral, must be employed for supporting the fragment before the flame. Very small forceps will be sufficient, when the mineral has but little fusibility. For substances easily fusible a small platina or silver spoon may be employed. It is important, that these metallic supports should be very small, that they may not absorb too much caloric. When metallic oxides are to be reduced, a piece of very compact charcoal forms the best support. A small cavity is made in the charcoal, in which even minerals in a state of powder may be conveniently examined, especially if the cavity be partly covered by another piece of charcoal.

152. Minerals, while exposed to the action of the blowpipe, exhibit very different appearances, which, being directly before the eye, are easily observed, and should be minutely described. Sometimes their color is changed, or entirely disappears. Some minerals decrepitate, others split or exfoliate, when exposed to the flame. Some indurate and contract their bulk; others effervesce, or, rising in little blisters, melt with intumescence. It is also important to notice the vapor or odor, which may escape during the experiment; even the color, which some minerals communicate to the flame, is to be regarded.

153. The degree of fusion, and the results obtained, are to receive attention. On some minerals the blowpipe produces no effect whatever; others are partially fused; and others again melt with great ease.

The results of fusion may depend in some degree on the intensity or continuance of the heat, as well as on the nature of the mineral. Some minerals by the action of the blowpipe are merely softened, and alter their shape a little; or, if the substance be in loose grains, they become agglutinated. Others are converted into a kind of porcelain, in which only a few points are vitrified. Some melt into a *slag*, which is a compact substance, containing metallic matter; others yield a tumefied mass, or are reduced into a *scoria*, which is light and porous; and others give an *enamel*, which has a vitreous aspect, but is not transparent; sometimes the enamel is only superficial.

Many minerals, when melted, yield a globule of perfect *glass*, which, in different substances, has various colors, and possesses different degrees of transparency. Both enamels and glasses are sometimes porous or vesicular.

When minerals contain foreign ingredients, their fusibility and the appearance of the product may be much altered.

The greatest heat of the blowpipe, according to Kirwan, never exceeds 130°, on Wedgewood's Pyrometer; but Brongniart extends it to nearly 150° on the same scale.

154. The compound blowpipe, sometimes mentioned in this treatise, is a very ingenious and valuable instrument, invented by Mr. Robert Hare, of Philadelphia. In this instrument the heat arises from the combustion of a united stream of hidrogen and oxigen gases; and there is scarcely any substance, not combustible, which it does not melt. Professor Silliman, of Yale College, was early associated with Mr. Hare in his experiments, and has since greatly extended them. See Bruce's Min. Journal, vol. i.

155. Certain substances, called *fluxes*, are sometimes added to the fragment under examination to promote its fusion; and by their assistance many minerals, otherwise infusible, may be melted. There are some cases, however, in which the mineral, although not really melted, unites with the flux, in which it appears to be minutely divided and suspended, or even dissolved. It is to be remembered, that the appearances of the mineral during fusion, and also the results of fusion are variously modified by the action of fluxes. The same flux becomes differently colored by different minerals; and different fluxes receive different colors from the same mineral.

One of the fluxes most commonly employed with the blowpipe is the sub-borate of soda (borax). In some cases the color, communicated to the flux by metallic oxides, may assist in determining the kind of metal present.*

2. *Action of acids; and other tests.*

156. In most cases it is best to employ either the nitric or sulphuric acid. The only apparatus for these experiments is a piece of glass; and nothing is more convenient, than the crystal of a watch. A small fragment of the mineral is to be placed in the glass, and a

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* It is sometimes necessary to operate on larger masses, than can be exposed to the flame of a blowpipe. In this case recourse may be had to a crucible, placed in a forge, which, on some accounts, is preferable to a wind furnace. And although the greatest heat of a common forge does not exceed 125° W. yet, by means of a large bellows, heavily loaded, the heat may be raised to 168° W. When the hearth of the forge has become heated by a previous experiment, the greatest heat may be obtained in less, than half an hour. It is often proper to examine the ores of metals in a crucible, making use of suitable fluxes; especially when an opinion is to be formed concerning the expediency of working such ores in the large way.

sufficient quantity of acid poured on to cover it. If the acid have any action on the mineral, it is then to be observed, whether the solution take place quietly, or with effervescence; and, when a gas arises, its properties are to be noticed. In some cases the solution is complete; in others a residue is left; and sometimes the solution is gelatinous. It is also to be observed, whether a mineral lose its color by solution, or communicate color to the solvent; whether it dissolves, when in grains of a sensible magnitude, or only when reduced to a fine powder; in fine, whether the solution can be effected at the common temperature of the air, or only by the assistance of heat.

Liquid ammonia may in certain cases be employed with advantage, as a test. In fact, the chemical characters may be indefinitely multiplied, according to the nature of the mineral. Some, not here noticed, will be mentioned under the minerals, which exhibit them.

CHAPTER III.

SYSTEMATIC ARRANGEMENT OF MINERALS.

SECTION I.

General principles of arrangement.

157. The same reasons, which require a distribution of Natural Science(1) into different branches, render subdivisions and systematic arrangement in each branch peculiarly important and useful. Indeed without a systematic arrangement of facts, these branches of knowledge could not be considered sciences; for every science involves a knowledge not only of facts, but of the mutual relations, which exist between these facts; and these relations are the basis of scientific arrangement. Hence to obtain a knowledge of the science of mineralogy, we must examine the properties of minerals, compare them with each other, and, according to the results of this comparison, establish a systematic arrangement.

158. Such arrangements have already been successfully effected in Zoology and Botany. The subdivisions, most commonly employed in those two kingdoms, are the following, descending from the larger to the smaller; viz. *class*, *order*, *genus*, *species*, and *varieties*. Of these divisions the *species* is undoubtedly the most important, and ought to be first formed.

159. In arranging a system of bodies our attention must be directed to the differences as well, as resemblances, which exist between the bodies to be arranged. Thus, if we compare certain plants, for

example, we shall find them to resemble each other in most of their properties, although in some less important properties they may differ. If we neglect those properties, in which they differ, and confine our attention to the points of resemblance only, we can form these plants into one group, which is called a *species;* and all other plants, possessing the properties, which are common to this group, will belong to the same species. The differences, which exist between the plants, belonging to this group, may be employed in subdividing the species into varieties.

Let several groups or species be formed according to the same principle. If now we compare certain groups or species of plants, we shall perceive them to agree in some properties, while in others they are unlike. Abstracting the attention from those properties, in which these species differ, and regarding their resemblances only, we can form them into one group, which is called a *genus*. Here the points of resemblance characterize the *genus*, and those of difference, the *species*. By similar comparisons and abstractions we may proceed to establish *orders* and *classes*. It must be evident, however, that the properties, employed to form the species, are more numerous, than those, which determine the genus; and thus continue to diminish, as we ascend to the higher divisions.

160. The same general principles, so far as they are applicable, ought undoubtedly to be employed in arranging the mineral kingdom. But here difficulties arise, which do not exist among animals nor vegetables. These difficulties originate from the inorganic nature of minerals, and make their appearance at the very foundation of the arrangement, viz. in forming the species.

161. Could we satisfactorily determine what constitutes *a species* in mineralogy, little difficulty would remain in forming the other divisions. Deprived of organization, a mineral has not the power of reproducing another like itself. In organized bodies, on the contrary, this power of reproduction preserves all the species perfectly distinct, however nearly they may resemble each other in their general properties. Further, in bodies possessing organic structure, one species can never pass into another by imperceptible degrees; whereas minerals, being formed merely by the juxtaposition of their parts, and being continually subjected to the influence of external agents, during the period of their formation, are frequently contaminated by substances, foreign to their true composition; and individuals of different species are thus made to approach indefinitely near to each other in their appearance and properties. It must hence be obvious, that no small difficulty attends the determination of the species in

mineralogy; and accordingly we find, that different opinions have been entertained, and different methods employed.

162. So great in fact has been the diversity of opinions on this subject, that scarcely any two persons have adopted precisely the same division of minerals into species. But, neglecting the minor and unimportant differences between the various methods of arranging minerals, we may reduce them to two, which may be called the *mineralogical* and *chemical* methods; the former depending chiefly on the *external* characters of minerals, the latter on their chemical *composition.*

Some indeed have employed the structure and form of crystallized substances, more particularly the form of their integrant particles, as the leading principle of the arrangement. It is perfectly obvious, however, that this principle is limited in its application, for all minerals are not crystallized. But its results coincide very remarkably with those, obtained by the chemical method. Indeed the Abbé Haüy, who first directed the attention of mineralogists to this method of arrangement, has, by examining the structure and form of some crystallized minerals, in a certain degree anticipated the results of analysis.

163. In that, which we call the Mineralogical method, the species is determined by the *external characters.* Hence, those minerals, which possess the same external characters, are supposed to belong to the same species; and consequently, if two minerals differ in their external characters, they must be referred to different species, although the results of analysis should declare both minerals to be the same substance.

164. In the Chemical method the species is determined by the *true composition* of the mineral, so far as that can be ascertained. Hence, if the composition of two minerals is known to be the same, they are supposed to belong to the same species, although their external characters should be more or less different.

165. It must however be remarked, that, in the present state of our knowledge, neither of these two methods can be rigidly adopted, and thus each preserved perfectly distinct. Even those, who depend most on the use of the external characters in arranging minerals, are, in many cases, evidently guided by chemical principles. And, although these methods so materially differ in principle and in some parts of the resulting arrangement, still there are many points, in which they coincide, that is, a large number of species are the same in *both methods.* This coincidence results from the fact, that minerals, which possess similarity of composition, generally exhibit a re-

semblance in their external characters. This, however, is not always the case.

166. As each of the aforementioned methods of arranging minerals has received the support of very respectable mineralogists, it is proper to give the outlines of both, whichsoever may be adopted as our guide in the following work. In describing that method, which depends essentially on the use of the external characters, our attention will be confined to the system of Professor Werner, as it has been delineated by his pupils. In stating the principles of the chemical method, there will be occasion to refer to the arrangement of minerals by the Abbé Haüy.

SECTION II.

Arrangement of minerals, according to the system of Werner.

167. The Wernerian arrangement of minerals is, in a certain degree, a mixed method. But, as the species, the most important division, is determined almost uniformly by the external characters, it cannot with propriety be denominated a chemical method, although its divisions may not unfrequently correspond with chemical results. The basis of the Wernerian system, as stated by Professor Jameson, an intelligent mineralogist, who has attended the lectures of Werner, is "the natural alliances and differences, observable among minerals." (Jameson's System of Mineralogy i, Introd. p. xxiii.) These alliances and differences are there said, on the authority of Werner, to depend on the quality, quantity, and mode of combination of the constituent parts. But it is expressly asserted by Prof. Jameson (Introd. p. xxiv), that Werner "does not pretend, that his arrangement shall always correspond with the experiments of the chemist; for it is *only* when chemical results agree with the *natural alliances* of the mineral, that he gives them a place in his system." It is also said (p. xxv of the same Introd.), that "a chemical oryctognosy, in so far, as it stands in opposition to the natural alliances, observable among minerals, must be rejected;" and it is added (p. xxxvi), that the greater number of species in the mineral kingdom have been "arranged solely by agreements and differences in the external characters." The preceding authority is sufficient, it is conceived, for asserting, that the Wernerian arrangement essentially depends on the use of the external characters; and the system itself, in many parts, affords indubitable evidence of the same fact.

The divisions and subdivisions, introduced by Werner into the mineral kingdom, are the following, taken in a descending series; viz. *class*, *genus*, *species*, *subspecies*, and *kind*.

168. The number of classes is four; viz. *earths* and *stones; salts; combustibles;* and *ores.* This division was first introduced by Cronstedt about the middle of the last century.

169. Each class is subdivided into genera. In most cases the genera are determined by the earth, or salt, or combustible, or metal, which is supposed to be either the predominant, or characteristic ingredient. It will be noticed, that a distinction is here made between the *predominant* and *characteristic* ingredient. It is indeed commonly the case, that the characteristic ingredient, or that, which is most effective in producing the peculiar characters of the mineral, is also predominant in quantity. But there are some minerals, which do not appear to be characterized by that ingredient, which is present in the largest proportion. This distinction is undoubtedly important; and could we, in cases of minerals, composed of several earths, estimate the relative energies as well, as the relative quantities of the different ingredients, we might ascertain what is essential to the true composition of such minerals.

170. The first or earthy class contains nine genera. Seven of these are determined by the predominant or characteristic earth; viz. the zirconian, siliceous, aluminous, magnesian, calcareous, barytic, and strontian genera. They, however, exhibit a number of anomalies. Thus sapphire is placed in the siliceous genus, although it is nearly pure alumine; and opal, which, in some varieties, does not contain a particle of alumine, is nevertheless referred to the aluminous genus.

But sapphire and opal are thus arranged in perfect consistence with the true principles of this system. For the fact appears to be this; a certain number of external characters, which siliceous minerals usually exhibit, being assumed as generic characters, or as a type of the genus, every mineral, possessing these characters, whether it contain any silex or not, is arranged under the siliceous genus.

We have mentioned seven of the genera, belonging to the first class; the remaining two are introduced into the earthy class, merely in consequence of possessing certain external characters, and in direct opposition to their true composition. One of these is the diamond genus, composed of pure carbon, and belonging to the class of combustibles. The other is called the hallite genus (from the Greek ἁλς, a salt), because the minerals, which it contains, resemble native salts; and they are in fact true salts.

171. The second class, salts, is divided into four genera; viz. carbonates; nitrates; muriates; and sulphates of the alkalis, earths, and metallic oxides. But the term salts is here to be understood in

a much more limited sense, than when employed by chemists. It includes only those salts, which have some taste and a considerable degree of solubility in water.

172. Combustibles, which form the third class, are also divided into four genera; viz. sulphur; bitumen; graphite; and resin.

173. The class of ores contains as many genera, as there are distinct metals, found in the state of an ore.

In forming and naming most of the genera, even in this system, mineralogists have been more or less guided by chemical principles, whatever deviations may exist in the arrangement of certain species. In forming the metallic genera an attention to the constituent parts of minerals is unavoidable; for, were these genera to be established by external characters, independent of chemical analysis, the various species of ores, belonging to the same metal, would not always be collected into the same genus. Indeed several species of ores would undoubtedly be arranged among earthy minerals. Thus no one, relying on external characters only, would associate carbonate of lead with the other ores of that metal, nor even place it in any metallic genus.

174. The genera are subdivided into a greater or less number of species; and these, as before remarked(167), are determined almost uniformly by the use of the external characters. It is true, indeed, that Werner, in the introduction to his treatise on External Characters, says, that all minerals, which differ essentially in their chemical composition, ought to form different species; and that those, which do not differ essentially in their composition, belong to the same species. This principle, however, is indefinite, and in many cases entirely useless in establishing the species, unless we are informed what constitutes an *essential difference* in chemical composition. Indeed the aforementioned principle seems to be practically admitted only on the supposition, that the external characters are *always a true index* of the chemical composition; and, of course, that all essential differences in composition are clearly indicated by corresponding differences in the external characters. For, whenever the external characters and chemical composition are *at variance*, the species is determined solely by *the external characters*. The truth of this will appear by referring to the two species Apatit and Spargelstein of Werner; both of which are phosphate of lime, and really constitute but one species, although somewhat different in their external characters. Gypsum and selenite are in a similar situation.

When the species is extensive, it is subdivided into subspecies; and these are often further divided into kinds.*

175. A careful examination of this system will render it extremely probable, that its author has, in some instances, supposed his distinctions to be formed by external characters alone, while, though perhaps unconscious of the fact, he has been in a great degree guided by the sure light of chemistry. In many instances, however, no one will deny, that the distinctions depend on external characters alone.

In favor of this system it is urged, that the use of the external characters enables us in a moment, almost by a glance of the eye, to ascertain the species, to which a given mineral belongs; and also to describe that mineral in a very concise manner, but, at the same time, so accurately, that another person may recognise it. It is also asserted, that, by enumerating *every external character*, a complete picture of the mineral, or rather of the species, to which it belongs, is presented to the view; and that the aggregate of external characters, exhibited by a given species, can never be found in a mineral of a different species, although a number of the characters, included in that aggregate, may be common to both species.

On the other hand, it is objected to this system, that the method, which it employs for determining the species, is not scientific, being founded on principles both arbitrary and variable; and that consequently different species are often formed without any specific difference. It is also objected, that, although the aggregate of external characters be presented in description, no discrimination is made between those, which are specific and distinctive, and those, which are not so. Hence the most unimportant characters appear in the description of equal value with those, which are really distinctive, and the reader is of course unable to characterize the species. It is further objected, that those, who adopt this system, so rigidly avoid all experiment, that, in their descriptions, they do not avail themselves of all the advantages in their power. Thus they express the hardness of minerals very indefinitely, as *pretty hard*, &c.; they give the specific gravity of bodies by estimation, saying *middling heavy*, &c. instead of obtaining it by experiment; and they decline a measurement of the angles of crystals, although this measurement would render the crystalline form and structure characters of the first importance.

It is obvious, that some of the preceding objections, though perfectly just, and true in fact, do not necessarily attach themselves to the

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* In the earthy class certain species, having a general resemblance, are often collected into *families*.

system, as they have no connexion with the divisions and arrangements, which it proposes.

SECTION III.

Arrangement of minerals, according to their chemical composition, or constituent parts.

176. We are now to direct our attention to that arrangement of minerals, which is designed to be strictly chemical. But, in order the more accurately to estimate the merits of the chemical method, it must be remembered, that our only object, at present, is to *establish a systematic arrangement*, or classification of minerals, on certain *fixed principles*.—To *describe* a mineral in such manner, that it may be easily recognised and referred to its place in a system *already formed*, is a *distinct object*; and permits the use of those properties of minerals, which would be *insufficient to determine the arrangement itself*. The mode of describing minerals will constitute the subject of the next section.

177. We have already remarked, that the *species*, the most important division, ought to be first formed.

It must be extremely obvious, that those minerals, which most resemble each other, belong to the same species. We are then to inquire what constitutes the most perfect resemblance between two or more minerals. Can similarity of color, form, fracture, hardness, &c. constitute a resemblance so perfect, as that, which arises from identity of composition? Or can a difference of color, form, fracture, &c. establish so important a distinction between minerals, as that, which is produced by dissimilarity of composition? Would not two minerals, both composed of phosphoric acid and oxide of lead, in the same proportion, belong to the *same species*, although the color of one should be brown, and that of the other green? Would not two minerals, composed of phosphoric acid and lime, in the same proportion, belong to the same species, although the forms of their crystals, essentially the same, should exhibit different modifications? In fine, can properties, liable to numerous variations from trivial and accidental causes, be supposed to establish the identity of two or more minerals with that degree of evidence, which is afforded by a well ascertained similarity in composition? We hesitate not to answer these questions by saying, that the *true composition* of minerals ought to be the basis of arrangement; and by this only ought the species to be established. This only can give permanence of character to the species. The composition of a mineral, that is, the ingredients proper and essential to its composition, may remain unaffected by the accidental presence of certain foreign ingredients, which materially change several of the external characters.

178. Hence a species may be thus defined; *a collection of minerals, which are composed of the same ingredients, combined in the same proportions.*

179. But, granting that identity of composition constitutes the best specific character of minerals, are we sufficiently well acquainted with the composition of minerals to employ it, as the principal character, in the determination of the species? Is chemical analysis, in the present state of our knowledge, sufficiently accurate and perfect for this purpose? To this it may be answered, that the various species of *alkaline* and *earthy salts*, some species of *combustibles*, and almost every species among the *ores of the metals* can be limited and established by their well known composition. Difficulties may sometimes arise from the presence of foreign ingredients; but they are not of sufficient importance nor extent to affect the general principle of arrangement.

180. There remains, however, one class of minerals, composed chiefly of different *earths*, combined in various proportions, such as garnet, feldspar, &c. whose composition is not yet sufficiently understood, to be employed, as the basis of specific or even generic arrangement. This extensive class of minerals is really involved in some very peculiar difficulties. Analysis can indeed inform us what earths are present in these minerals, and in what proportions; but it has not yet been able to discover in what manner these earths are here combined, nor to distinguish between those ingredients, which are essential to the composition, and those, which are not, and which may in fact be considered as accidentally present.

Some minerals, which strongly resemble each other in their physical or external properties, and which, judging by these characters, evidently belong to the same species, do, however, when analyzed, widely differ in their composition. Others, on the contrary, possessing very different external characters, appear to be composed of nearly the same ingredients, combined in proportions very nearly the same.

181. This singular difficulty in regard to earthy minerals undoubtedly arises from two sources; one of which is the degree of imperfection still attached to the present modes of analysis. The other source, and probably the most extensive in its influence, is our inability to determine what ingredients are essential in a compound; or rather which one, two, or more of its ingredients may be most influential in producing its physical properties. We have

already noticed(169) a distinction between a predominant and characteristic ingredient. This principle is undoubtedly important in its application to the present case. Some one or two of the ingredients of a compound mineral, although present in but a small proportion, may be much more powerful in determining the peculiar characters of that mineral, than another ingredient, which exists in a much greater quantity. It is indeed very probable, that certain earths may be almost always present, in small quantities, in a mineral, and yet not essential to the composition of that mineral. These various intermixtures, unessential to the species, may be supposed to have arisen, at the moment of the formation of the mineral, from the various and complicate affinities, existing between the several earths and their compounds. Foreign ingredients may have thus been interposed, or essential ingredients made to exist in excess.

Hence, perhaps, the reason why different crystals of the same substance yield to mechanical division with very different degrees of ease. Hence also one cause of the different results of analysis in minerals of the same species. Hence also it appears, that, notwithstanding the numerous though often trivial differences in these results, there may still be a unity of composition in each species. Hence also it is obvious, that, in analyzing minerals, an attention to their gangue or matrix is important; for this may have furnished accidental ingredients, or caused essential principles to exist in excess.—It ought here to be remarked, that the difficulties, which have resulted from diversity of analysis in minerals, supposed to belong to the same species, are gradually disappearing in consequence of the progress of chemistry. This progress is clearly evinced by the discovery of new earths and metals; and also by the detection of alkalis in many minerals, where, till lately, those substances were not suspected to exist.

182. It must be obvious from the preceding observations, that, until the analysis of *earthy* minerals becomes more decisive, some other mode or modes must be employed for determining the species. But, whatever these modes may be, they ought to employ those characters only, which depend on the nature or true composition of minerals. In many cases of crystallized minerals the species may be determined by the form of the integrant particles; for these forms undoubtedly depend on the elementary particles or true composition. It is the adoption and extension of the principles just stated, which constitute the peculiar traits of the system of mineralogy by the Abbé *Haüy*. This principle and its application require a more particular illustration.

183. In the section on crystallization(24) we have already defin-

ed an integrant particle; and shown in what manner its form may frequently be ascertained by mechanical division(44). It was there remarked, that it is known from observation, that, in a large number of species of minerals, each species has integrant particles of a form peculiar to itself(50). But it must be distinctly noticed, that, in some instances, different species do certainly possess integrant particles of precisely the same form and relative dimensions, although differing in other properties.

It may, however, undoubtedly be assumed as a universal principle, that every species of minerals has integrant particles, whose true composition is peculiar to that species. In other words, no two really distinct species of minerals can be found, whose integrant particles exhibit the same form and agree in their composition; for, if their forms be the same, their composition and many of their physical properties will differ.

184. It hence appears, that an integrant particle in the mineral kingdom corresponds to an individual among animals, or vegetables. As each plant, abstracted from its individual qualities, is a representative of all the plants, belonging to the same species, and of the species itself, so an integrant particle represents the species, to which it belongs. The integrant particles of the same species possess the same composition, the same form and other physical properties; and an aggregate of these particles, whether it be crystallized or amorphous, would exhibit the mineral in a pure state, and possessing all the essential properties, which belong to that species.

We therefore conclude, that, in cases, where the results of chemical analysis are not satisfactory, the form and some other physical properties, which are essential to the integrant particles, may furnish us with specific characters, on which very great reliance may be placed in determining that composition, which characterizes the species. Indeed the history of the Arragonite justifies us in saying, that such irreconcilable differences of *structure* and other important properties may exist between two minerals, whose composition, in the present state of analysis, appears to be the same, as to render it proper to suspend a decision in regard to such minerals.

185. The preceding view of the *nature*, or properties of the integrant particle does not, perhaps, differ from that, given by the Abbé Haüy in his Treatise on Mineralogy. But although he admits, that it belongs to chemical analysis to establish the basis of arrangement, yet, in determining the species, he appears to be governed *chiefly* by the *form* of the integrant particles, except in those cases, where different species have integrant particles of the same form. Hence he de-

fines a species, *a collection of bodies, whose integrant particles are alike, and composed of the same principles, united in the same proportions.* The latter clause of the definition he adds for the purpose of including those cases, in which integrant particles of different species have the same form.*

186. The form of the integrant particle is indeed dependant on the true composition of the mineral, and is unquestionably, in many instances, a very important character to indicate what is essential to that composition. But the acknowledged fact, that some species, really distinct, have integrant particles of precisely the same form, proves that the character, derived from the form of the integrant particle, being less general, ought to be subordinate to the true composition. It is hence obvious, that the form of the integrant particle can never be adopted, as a universal standard, for establishing the species among minerals.

187. Further, it is by no means evident, that certain minerals, which have never been seen crystallized, do not constitute really distinct species, and are in fact only a mixture of several species. We have remarked, that every species has integrant particles, whose composition, and very frequently, whose form and some other physical properties, are peculiar to that species, and would, if well understood, distinguish it from every other species. But, would not the integrant particles of a mineral remain the same in their real nature, whether regularly arranged in a crystal, or collected into an amorphous mass? In order that minerals may crystallize, they must be placed in certain circumstances, favorable to this process. Now we find some minerals have crystallized much less frequently than others. And where is the inconsistency in supposing, that some species of minerals seldom or never crystallize? We do not indeed know all the circum-

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* Notwithstanding the great reliance, which M. Haüy places on the form of the integrant particle, he has remarked in his *Tableau Comparatif*, that he does not consider a knowledge of the form of the integrant particle indispensable to the admission of a mineral to the rank of a distinct species, provided its composition be well ascertained, and found to be different from that of any known species. And it was under these circumstances that he first introduced the chromate of iron, as a distinct species.

It appears, that M. Haüy's first object in forming his system of crystallography was to unite different crystallized varieties of the same species about one common point, as a nucleus or primitive form; and he was thus almost necessarily led to form a classification of *crystallized* minerals. But, however perfect this system may be in regard to the laws, by which various secondary forms are derived from the same primitive form, it is not, even by its celebrated author, supposed equally competent to establish a mineralogical method.

stances, under which minerals were placed at the time of their formation; but is it not perfectly consistent to believe, that the presence of certain earths, not essential to the species, may, by their counteracting affinities, prevent crystallization? This we know to be sometimes the case in mixtures of certain salts. It is true, the number of supposed species, which has never been seen crystallized, is indeed small. But, if they are really distinct species, their claims to that rank ought to be asserted, although they have never been permitted to delight our eyes by their regularity of form.

188. It is unnecessary to describe the genera, orders, and classes, which exist in the system of the Abbé Haüy; for they are strictly chemical as far, as the present state of the science permits, and, of course, do not materially differ from the arrangement, employed in this treatise.

189. It may be useful here to recapitulate the principles, we have endeavored to establish for a scientific arrangement of minerals, and to make some additional remarks on the subject.

1. The true composition of minerals is the only sure criterion for determining the species, and, when known, should be employed in all cases.

2. When the composition of minerals is entirely unknown, or but imperfectly understood, other characters, depending more or less on the composition, must be employed. Of these the more important are undoubtedly derived from the crystalline *form* and *structure;* the latter of which may be extended to foliated masses, not possessed of a regular form; for these often easily yield to mechanical division. Indeed a careful attention to crystalline characters may sometimes remove apparent difficulties in the results of analysis.

3. The form of the integrant particle may often be employed with great advantage; but this alone cannot be relied upon with certainty, because the same form is sometimes common to different species; and hence, if two minerals are found to have integrant particles of the same form, the other properties of these minerals, examined in a state of purity, must agree, in order to establish the identity of the two substances.

4. When minerals, whose ingredients are capable of combining in various proportions, are crystallized, the form of the integrant particle may be of great use in limiting the species.

5. The form of the integrant particle, and the primitive form of crystals may be employed with advantage to distinguish what ingredients, found in a mineral, are unessential to the species; for whatever can be added to a mineral, or taken from it, without affecting

these forms, may be considered foreign or not essential. The siliceous carbonate of lime (calcareous sandstone of Fontainbleau) affords a striking instance of a mineral greatly contaminated by a foreign substance, without affecting the form of the integrant particle.

6. When analysis is wanting, much benefit may be obtained from the primitive forms of crystals in establishing the species; for it is worthy of notice, that, when two or more crystals, belonging to different species, have the same primitive form, their other physical characters are, in general, strikingly different; as in the case of spinelle and magnetic oxide of iron. Indeed the primitive form may, in many instances, be employed instead of that of the integrant particles.

7. The structure and actual forms of secondary crystals are also important, provided the various angles of the crystal be accurately measured.*

8. When all assistance from analysis or the crystalline form is denied, the species must be determined by a well chosen aggregate of those external characters, such as structure, fracture, hardness, &c. which depend most intimately on the nature of the mineral. It is however to be understood, that, in all cases, where the composition is unknown, the species are to be considered provisional, till the progress of chemistry shall enable us to reexamine them.

190. The number of species, whose composition is not well known, even if it were greater than it is, ought not to be offered as an objection to the principles, we have just stated, for establishing the species. An objection of this kind would be saying, that, because we have not sufficient light on every object, it should be rejected in cases, where it shines with the greatest clearness. Neither can any difficulty or confusion arise from adopting a method somewhat mixed, depending in different parts on different principles. For so far, as the method is mixed, it arises from an imperfect knowledge of the true composition of certain minerals; and there is reason to believe, that the provisional species will gradually disappear, either by becoming well established, or by being associated with other species.

191. The preceding principles, it is believed, will enable us to limit and determine every species of simple minerals with as much accuracy, as the present state of our knowledge will permit. They embrace not only well crystallized minerals, but those, which are imperfectly crystallized, or which exist in foliated masses, destitute of

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* The nature of amorphous minerals, whether granular or compact, may often be ascertained by their intimate connexion with well defined crystals, or even with laminated masses of the same substance. Of this, epidote furnishes an important illustration.

regular form; they extend not only to amorphous minerals in a state of purity, but also to those, whether crystallized or amorphous, which are more or less contaminated by foreign ingredients. For it must be remembered, that a systematic arrangement is not designed to embrace those minerals, which are merely compounds of different species. Difficulties may sometimes arise in determining whether a given mineral is only a mixture of different species, or whether it belongs to some distinct species, but is greatly contaminated by other minerals.

192. We are now briefly to state the manner, in which the higher divisions are formed. Here also chemistry is to be our guide; for the genera, orders, and classes are to be determined, as far as may be, by the composition of minerals, or by some of their chemical properties.*

193. A *genus* will therefore be composed of certain species, which possess some common ingredient, and resemble each other in their chemical properties. In selecting the common ingredient, a preference should be given to that, which is most fixed and permanent. Thus all minerals, which are composed of *lime, united to an acid,* will form one genus, characterized by a common earth, and receiving its name from that earth.

194. An *order* will then be composed of certain genera, whose *bases* resemble each other in their nature. Thus all the earths have certain common properties, in which they resemble each other. Hence all those genera, which have for their base *an earth, united to an acid,* will form one order, which embraces the earthy salts. It is also to be understood, that the chemical properties of the different genera, united in the same order, should be similar.

195. A *class* is formed by the union of several orders. But it must be evident from the general principles of arrangement, that the relations, which unite orders into classes, must be more abstract and general, than those, which exist between the several species of a genus, or the several genera of an order. The relations, which characterize the classes, will be sufficiently explained in the subjoined *tabular view* of minerals.

196. The species, when necessary, may be divided into *subspecies, varieties,* and even *subvarieties;* but these subdivisions are determined chiefly by the external characters. By these means we are

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* It may be said, that the arrangement here proposed is not strictly chemical, because the alkalis and earths are not considered as metallic oxides; but, at present, it would be neither expedient nor convenient to place the alkaline and earthy minerals in the class of metals.

enabled to preserve a scientific arrangement, and, at the same time, to subdivide an extensive species, and to descend to any degree of minuteness in description, which the importance or utility of the species may require. The following general principles will determine the divisions into subspecies, &c.

1. The presence of any ingredient, not essential to the species, but which, nevertheless, produces a considerable change in the specific gravity, fusibility, or other important properties of the mineral, may be the basis of a distinction into subspecies.

2. Different structures and different degrees of cohesion between the particles are often found in minerals of the same species, and require divisions into subspecies or varieties. Thus, if only specific characters were given, it would be almost impossible to recognise all the varieties of carbonate of lime, sometimes finely crystallized, sometimes stalactitic, sometimes in a state of powder, and sometimes exhibiting a structure, which is granular, fibrous, or compact. But, by forming a number of subspecies and varieties, every important diversity of appearance in the species may be noticed.

3. Subspecies and varieties may sometimes be founded on particular colors, when these colors, although arising from ingredients unessential to the species, are sufficiently constant. Sometimes the difference of color, which appears in minerals of the same species, is produced by different coloring matters, and may be employed for subdividing the species.

SECTION IV.

Description of minerals.

197. It has already been remarked (176), that the description of a mineral, for the purpose of enabling any one to recognise it and refer it to its true place in a system, *already formed*, permits the use of those characters, which would be insufficient to establish a mineralogical method. Hence, in describing a mineral, we may employ every character, whether physical or chemical, which can afford some important assistance in distinguishing that mineral from those, which belong to other species, and in conveying an accurate idea of its appearance.

198. It must be perfectly obvious, that whatever is employed in establishing the species should, in itself, be of universal application; such is the true composition of minerals. But it is equally obvious, that any character, which almost uniformly belongs to a particular species, will be useful in describing and distinguishing that species. It is hence evident, that all those external characters, such as form,

hardness, structure, &c. which depend more or less intimately on the composition of the mineral, are to be employed in description. Even those characters, which arise from the presence of superfluous or unessential ingredients, if their occurrence be sufficiently uniform, are of important use. Hence the very frequent appearance of a particular color may furnish a strong presumption, that the mineral in question belongs to a certain species. Much assistance may also be derived in some crystallized minerals from the frequent assumption of a particular form by some one species; or from certain peculiarities of form, arising from truncation or bevelment, &c.

199. The primitive form of the crystal, when it can be ascertained, is by no means to be omitted in description. This character, however, is incapable of universal application; for a large proportion of minerals are most frequently found either amorphous, or so imperfectly crystallized, that mechanical division is with difficulty applied. And, in regard to many minerals, much experience and practical skill are requisite to discover the natural joints and dissect a crystal with sufficient degree of accuracy; more especially to obtain the form of the integrant particles.

But a measurement of the angles of a crystal, whether those, formed by the inclination of contiguous faces to each other, or the plane angles of the faces, may be easily and accurately effected, and constitutes a very important and useful character. For, in any given species, all the crystals, belonging to the same variety of form, have their corresponding faces inclined to each other in angles of a constant quantity. This measurement is often particularly useful in cases, where certain faces of a crystal have taken an undue extent, and where other deviations from the usual form have been produced. Thus in hexaedral prisms of quartz, terminated by six-sided pyramids, the mutual inclinations of the faces remain the same, however much the prism may be compressed, or the faces of the pyramids unduly extended.

200. It is extremely important, that the characters, used in describing minerals and referring them to their proper species, should be susceptible of easy and expeditious application. Hence the advantage of employing certain chemical characters, and also those *external* characters, which can afford a satisfactory degree of evidence.

But the various external characters, which may be usefully employed in description, ought not to be indiscriminately detailed. On the contrary, those, which are most important, distinctive, and characteristic, should be particularly designated, either by being placed first in the description, or by being collected into a distinct paragraph.

Hereby a pupil will save time and labor, and may avoid many perplexities.

201. Another character, peculiarly important to the practical mineralogist, and which ought never to be omitted in description, remains to be mentioned. This is called the *geological* character, and depends on particular associations, existing among minerals. It appears from observation, that certain minerals often occur together; while others, on the contrary, have seldom or never been found associated. Further, some minerals have a particular gangue or repository, in which they are contained. Thus the staurotide (granatit of Werner) is most usually found in a micaceous slate.

The greater number of simple minerals are found in compound rocks or aggregates. But the nomenclature and description of these compounds belong to geology, and will be given at the close of this volume. A very few general remarks will be sufficient to explain the geological characters, employed in the following descriptions.

202. Those minerals, which fall under the cognizance of geology, may be divided into five classes.

1. The first class contains the *primitive* or *primary* rocks, such as granite, gneiss, micaceous slate, certain limestones, &c. These rocks are chiefly composed of various simple minerals, irregularly crystallized, and aggregated without the intervention of any cement. They never contain organic remains of animals or vegetables. When connected with rocks, belonging to a different class, they occupy the lowest place, in reference to the centre of the earth. They are therefore supposed to have been first formed, and have accordingly received the name of *primitive* rocks.*

2. There exists another class of rocks, less distinctly the result of crystallization than the preceding, in part composed of mechanical deposites, and sometimes containing petrifactions. This class, to which belong graywacke, certain varieties of greenstone and limestone, &c. lies over the primitive rocks, when both classes occur together, and is called the *transition* class.

3. The third class is composed of those, which are called *secondary* rocks. These are always situated over or above the primitive or transition rocks, and often abound with organic remains or petrifactions. They appear to be chiefly mechanical deposites from water; in this class we find sandstones, and certain varieties of limestone.

4. *Alluvial* substances constitute the fourth class. They consist

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* For an explanation of the word *formation*, as applied to extensive deposites of minerals, see remarks on geology, at the close of this volume.

of clay, sand, pebbles, &c. and are evidently produced in a great degree by the disintegration of the preceding classes.

5. *Volcanic* productions form the fifth class.

CHAPTER IV.

NOMENCLATURE OF MINERALS.

203. The nomenclature of most minerals is at present so incumbered with synonyma, that it has become extremely perplexing to the student. He is hereby reduced to the alternative of perpetually recurring to books, or of loading the memory with several names, taken from the various languages, in which modern works on mineralogy have appeared. These remarks may be illustrated by the example of epidote. This mineral, which is called *epidote* by Haüy, is named *pistazit* by Werner, *thallite* by Lemetherie, *akanticone* by Dandrada, *delphinite* by Saussure, *glassy actynolite* by Kirwan, *arendalit* by Karsten, *glasiger strahlstein* by Emmerling, *la rayonnante vitreuse* by Brochant; &c. This is indeed an extreme case, and few other minerals have received so many synonyma.

We are not only deluged with various names given to the same mineral, but, in some cases, confused by the application of the same name, by different writers, to substances perfectly distinct. This multiplication of names is, in many cases, altogether unnecessary; and sometimes, when a new name has been substituted for one already existing, the former has been found equally objectionable with the latter. In all cases, where the chemical nomenclature cannot be applied, it would perhaps be a good general rule to permit the mineral to bear the name, given it by its discoverer.

204. By some writers the chemical nomenclature has been employed as far, as practicable; but most of the names, by which minerals are known, have been derived from the name of the place, where they were first observed; or from the name of the discoverer; or from the prevailing color, or some other characteristic property of the mineral. Sometimes the allusion of the name to the property is very obscure, and sometimes very trifling; see the names grammatite, analcime, chabasie, &c.* When the composition is unknown, those names, which are altogether unmeaning in regard to any property of the mineral, are perhaps the least objectionable; for they certainly cannot lead to error.

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* See Traité de Minéralogie par le C^{en}. Haüy, tome 3, pp. 176; 180; and 227.

205. In this treatise, the chemical nomenclature will be employed to designate *the species* in all cases, where the composition of the mineral is supposed to be sufficiently understood; it will, however, be accompanied by some familiar, mineralogical name, when such name exists, and by synonyma from some of the most valuable modern writers. But many of the aforementioned species embrace important varieties, which it is necessary to distinguish. This is peculiarly the case with the carbonate and sulphate of lime. Now these varieties must be distinguished either by the addition of certain modifying epithets to the name of the species, or by some single name. The latter mode is more simple and convenient for general use, and is probably attended with fewer objections, than the former. We shall, therefore, whenever it is practicable, distinguish subspecies and varieties by mineralogical names already in use and well known.

In a few instances, a single species, as determined by the composition, is divided by Werner, according to the external characters, into two or more species; and distinct, mineralogical names have been imposed on each. These names may be retained in the chemical method to designate subspecies or varieties. This is the case with the species, phosphate of lime; it is divided by Werner into two species, *apatit* and *spargelstein*, which are merely varieties, but which it is useful to distinguish. Many obvious advantages will result from retaining these names already in use, and employing them for the purpose just mentioned. Thus sulphuret of arsenic contains two subspecies, the red and the yellow, which have long been known and distinguished by the names *realgar* and *orpiment;* and there does not appear any sufficient reason for their disuse.

206. It cannot with propriety be objected, that the giving of distinct names to the subspecies and varieties will too much incumber the memory. For something must be remembered; and in cases, where a significant appellation is unknown, or would be inconvenient, the shortest name is undoubtedly to be preferred. It would indeed be a fortunate circumstance, if mineralogists would agree to designate minerals by some common nomenclature. But, while a systematic and significant nomenclature of all minerals cannot be formed; and while respectable mineralogists continue to establish the species by external characters alone, and studiously avoid the use of the chemical nomenclature in those cases, where it is applicable, every mineralogist must be acquainted with mineralogical names.

It is certainly convenient, at least for the purpose of conversation, to be able to designate a mineral by a single name. But, if names are given to species only, it will be necessary to employ description, or, at least, one or two epithets to distinguish any particular variety, of which we wish to speak.

207. The names of earthy minerals, whose true composition is not well known, and where consequently the chemical nomenclature is inapplicable, will, in general, correspond with those employed by Kirwan and Jameson, which are probably most familiar in this country, and are in most cases preferable to those of the Abbé Haüy. There must, however, be a number of deviations from their nomenclature. Some minerals, now known, are not mentioned by the two former writers. Other deviations necessarily arise from the late accurate and scientific researches of Haüy and other French mineralogists, who have shown, that, in some instances, minerals really distinct have been collected into one species. Two or more new species will hence arise, and must retain the names, they have received. In other cases it appears, that minerals, which really belong to the same species, have been separated, and must again be united. These new associations and separations cannot fail of producing some degree of confusion in the nomenclature; but the true interests and progress of the science ought not to be sacrificed to so trifling an inconvenience.

TABULAR VIEW OF SIMPLE MINERALS;

according to the order, in which they are arranged and described in this work.

208. In the following tabular view of simple minerals, the divisions into species and the nomenclature of the species are perhaps as strictly chemical, as the present state of mineralogical knowledge will permit. In the class of earthy compounds an accurate division into genera is impracticable. An attempt has therefore been made to arrange the species of this class, in some degree, according to their composition, as far as that can be ascertained from the results of chemical analysis. In other words, those minerals, which most resemble each other in the results of their analysis, are collected into the *same group*. We are hereby enabled to determine how far those minerals, which appear to be composed of the same ingredients, united in different proportions, resemble each other in their external characters.

209. In forming these groups, the latest analyses of the most experienced chemists have been employed, and principally those made by Klaproth, Vauquelin, and Chenevix. It has also been an object to select analyses made on the purest, crystallized specimens. In general, no ingredient has been considered essential, which does not occur in at least five per cent. in specimens apparently pure; while,

at the same time, some ingredients, which occur in greater proportions in specimens obviously impure, have been rejected as accidental. After all, it must be obvious, that this arrangement of the earthy minerals is liable to various alterations, in proportion as chemical analysis becomes more correct. The important question, which remains to be answered, in regard to the greater number of the species in the earthy class, is this; which two or more of the ingredients, mentioned in the results of chemical analysis, are *essential to the true composition* of each species.

In the tabular view, *subspecies* are distinguished from *varieties* by a larger type, and by their position in the column.

A number of species, recently discovered, and concerning which little is yet known, are alphabetically arranged in an appendix to the earthy class.

Those species, which have never been analyzed, are marked by an asterisk. The place of such minerals, when not contained in the appendix, is determined merely by some external analogies.—Subvarieties are not included in the tabular view; and in the descriptions are not numbered.

TABULAR VIEW.*

CLASS I.

Substances not metallic, composed entirely, or in part, of an Acid.

This class contains four orders. In the first order, the acid is free or not combined; in the second, it is combined with an alkali; in the third, with an earth or earths; and in the fourth, with both an alkali and an earth. Hence the presence of an acid, provided it be not united to a metallic base, characterizes this class.

ORDER I.

Acids not combined.

The base of the acid determines the genus. All the species in this order have oxigen, as a common ingredient, so combined with a base, as to produce an acid.

GENUS I.

Species 1. Sulphuric acid.
2. *Sulphurous acid.*

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* Those species, which are printed in Italics, have not hitherto been observed in crystals, nor even with a crystalline structure.

GENUS II.

Species 1. *Muriatic acid.*

GENUS III.

1. *Carbonic acid.*

GENUS IV.

1. Boracic acid.

ORDER II.

Alkaline Salts.

These salts are composed of an alkali, united to an acid. Hence an alkali, so combined as to form a salt, characterizes this order. Each alkali designates a genus.

GENUS I. *AMMONIA.*

Species 1. Sulphate of Ammonia.
2. Muriate of Ammonia.

GENUS II. *POTASH.*

1. Nitrate of Potash.

GENUS III. *SODA.*

1. Sulphate of Soda.
2. Muriate of Soda.
3. Carbonate of Soda.
4. Borate of Soda.

ORDER III.

Earthy Salts.

These consist of an earth, or of earths, united to an acid. Hence an earth, so combined as to form a salt, characterizes this order. Each genus is determined by the earth it contains.

GENUS I. *BARYTES.*

SUBSPECIES
AND VARIETIES.

Species 1. Sulphate of Barytes.
    lamellar
    columnar
    radiated
    fibrous
    concreted
    granular
    compact
    earthy
  fetid
2. Carbonate of Barytes.

GENUS II. *STRONTIAN.*

1. Sulphate of Strontian.
    foliated
    fibrous
  calcareous
2. Carbonate of Strontain.

SUBSPECIES
AND VARIETIES.

GENUS III. *LIME.*

SPECIES 1. Arseniate of Lime.
2. Nitrate of Lime.
3. Phosphate of Lime.
        - Apatite.
        - Asparagus stone.
        - fibrous
        - amorphous
    - siliceous
4. Fluate of Lime.
        - Fluor spar.
        - compact
        - earthy
    - argillaceous
5. Sulphate of Lime.
    - Selenite.
        - massive
    - Gypsum.
        - fibrous
        - granular
        - compact
        - branchy
        - snowy
        - earthy
    - Plaster stone.
6. Anhydrous Sulphate of Lime.
        - sparry
        - compact
    - silico-anhydrous
7. Carbonate of Lime.
    - calcareous spar.
        - crystallized
        - laminated
    - granular
    - fibrous
    - compact
        - coarse grained
    - Chalk.
    - Agaric Mineral.
        - Fossil farina.
    - concreted
        - Pisolite.
        - Oolite.
        - calcareous sinter.
        - Tufa.

SPECIES	SUBSPECIES AND VARIETIES.
	Argentine.
	Silvery chalk.
	magnesian
	common
	Dolomite.
	siliceous
	Madreporite.
	Calp.
	fetid
	bituminous
	ferruginous
	Brown spar.
	Marl.
	indurated
	common
	Bituminous marlite.
8. Arragonite.	
	fibrous
	coralloidal
9. Siliceous Borate of Lime.	
	Botryolite.

GENUS IV. *MAGNESIA.*

1. Sulphate of Magnesia.
2. Carbonate of Magnesia.
3. Borate of Magnesia.
4. Fluate of Magnesia.

GENUS V. *ALUMINE.*

1. Mellate of Alumine.

ORDER IV.

Salts with an alkaline and earthy base.

1. Alkaline sulphate of Alumine.
2. Fluate of Soda and Alumine.
3. Glauberite.

CLASS II.

Earthy compounds, or Stones.

The minerals, which belong to this class, are composed chiefly of earths, combined with each other; they frequently contain some metallic oxide, and sometimes an alkali, or acid.

Alumine, silex and fluoric acid.	*Species* 1. Topaz.	
		Pycnite.

		SUBSPECIES AND VARIETIES.	
Alumine nearly pure.	*Species* 2. Sapphire.		
		perfect	
			blue
			violet
			red
			yellow
			limpid
		Corundum.	
			Adamantine spar.
			Emery.
Alumine and water.	3. Diaspore.		
	4. Wavellite.		
Alumine and magnesia.	5. Spinelle.		
		Ruby.	
		Ceylanite.	
Alumine and silex.	6. Fibrolite.		
	7. Cyanite.		
	8. Staurotide.		
Alumine, silex and lime.	9. Chrysoberyl.		
Alumine, silex and zinc.	10. Gahnite.		
Ittria & silex.	11. Gadolinite.		
Zirconia and silex.	12. Zircon.		
		Jargon.	
		Hyacinth.	
	13. Quartz.		
		common	
			limpid
			smoky
			yellow
			blue
			rose red
			irised
			aventurine
			milky
			greasy
			radiated
			tabular
			granular
			arenaceous
			pseudomorphous
		Amethyst.	
		Prase.	
		ferruginous	
			yellow
			red
			greenish
		fetid	
		Cat's eye.	

SUBSPECIES
AND VARIETIES.

Silex nearly pure. *SPECIES*

Chalcedony.
common
Cacholong.
Carnelian.
Sardonyx.
Plasma.
Hyalite.
Heliotrope.
Chrysoprase.
Opal.
precious
common
Hydrophane.
Girasole.
Semi-opal.
Flint.
swimming
Hornstone.
Silicicalce.
Buhrstone.
Jasper.
common
striped
Egyptian

14. *Tripoli.*
15. *Porcellanite.*

Silex, alumine and alkali.

16. *Siliceous Slate.*
Basanite.
17. *Petrosilex.*
18. *Clinkstone.*
19. *Pumice.*
20. *Obsidian.*
vitreous
Pearlstone.
21. *Pitchstone.*
22. Spodumen.
23. Lepidolite.
24. Mica.
laminated
lamellar
prismatic
25. Leucite.
26. Fettstein
27. Lapis Lazuli.
Lazulite.
28. Schorl.
common
Tourmaline.
Indicolite.
Rubellite.
29. Andaluzite.

			SUBSPECIES AND VARIETIES.
Silex, alumine, lime and alkali.	*Species* 30.	Feldspar.	common Adularia. opalescent aventurine Petuntze. granular compact
	31.	*Jade.*	Nephrite. Saussurite. Axestone.
Silex, alumine and glucine.	32.	Emerald.	precious Beryl.
	33.	Euclase.	
Silex, alumine and lime.	34.	*Basalt.*	columnar tabular globular amorphous
	35.	**Wacke.*	
	36.	Dipyre.	
	37.	Scapolite.	
	38.	Wernerite.	
	39.	Axinite.	
	40.	Garnet.	precious Pyrope. common Melanite. manganesian
	41.	Aplome.	
	42.	Epidote.	Zoisite. Skorza. manganesian
	43.	Cinnamon Stone.	
	44.	Allochroite.	
	45.	Idocrase.	
	46.	*Meionite.	
	47.	Byssolite.	
	48.	Prehnite.	crystallized Koupholite. fibrous
Silex, alumine, lime and water.	49.	Ædelite.	
	50.	Stilbite.	
	51.	Zeolite.	mealy Crocalite. Needlestone.
	52.	*Laumonite.	
	53.	*Melilite.	

			SUBSPECIES AND VARIETIES.
Silex, alumine, soda and muriatic acid.	SPECIES 54.	Sodalite.	
Silex, alumine, alkali and water.	55.	Natrolite	
	56.	Analcime.	
	57.	*Bildstein.*	
	58.	Nacrite.	
	59.	Chabasie.	
Silex, lime and cerium.	60.	Allenite.	
Silex, lime and iron.	61.	Yenite.	
Silex, lime and water.	62.	Schaalstein.	
	63.	Ichthyophthalmite.	
Silex, barytes, alumine & water.	64.	Harmotome.	
Magnesia and silex.	65.	Chrysolite.	common Olivine.
	66.	Labrador stone.	
Silex, magnesia and lime.	67.	Tremolite.	common fibrous Baikalite.
	68.	Asbestus.	Amianthus. common Mountain cork. ligniform compact
	69.	Diopside.	
	70.	Sahlite.	
	71.	Amianthoide.	
Silex, magnesia, alumine and lime.	72.	Augite.	common Coccolite.
	73.	Hornblende.	common Basaltic lamellar fibrous slaty Actynolite. common acicular
	74.	Diallage.	granular resplendent Bronzite.
	75.	*Macle.	

		SUBSPECIES AND VARIETIES.
	Species 76. Native Magnesia.	
	77. *Magnesite.*	Keffekil. Argillo-murite.
Silex, magnesia and alumine.	78. *Serpentine.*	precious common
	79. Steatite.	common Potstone.
	80. Talc.	common indurated
	81. Chlorite.	common slaty foliated Green earth.
Silex and alumine.	82. Sommite.	
	83. Anthophyllite.	
	84. Pinite.	
	85. *Argillaceous Slate.*	Argillite. Shale. Novaculite. Aluminous slate: graphic
	86. *Clay stone.*	
	87. *Clay.*	Native Argill. Collyrite. Kaolin. Cimolite. adhesive Potter's Lithomarge. Fuller's Earth. Bole. Reddle. Yellow Earth. Umber.
	88. *Alum stone.*	
	Appendix.	
	89. *Bergmanite.	
	90. **Chusite.*	
	91. *Fuscite.	
	92. **Gabronite.*	
	93. *Haüyene.	
	94. *Iolite.	
	95. *Petalite.	

SUBSPECIES AND VARIETIES.

Species 96. *Pseudo-sommite.
97. **Sideroclepte.*
88. *Spinellane.
99. *Spinthere.

CLASS III. COMBUSTIBLES.

1. *Hidrogen Gas.*
   - carburetted
   - sulphuretted
2. Sulphur.
3. *Bitumen.*
   - Naptha.
   - Petrolium.
   - Maltha.
   - elastic
   - Asphaltum.
   - Retinasphaltum.
4. *Amber.*
5. Diamond.
6. Anthracite.
   - slaty
   - granular
   - conchoidal
   - columnar
7. Graphite.
   - foliated
   - granular
8. *Coal.*
   - cannel
   - slaty
   - coarse
9. *Lignite.*
   - Jet.
   - brittle
   - Bituminous Wood.
   - brown
   - earthy
10. *Peat.*
    - fibrous
    - compact

CLASS IV. ORES.

GENUS I. *GOLD.*

1. Native Gold.

GENUS II. *PLATINA.*

1. Native Platina.

GENUS III. *SILVER.*

1. Native Silver.
   - auriferous

SUBSPECIES
AND VARIETIES.

Species 2. Antimonial Silver.
3. Arsenical Silver.
4. Sulphuret of Silver.
5. Sulphuretted Antimonial Silver.
    brittle
6. *Black Silver.*
7. *Carbonate of Silver.*
8. Muriate of Silver.
    argillaceous.

GENUS IV. *MERCURY.*

1. *Native Mercury.*
2. Argental Mercury.
3. Sulphuret of Mercury.
        common
        fibrous
    bituminous.
4. Muriate of Mercury.

GENUS V. *COPPER.*

1. Native Copper.
2. Sulphuret of Copper.
        pseudomorphous
3. Pyritous Copper.
    variegated
4. Gray Copper.
    arsenical
    antimonial
5. Red oxide of Copper.
        foliated
        capillary
        compact
    ferruginous
6. Azure Carbonate of Copper.
        earthy
7. Green Carbonate of Copper.
        fibrous
        compact
        earthy
    ferruginous
8. Dioptase.
9. Muriate of Copper.
        sandy
10. Sulphate of Copper.
11. Phosphate of Copper.
12. Arseniate of Copper.
        obtuse octaedral
        acute octaedral

SPECIES	SUBSPECIES AND VARIETIES	
		foliated
		prismatic
		fibrous
	ferruginous	

GENUS VI. *IRON.*

1. Native Iron.		
2. Arsenical Iron.		
	argentiferous	
3. Sulphuret of Iron.		
		common
		radiated
		hepatic
	magnetic	
	arsenical	
4. Magnetic Oxide of Iron.		
		Native magnet.
		Iron sand.
5. Specular Oxide of Iron.		
	micaceous	
6. Red Oxide of Iron.		
		scaly
		Hematitc.
		compact
		ochrey
7. Brown Oxide of Iron.		
		scaly
		Hematitic.
		compact
		ochrey
8. *Argillaceous Oxide of Iron.*		
		columnar
		granular
		lenticular
		nodular
		common
		Bog ore.
9. Carbonate of Iron.		
10. Sulphate of Iron.*		
11. Phosphate of Iron.		
		foliated
		earthy
		Green iron earth.
12. Arseniate of Iron.		
13. Chromate of Iron.		
		crystallized
		granular
		amorphous

GENUS VII. *LEAD.*

1. *Native Lead.*		
2. Sulphuret of Lead.		

SPECIES	SUBSPECIES AND VARIETIES.
	common
	compact
	fibrous
	antimonial
	argento-antimonial
	argento-bismuthal
3. *Oxide of Lead.*	
	earthy
4. Carbonate of Lead.	
	crystallized
	acicular
	columnar
	compact
	black
5. Carbonated Muriate of Lead.	
6. Sulphate of Lead.	
7. Phosphate of Lead.	
	acicular
	arseniated
	bluish
8. Arseniate of Lead.	
9. Chromate of Lead.	
10. Molybdate of Lead.	
GENUS VIII. *TIN.*	
1. Oxide of Tin.	
	fibrous
2. *Pyritous Tin.*	
GENUS IX. *ZINC.*	
1. Sulphuret of Zinc.	
	yellow
	brown
	black
	fibrous
2. Red Oxide of Zinc.	
3. Siliceous Oxide of Zinc.	
	foliated
	common
4. Carbonate of Zinc.	
5. Sulphate of Zinc.	
GENUS X. *NICKEL.*	
1. Native Nickel.	
2. *Arsenical Nickel.*	
3. *Oxide of Nickel.*	
GENUS XI. *COBALT.*	
1. Arsenical Cobalt.	
	dull

SUBSPECIES AND VARIETIES.

SPECIES 2. Gray Cobalt.
3. *Sulphuret of Cobalt.*
4. *Oxide of Cobalt.*
    black
    brown
    yellow
5. Sulphate of Cobalt.
6. Arseniate of Cobalt.
    acicular
    earthy
    argentiferous

GENUS XII. *MANGANESE.*

1. Oxide of Manganese.
    radiated
    compact
    earthy
    ferruginous
2. Sulphuret of Manganese.
3. Carbonate of Manganese.
4. Phosphate of Manganese.

GENUS XIII. *ARSENIC.*

1. Native Arsenic.
    concreted
    specular
    amorphous
2. Sulphuret of Arsenic.
    Realgar.
    Orpiment.
3. Oxide of Arsenic.

GENUS XIV. *BISMUTH.*

1. Native Bismuth.
2. Sulphuret of Bismuth.
3. *Oxide of Bismuth.*

GENUS XV. *ANTIMONY.*

1. Native Antimony.
    arsenical
2. Sulphuret of Antimony.
    radiated
    foliated
    compact
    plumous
3. Oxide of Antimony.
    earthy
4. Sulphuretted Oxide of Antimony.

SUBSPECIES AND VARIETIES.

GENUS XVI. *TELLURIUM.*

Species 1. Native Tellurium.
    auro-argentiferous.
    auro-plumbiferous.

GENUS XVII. *CHROME.*

GENUS XVIII. *MOLYBDENA.*

1. Sulphuret of Molybdena.

GENUS XIX. *TUNGSTEN.*

1. Calcareous Oxide of Tungsten.
2. Ferruginous Oxide of Tungsten.

GENUS XX. *TITANIUM.*

1. Red Oxide of Titanium.
2. Ferruginous Oxide of Titanium.
    Menachanite.
    Nigrine.
    Iserine.
3. Silico-calcareous Oxide of Titanium.
4. Octaedral Oxide of Titanium.

GENUS XXI. *URANIUM.*

1. Black Oxide of Uranium.
2. Green Oxide of Uranium.
    crystallized
    earthy

GENUS XXII. *COLUMBIUM.*

1. Oxide of Columbium.
    ferruginous
    Ittrious

GENUS XXIII. *CERIUM.*

1. *Oxide of Cerium*

ELEMENTARY TREATISE
ON
MINERALOGY.

CLASS I.

Substances not metallic, composed entirely, or in part, of an Acid.

This class is characterized by the presence of an acid, which may be free or not combined; or combined with an alkali; or with an earth; or with both an alkali and earth.*

ORDER 1. *Acids not combined.*

Twelve acids, either disengaged, or in combination with other substances, are known to exist in the mineral kingdom. They are the carbonic, phosphoric, fluoric, sulphurous, sulphuric, muriatic, nitric, boracic, chromic, molybdic, arsenic, and mellitic acids. All these, the sulphurous excepted, are usually found in combination with bases, forming native salts.

Several of the preceding acids, however, have been sometimes observed to exist native in a free state, or *not combined* with any base. They are the sulphuric, sulphurous, muriatic, carbonic, and boracic acids. But their occurrence in a disengaged state is very rare, in consequence of their great tendency to combine with other bodies.

These acids have perhaps never been observed in primitive earths. They never occur in large quantities; the carbonic is the most abundant. In most cases they undoubtedly arise from the decomposition of other minerals.

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* If the definition of minerals already given (Introd. 5.) be rigidly applied, *air* and *water* would probably be introduced into the mineral kingdom; for they are inorganic bodies, found native at the surface of the earth. They have, in fact, no inconsiderable action upon some minerals; and this action it is important to notice, whenever it exists. But the natural history of air and water, and the investigation of their various properties undoubtedly belong to Philosophy and Chemistry.

Water, indeed, often contains various minerals in solution, and is then called a *mineral water*. Such waters will be noticed, as far as may be convenient, under the several substances, which they hold in solution.

GENUS I.

This genus contains two acids, whose base is sulphur.

Species 1. Sulphuric Acid.

The existence of sulphuric acid in a free state is extremely rare. It may always be recognised by its strongly acid taste, and by the white, insoluble precipitate, which it invariably produces in solutions of the nitrate or muriate of barytes. It has been found native both in a concrete and imperfectly liquid state. To distinguish this native sulphuric acid from sulphates with an excess of acid, recourse may be had to evaporation; in the former case little or no residue is perceived.

(Localities.) Mr. Baltassari has found this acid in a concrete state in the grottos of the volcanic mountain, Zaccolino, near Sienna. These concretions are in the form of cauliflowers, pendent from the ceiling of the grottos, and adhering to sulphate of lime, on which this acid can have no action. They are probably a compound of sulphuric and sulphurous acids. The same grottos contain sublimed sulphur and sulphurous acid.—Mr. Pictet mentions a cavern near Aix, in Savoy, from the roof of which this acid, mixed with water and a little sulphate of lime, is observed to drop.—It has also been seen by Dolomieu in many caverns of Etna.

In the *United States*. In *New York*, at Clifton Springs, in Farmington, 11 miles from Geneva, this acid is mixed with native sulphur, from which it may be extracted by water. *(Godon.)*

Species 2. Sulphurous Acid.

The presence of this acid, which, when disengaged, always exists in a gaseous state, may be determined by its peculiar and suffocating odor.

(Localities.) It has been found only in volcanic countries; and most usually issuing from fissures in the lava, near volcanoes, whose eruptions it either accompanies or follows. It has also been found in certain hot springs, near volcanoes, in Italy. Although in most cases its existence in any one place is transient, depending on the activity of some neighboring volcano, it appears to be constantly disengaged from the Solfaterra, not far from Naples; and from the summit of Stromboli, &c.

GENUS II.

Species 1. Muriatic Acid.

Muriatic acid, when not united to other substances, is a gas, having a peculiar odor, and produces a white precipitate in a solution of the nitrate of silver.

(Localities.) The existence of native muriatic acid appears to be nearly confined to volcanic regions, where it is observed in a gaseous state near volcanoes, especially during their eruptions. Spallanzani has obtained muriatic acid from the volcanic glass and pumice of Lipari. He supposes the acid to have gradually penetrated these volcanic products, after their ejection from the volcano; for in lavas recently ejected he did not find this acid.—Not far from Valadolid, in New Spain, are springs, whose waters contain muriatic acid gas. *(Humboldt.)*

GENUS III.

Species 1. Carbonic Acid.

This acid is sometimes found in a state of gas; and sometimes it is dissolved or rather diffused in water, with which its union is extremely feeble. A few simple experiments are sufficient to detect the presence of this acid, whether gaseous, or contained in water. Its great specific gravity, causing it to occupy the lower parts of the cavity, in which it exists, its power of extinguishing flame, and of producing a precipitate in lime water, sufficiently characterize it, when in a state of gas. To water, which has absorbed it in any considerable quantity, it usually communicates an acidulous taste. But, if other substances, contained in the same water, render this acid imperceptible to the taste, it must then be liberated by heat.

(Localities.) A knowledge of those places, in which carbonic acid has been observed, or in which it may be supposed to exist, is extremely important, on account of the deletereous effects, which are often produced on those, who are immersed in this gas. Thus, as it often exists in large quantities in mines, caverns, pits, and in some wells, it is dangerous and often fatal to descend into such places without sufficient precaution.

The existence of carbonic acid in a gaseous state is almost exclusively confined to volcanic countries, and to those, which contain certain deposites of carbonate of lime, usually called secondary limestone. In such countries it is often very abundant, occupying the lower parts of caverns, pits, fissures, &c. or even filling them entirely. Between Naples and Pozzuolo, in Italy, is the celebrated *Grotta del Cane.* On the floor of this cavern, or rather excavation, a stratum of carbonic acid gas, about eight inches in thickness, is constantly found. If a *dog* or any other animal be plunged into this stratum of gas, it soon expires. The Abbé Breislak supposes the quantity of carbonic acid, now disengaged in this grotto and its vicinity, to be much less, than it was in the time of Pliny.—Near Bolsenna, in Italy, if an aperture of seven or eight feet in depth be made in the earth, this acid gas is immediately disengaged.

Mineral waters, containing Carbonic acid, are by no means uncommon among rocks or earths of a secondary or late formation, and also in volcanic countries. Those of Pyrmont and Spa in Germany, and of Châteldon and Vichy in France, are well known; at Vichy the water is warm, a circumstance rather uncommon, when it contains Carbonic acid.

In the *United States* several springs, impregnated with Carbonic acid, have been observed. The mineral waters of Balltown, Saratoga, and New Lebanon, in the state of *New York*, are well known. A French chemist has obtained from 25 ounces of the Balltown water 3 times its bulk of carbonic acid gas; 31 grains of muriate of soda; 22 grains of supercarbonate of lime; 12½ grains of muriate of magnesia; 5 grains of muriate of lime; and 4 grains of carbonate of iron. The existence of a mineral water, of the composition just described, may obviously be productive of much benefit to the public.

(Remarks.) Different opinions have been expressed on the origin of this native acid. By some it is supposed to originate from the decomposition of carbonate of lime by subterraneous fires, or by some other acid, or by the action of sulphur; and by others it has been suggested, that, in volcanic countries, this acid does not pre-exist in any compound, but arises from the direct combination of oxigen and carbon.

GENUS IV.

Species 1. Boracic Acid.

Boracic acid, when pure, is concrete; and usually presents itself in the form of small, white, shining scales, which are soft and even unctuous to the finger. When dissolved in alcohol, this acid communicates to its flame a greenish tinge. It has little taste, and is sparingly soluble in water, especially when cold. When in the form of scales, its specific gravity is 1.47. *(Kirwan.)* Before the blowpipe it melts into a transparent glass.

(Localities.) It is found in solution in the warm waters of several small lakes in Tuscany. According to Mr. Hoeffer, it is sometimes in the proportion of nearly nine grains to one hundred grains of water. If this be correct, its solubility must be greatly increased by the presence of other substances in the same waters; and it is in fact accompanied by several borates, and by the sulphates of alumine, ammonia, &c.—It is also found on the shores of the same lakes in a concrete state, in the form of stalactites, or small scales, or crystalline grains, of a grayish white color with yellowish spots.

A substance, found by Mr. Mascagni, near the warm spring of *Sasso*, in Tuscany, has, from that circumstance, received the name of *Sassolin*; but Klaproth has ascertained, that it contains 86 per cent. of Boracic acid.

Probably this acid will be found to exist more abundantly, than has been generally supposed. Smithson Tennant has described a specimen of concrete Boracic acid from Lipari, of a scaly, shining appearance, and slightly yellowish from contamination with sulphur. Indeed a thin crust of sulphur adhered to one side. This specimen was 7 or 8 inches long, and 5 or 6 inches broad, and appeared to have been taken from a larger mass. (Geolog. Trans. v. i.)

ORDER II. *Alkaline Salts.*

This order is characterized by the presence of an alkali, united to an acid, and forming a salt. Few of the alkaline salts ever occur in large masses; and they are very often more or less mingled with each other. They all communicate some peculiar taste to the tongue, and, when pure, are devoid of color. They often appear as an efflorescence on other substances. They are easily soluble in water, and hence are also frequently found dissolved in that fluid. This order contains three genera.

GENUS I. *AMMONIA.*

This alkali, when not combined, exists in a gaseous state, and has occasionally been observed in mineral waters. But in those cases it has undoubtedly originated from animal or vegetable substances. Only two species, the sulphate and muriate of ammonia, will be described under this genus. The carbonate of ammonia has, however, been found in some mineral waters. (*Thompson.*)

Species 1. Sulphate of Ammonia.*

This salt has a sharp and somewhat bitter taste. When triturated with pure lime, it is decomposed, and the odor of ammonia becomes perceptible. It is not acted upon by sulphuric acid; and, when heated nearly to redness, is chiefly decomposed.

It occurs in stalactites, or in crusts, or in an earthy state. Its color, from contamination with other substances, is gray or yellow of different shades.

When pure, it is composed of ammonia 14.24, sulphuric acid 54.66, water 31.10. (*Kirwan.*)

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* Ammoniaque sulfatée. Haüy. Brongniart. Mascagnin. Reuss. Vitriolic Ammoniac. Kirwan.

(Localities.) It is found in the vicinity of volcanoes. Near Turin it appears on the surface of the earth. It is also found in and near certain lakes in Tuscany, adhering to the sides of fissures.

Species 2. Muriate of Ammonia.*

Sal ammoniac.

The sharp, urinous taste of this salt, the strong odor of ammonia, which it yields, when triturated with pure lime, and the disengagement of muriatic acid gas by the affusion of sulphuric acid, are three of its most important characters; by the last of which also it is sufficiently distinguished from the sulphate of ammonia. It is entirely volatilized by heat, rising in white fumes; and is soluble, when pure, in about three times its weight of water.

This salt usually appears in the form of an efflorescence or a crust, adhering to other substances, or in staláctical concretions. It is often in a state of powder, and completely enveloped in other minerals, particularly in lava. In this case, though imperceptible to the eye, it may be detected by trituration with lime. It has also been observed in small crystals, badly defined. Its color, arising from the mixture of foreign substances, may be gray, yellowish white, or even green, or nearly black.

Pure Muriate of ammonia is composed of ammonia 25.00, muriatic acid 42.75, water 32.25. *(Kirwan.)* A specimen of the native Muriate from Bucharia yielded Klaproth 2.5 of the sulphate of ammonia.

(Localities.) This salt is found most frequently in the vicinity of volcanoes, near their craters, or in the fissures of the lava; having been sublimed from the interior of the volcano. At the Solfaterra, which may be called a half-extinguished volcano, the sublimation of this salt is very abundant. It has even been collected for use by condensing it in long tubes, placed over the apertures, from which it issues.—This mineral, according to Kirwan, has been found in the interior of Asia and Africa, at a distance from any volcanic eruptions.—In Persia it is mixed with clay or earths, or effloresces on certain rocks.—It exists also in the vicinity of the coal mines of Newcastle, Eng. and in the waters of certain lakes in Tuscany.

(Remarks and uses.) This salt, for the purposes of commerce, is obtained chiefly from Egypt, where it is manufactured from the excrements of certain animals, which feed on plants, impregnated with muriate of soda. The Muriate is sublimed from the soot, which arises

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* Ammoniaque muriatée. Haüy. Brongniart. Natürlicher Salmiack. Werner. Natural Sal Ammoniac. Jameson. Le Sel Ammoniac natif. Brochant. Sal Ammoniac. Kirwan.

from the combustion of these excrements. Ten parts of soot yield three of this salt.—It is also prepared in various parts of Europe by different processes.

Muriate of ammonia is employed in medicine and the arts. In dying, it is used to heighten certain colors; in the tinning of iron and in soldering, to clean the surface and prevent oxidation. As it renders lead more brittle, it is sometimes employed in the manufacture of shot.

GENUS II. *POTASH.*

Only one species, the nitrate of potash, will be described under this genus. Probably three other species actually exist native. The carbonate and muriate of potash have occurred in minute quantities in some mineral waters; and the latter of these frequently accompanies the nitrate. Sulphate of potash also is said by Mr. Bowles to exist in certain parts of Spain.

SPECIES 1. NITRATE OF POTASH.*

Nitre. Saltpetre.

This salt, whether pure, or mixed with earthy or saline substances, may generally be recognised by placing it on hot coals. A vivid combustion, accompanied by a hissing noise and slight detonations, is produced by the oxigen, contained in the salt. Indeed, however minute the quantity of the salt, it discovers itself by the production of vivid points on the coal. Its taste is somewhat sharp and cooling.

It usually occurs in the form of an efflorescence or a crust; and these efflorescences appear to be composed of very minute fibres or capillary crystals.† Substances thus incrusted often have a mouldy appearance. Its color may be grayish or yellowish white, or nearly snow white.

Pure Nitrate of potash is composed of potash 51.8, nitric acid 44.0 water 4.2. (*KIRWAN.*) A specimen of the native Nitrate from Molfetta yielded Klaproth nitrate of potash 44.55, carbonate of lime 30.40, sulphate of lime 25.45, muriate of potash 0.20;=100.60.

(*Geological situation.*) Nitrate of potash is found native in all countries, where there are circumstances, favorable to its production;

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* Potasse nitratée. HAUY. BRONGNIART. Natürlicher Salpeter. WERNER. Natural Nitre. JAMESON. Le Nitre natif. BROCHANT. Nitre. KIRWAN.

† This salt, when artificially crystallized, often exhibits hexaedral prisms, terminated by hexaedral pyramids, and perfectly resembling one variety of crystallized quartz, as far as the eye can determine. But in the Nitrate the faces of the pyramid form with the sides of the prism an angle of 143° 61′, whereas in the similar crystals of quartz the aforesaid angle is only 141° 40′.

and, although much more abundant in some countries than others, it never presents itself in very large masses. It frequently effloresces on the soil; but never exists at a greater depth, than that of a few yards beneath the surface. Sometimes also it invests the sides of caverns and fissures in calcareous rocks, which it often corrodes.

The existence of dry atmospheric air, and perhaps of animal or vegetable substances, in a state of decomposition, is requisite to the spontaneous production of Nitre. It also appears, that the presence of carbonate of lime greatly accelerates the formation of this salt; perhaps it is a necessary agent in many cases.

Native Nitre has seldom or never been found in pure clay, or in pure sand. But, if those earths, from which the Nitrate of potash has been extracted by lixiviation, be replaced in their original situation, they again become impregnated with the same salt. Old walls and the vicinity of stables, &c. very often present efflorescences of Nitre.

(Localities.) One of the most remarkable localities of this salt in Europe is in the *Pulo*, or cavity of Molfetta, in the kingdom of Naples. This cavity, which is about 100 feet deep, contains several grottos or caverns, in the interior of which is found the Nitrate of potash in efflorescences or crusts, attached to compact limestone. When these efflorescences are removed, others appear in about a month. The soil in this cavity is calcareous, and richly impregnated with Nitre.

The Ukraine, Podolia, Hungary, Spain, Italy, Peru, and India furnish more or less of this salt for the purpose of commerce. It is in most cases extracted by lixiviating the earths, which compose the soil. —It has also been observed in the waters of certain springs in Hungary.

In the *United States.* The calcareous caverns, which abound in the state of *Kentucky*, furnish large quantities of Nitre. The earths, which exist in these caverns, and which contain both the Nitrate of potash and the nitrate of lime, are lixiviated; and the lixivium is then made to pass through wood ashes, by the alkali of which the nitrate of lime is decomposed.* After due evaporation, the Nitre is permitted to crystallize. One of the most remarkable of these caverns is in Madison County, on Crooked Creek, about 60 miles S. E. from Lexington. This cavern extends entirely through a hill, and affords a convenient passage for horses and waggons. Its length is 646 yards; its breadth is generally about 40 feet; and its average height about 10

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* It appears that two bushels of ashes, made by burning the dry wood in hollow trees, contain as much alkali, as eighteen bushels of ashes, obtained from the oak.

feet. One bushel of the earth in this cavern commonly yields from one to two pounds of Nitre; and the same salt has been found to exist at the depth of at least 15 feet; even the clay is impregnated with nitrate of lime.

Kentucky also furnishes native Nitre under a very different form, and constituting what is there called the *rock ore*, which is in fact a sandstone, richly impregnated with Nitrate of potash. These sandstones are generally situated at the head of narrow vallies, which traverse the sides of steep hills; they rest on calcareous strata, and sometimes present a front from 60 to 100 feet high. When broken into small fragments and thrown into boiling water, the stone soon falls into sand, one bushel of which, by lixiviation and crystallization, frequently yields 10lbs. and sometimes more than 20lbs. of Nitrate of potash. The Nitre, obtained from these rocks, contains little or no nitrate of lime, and is said to be superior for the manufacture of gunpowder to that, extracted from the aforementioned earths.

Masses of native Nitre, nearly pure, and weighing several pounds, are sometimes found in the fissures of these sandstones, or among detached fragments. Indeed it is said, that these masses of native Nitre sometimes weigh several hundred pounds. (*Brown* in Trans. Am. Philos. Soc. v. vi.; and Bruce's Min. Jour. v. i.)—Similar caverns occur in Tennessee and in some parts of Virginia and Maryland;—at Hughe's cave near Hagarstown, in Maryland, this salt has already been manufactured. (*Hayden.*)

(*Artificial nitre beds.*) The various sources of native Nitre are not, however, sufficient to answer the demands of chemistry and the arts. To supply this deficiency artificial nitre beds are prepared, in which are placed earths from the vicinity of inhabited buildings, old plaster, vegetable matter, &c. To these are added blood, urine, &c. After sufficient time, the earth, which remains in these beds, is lixiviated, and an impure nitre is obtained.

We have not room minutely to describe the process of manufacturing this salt; but perhaps the following simple mode of purifying the impure nitre is not generally known. It is thus given by Brongniart.

The impure nitre, previously pulverized, is to be washed three times in cold water in the proportion of 35lbs. of water to 100lbs. of the salt; taking care entirely to pour off each water, before another is added. These washings separate the greater part of the muriate of soda, and the deliquescent salts, such as nitrate of lime, &c. When thus washed, the nitre is to be dissolved in one half its weight of boiling water. On cooling, the salt begins to crystallize, and, by agitating the liquid during this process, extremely minute crystals are obtained. These crystals, when drained, are to be washed with 5lbs. of cold water for every 100lbs. of the salt, and then dried in a temperature of about 45°. The nitre, thus obtained, is well adapted to the manufacture of gunpowder.

(Uses.) The uses of this valuable salt in medicine, chemistry, metallurgy, and in the manufactures of gunpowder, nitric acid, &c. are well known.

GENUS III. *SODA.*

Four species, some of which are very important, will be described under this genus. A fifth, the nitrate of soda, probably exists native, but is extremely rare.

Species 1. Sulphate of Soda.*

Glauber's salt.

The taste of this salt is at first saline and cooling; but it leaves an impression nauseously bitter. It is very soluble in water, and yields prismatic crystals, terminated by diedral summits. The crystals are usually irregular, and deeply striated. They rapidly effloresce in the air.

This salt occurs in an earthy state; sometimes also in efflorescences or crusts, and rarely in concretions, or in prismatic or acicular crystals. Its color is usually yellowish or grayish white.

Pure Sulphate of soda is composed of soda 18.48, sulphuric acid 23.52, water 58.00. *(Kirwan.)* The native Sulphate is usually much contaminated by other salts, among which are the carbonate and muriate of soda, sulphate of magnesia, &c. The substance, found at Sedlitz, in Bohemia, and sometimes called *Reussin*, is composed of sulphate of soda 66.04, sulphate of magnesia 31.35, the remainder being muriate of magnesia, and sulphate of lime.

Sulphate of soda, in many of its properties, resembles the sulphate of magnesia (Epsom salt); but it is less bitter, and its solution remains apparently unaffected by the addition of an alkali, whereas a solution of the magnesian sulphate, when similarly treated, yields a copious precipitate.

(Geological situation.) This salt is often contained in mineral waters; but, whether thus dissolved, or in an earthy state, it is found most frequently in the vicinity of springs or mines of muriate of so-

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* Soude sulfatée. Haüy. Brongniart. Natürliches Glaubersalz. Werner. Natural Glauber Salt. Jameson. Le Sel de Glauber natif, Brochant. Glauber's Salt. Kirwan.

da. Its formation is, in many cases, undoubtedly to be attributed to the mutual action of muriate of soda and sulphate of magnesia.

Sometimes its efflorescences are attached to certain argillaceous slates; and sometimes they appear on the walls of brick buildings, &c.

(*Localities.*) Small quantities of this salt exist in most countries, especially in the colder latitudes; but it is seldom found in large masses. It is abundant in the lakes of Siberia, on the bottom of which it appears, when the temperature of the atmosphere is reduced to the freezing point of water; it is sometimes so abundant as to be collected for use.—At the foot of the Uralian mountains, near Tscheliabinsk, it effloresces on the soil in the spring of the year, but does not appear to extend far below the surface.

The Sulphate of soda, employed in medicine, is chiefly obtained during the extraction of muriate of soda from sea water, or of muriatic acid from the muriate of soda.

Species 2. Muriate of Soda.*

Common salt.

This salt is easily distinguished by its well known *saline taste.* It is not unfrequently crystallized; and the primitive form, under which also it usually appears, is a cube. But it most frequently occurs in large masses, whose fracture is foliated, sometimes conchoidal, and, when recently made, presents a strong vitreous lustre. These masses are often composed of granular distinct concretions.

Sometimes also it is in capillary crystals, or in masses, composed of parallel fibres.

This salt is in general strongly translucent, and sometimes even transparent and limpid. Its color is commonly gray or white, often tinged with other colors; but it also presents certain shades of red, blue, violet, brown, green, or yellow, all arising from impurities. Its spec. gravity is 2.14.

In the fire it decrepitates. In the air it is not deliquescent, unless it contain muriate of magnesia or some other deliquescent salt. Pure Muriate of soda is composed of soda 53.00, muriatic acid 38.88, water 8.12. (*Kirwan.*) The impurities, which sometimes color and contaminate the native Muriate, may be separated by solution in water.

(*Geological situation.*) This salt frequently occurs in large and

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* Soude muriatée. Hauy. Brongniart. Natürliches Kochsalz. Werner. Natural Rocksalt. Jameson. Le Sel de Cuisine. Brochant. Common Salt, Kirwan.

extensive solid masses; and is often dissolved in the waters of certain springs and lakes. The ocean, however, is the great depository of Common Salt; for nearly one thirtieth part of its weight is Muriate of soda. Other salts, viz. the muriates and sulphates, both of magnesia and lime, exist in the waters of the ocean; so that the average quantity of saline ingredients is about $\frac{1}{23}$ of the whole. This proportion is nearly the same in all latitudes.*

Muriate of soda, whether solid in mines, or dissolved in springs, occurs only among secondary rocks. But, although neither mines nor springs have been found in primitive earths, they are usually not far distant from the foot of primitive mountains.—This salt, which is usually deposited in thick, and sometimes extensive beds, may exist at the surface of the earth, or at a great depth below the soil. Sometimes also it has been deposited in regions greatly elevated above the level of the sea; and, in a few instances, is known to constitute whole mountains of very considerable elevation.

Muriate of soda is almost constantly associated with certain other minerals. Thus, with very few exceptions, it is accompanied by beds of clay, which often alternate with those of the salt. This clay is more or less impregnated with the salt, and often contains large masses of it. Other minerals, as sand, sandstone, compact, fetid, and bituminous limestone, usually accompany these deposites of Salt.

But the intimate connexion, which exists between this salt and sulphate of lime or gypsum, forms one of its most striking geological characters. Muriate of soda is in fact almost always associated with gypsum, over which the beds of this salt are usually placed, or even alternate with it. The salt, with which the gypsum is sometimes impregnated, is worth extraction.

Elephants' teeth, shells, bitumen, sulphur, &c. have been found in the various beds of minerals, which accompany this salt.

Salt springs are always connected with clay, the presence of which in fact seems necessary to the existence of these springs. And, although salt springs occur in countries, in which mines of this salt have not yet been discovered, it is extremely probable, that such mines actually exist beneath the soil, and impregnate the water. The sulphates of lime and of soda are usually found in these springs.

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* There are a few exceptions to these general remarks. The Baltic is much less salt, than the ocean, and contains, when an easterly wind prevails, only $\frac{1}{108}$ of saline matter.—The Dead Sea, in Palestine, is an exception of the opposite kind. According to Klaproth, one hundred parts contain water 57.4 muriate of magnesia 24.2, muriate of lime 10.6, muriate of soda 7.8; the last ingredient constituting about $\frac{1}{13}$ of the whole.

Salt lakes sometimes furnish Muriate of soda, already crystallized by natural evaporation, and deposited at their edges, or on the bottom of the lake.—There is scarcely a mineral spring, which does not contain more or less of Muriate of soda.

(Localities.) It is worthy of grateful notice, that this mineral, so necessary to supply the wants of man, is almost universally distributed over the face of the globe. The following are some of its most interesting localities.

In England, near Northwich, Cheshire county, there is a rich and lucrative mine of this salt, whose beds alternate with those of clay, and commence at the depth of 35 or 40 yards below the surface. The upper bed of Salt varies from 20 to 30 yards in thickness; and the strata above it consist of clay, sandstone, and sulphate of lime. The salt is sometimes limpid and sometimes red. It is transported to Liverpool, where it is purified by solution in sea water, and subsequent evaporation; but this process does not separate the sulphate of lime. The annual produce of this mine is stated to be such, that many thousand tons are sent to those parts of the Prussian coast, most nearly adjacent to the celebrated Polish salt mines. (Edin. Rev. v. xix.)

France contains many salt springs; but no mines have been discovered.

In Spain are many salt springs; and at Cardona, in Catalonia, is a mountain of this salt. Its height is estimated at about 500 feet; and it is about 3 miles in circumference. The whole mountain forms one homogeneous mass, not stratified, and unaccompanied with sulphate of lime, unless it should be found to rest on this mineral.

Germany contains a number of mines, and abounds with springs of this salt. The salt mines of Tyrol are situated in a mountain; and are explored by excavating galleries, into which fresh water is introduced, and suffered to remain, till it is saturated.

In Hungary and Poland there appears to be an immense deposite of Muriate of soda, at the foot of the Carpathian mountains, on both sides. Indeed this mineral seems to extend with but few interruptions from the Black Sea to the Alps. The salt mine of Wieliczka, near Cracow, in Poland, has been worked since 1251; and, in 1780 had been sunk to the depth of about 900 feet; the salt commences about 200 feet below the soil. The galleries are completely dry; and the mine contains springs of both fresh and salt water. In this mine also are excavated several chapels, some of which are furnished with an altar, a crucifix, and statues, all of solid salt.

In Moldavia is a mountain of Salt, which in several parts is not covered even with soil.

Russia obtains this salt not only from mines and springs, but also from salt lakes. In the province of Astracan are lakes, whose waters, when much concentrated, and sometimes the salt obtained from them, have a dark red color. (*PALLAS.*) The country near the Caspian Sea so abounds with Muriate of soda, that, in the vicinity of Gourief, the fogs, dews, and even the juices of plants become saline. (*PALLAS.*)

In Caramania, in Asiatic Turkey, this salt, in consequence of its hardness and the dryness of the air, is sometimes employed in the construction of buildings. (*CHARDIN.*)

In Africa the deposites of Muriate of soda are very abundant, and extensive. In the mountains, which form the northern boundary of the desert of Lybia, is an immense plain, covered with Common Salt. (*HORNEMAN.*)

In America the localities of this mineral have been but little explored. It appears, however, to exist in many places under one or both of its usual forms. In Peru are numerous mines, situated at a very great elevation above the sea; some are near Potosi. The salt is very hard, and usually of a violet color.—It has also been found in several parts of Chili, &c.

In California it is found in very solid masses; and in St. Domingo, near lake Xaraguay, it exists in a mountain.

In the *United States*, salt springs are numerous in several districts. These springs sometimes flow naturally, but are more frequently formed by sinking wells in those places, where this salt is known to exist, as in certain marshes, and in *salt licks*, so called, having formerly been the resort of wild animals to *lick* the clay, impregnated with this Muriate. These springs are found on the banks of the Hockhocking, Scioto, Wabash, Tennessee, Kanhaway, Great Sandy, and various other rivers, all west of the Alleghany mountains, and emptying their waters into the Ohio. They occur also in the state of *New York* near the Onondago and Cayuga lakes; those of Onondago rise in a marsh on the border of the lake, at some distance from hard ground; they are richly impregnated, one gallon of the water sometimes containing from ¼ to ⅓ a pound of the salt. Some springs, however, on the eastern waters of the Ohio are considerably richer than these.

The whole quantity of Salt, annually extracted from saline springs in the United States, undoubtedly exceeds 600,000 bushels. Of this the springs of Onondago and Cayuga alone furnish about 300,000 bushels, and the Wabash *saline*, which belongs to the United States, yields 130,000 bushels.

Much of the salt, employed in the arts, is obtained from saline springs, and especially from the sea, by evaporation, effected either by the action of the sun and the air, or by the application of fire. We have room to remark only, that the quality of the salt depends greatly on the mode of extracting it, whether by crystallization, or by a very rapid evaporation. When the solution is boiled or evaporated to dryness, the salt will, in general, be greatly contaminated by several earthy salts, particularly the muriates of lime and magnesia, which render it deliquescent.

The uses of this salt, though numerous and important, are too well known to require any particular notice.

Species 3. Carbonate of Soda.*

Soda; in commerce.

This species embraces two varieties, differing in the quantity of carbonic acid, which they contain. One, which is the most common, is obviously in the state of a sub-carbonate; while the other appears to be a Carbonate, or perhaps sometimes contains an excess of acid. We shall embrace both varieties in one description, noting their different characters.

This salt, especially the sub-carbonate, has a warm, alkaline taste, but is not very caustic. It strongly effervesces with acids, and is very soluble in water. The sub-carbonate changes the vegetable blue to green, and rapidly effloresces, while the other remains unchanged by the air.

Like many other salts, the common variety occurs in efflorescences or crusts more or less thick, or in small flakes, or in a dry, dusty powder. But that, which is saturated with acid, sometimes appears in thick layers, having a granular texture, and sometimes in crusts, composed of acicular, translucent crystals, aggregated together and resembling fibrous gypsum. The color is grayish or yellowish white.

The pure sub-carbonate is composed of soda 21.58, carbonic acid 14.42, water 64.00. (*Kirwan.*) Native specimens of this variety are always mixed with other salts, particularly the muriate and sulphate of soda and carbonate of lime. In a specimen of the Carbonate, from Sukena, Klaproth found soda 37.0, carbonic acid 38.0, sulphate of soda 2.5, water 22.5. Another from near Buenos Ayres yielded Cabral de Mello soda 24.25, carb. acid 44.25, muriate of soda 9.50, sulphate of soda 1.25, water 20.75.

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* Soude carbonatée. Haüy. Brongniart. Natürliches mineral alkali. Werner. Natron. Kirwan. Jameson. L'Alcali mineral natif. Brochant. This salt, called *nitrum* and *natrum* by the ancients, must not be confounded with the *nitre* of the moderns, which is the nitrate of potash.

(Geological situation.) This salt appears in efflorescences or crusts on certain dry and warm soils; or on the surface of decomposing rocks; or on the walls of cellars and other damp places, especially if near the sea. It is also found abundantly in the waters of certain shallow lakes, situated in dry and flat countries. These lakes become in part or entirely dry, during the heat of summer; and this salt is deposited on their sides or bottoms.

This Carbonate is supposed by Berthollet frequently to arise from the mutual decomposition of muriate of soda and carbonate of lime, especially in warm and moist places.

Carbonate of soda is exceedingly common in mineral springs, and, in many cases, constitutes one of the principal ingredients. Hence the phrase *soda water.*

(Localities.) In Hungary, near Debreczin, the common variety of this salt is very abundant, both efflorescing on the soil, and deposited from lakes; large quantities are here collected for use.—At Bilin, in Bohemia, it effloresces on gneiss.

In Egypt it is plentifully found in what are called *the lakes of Natron.* These lakes, six in number, are westward of the Nile, not far from Terrana, in a valley, surrounded by limestone. The carbonate and muriate of soda exist together in these waters; but, when the water is diminished by natural evaporation, these salts are deposited in distinct layers, the muriate of soda being underneath. In one of these lakes, the waters on the eastern side contain only muriate of soda, while in those of the western side Carbonate of soda only is dissolved; but the two solutions do not mingle. *(BRONGNIART.)*

The Carbonate of soda, strictly so called, is found in the province of Sukena, two days journey from Fezzan, in Africa. It appears in crusts, composed of minute crystals, at the foot of a mountain. It is there called *trona,* and is transported to Egypt, Tripoli, &c.—This variety is also found near Buenos Ayres in considerable quantities, whence it has been transported to England. It there exists in stratified masses, from two to six inches thick, resting on clay, which is strongly impregnated with common salt. It has a light yellowish gray color, a granular texture, is easily broken, and does not effloresce in the air. *(CABRAL DE MELLO.)*

(Uses.) Large quantities of this salt are used in the manufacture of glass and hard soap. But the value of most of that, which is furnished by the mineral kingdom, is much diminished by adulteration with other salts. Indeed a large proportion of the soda, employed in the arts, is obtained by the combustion of the *salsola,* and other plants, growing near the sea; and is, in commerce, called *barilla* or *kelp.*

Species 4. Borate of Soda.*

Borax.

The characters of this mineral in its native state are almost entirely unknown. It is partially purified and crystallized in the East Indies and China, whence it is exported to Europe, under the name of *Tincal.* It must however undergo further purification to render it useful in the arts. During this process, which has hitherto been conducted chiefly by the Dutch, it is said to lose about 20 per cent.

When received from India, it is in the form of prismatic crystals, of very different sizes, more or less perfect, and always invested with a crust, which has apparently been produced by the application of some greasy substance to the surface of the crystal. This crust is usually of a dirty gray color, sometimes with a tinge of green or yellow; and is supposed to have been applied to prevent the salt from efflorescing.—That, received from China, differs from the preceding by being more limpid and purer.

It is unnecessary minutely to describe the characters of this well known salt in its purified state. It has an alkaline or soapy taste, and changes the vegetable blue to green; it is of course a sub-borate. It does not effervesce with acids. A specimen of tincal, analyzed by Klaproth, yielded soda 14.5, boracic acid 37.0, water 47.0;=98.5.

(Geological remarks and Localities.) This salt appears to be found at the bottom of certain lakes, or to exist in their waters, having probably been extracted by the water from contiguous earths. In some parts of Thibet it is said to have been dug from the earth in small crystalline masses. In Persia we are told it is artificially prepared, as we obtain nitre.

Asia, and particularly Thibet, is the only country, which furnishes this salt in any considerable quantity. It is said to exist in Peru, Ceylon, and Lower Saxony.

(Uses.) It is much employed, as a flux, in the examination of minerals, and the soldering of metals; but ought previously to be fused to remove its water of crystallization.

ORDER III. *Earthy Salts.*

These consist of an earth or of earths, united to an acid. Hence an earth, so combined with an acid, as to form a salt, characterizes this order. Many of the salts, which belong to it, exist in great abundance, and are appropriated to numerous and important uses. Some

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* Soude boratée. Hauy. Brongniart. Borax. Kirwan. Le Tinkal. Brochant.

of them are, in common language, usually called stones. Those salts, which have an alkaline earth for their base, are here placed next to the alkaline salts.

GENUS I. *BARYTES.*

This genus contains only two species, the sulphate and carbonate of barytes. Although neither of these species is very abundant, the former occurs in much greater quantities, and is much more common, than the latter.

Species 1. Sulphate of Barytes.*

Heavy spar.

One of the most striking characters of this mineral is its great specific gravity, which varies from 4.29 to 4.50. When its structure is foliated and sufficiently regular, the laminæ easily separate in three directions, parallel to the faces of a four-sided prism (Pl. III, fig. 1.), whose bases are rhombs, having angles of 101° 32′ and 78° 28′. This prism is the primitive form of crystallized Sulphate of barytes; and any one side of the base is to the height, as 45 to 46. Mechanical division, parallel to the bases, is most easily effected. The integrant particles are triangular prisms.

Sulphate of barytes is harder than crystallized carbonate of lime, but may be scratched by fluate of lime. Some varieties are opaque; but it is generally translucent, and sometimes transparent, exhibiting double refraction. To observe the last mentioned property, an obtuse angle of one of the bases of the primitive form may be truncated, and the object observed through the new face thus produced, and also through the opposite base.

Its more common color is white, either pure, or variously tinged with yellow, red, &c. but it also presents several shades of red and gray, and sometimes of yellow, blue, green, and brown.

(*Chemical characters.*) This mineral is well characterized by its chemical properties, joined to its great specific gravity. When a fragment is exposed to the flame of a blowpipe, it almost always strongly decrepitates. While melting, it gives a greenish tinge to that part of the flame beyond the fragment, and is at last converted into a solid, white enamel, which, in the course of ten or twelve hours, falls into powder. If a piece of this enamel be applied to the tongue, it produces a taste, resembling that of rotten eggs; and has evidently been converted, at least in part, into a sulphuret of barytes. The

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* Baryte sulfatée. Hauy. Brongniart. Schwer spath. Werner. Heavy spar. Jameson. Baroselenite. Kirwan. Le Spath pesant. Brochant.

powder just mentioned, when recently calcined, shines in the dark with a reddish light, after being exposed to the rays of the sun.

When pure, it is composed, according to Vauquelin and Thenard, of barytes 75, sulphuric acid 25. But, by the analysis of Clément and Désormes, the proportions are barytes 67.82, sulph. acid 32.18. Chenevix found the proportion of earth to acid as 74 to 26; and Bucholz as 69 to 31. It frequently contains a few hundredth parts of silex, alumine, oxide of iron, and sometimes of sulphate of strontian.

(Distinctive characters.) This mineral may easily be confounded with sulphate of strontian, although the latter has a specific gravity somewhat less. But the sulphate of strontian, after fusion, never communicates to the tongue that peculiarly disagreeable taste, excited by the enamel from Sulphate of barytes. Further, the flame of the blowpipe is never colored green by sulphate of strontian, but often receives a reddish tinge.—It also resembles the carbonates of barytes and strontian; but these two salts always effervesce with diluted nitric acid, and slowly dissolve, while the Sulphate of barytes never effervesces, except from accidental impurities.—It differs from fluate of lime by its greater specific gravity, and by never phosphorescing, when merely reduced to powder and thrown on burning coals.—From some varieties of feldspar, which it resembles, a careful examination will easily distinguish it.—One variety of this Sulphate strongly resembles certain specimens of the carbonate of lead; but the latter has a greater specific gravity, a conchoidal fracture, and is blackened by the hydrosulphuret of ammonia, which has no action on the Sulphate of barytes.

This species admits a number of subdivisions, founded on diversity of form or structure, or force of cohesion, or the presence of foreign ingredients, which affect the physical characters.

Var. 1. LAMELLAR SULPHATE OF BARYTES.* This variety usually occurs in foliated masses; but not unfrequently it appears in beautiful crystals, whose surfaces, though sometimes dull, generally present a splendent and pearly lustre. M. Haüy has described sixty three modifications of the primitive form. These crystals are almost always well defined; and their magnitude is often considerable, presenting sometimes a thickness of nearly two inches. It most commonly appears in prisms, either right or oblique, having four, six, or eight sides. But these prisms are usually so short or compressed, that they assume a *tabular* form; and these tables or prisms are subject to numerous truncations and bevelments.

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* Geradschaaliger schwerspath and saulen schwerspath. WERNER. Straight lamellar and prismatic heavy spar. JAMESON.

Sometimes it presents the primitive form; which, in some specimens, has the solid angles, formed by the obtuse edges and the bases, truncated.—Sometimes a six-sided table (Pl. III, fig. 2.).—Sometimes also a rectangular four-sided table, with a bevelment on all its terminal or narrow faces (Pl. III, fig. 3.).—The solid angles, formed by the edges of the bevelments on the preceding crystal, are often truncated, and sometimes also the edges of two opposite bevelments.—Sometimes its form is an eight-sided table, with a bevelment on all its terminal faces, and the edges of these bevelments truncated (Pl. III, fig. 4.).—Sometimes an oblique four-sided prism, terminated by two planes, standing on the acute lateral edges.—The preceding prism is sometimes terminated by four faces, placed on the lateral edges, and those, which stand on the acute edges, meet in a line.—It also occurs in cuneiform octaedrons.

Its structure, and of course its fracture, is foliated; its lustre shining and rather pearly. It breaks into rhomboidal fragments. When massive, it is only translucent, but the crystals are sometimes limpid and transparent. Its color is usually some variety of white or red.

A specimen from Sussex county, New Jersey, whose specif. grav. was 4.417, yielded Mr. Chilton barytes 61.34, sulph. acid 30.67, silex 3.0, alumine and oxide of iron 1.0, water 2.0, with a trace of strontian ;=98.01. Another specimen, from Hatfield, Mass. whose spec. grav. was 4.28, was found by Dr. Gorham to contain barytes 58.50, sulph. acid 29.83, silex 4.0, alumine 2.0, water 3.0 ;=97.33.

Some specimens of this variety appear to be partially disintegrated.

CURVED LAMELLAR SULPHATE OF BARYTES.* In this subvariety the foliæ are curved, and sometimes unite in a point, like the petals of a flower; hence in some specimens the fracture has a fibrous, radiated, or even splintery aspect. Its masses, though usually amorphous, are sometimes globular or reniform; and, in some instances, different colors appear in stripes.

CRESTED SULPHATE OF BARYTES.† This is merely an aggregation of thin tables, whose edges are rounded and indented.

2. COLUMNAR SULPHATE OF BARYTES.‡ It occurs in long, acicular prisms, collected into little bundles or columnar groups, and sometimes intersecting each other confusedly; the surface is deeply and

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* Krumm-schaaliger schwer spath. WERNER. Curved lamellar heavy spar. JAMESON.

† Baryte sulfatée crêtée. HAUY. BRONGNIART.

‡ Stangen spath. WERNER. Columnar heavy spar. JAMESON. Baryte sulfatée bacillaire. HAUY. BRONGNIART.

longitudinally striated, and has a pearly lustre. It is translucent, and its color is white, either pure, or tinged with yellow, &c.

This variety strongly resembles some specimens of carbonate of lead; but may be distinguished, as already mentioned.

3. RADIATED SULPHATE OF BARYTES.* It is found in roundish masses, of a moderate size, having a rough or uneven surface. This roughness of the surface appears to arise from the projecting edges of the numerous crystals, of which these masses are composed. Its fracture is fibrous, and has a resinous lustre; the fibres are broad and more or less distinctly *radiate* from a centre. In some specimens the fracture is foliated in certain directions. It is strongly translucent; and its color exhibits different shades of gray.

The phosphorescent property of this variety has been long known. To exhibit this property, the mineral is calcined, and reduced to powder; this powder, by means of gum water, is formed into little cylinders or cakes, which, after exposure to the light, become capable of shining in the dark.

It has been found at Monte Paterno, near Bologna, in Italy, imbedded in argillaceous marl, in which it seems to have been formed. The surface of detached masses is sometimes *smooth*, in consequence of their having been rolled.

4. FIBROUS SULPHATE OF BARYTES.† This variety is mentioned by Karsten. It occurs in reniform or tuberose masses, composed of diverging fibres. Its color is brown; its external lustre resinous; and its spec. grav. only 4.08.—It has been found at Neu-Leiningen, in the Palatinate.

5. CONCRETED SULPHATE OF BARYTES.‡ This occurs in reniform, undulated, or stalactical concretions. These stalactites are sometimes bent and twisted in a singular manner; and, from some resemblance to the intestines, have received the name of *tripe stone*. Its zones sometimes alternate with those of fluate of lime. In some tubular stalactites the cross fracture is fibrous, and the longitudinal fracture foliated. It sometimes receives a good polish.

It has been found in the mines of Saxony and Derbyshire;—also near the warm springs of Liege in fibrous concretions.

Fine specimens, found at Wieliczka, and supposed to belong to this variety, are said, on the authority of Klaproth, to be anhydrous sulphate of lime.

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* Baryte sulfatée radiée. HAUY. BRONGNIART. Bologneser spath. WERNER. Bolognese spar. JAMESON.

† Baryte sulfatée fibreuse. BRONGNIART.

‡ Baryte sulfatée concrétionnée. HAUY. BRONGNIART.

6. GRANULAR SULPHATE OF BARYTES.[*] It is always in amorphous masses. Its structure is granular, and the grains are usually small. Its fracture is most commonly foliated, sometimes a little splintery, and has a strongly glimmering and pearly lustre. It is feebly translucent, and sometimes of a beautiful snow white color; it is also gray, or yellowish.

According to Klaproth, it contains barytes 60, sulph. acid 30, silex 10.

It strongly resembles some granular limestones, but is easily distinguished by its greater spec. gravity.

Lamellar, granular, and compact Sulphate of barytes bear to each other relations, similar to those existing between lamellar, granular, and compact carbonate of lime.

7. COMPACT SULPHATE OF BARYTES.[†] This variety usually appears in amorphous masses; sometimes also nodular or reniform. Its fracture is earthy, uneven, or splintery, and is nearly or quite dull. It is opaque or perhaps translucent at the edges; and its common colors are white or gray, often tinged with yellow.

The substance, known in Derbyshire and other parts of England by the name of *cawk*, sometimes belongs to this variety; and sometimes, according to Kirwan, its structure is lamellar or fibrous. It is found in mines, interspersed among the ores.

8. EARTHY SULPHATE OF BARYTES.[‡] This occurs in coarse, earthy particles, usually cohering a little. They feel rough; and their color is a dull white, often with a shade of yellow, &c. Their great spec. grav. however is perceptible.

It is a rare variety. Near Freyberg, in Saxony, it invests crystallized Sulphate of barytes.

SUBSPECIES 1. FETID SULPHATE OF BARYTES.[§]

This mineral is either compact, or has a foliated structure. By friction or the application of heat, it exhales a fetid odor, resembling that of sulphuretted hydrogen. Its color is gray of different shades; and its spec. grav. is sometimes only 2.66. (*KIRWAN.*)

A specimen from Andrarum, in Scania, yielded Bergman sulphate

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[*] Körniger schwer spath. WERNER. Granular heavy spar. JAMESON. Baryte sulfatée grenue. BRONGNIART.

[†] Dichter schwer spath. WERNER. Compact heavy spar. JAMESON. Baryte sulfatée compacte. HAUY. BRONGNIART.

[‡] Schwer spath erde. WERNER. Heavy spar earth. JAMESON. Baryte sulfatée terreuse. BRONGNIART.

[§] Baryte sulfatée fétide. HAUY. BRONGNIART.

of barytes 38, silex 33, sulphate of alumine 22, sulphate of lime 7, mineral oil 0.5 := 100.5.

At Kongsberg, in Norway, it accompanies ores of silver.—In the *United States* it is found in *Virginia*, Albemarle Co. both lamellar and compact, of a lead gray color. (*Seybert.*)

(*Geol. sit. of the species.*) Sulphate of barytes, although not a rare mineral, is seldom found in large masses. It never constitutes whole mountains, and has but rarely been seen in beds. It usually occurs in veins, which may traverse primitive, transition, or secondary rocks; the veins are often large and rich in ores. This mineral frequently accompanies the sulphurets of zinc, lead, iron, copper, antimony, and mercury, and other ores. It is said to be rarer in granite, than in rocks of a later formation.

(*Localities.*) Sulphate of barytes is found in most countries, where mines have been worked. Very fine crystals are obtained in the mines of Hungary, Saxony, &c.

In the *United States.* At the lead mines of St. Genevieve, on the western bank of the Missisippi, in tabular crystals. (*Meade.*)—In *North Carolina*, in Buncomb Co. in argillaceous slate.—In *Virginia*, at Austin's lead mine, on the great Kanhaway;—at Fincastle, &c.—In *Maryland*, at Liberty, in Frederick Co. with gray copper;—also in Washington Co.—In *Pennsylvania*, at the Perkiomen lead mine, 25 m. west from Philadelphia;—also in large quantities in secondary rocks at the west foot of the Blue Ridge, Bedford Co. (*Wister.*)—In *New Jersey*, near Newton, Sussex Co. it occurs both in lamellar masses and tabular crystals; the vein traverses limestone, being inclined to the horizon at about 40°, and in its vicinity are found detached masses of the Sulphate of barytes, containing a spheroidal nucleus of chalcedony, quartz, limestone, &c. 5 or 6 inches in diameter. (*Chilton.*)—Also on the west side of Paulin's Kill, not far from the locality last mentioned, is another vein of this Sulphate.—In *Connecticut*, at Cheshire, 15 m. north from New Haven, it occurs in foliated masses with quartz, sandstone, and the carbonates of lime and copper;—also in lamellar rolled pieces in a rivulet, passing through Berlin and Farmington. (*Silliman.*)—In *Massachusetts*, at Hatfield, Hampshire Co. it exists both in tabular crystals and foliated masses; the veins are narrow at the surface, but become wider at the depth of a few feet; they traverse granite or gneiss, and are inclined to the horizon at about 40°. (*Gorham.*)—Also at the lead mine in Southampton, 8 m. southwest from Northampton;—also at Middlefield, in Hampshire Co. where both the lamellar and granular varieties occur.

(Uses.) It is sometimes employed as a flux in metallurgic operations; also in chemistry, and in some medical preparations. It is said to be a good base for water colors.

Species 2. Carbonate of Barytes.*

This species, like the preceding, has a very great specific gravity, varying from 4.29 to 4.33. Its structure is usually fibrous; its longitudinal fracture is shining and intermediate between fibrous and foliated, but its cross fracture is undulated, uneven, or splintery, with a resinous lustre, less shining than that of the former fracture.

This mineral is usually in small, fibrous masses. Its crystals are rare, generally imperfect, and attached to the same substance in a massive state. They are commonly six-sided prisms, terminated by six-sided pyramids, the vertices being often truncated. M. Haüy has described three modifications of the primitive form, which is a rhomb slightly obtuse. It is sometimes in concretions, or in an earthy state.

It is strongly translucent, and usually of a light yellowish gray color, sometimes whitish, or with a tinge of green. Its hardness is about equal to that of the preceding species.

(Chemical characters.) It effervesces, and, if pure, entirely dissolves in *diluted* nitric or muriatic acid. When nitric acid is employed, a white deposite usually appears, while the solution is going on. Before the blowpipe it decrepitates, and easily melts into a kind of enamel; but does not lose its carbonic acid.

When pure, it is composed, according to Klaproth, of barytes 78, carbonic acid 22. The native specimens are sometimes contaminated with a little alumine, carbonate of strontian, &c.

(Distinctive characters.) Its effervescence and solution in diluted acids distinguish it from the sulphates of barytes and strontian.—It has a greater spec. grav. than carbonate of strontian; and further, if a small quantity of the solution of Carbonate of barytes in nitric acid be added to alcohol, it gives to the flame of the latter a yellowish tinge; whereas, if carbonate of strontian be treated in a similar manner, a purple flame is produced. The same distinction may be observed by burning paper, previously dipped in these solutions.

(Geological situation and Localities.) Carbonate of barytes was discovered at Anglesark, in Lancashire, England, by Dr. Withering, in honor of whom it has been called Witherite. It is a rare mineral, and has been found only in small quantities. At Anglesark it is contained principally in the upper part of a vein of sulphuret of lead,

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* Baryte carbonatée. Haüy. Brongniart. Witherit. Werner. Witherite. Jameson. Barolite. Kirwan. La Witherite. Brochant.

traversing sandstone, &c. and accompanied by sulphate of barytes, &c. It here occurs in spherical masses, whose surfaces are covered with little projections, arising from the union of pyramids, which terminate the prisms, of which these balls are composed.—In Styria it is sometimes in an earthy state, investing crystals or masses of the same substance.

(Remarks.) Its action on the animal system is extremely powerful; operating in doses of a few grains, as a fatal poison to dogs. The native Carbonate is much more powerful, than the artificial, when received into the stomach; for the latter in large doses excites vomiting only, but is not fatal.

GENUS II. *STRONTIAN.*

This genus, like the preceding, has only two species, the sulphate and carbonate of strontian, which, in most of their characters, resemble the salts of barytes. There is, indeed, a remarkable similarity between the two sulphates, and between the two carbonates of barytes and strontian.

Species 1. Sulphate of Strontian.*

The great weight of this mineral is its most striking physical character; its spec. grav. extending from 3.58 to 3.95. The forms of its crystals closely resemble those of the sulphate of barytes, but differ a little in the quantity of their angles. We here see the importance of an accurate measurement of the angles of crystals in discriminating minerals. The primitive form, like that of the sulphate of barytes, is a four-sided prism (Pl. III, fig. 5.); its bases also are rhombs, but with angles of 104° 48′ and 75° 12′, and the ratio of one side of the base is to the height as 114 to 113. Eight secondary forms have been described by Haüy. Its integrant particles are triangular prisms.

Its hardness is a little less, than that of fluate of lime, but rather exceeds that of sulphate of barytes. It possesses double refraction.

(Chemical characters.) The blowpipe melts it, and the globule thus produced often excites a slightly sourish taste. It usually communicates to the blue flame of the blowpipe a purple or reddish tinge, more or less sensible.

A crystallized specimen from Sicily yielded Vauquelin strontian 54, sulphuric acid 46. In the fibrous variety from Pennsylvania Klaproth found strontian 58, sulph. acid 42.

(Distinctive characters.) This mineral may be distinguished

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* Strontiane sulfatée. Haüy. Brongniart. Celestin. Werner. Celestine. Jameson. La Célestine. Brochant.

from the carbonates of strontian and barytes by the effervescence and solution of the two last in nitric acid, especially if diluted. Sometimes, however, effervescence appears in the Sulphate of strontian in consequence of the intermixture of carbonate of lime, but it soon ceases.—To distinguish this salt from the sulphate of barytes, see the last named species.

Var. 1. FOLIATED SULPHATE OF STRONTIAN.* It occurs both massive and regularly crystallized. Its crystals are usually four or six-sided prisms, variously modified, and terminated by 2, 4, or 8 sided summits, but less frequently compressed into tables, than those of the sulphate of barytes. Among its more common forms is an oblique four-sided prism, terminated at both extremities by four faces, standing on the lateral edges; two of these faces meet in a line, and contain an angle of 104° 48′.—Very frequently the preceding crystal has its obtuse lateral edges truncated, thus becoming a six-sided prism (Pl. III, fig. 6.). The crystals are often long and slender, and collected into fascicular groups; their surface has a strong lustre, but they are seldom transparent. When massive, it is only translucent.

The fracture is foliated and glistening; and the color is some shade of blue, or milk white, and sometimes gray, or reddish.

This variety is abundant near Bristol, England.—Very fine crystals are obtained from Sicily, where they occur in cavities in beds of native sulphur, which alternate with those of sulphate of lime.

2. FIBROUS SULPHATE OF STRONTIAN.† It presents itself in fibrous masses, composed of acicular prisms or fibres, applied to each other, usually parallel, but sometimes diverging. In one direction its fracture is sometimes foliated. It is more or less translucent; and its color varies from sky blue to bluish gray, or even milk white. It is said to lose its color in cabinets. (JAMESON.)

This variety is rare. It sometimes occurs in thin beds or layers, like fibrous gypsum, its fibres being perpendicular to the sides of the bed.

In the *United States* it has been found near Frankstown, in the Bald Eagle mountain, Huntingdon Co. *Pennsylvania*, where it is said to exist in layers about one inch thick between the strata of a brownish gray slate; its color is a fine light blue. (SEYBERT.) Sulphate of strontian is supposed to have been found in small quantities in gneiss, near Baltimore; but the writer knows not of which variety.

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* Blättriger Celestin. WERNER. Foliated Celestine. JAMESON. Strontiane sulfatée cristallisée. BRONGNIART.

† Fasriger Celestin. WERNER. Fibrous Celestine. JAMESON. Strontiane sulfatée fibreuse. HAUY. BRONGNIART.

Subspecies 1. CALCAREOUS SULPHATE OF STRONTIAN.*

This subspecies is found in masses usually spheroidal and compressed, and frequently of the size of a man's head. In the interior they are often divided into prisms by interstices, which are sometimes lined by small crystals of the same substance. It has a dull, splintery fracture, a yellowish or bluish gray color, and is usually opaque.

It has been found only at Montmartre, near Paris; and is imbedded in argillaceous marl. It contains nearly 9 per cent. of carbonate of lime.—To the eye it often much resembles compact limestone.

The geological situation of this species is not much known. It is in many cases accompanied by sulphur and sulphate of lime.

Species 2. Carbonate of Strontian.†

The specific gravity of this species varies from 3.40 to 3.67. It usually appears in masses, composed of diverging fibres, which are often in the form of fascicular groups. The fracture, perpendicular to the direction of the fibres, is uneven or splintery, with a resinous lustre. It also occurs in hexaedral prisms, or in acicular crystals, grouped in the cavities of massive Carbonate of strontian.

It is a little harder than carbonate of barytes; is more or less translucid; and its usual colors are greenish or yellowish white, or nearly apple green.

(Chemical characters.) It communicates a purple or reddish purple color to the flame of the blowpipe; and, when gently heated by this instrument, it swells and sends out minute filaments, of which the extremities only are melted. The fragment itself is infusible, but loses its color. In nitric acid it dissolves with effervescence; and paper, when dipped in this solution and dried, burns with a purple flame.

It is composed, according to Klaproth, of strontian 69.5, carbonic acid 30.0, water 0.5. By the analysis of Dr. Hope the proportions are strontian 61.21, carb. acid 30.20, water 8.59.

(Distinctive characters.) This mineral strikingly resembles the carbonate of barytes; but the latter has a greater spec. gravity, does not send out filaments before the blowpipe, and easily melts without changing the color of the flame.

(Localities.) This mineral was first discovered at Strontian, in Scotland, in a vein traversing gneiss; it is there accompanied by sul-

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* Strontiane sulfatée calcarifère. Hauy. Strontiane sulfatée terreuse. Brongniart.

† Strontiane carbonatée. Hauy. Brongniart. Strontianit. Werner. Strontiane. Jameson. Stronthianite. Kirwan. La Strontianite. Brochant.

phuret of lead, carbonate of barytes, &c. Humboldt has since brought it from Peru; but it is a rare mineral.

It does not possess those poisonous properties, which belong to the carbonate of barytes. *(Brochant.)*

GENUS III. *LIME.*

This genus embraces nine species, some of which are extremely abundant, and important in their uses. It will be recollected, that the term *salt* is applied to minerals of a certain composition, independent of physical characters. Hence it is, that many salts in this genus exhibit the properties of those substances, usually called stones.

Species 1. Arseniate of Lime.*

The physical characters of this mineral will hardly enable one to distinguish it. It has hitherto been found in acicular crystals or fibres, which are commonly united either in bundles, or in mammillary or globular masses, or in crusts. The fibres diverge, and sometimes radiate from a centre. It is easily broken, and the fracture has a silken lustre. The more distinct crystals are translucid. Its true color is milk white or snow white; but, from the presence of arseniate of cobalt, its *surface* is very frequently violet or reddish white. Its spec. gravity is 2.64.

(Chemical characters.) It is insoluble in water; but dissolves in nitric acid without effervescence. Before the blowpipe the arsenic acid is volatilized with the odor of arsenic, but the lime remains pure. Klaproth has obtained from it lime 25.00, arsenic acid 50.54, water 24.46.

(Distinctive characters.) From carbonate of lime it is distinguishable by the blowpipe, and its want of effervescence in nitric acid. —From the white oxide of arsenic, by its insolubility in water, and *partial* volatility.

(Localities.) It is a rare mineral, and has been seldom observed. Near Wittichen in Suabia, it is disseminated in the fissures of granite, and is accompanied by the arseniate of cobalt, and the sulphates of lime and barytes.

Species 2. Nitrate of Lime.†

The taste of this salt is sharp and bitterish. It is found native in

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* Chaux arseniatée. Hauy. Brongniart. Arsenik blüthe. Werner. Arsenic Bloom. Jameson. Pharmacolite. Brochant.

† Chaux nitratée. Hauy. Brongniart. Nitrated calx. Kirwan.

efflorescences, or in delicate needles, often united in little silken tufts, or in a state of powder, disseminated in earths.

It is very deliquescent, and extremely soluble in water. On burning coals it slowly melts, and slightly detonates, as it dries, during which it loses its acid. The powder, remaining after calcination, does not attract moisture from the air, and is phosphorescent in the dark.

It is composed of lime 32.00, nitric acid 57.44, water 10.56. (*Kirwan.*)

From nitrate of potash it may be distinguished by its taste and deliquescence.

(*Geological situation.*) This salt almost always accompanies the nitrate of potash; and, like that salt, is daily formed, when circumstances are favorable. Hence it is often found efflorescing on walls, in caverns, near stables, &c. and on calcareous rocks, especially if in the vicinity of decomposing vegetables. The earths of calcareous caverns are often richly impregnated with this salt. It sometimes exists in mineral waters.

In the *United States*, it is abundant in the calcareous caverns of *Kentucky*, &c. (See nitrate of potash, for this locality.)

Species 3. Phosphate of Lime.*

This species, though perfectly well characterized, embraces several varieties, some of which exhibit physical characters, not common to the whole species. When crystallized, which is most frequently the case, its forms are prismatic, and present either a six-sided prism, or some modification of that form. Indeed its primitive form is a regular hexaedral prism, in which one side of the base is to the height nearly as 10 to 7. Seven secondary forms have been described by Haüy. Its integrant particles are equilateral, triangular prisms. (Introd. 46.)—It is a little harder than fluor spar, but does not strike fire with steel. Its spec. gravity usually lies between 3.02 and 3.21. Most of its varieties phosphoresce, when their powder is thrown on hot coals.

(*Chemical characters.*) In the nitric and muriatic acids it dissolves slowly, and without effervescence, or barely with the extrication of a few bubbles. Sometimes, however, foreign ingredients cause the earthy variety to effervesce a little. Before the blowpipe it is infusible.

The first variety (Apatite) yielded Klaproth lime 55, phosphoric

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* Chaux phosphatée. Haüy. Brongniart. Phosphorite. Kirwan.

acid 45. In the second variety (Asparagus stone) Vauquelin found lime 54.28, phosphoric acid 45.72.

(*Distinctive characters.*) Its solubility in acids and inferior hardness may serve to distinguish it from the chrysoberyl, tourmaline, topaz, chrysolite, beryl, emerald, and some varieties of quartz, all of which it sometimes more or less resembles, especially the *emerald*, *beryl*, and chrysolite.—From carbonate of lime it differs by its greater hardness and want of effervescence in acids ;—and it does not, like the fluate of lime, when its powder is thrown into warm sulphuric acid, yield a gas, capable of corroding glass, unless from the accidental presence of a small quantity of that salt.

Var. 1. APATITE.* *JAMESON.* This variety, usually in crystals, sometimes presents a low six-sided prism, the primitive form.—The lateral and terminal edges, and even the solid angles of this prism are subject to truncation.—Sometimes all the edges are truncated (Pl. III, fig. 7.) ; the new lateral faces, produced by truncation, are often longitudinally striated, and the terminal edges are sometimes very deeply truncated. The prisms are generally short, and sometimes even tabular.

Its fracture, parallel to the base, is foliated, but, in the direction of the sides, it is uneven, or imperfectly conchoidal. It is translucent, sometimes almost opaque, and sometimes nearly or quite transparent and limpid. This mineral exhibits a great variety of colors, belonging to white, green, blue, yellow, red, violet, or brown, variously shaded and intermixed. On burning coals its powder phosphoresces.

The same gangue, which contains the crystals, often embraces grains or small granular masses, having a crystalline structure, but nearly or quite destitute of a regular form.

The Apatite occurs in veins, or is disseminated in granite, gneiss, or other primitive rocks. It is associated with quartz, feldspar, fluate of lime, garnets, the oxides of iron, tin, &c.

(*Localities.*) In the *United States*, the Apatite is not uncommon. In *Maryland*, near Baltimore, it exists in grains or hexaedral prisms in granite ; its color varies from bluish green to lemon yellow. (*GILMOR.*)—In *Pennsylvania*, in various parts of the state, particularly in the granite and gneiss of Germantown, accompanied by the *beryl*, garnets, schorl, &c. it is both crystallized and massive, and often of a grass green color. (*WISTER.*)—In *New York*, at Anthony's

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* Apatit. WERNER. Chaux phosphatée Apatite. BRONGNIART. The name of this variety is from the Greek, *απαταω*, to deceive ; it having often been mistaken for other minerals.

Nose, on the Hudson, in greenish yellow crystals, in pyrites. (*Woodbridge.*)—In *Connecticut*, at Milford Hills, near New Haven, in imperfect, pale green crystals, in granite. (*Silliman.*)—In *Maine*, at Topsham, pale green crystals of Apatite, often badly defined, but phosphorescing strongly on hot iron, are disseminated in granite; they are seldom found more than 3 or 4 inches below the surface of the granitic mass, which also abounds with garnets.[*]

2. ASPARAGUS STONE.[†] *Jameson.* The name of *asparagus stone* has been given this variety in consequence of its so frequently exhibiting an asparagus green color. It is distinguished from the Apatite partly by its color, partly by its crystalline form, and more particularly by its want of phosphorescence on hot coals. It sometimes presents the primitive form, either perfect, or with truncated lateral edges, but most frequently the hexaedral prism is terminated by six-sided pyramids, whose faces correspond with the sides of the prism, and form with them an angle of 129° 14′; sometimes the lateral edges are truncated. These prisms are usually longer than those of the Apatite. It is sometimes in small crystalline masses without a regular form.

Its longitudinal fracture is often more distinctly foliated, than that of the Apatite, and its cross fracture sometimes less so. It is translucent, and frequently transparent. Beside asparagus green, it presents other shades of green, or is greenish white, or nearly gray, brownish, bluish, &c.

It is somewhat remarkable, that its powder does not phosphoresce on burning coals. It has however been observed, that the artificial phosphate of lime never phosphoresces.

(*Localities.*) This variety is found abundantly near Cape de Gate, in the province of Grenada, in Spain; its gangue is a decomposed stone, concerning which mineralogists are not agreed.—It is found near Vesuvius, mixed with idocrase.—Near Arendal, in Norway, it exists in crystals or small masses, of a brownish, or greenish blue color, in primitive rocks; these crystals have been called *Moroxite.*

In the *United States*, this variety is found in gneiss at Germantown, *Pennsylvania*; it is in hexaedral prisms, sometimes truncated on the lateral edges, but more frequently it is destitute of a regular form; its color is bluish green, sometimes gray; and on burning coals it does not phosphoresce. (*Godon.*)

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[*] The writer is not confident, that some of the abovementioned localities do not belong to the next variety.

[†] Spargelstein. Werner. Chaux phosphatée Chrysolithe. Brongniart.

3. FIBROUS PHOSPHATE OF LIME. This variety, still rare, is sometimes in masses, composed of delicate fibres, collected into groups, and radiating from a centre. It is phosphorescent.

The supposed phosphate of lime, found at Dyce in Aberdeenshire, in masses, composed of pale greenish white, delicate fibres, having a silken lustre, and phosphorescing on hot coals, is said by Cabral de Mello to be composed of sulphate of lime 76.0, silex 17.0, magnesia 2.67, water 2.0, oxide of iron 2.33. (Nich. Jour. v. 36.)

4. AMORPHOUS PHOSPHATE OF LIME.* This variety has most commonly an earthy aspect; and occurs in masses more or less solid, whose surface often presents mammillary projections. Its fracture is nearly or quite dull, and is sometimes earthy, sometimes uneven, and sometimes imperfectly foliated. It is opaque; and its color is grayish or yellowish white, often diversified by spots or zones of a yellowish or brownish tinge. Its powder phosphoresces on burning coals with a very beautiful, greenish yellow light. It is phosphorescent even by friction in the dark.

According to Pelletier, it contains lime 59, phosphoric acid 34; the remainder being small quantities of the fluoric, carbonic, and muriatic acids, with a little silex and oxide of iron. Possibly these foreign ingredients may sometimes render it fusible.

It is found near Truxillo, in Estramadura, Spain, where it is deposited in beds, intermingled with quartz, and constitutes whole hills.

Subspecies 1. SILICEOUS PHOSPHATE OF LIME.†

This differs from the preceding varieties by giving fire with steel. It occurs in porous masses, whose fracture is earthy, granular, or a little foliated. Its color is gray, shaded with violet. On hot iron it phosphoresces strongly.

It is found in certain tin mines of Bohemia.

Species 4. FLUATE OF LIME.‡

The more common variety of this mineral may be easily recognised by the striking beauty of its colors, and the form and perfection of its crystals. But the most distinguishing characters of this earthy salt are found among its chemical properties.

Although sometimes amorphous, it is most commonly crystallized;

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* Chaux phosphatée terreuse. HAUY. BRONGNIART. Phosphorit. WERNER. Phosphorite. JAMESON.

† Chaux phosphatée silicifère. HAUY. BRONGNIART.

‡ Chaux fluatée. HAUY. BRONGNIART. Fluss. WERNER. Fluor. KIRWAN. JAMESON. La Fluor. BROCHANT.

and the primitive form of its crystals is a regular octaedron, which may easily be obtained by mechanical division. (Introd. 39.) Thirteen secondary forms have been described. Its integrant particles are probably regular tetraedrons. Unlike most of the other calcareous salts, it has seldom or never occurred under any imitative form.

It may be scratched by iron, but is harder than crystallized carbonate of lime. Its spec. gravity varies from 3.09 to 3.20. When reduced to powder, and placed on hot coals, it almost invariably phosphoresces with a very beautiful light, commonly of a greenish or violet color. (Introd. 143.) It also shines in the dark by the friction of two pieces against each other.

(Chemical characters.) If sulphuric acid be poured on this mineral in a state of powder, and slightly heated, white fumes appear, having a pungent smell, and possessing the peculiar property of corroding glass. These fumes are fluoric acid, and, in connexion with the physical characters, will almost always enable us easily to determine the presence of Fluate of lime. It is insoluble in water. Before the blowpipe it usually decrepitates, and melts into a whitish, transparent glass.

According to Klaproth, it is composed of lime 67.75, fluoric acid 32.25.

From the carbonate and sulphate of lime it is easily distinguished by its greater hardness, and its chemical characters.

Var. 1. FLUOR SPAR.* *JAMESON.* (Foliated Fluate of lime.) This variety, though sometimes massive, is almost always regularly crystallized. Its crystals most frequently present the form of a cube, often perfect, and sometimes truncated on all its edges by planes, which form with the sides of the cube an angle of 135°.—Sometimes a bevelment is applied to the edges of the cube.—Sometimes all the solid angles of the cube (Pl. III, fig. 8.) are truncated; if the triangular planes *a*, *a*, produced by truncation, do not touch each other, the faces *b*, *b* are octagonal; if those planes touch only, as in the figure, the faces *b*, *b* become squares; but, if the truncating planes intersect, they then become hexangular, while the faces *b*, *b* remain squares. The structure of this crystal is easily explained. The cube is here a secondary form, constructed around an octaedral nucleus. But, the decrements having ceased before the cube was completed, the crystal remains a cubo-octaedron, having six faces parallel to those of a cube, and eight faces parallel to those of an octaedron. The incidence of *a* on *b* is 125° 16′.—The dodecaedron with rhombic faces, and the prim-

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* Fluss spath. WERNER. Chaux fluatée spathique. BRONGNIART.

itive octaedron, sometimes truncated on all its edges, are among the rarest forms of this mineral.

These crystals are almost always extremely well defined, and often very large; the cube in some cases presenting a face of several square inches. Their surface is generally smooth with a strong lustre. They are often variously grouped.

Its fracture is always foliated, though sometimes imperfectly, and has usually a shining, vitreous lustre. The crystals easily yield to mechanical division, the laminæ separating in four directions, parallel to the faces of a regular octaedron. Its fragments are either tetraedral or octaedral, resulting from the directions of the natural joints just mentioned. Its transparency is extremely variable; most frequently perhaps it is strongly translucent, but many of its crystals, especially the cubes, are transparent.

Its colors are uncommonly numerous; and, by the beauty, which they confer on its specimens, deserve attention. It is sometimes limpid, but most frequently presents some variety of white, gray, violet, blue, green, yellow, red, brown, or black. Different colors often meet in the same specimen, and are arranged in spots, zones, &c. Certain varieties, from resemblance in color, have been called false gems; thus there is the false amethyst, sapphire, emerald, &c.

Some varieties of this Fluate are rendered interesting by the color of their light, while phosphorescing. One, of a violet color, from Siberia, when placed on burning coals, does not decrepitate, but shines with an emerald green light; it has hence received the name of *Chlorophane.*

Another interesting variety, from Siberia, of a pale violet color with greenish spots, is made to shine, when in small fragments, with a *whitish* light, by the heat of the hand only; at 212° Fahr. its phosphorescence is *green*, and with a still stronger heat it becomes *blue.* But in all cases, when phosphorescence ceases, the color of the mineral has disappeared.

MASSIVE PHOSPHATE OF LIME. This subvariety is not uncommon; it has a foliated fracture, and is the result of crystallization. Its masses are often composed of distinct concretions, sometimes granular; and sometimes they are prismatic and intersected by others in the form of zones.

Very fine crystals are obtained in Derbyshire, England; indeed this mineral is sometimes called Derbyshire spar. Rose colored octaedrons have been found near Mont Blanc.

2. COMPACT FLUATE OF LIME.* This variety, which is rare, always occurs in compact masses, whose fracture is even, imperfectly conchoidal, or a little splintery, with a feeble, resinous lustre. It is more or less translucent; and its usual colors are gray, greenish gray, or brown, sometimes diversified by other colors in spots.

It often resembles certain varieties of compact limestone or petrosilex.

3. EARTHY FLUATE OF LIME.† This is in friable masses, composed of small grains, which are sometimes arranged in parallel layers. Its color is greenish white, or has a tinge of violet.

SUBSPECIES 1. ARGILLACEOUS FLUATE OF LIME.‡

This has been found crystallized in cubes, opaque, and of a gray color, near Buxton, in England. These crystals contain considerable quantities of ferruginous clay, which however has not affected the form. They are sometimes corroded.

(Geol. sit. of the species.) Fluate of lime almost always occurs in veins. It has however been observed in beds; and, in a few instances, appears to enter into the composition of primitive rocks. *(BRONGNIART.)* These veins are obviously of different ages. In the most ancient, this mineral is associated with ores of tin; while in those, which appear to be more recent, it is connected with the sulphurets of lead, zinc, iron, and copper. These sulphurets, especially that of iron, are often disseminated in masses of Fluate of lime, or traverse them in a zigzag direction, and, by their metallic lustre, contribute much to the beauty of certain specimens. The veins are often very large, and composed almost entirely of Fluate of lime. In addition to metallic substances, however, it is often associated with quartz, the carbonate and phosphate of lime, sulphate of barytes, &c.—In Derbyshire, veins of Fluate of lime traverse compact limestone, containing shells. At Oxford, England, is a bivalve shell, lined with imperfect crystals of Fluate of lime. *(KIDD.)*

(Localities.) In the *United States.* Mr. Bradbury, an English naturalist, has found it, both limpid and violet, apparently in rolled pieces, on the banks of the Missouri. *(SILLIMAN.)*—In *Virginia*, near Woodstock or Miller's town, Shenandoah Co. in small, loose masses in the fissures of a limestone, containing shells. *(BARTON.)*—In *Maryland*, on the west side of the Blue Ridge, with sulphate of

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* Chaux fluatée compacte. HAUY. BRONGNIART. Dichter Fluss. WERNER. Compact Fluor. JAMESON.

† Chaux fluatée terreuse. HAUY. BRONGNIART. Fluss erde. WERNER.

‡ Chaux fluatée aluminifère. HAUY. BRONGNIART.

barytes. (*Hayden.*)—In *New Jersey*, near Franklin Furnace, in Sussex Co. disseminated in lamellar carbonate of lime, and accompanied with mica and carburet of iron;—also near Hamburg, in the same Co. on the turnpike to Pompton, in a vein of quartz and feldspar. (*Bruce.*)—In *New York*, near Saratoga springs, in limestone; it is nearly colorless and penetrated by pyrites.—In *Vermont*, at Thetford.—In *Connecticut*, at Middletown, in a vein, and is accompanied by the sulphurets of lead, zinc, and iron. (*Bruce.*)—In *Massachusetts*, at the lead mine in Southampton, where it is imbedded in sulphate of barytes, or granite; its colors are green, purple, &c.—In *New Hampshire*, at Rosebrook's Gap, in the White Mountains, in small, detached pieces. (*Gibbs.*)

(*Uses.*) It is sometimes employed as a flux for certain ores; and hence the name of *Fluor*. In some places, particularly in Derbyshire, it is cut into plates, vases, &c. for ornamental purposes, and polished; it is sometimes extremely beautiful. It also furnishes the fluoric acid, which has recently been employed with advantage for engraving on glass. (See Bruce's Min. Jour. v. i. p. 33.)

Species 5. Sulphate of Lime.*

Gypsum.

The examination of this mineral is interesting in many respects, particularly on account of its uses in agriculture and the arts. It is often in amorphous masses; and not unfrequently in crystals, whose primitive form is a four-sided prism (Pl. III, fig. 9.), whose bases are parallelograms with angles of 113° 8′ and 66° 52′; the sides of the base and the height of the prism are as the numbers 12, 13, 32. Of this nucleus, which is easily obtained, five modifications have been observed. The integrant particles have the form of the nucleus.

It possesses double refraction, which must be observed in the manner already prescribed for sulphate of barytes. In hardness it is inferior to crystallized carbonate of lime, for, in general, it may be scratched even by the finger nail. Its spec. gravity usually lies between 2.26 and 2.31; but is sometimes as low as 1.87, according to Kirwan.

(*Chemical characters.*) By the blowpipe it may be melted, though not very easily, into a white enamel, which, in a few hours, falls into powder. If the fragment is crystallized, it not only whitens instantly and becomes brittle, but very easily exfoliates in one direction. In order, however, to melt these laminæ, the flame should play in the di-

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* Chaux sulfatée. Haüy. Brongniart. Gypsum. Kirwan.

rection of the laminæ against their edges, and not perpendicularly to their surface. These different effects, according to the different directions of the flame, are supposed by Haüy to arise from the great length of the integrant particles, compared with the dimensions of their bases; for the laminæ are composed of an indefinite number of these little prismatic solids, which must necessarily cohere more strongly in the direction of their length or sides, than in that of their bases. It does not effervesce with acids, unless it be impure. It is soluble in about 500 times its weight of water. It does not burn to lime.

Sulphate of lime is composed of lime 32, sulphuric acid 46, water 22. (*Bergman*) It is sometimes contaminated by small quantities of carbonate of lime, alumine, silex, and oxide of iron.

(*Distinctive characters.*) Its inferior hardness, together with its chemical characters, will serve to distinguish it from the carbonate, phosphate, and fluate of lime.

The different structures and the extent of this species require a number of subdivisions.

Subspecies 1. SELENITE.* *Jameson.* (Foliated Sulphate of lime.)

Though always crystallized, it occurs both in foliated masses, and in regular crystals. One of its most simple forms is a tabular solid or low prism, whose bases are rhomboidal with angles of 126° 52′ and 53° 8′, and whose narrow sides are all bevelled by trapezoidal planes, which, on two opposite sides, are inclined to each other in an angle of 143° 53′, but, on the other two sides, in an angle of 110° 36′.—This crystal is sometimes elongated (Pl. III. fig. 10.), and then assumes a prismatic form, having six sides, but all the angles remain the same.—Sometimes the preceding crystal is terminated by four planes (Pl. III, fig. 11.).—There is also a prism with eight sides, terminated by four-sided summits. The trapezoidal faces of the preceding crystals are in general longitudinally striated.

The crystals of Selenite are frequently united, or collected into groups of various forms. Sometimes a hemitrope is formed; and sometimes large crystals are penetrated by smaller.

The geometrical beauty of the crystals is often much impaired by the bluntness of their edges and angles, and the convexity of their faces. This convexity is often so great, that the crystal becomes *lenticular;* and two lenticular crystals frequently unite in such manner as to form a re-entering angle on one side. Sometimes these lenses are grouped in the form of a crest, or like the petals of a rose, or in stars, &c.

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* Chaux sulfatée Selenite. Brongniart. Fraueneis. Werner.

Its fracture is foliated, shining or splendent, and sometimes pearly. The laminæ separate in three directions, parallel to the sides of the primitive form, but most easily in the direction of the bases; when thin, they are flexible, but not elastic, like mica; they break into rhomboidal fragments. Though sometimes translucent, it is most commonly transparent. Some specimens are limpid, but its color is usually white, either pure, or with shades of gray or yellow, and may be reddish, violet, brown, &c. The surface is sometimes irised, or pearly.

Var. 1. MASSIVE SELENITE.* This variety is in masses, whose structure is laminated, or sometimes only lamellar. The laminæ are often large and transparent, easily yielding to mechanical division. Sometimes they are arranged in clusters or radiate from a center. As they become smaller they constitute masses, which gradually pass into granular gypsum, to which they have the same relation, as calcareous spar to granular limestone.

The laminæ of Selenite have sometimes a *specular* surface, extremely beautiful.

ACICULAR SELENITE. This is found in acicular crystals, particularly in old mines, or in volcanic countries, and appears to be of recent formation.

(*Geological situation.*) The crystals of Selenite are very often disseminated in beds of clay or marl. But their color does not appear to have been affected by that of the clay or marl, except in a few cases, where the coloring matter has obviously entered by filtration. When massive, and sometimes when in crystals, Selenite is associated with extensive beds or strata of gypsum, and sometimes with carbonate of lime, &c. In a few instances it has been observed in veins, with sulphuret of lead, in primitive rocks.

SUBSPECIES 2. GYPSUM.†

The term *Gypsum*, though sometimes extended to the whole species, is more frequently appropriated to those varieties of Sulphate of lime, which have a *fibrous* or *granular* structure, being the result of a confused crystallization, and to those, whose texture is *compact*, or *earthy*.

Var. 1. FIBROUS GYPSUM.‡ Its fibres are parallel and often curv-

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* This includes a part of the *blættriger Gips* of Werner, and the *foliated Gyps* of Jameson.

† Gips. WERNER. Gyps. JAMESON. Chaux sulfatée Gypse. BRONGNIART.

‡ Fasriger Gips. WERNER. Fibrous Gyps. JAMESON. Chaux sulfatée fibreuse. HAUY. Chaux sulfatée Gypse fibreux. BRONGNIART.

ed. Though sometimes coarse, they are often fine and delicate, glistening with a pearly or satin lustre; some specimens, like a mirror, reflect the flame of a candle. In some cases the fracture is foliated in one direction. It is sometimes in stalactites or concretions.— It is usually translucent, and its colors are white or gray, often more or less shaded with yellow, red, &c. sometimes in spots or veins.

It most frequently occurs in thin beds or layers.

2. GRANULAR GYPSUM.* This is a common variety. It occurs in masses, having a granular structure; but the grains are extremely variable in their size. Sometimes, when the grains are very small, it is friable, like certain sandstones.

Its fracture is both granular and foliated with a moderate lustre. Its fragments are translucent, sometimes at the edges only; and its color is some variety of white, gray, or red, or even of yellow, green, brown, or black, or is spotted, &c.

This variety often strongly resembles granular limestone, but may be distinguished by its inferior hardness, which permits it to be scratched by the finger nail.

According to the size of its foliæ or grains this variety passes, on the one side, into massive Selenite, and, on the other, into the following variety.

3. COMPACT GYPSUM.† This is found in compact masses of a fine grain, whose fracture is even, or splintery, and nearly or quite dull, or sometimes a little foliated. It is nearly opaque, and its colors are commonly white or gray, sometimes shaded with yellow, red, &c. or variously mingled. Its spec. gravity is sometimes only 1.87. (*KIRWAN.*) It is sometimes in concretions.

Compact Gypsum, and some varieties of granular Gypsum are employed in sculpture and architecture under the name of *alabaster*. The same name is also given to certain varieties of carbonate of lime. It may be well to employ the terms gypseous and calcareous alabaster.

4. BRANCHY GYPSUM.‡ This rare variety occurs in little *branches*, singularly curled or twisted, and collected into little tufts. M. Brongniart supposes it to be formed, like the coralloidal variety of the arragonite. It is found near Matlock, in Derbyshire, &c.

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* Blættriger Gips. WERNER. Foliated Gyps. JAMESON. Chaux sulfatée Gypse compacte. BRONGNIART.

† Dichter Gips. WERNER. Compact Gyps. JAMESON. Chaux sulfatée compacte. HAUY. Chaux sulfatée Gypse compacte. BRONGNIART.

‡ Chaux sulfatée Selenite rameuse. BRONGNIART.

5. SNOWY GYPSUM.* This is found in small, reniform or flattened masses, which have the aspect of *snow*. They are composed of very minute plates or spangles, and are easily reducible to powder. These little plates are snow white and pearly, resembling white talc; but they are not unctuous to the touch, like talc, and are more easily melted.

It is found in masses of Sulphate of lime; and sometimes adhering to lenticular crystals of selenite, as at Montmartre, near Paris. It may perhaps arise from the disintegration of massive selenite, at least in some cases.

6. EARTHY GYPSUM.† This undoubtedly results from the disintegration of some of the preceding varieties. It is composed of dusty or scaly particles, which resemble those of meal or chalk, and soil the finger a little. These particles are dull, and slightly cohering in small masses. Their color is gray or white with a tinge of yellow.

It is found in the cavities or fissures of other varieties of Gypsum, and also in those of other rocks in the vicinity of Gypsum. It appears to be of daily formation, being produced by the agency of rain water; for it is found more plentifully in wet than in dry seasons. It is a rare variety.

SUBSPECIES 3. PLASTER STONE.‡ (Plaster of Paris.)

This would not be entitled to a distinct notice, were it not for the foreign ingredients, which it contains, and which, in many instances, greatly improve it, as a cement. In order to render calcined Sulphate of lime a good cement, there must be present a certain quantity of quicklime. But the mineral, of which we now speak, sometimes contains the proper quantity of carbonate of lime to constitute a good cement after calcination. Hence it slightly effervesces with acids. Sometimes also it embraces clay or sand, which injures it as a cement. —Its texture is earthy or granular with coarse grains, and sometimes foliated. It is sometimes white, but it also presents various shades of other colors, arising from the presence of oxide of iron. At Montmartre, near Paris, it is yellowish.

(*Geol. sit. of Gypsum.*) This mineral, next to carbonate of lime, is more abundant, than any other earthy salt. It is sometimes depos-

* Chaux sulfatée niviforme. HAUY. Chaux sulfatée Gypse niviforme. BRONGNIART.

† Gips erde. WERNER. Gyps earth. JAMESON. Chaux sulfatée terreuse. HAUY. Chaux sulfatée Gypse terreux. BRONGNIART.

‡ Chaux sulfatée grossière. BRONGNIART. Chaux sulfatée calcarifère. HAUY.

ited on the sides of primitive mountains at a considerable elevation; sometimes in vallies; and sometimes it constitutes whole hills, or exists in extensive strata at the surface of the earth, or at a great depth below.

There appears to be several distinct formations of this species, well characterized by their relative situation and accompanying minerals. In other words, Sulphate of lime is found among primitive, transition, and secondary rocks.

The oldest formation, or primitive Gypsum, is found resting on primitive rocks, or even contained within them. It is most frequently granular, sometimes lamellar, usually white, and often much resembles granular limestone. It is sometimes mixed with mica, talc, feldspar, &c. but never embraces clay, marl, nor remains of organic beings. This formation has been found in several parts of the Alps, between strata of mica slate, or gneiss, sometimes alternating with them, and accompanied by limestone, or hornblende slate.

Another formation of Gypsum appears to belong to transition rocks. It is sometimes associated with gray-wacke slate; (Von *Buch.*) and, according to Brongniart, it often covers carbonate of lime, being frequently connected with the fetid limestone. But it is not obvious, *where* the last mentioned author draws his line of distinction between transition and secondary rocks; and it must be confessed, that the later transition and the older secondary rocks, when belonging to the same mineral species, do sometimes pass into each other by imperceptible shades.

But, in most cases, Sulphate of lime is undoubtedly of secondary or late formation. It occurs near the foot of primitive mountains or in vallies; and sometimes under plains, or forming hills of a moderate elevation, often at a great distance from primitive mountains. Its beds, either horizontal or inclined, are often very thick and not distinctly stratified. It is associated with compact limestone, which is often fetid; also with sandstone, muriate of soda, and almost always with strata of *clay* or *marl*, with which it usually alternates.—It has also been found in compact limestone, not associated with marl.

Quartz, borate of magnesia, garnets, arragonite, large masses of sulphur, and even hornstone, and fragments of compact limestone are sometimes imbedded in Gypsum. But this mineral is rarely connected with metals or coal.

Organic remains of fish, birds, and quadrupeds, and also of the vegetable kingdom sometimes occur in secondary Gypsum; but they are generally more abundant in the beds of marl, which separate those of Gypsum, or alternate with them. In this marl, shells are often found, though seldom in Gypsum.

Secondary Gypsum undoubtedly exhibits several distinct formations, deposited at different periods of time, and capable of being marked by peculiar geological characters; but numerous observations are still wanting to complete our knowledge of its natural associations.

It is sometimes found lying immediately upon that, which is supposed to be the *oldest secondary limestone.* The beds of this Gypsum are frequently covered by a variegated sandstone; they contain both granular and compact Gypsum, mixed with selenite, and frequently alternate with fetid limestone. It is not unfrequently accompanied by *muriate of soda,* for its connexion with which, see that article.

Other deposites of Gypsum are found resting on this variegated sandstone just mentioned, or even alternating with it, and, at the same time, are *covered* by shell limestone. They contain both granular and fibrous Gypsum, often alternate with clay and marl, and are obviously of more recent formation, than those, which lie under the variegated sandstone.

Both the preceding formations are common in Germany.

Another formation of secondary Gypsum, apparently more recent, than either of the preceding, has been observed in the vicinity of Paris, and perhaps in one or two other places. This interesting deposite rises, in several instances, into small hills, of which Montmartre is the best known. It lies immediately *over* horizontal strata of a coarse grained *shell* limestone, and hence materially differs from the preceding formation, which lies *underneath* the same kind of limestone; it farther differs by not alternating with sandstone, and by not being fibrous.

This formation at Montmartre is not purely gypseous, but is composed of alternate strata of Gypsum, clay, and marl. The Gypsum is in fact divided into three principal masses by these marly strata; and each mass is further subdivided by thin strata of clay and marl. The highest of these three masses is peculiarly interesting. Its homogeneous beds discover a tendency to divide into prisms, altogether similar to those of basalt. Here also are found the skeletons and scattered bones of birds and unknown quadrupeds, also bones of tortoises, and a few shells, belonging to fresh water fish. Among the remains of quadrupeds are skeletons of mammiferous animals, which are unlike any now known to exist, and which do not occur in the lower masses. These organic remains are more solid and better preserved in the Gypsum, than in the marl.

Immediately on this Gypsum rest strata of marl, containing petrified trunks of palm trees, and some fresh water shells. It is hence evident, that this formation of Gypsum has been deposited from fresh water.

Gypsum is sometimes found in efflorescences or concretions in volcanic countries.

In fine, Sulphate of lime is more or less disseminated in almost every soil. Hence it is frequently dissolved in the waters of springs and wells. Such waters are said to be *hard*, because they decompose solutions of soap, the acid of the Sulphate combining with the alkali of the soap.—It exists also in sea water.

(Localities.) It is unnecessary to cite any foreign localities of this mineral in addition to those, mentioned in the geological remarks. It occurs abundantly in Nova Scotia; but its geological situation the writer has been unable to ascertain.

In the *United States*. In *Virginia*, Sulphate of lime occurs near Abingdon, on Holstein river—also in fibrous masses near Preston's salt works. *(Seybert.)* In *Maryland*, in small quantities near Baltimore—and fine crystals of Selenite are found in the alluvial soil on Chesapeak Bay. *(Hayden.)*—In *New Connecticut*, at Poland, Trumbull Co. in fine crystals, resembling those from Oxford, England. *(Silliman.)*—Near *Niagara Falls*, both Selenite and Gypsum occur in connexion with fetid limestone; *(Mitchill.)* this Gypsum is sometimes snow white and granular.—In *New York*, Sulphate of lime is very abundant in several parts of the State, particularly in Onondago and Madison counties; also in the vicinity of Cayuga lake, whence, in 1812, 6000 tons of Gypsum were exported to Pennsylvania; *(Beck,)*—near Onondago it is sometimes laminated and specular, and the Gypsum of that vicinity has usually a dark color, sometimes nearly black; it is sometimes fibrous;—at Sullivan, the Gypsum is either brownish or white;—in the vicinity of Saratoga springs, Sulphate of lime is said to exist in limestone.—In *Massachusetts*, in small quantities at Milton, near Boston.

(Uses.) Sulphate of lime, particularly Gypsum, has been employed in several countries, as a manure for dressing the soil, and appears to be useful both on sandy and clayey soils. Its action on the soil, or the plant, is not yet perfectly well explained; but it probably operates in some degree, as a stimulant. In many parts of the United States it has been found an important article of manure in the cultivation of grasses, roots, and grain.

Sulphate of lime, both Gypsum and Selenite, is employed in the imitative and ornamental arts. We have already noticed the use of compact and granular Gypsum under the name *Alabaster*. It is, however, less durable and less valuable, than marble, for works in statuary.

This mineral, when deprived of its water of crystallization by calcination, constitutes *plaster*; and this plaster, when mixed with a certain quantity of quicklime, forms a good cement. But the finer kinds of plaster, especially that obtained by calcining selenite, being reduced to powder, and mixed with gum water, are employed for casting statues and busts in moulds, for taking impressions of medals, &c. and for *stucco* and other ornamental works. In the stucco, various colors, previously ground in water, are introduced. All these works, when dry, are susceptible of a polish.

The temple of Fortune, called Seja, appears to have been built with some variety of sulphate of lime. It had no windows, but transmitted a mild light through its walls. (Pliny L. 36. c. 22.)

Species 6. Anhydrous Sulphate of Lime.*

It is not many years, since the characters of this mineral, as a distinct species, were well established. It now appears, that a total absence of the *water of crystallization* is essential to this salt; and hence it is called *anhydrous*.†

It scratches crystallized carbonate of lime, and of course is considerably harder than the common sulphate of lime; indeed it is not very easily scratched by fluate of lime. When its structure is foliated and regular, the laminæ easily separate in three directions, at right angles to each other, thus giving a prism, whose bases are parallelograms, of which the sides are as 13 to 16. This primitive solid, which is nearly a cube, is further divisible into triangular prisms, showing the form of the integrant particles. Its spec. gravity is from 2.92 to 2.96.

(Chemical characters.) Before the blowpipe it does not whiten and exfoliate, like the preceding species, but the edges of small fragments are converted into a friable, white enamel. Its varieties are not equally fusible, and it is sometimes necessary to make the flame play on the edges of small fragments.

According to Vauquelin it is composed of lime 40, sulphuric acid 60; Klaproth and other chemists have obtained similar results.

This substance sometimes absorbs water by exposure to the air, and passes to the state of a common sulphate of lime; and is then called *epigene* by Haüy. During this change, it is rendered more tender, its texture becomes less foliated, or nearly compact, and its specific gravity is reduced, sometimes to 2.31. The same specimen is sometimes only in part anhydrous, the other part having imbibed water.

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* Chaux anhydro-sulfatée. Hauy. Chaux sulfatine. Brongniart. Muriacit. Werner. Bardiglione. Bournon.

† From the Greek *Ανυδρος*.

Var. 1. CUBIC SPAR.* This variety occurs both in lamellar masses, and in crystals, whose usual form is a rectangular four-sided prism, differing little from a cube, and having its lateral edges sometimes truncated. The two opposite, broader faces of this prism often have a strong, pearly lustre.

Its structure and fracture are very distinctly foliated; its lustre strong and often pearly; if, however, the fracture be not made in the direction of the natural joints, it is granular or uneven. It is more or less translucent, and sometimes limpid; its usual colors are milk white, or gray, sometimes with shades of yellow, red, or violet.

In the salt mines of Hall, in Tyrol, it is mingled with muriate of soda.—It sometimes accompanies sulphuret of lead, or magnetic iron. At Segeberg, in the Duchy of Holstein, it sometimes contains the borate of magnesia.

2. ANHYDRITE.† *JAMESON.* This variety scarcely differs from the preceding, excepting in its structure. It occurs in masses more or less compact, whose fracture is splintery and partly foliated, in consequence of interspersed laminæ; sometimes also its structure is fibrous. It is translucid, sometimes in small fragments only; and its colors are smalt blue, bluish white, milk white, gray, or violet red.

In the salt mines of Wieliczka, it is found mammillary, and in stalactites, which are often twisted, and were formerly supposed to be sulphate of barytes.

SUBSPECIES 1. SILICO-ANHYDROUS SULPHATE OF LIME.‡

Its structure is granular, much resembling that of some marbles. On hot iron it phosphoresces with an orange colored light. It is translucent at the edges, and its color is gray, sometimes with bluish veins. Its spec. grav. is 2.87.

It is easily fusible by the blowpipe, and contains 8 per cent. of silex.

This subspecies is found at Vulpino, near Bergamo, in Lombardy. It receives a good polish, and is employed as marble.

SPECIES 7. CARBONATE OF LIME.

On some accounts, this is the most interesting species, which the mineral kingdom contains. It exists more abundantly, than any oth-

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* Wurfelspath. WERNER. Cube spar. JAMESON. Chaux sulfatine spathique. BRONGNIART.

† Anhydrit. WERNER. Chaux sulfatine compacte. BRONGNIART.

‡ Chaux anhydro-sulfatée quartzifère. HAUY. Chaux sulfatine quartzifère. BRONGNIART.

or simple mineral, and is by some supposed to constitute one eighth part of the exterior crust of the globe. In fact, calcareous minerals, belonging to this species, are every day produced; arising either from the disintegration of Carbonate of lime, which had previously existed in the mineral kingdom, or proceeding from the decomposition of calcareous substances, once attached to animals. This mineral surpasses all others in the facilities, which it affords for the study of crystallography, by the frequent occurrence of its crystals, the diversity of their forms, the regularity of their structure, and the ease, with which they yield to mechanical division.

This species presents an unusual number of varieties, differing exceedingly from each other in their external characters. Hence, in many cases, it is necessary to depend chiefly on the chemical characters. It exists not only in extensive, amorphous masses, and under almost every imitative form, known in the mineral kingdom, but very frequently in crystals.

These crystals permit an easy separation of their component laminæ; and mechanical division obtains for the primitive form a *rhomb* (Pl. III,. fig. 12), that is, a solid, whose sides are rhombs, having their two acute angles 78° 28′, and their two obtuse angles 101° 32′. The faces of this rhomb are inclined to each other at angles of 75° 31′ and 104° 29′.* Its integrant particles have the same form, according to Haüy; but Bournon says they are triedral pyramids with inclined bases.—In some hexaedral prisms the primitive rhomb is visible to the eye, its summits touching the terminal faces of the prism.

Carbonate of lime is harder than sulphate of lime, but may always be scratched by iron, and usually by fluate of lime. When pure and crystallized, its specific gravity varies from 2.68 to 2.74. When transparent, it possesses the property of double refraction in a high degree, which may be observed by looking through two parallel faces of a rhomboidal crystal or fragment at a black circle, drawn on white paper.

Phosphorescence is not essential to this species; but some varieties phosphoresce, either by projecting them in powder on burning coals, or by friction, or indeed by both methods.

(*Chemical characters.*) Carbonate of lime is soluble in nitric acid; and, by the escape of the carbonic acid, more or less effervescence is produced; some varieties, however, effervesce very slowly. Before the blowpipe it decrepitates, and, if pure, is perfectly infusible; but, by a strong heat, its carbonic acid is driven off, and quick-

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* According to Dr. Wollaston, the angle last mentioned is 105° 05′.

lime or pure lime, whose taste is well known, remains.—It is insoluble in pure water; but, if the water contain carbonic acid, it dissolves a small quantity of this mineral.

It is composed, according to the analysis of Vauquelin, of lime 57, carbonic acid 43; a little water is usually present.

(Distinctive characters.) Its greater hardness, and its effervescence in nitric acid distinguish it from sulphate of lime.—It is less hard than fluate of lime, and does not, when its powder is thrown into warm sulphuric acid, yield a gas, capable of corroding glass.—From the zeolite it differs by the fusibility of the latter.—Like the carbonates of barytes, strontian, and lead, this mineral effervesces with nitric acid; but it differs from them by burning to lime, by possessing a less spec. gravity, and by being precipitated from its solution in nitric acid by the oxalate of ammonia.

The various structures and forms of this species, and the intermixture of foreign ingredients, more or less intimately combined, render numerous subdivisions absolutely necessary.

Subspecies 1. CALCAREOUS SPAR.*

This subspecies occurs in crystals more or less regular, or in laminated masses; and may hence be divided into two varieties.

Var. 1. CRYSTALLIZED CALCAREOUS SPAR. It rarely exhibits the primitive form in distinct crystals. The *Iceland spar*, from the island of that name, occurs in laminated masses, very easily divisible into rhombs, perfectly similar to the primitive rhomb.

Of this nucleus or primitive rhomb Haüy has described at least 104 modifications, or secondary forms. Count Bournon has enumerated 59 modifications of the primitive form; but these modifications are variously combined, two or more of them being sometimes exhibited in different parts of the same crystal, and give rise to 616 varieties of form, of which the Count has given figures. He has also described 63 additional varieties of form, arising from a greater or less extent of the faces of the crystals. Of these various forms, more numerous than those of any other crystallized substance, we can mention but a few, and chiefly the most common.

1. A very obtuse rhomb† (Pl. III, fig. 13.), whose axis is equal to

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* Kalk spath. Werner. Calc spar. Jameson. Chaux carbonatée pure spathique. Brongniart. Common spar. Kirwan. Le spath calcaire. Brochant.

† A solid rhomb may be supposed to arise from two triangular pyramids, applied base to base. The two solid angles, formed by the meeting of three *equal* plane angles, will be the two *summits* or vertices of this double pyramid

that of the primitive rhomb. Each of the plane angles at the summits is 114° 19′; and the mutual inclinations of its faces are 134° 26′ and 45° 34′. This variety is common; and, when its edges are rounded, its form is somewhat *lenticular*. This epithet, however, is sometimes extended to the perfect crystals. (Equiaxe. *Haüy.)*

2. An acute rhomb (Pl. III, fig. 14.); the plane angles of each face are 104° 29′ and 75° 31′, the latter being the measure of the angles at the summits; the mutual inclinations of its faces are 101° 32′ and 78° 28′. This form is common, and is often found in shell limestone, even in the interior of the shells. (Inverse. *Haüy.)*

3. A very acute rhomb, in which the plane angles at the summits are each 45° 34′.

4. A rhomb slightly acute (Pl. III, fig. 15.), and differing but little from a cube. The plane angles of each face are 87° 42′ and 92° 18′. (Cuboïde. *Haüy.)*

5. A dodecaedron (Pl. III, fig. 16.), composed of two six-sided pyramids, applied base to base. Each face is a scalene triangle. In each half of this dodecaedron three alternate edges contain an angle of 104° 29′, and the other three an angle of 144° 20′; but the more obtuse edges in one half are opposed to the less obtuse in the other half. This variety is common, and has been called *hog-tooth* spar. Its crystals have been seen more than a foot in length. (Metastatique. *Haüy.)*

6. The summits of the preceding dodecaedron are sometimes formed by three rhombic planes (Pl. III, fig. 17.), which are parallel to the faces of the inclosed nucleus. The terminating planes, at each extremity, stand on the three more obtuse and alternate lateral edges. (Binaire. *Haüy.)*

7. The preceding crystal (fig. 17.) is sometimes truncated on the six solid angles of the common base of the two pyramids by hexagonal faces (Pl. III, fig. 18.), so that the form assumes a prismatic aspect. (Bibinaire. *Haüy.)*

8. A regular six-sided prism. Two, three, or four of its sides are sometimes broader, than the other four, three, or two. (Prismatique. *Haüy.)*

9. A hexaedral prism with pentagonal sides (Pl. III, fig. 19.), ter-

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Each of the other six solid angles of the rhomb is also formed by the meeting of three plane angles, of which one is equal to an angle at the summits, and the other two are each supplementary to the same angle. The rhomb is said to be obtuse or acute, according as each of the plane angles at the summits is greater or less than 90°; and its axis is a line, connecting the two summits, minated at each extremity by three pentagonal faces, which stand on alternate lateral planes, and form with them an angle of 116° 34′. The sides of this prism are sometimes so shortened, that they become isosceles triangles, and the crystal then somewhat resembles the head of a nail. This variety is common; and the summits are often so striated as to indicate the decrements. (Dodécaèdre. *Haüy.)*

10. Sometimes the bases of the terminating pentagons of the preceding crystal are enlarged (Pl. III, fig. 20.), thus producing an inequality in the breadth of the sides. (Dilatée. *Haüy.)*

Two other varieties, somewhat uncommon, are represented in Pl. III, fig. 21 and 22.*

These crystals present a foliated fracture, which has ordinarily a strong vitreous lustre; the fragments are rhomboidal. They are sometimes only translucent, or even opaque, at least in part, but are usually either semitransparent or transparent. Though often limpid, they are frequently white, sometimes tinged with yellow, &c. they are also yellowish brown, or present some shade of gray, yellow, green, red, violet, or black. Not unfrequently a play of colors appears at the surface, which is sometimes confined to the vicinity of the two summits of a rhomb.

Some crystals, especially those of a yellowish brown color, and those from bituminous or shell limestone, phosphoresce on hot iron.

2. LAMINATED CALCAREOUS SPAR. This variety is the result of a crystallization more or less confined or disturbed. ~~The structure~~ is always foliated. Sometimes the laminæ are very large, regularly arranged, easily separable, and often transparent; they are in fact composed of little rhombs, applied to each other by similar faces, so as to form a continuous mass in the same plane.

In other cases, the laminæ are smaller and irregularly situated; and, as their size is reduced, this variety begins to exhibit the structure of granular limestone. Most frequently it is translucent; and is usually white, sometimes tinged with yellow, &c.

(Geological situation.) Both varieties of Calcareous spar most commonly occur in veins, associated with a great variety of other minerals, as quartz, fluate of lime, sulphate of barytes, the sulphurets of lead, zinc, &c. They are found in all classes of rocks, and are

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* Werner gives a general view of these crystals by referring them to three predominant forms, viz. a *triangular* and *hexangular pyramid,* both of which are usually double, and a *hexaedral prism;* from these he derives the other forms by truncation, bevelment, &c.

Bournon arranges them under three modifications of the primitive form, viz. *rhombs,* different from the primitive rhomb, *prisms,* and *pyramids.*

very common in metallic veins. The finest crystals are obtained from cavities in veins; or from fissures, or between strata, in compact limestone.

The laminated masses are most common in veins, traversing calcareous rocks.—One variety with small laminæ, irregularly arranged, is formed by the filtration of water into cavities. But this may be distinguished from that, which belongs to older formations, by being less hard, and by being usually intermixed with compact limestone.

(Localities.) Among foreign localities Derbyshire, Iceland, and the Hartz in Saxony are particularly distinguished.

In the *United States.* In *Kentucky*, it occurs in fine, rhomboidal crystals, equal to the Iceland spar. *(Seybert.)*—In *New Jersey*, at Schuyler's copper mine, near Newark.—In *Connecticut*, on Milford Hills, 5 miles W. from Newhaven, in laminated masses, penetrated with chlorite, and in rhombic crystals at the marble quarry on the same hills;—also at the lead mine in Middletown, mixed with the sulphurets of lead, zinc, &c. *(Silliman.)*

Subspecies 2. GRANULAR LIMESTONE.* *Jameson.*

This subspecies is the result of a confused or irregular crystallization. Its structure is both foliated and granular. The grains are of various sizes from coarse to very fine, sometimes indeed so fine, that the mass appears almost compact. When these grains are white and of a moderate size, this mineral strongly resembles *white sugar* in solid masses.

Its fracture is foliated; but the faces of the laminæ, which vary in extent, according to the size of the grains, are sometimes distinguishable only by their glimmering lustre. When the structure is very finely granular, the fracture often becomes a little splintery.

Both its hardness and the cohesion of its grains are somewhat variable. It generally appears to be a little harder, than calcareous spar; and, in some cases, this hardness undoubtedly depends on the presence of siliceous particles; indeed it sometimes gives a few sparks with steel. Its spec. grav. usually lies between 2.71 and 2.84.

It is more or less translucent, but, in the dark colored varieties, at the edges only. Its color is most commonly white or gray, often snow white, and sometimes grayish black. It also presents certain shades of blue, green, red, or yellow. Most frequently the colors are uniform, but sometimes variegated in spots, veins, or clouds, arising from the intermixture of foreign substances.

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* Körniger kalkstein. Werner. Chaux carbonatée saccaroïde. Haüy. Brongniart. Foliated and Granular limestone. Kirwan. Pierre calcaire grenue. Brochant.

Some varieties of Granular limestone are flexible, when sawn into thin slabs.

Granular limestone is sometimes a pure Carbonate of lime. *(Bucholz.)* In a specimen of Carrara marble Kirwan found $\frac{3}{100}$ of alumine, and a few minute crystals of quartz.

It is, in most cases, distinguishable from the Dolomite, a magnesian Carbonate of lime, by the slow efferveecence of the latter in nitric acid.

(Geological situation.) Granular limestone exists in very large masses, and is almost exclusively found in primitive rocks. When thus found, it never embraces any remains of organized bodies. Sometimes, indeed, it has been observed among secondary rocks, but the shells, which it then contains, or its accompanying minerals, easily determine its relative age.

In some instances it forms the mass of the whole mountain; but more commonly it occurs in beds, which are often of very considerable extent and thickness, and sometimes more or less distinctly stratified. These beds are often contained in gneiss, mica-slate, argillite, porphyry, and greenstone; they alternate with these rocks, have the same inclination, and are undoubtedly of contemporaneous formation. Indeed this limestone is often mixed with the rock, which contains it, and even becomes one of its constituent parts. In the Pyrennees, according to Lapeyrouse, vertical beds of Granular limestone alternate with *granite*, and trap, or the limestone is even intermixed with those rocks.

This limestone contains various simple minerals, among which are quartz, mica, talc, garnets, tremolite, actynolite, asbestus, hornblende, serpentine, the sulphurets of lead, iron, &c. arsenical and magnetic iron, &c. The mica sometimes gives it a slaty structure.

(Localities.) There are few countries, in which Granular limestone is not found. Italy and Greece furnished the ancients with valuable quarries.

In the *United States*, there are numerous localities, of which we select a few. In *Maryland*, 9 miles from Baltimore, where it is employed to furnish marble; it is sometimes very white, semitransparent, and composed of large grains. *(Gilmor.)*—In *Pennsylvania*, in Montgomery Co. on the Schuylkill, in the town of White Marsh, &c. from 10 to 15 m. from Philadelphia; its quarries have been open several years. *(Conrad.)*—In *Connecticut*, on the Milford Hills, 7 miles W. from Newhaven; this limestone is distinctly stratified, and its strata have the same direction with the greenstone slate, in which they are contained, and with which they sometimes alternate; it has a fine grain, and is traversed by veins of calcareous spar, and magnesian limestone; these calcareous strata have an extent of several miles in length by about one fourth of a mile in breadth, and, toward the eastern extremity, are mixed with serpentine, &c.—also at New Milford, Reading, Oxford, Derby, &c. often very white, with large foliæ, and frequently penetrated by crystals of tremolite. (*SILLIMAN.*)—In *Rhode Island*, at Smithfield, where it occurs snow white, of a fine grain, translucid, and perfectly resembles the Carrara marble of Italy. (*MEADE.*)—In *Vermont*, at Pittsford, Middlebury, and various other places between the Green Mountains and Lake Champlain; at Middlebury the strata are irregular and inclined to the northwest. (*HALL.*)—In *Massachusetts*, at Stockbridge, &c. in Berkshire Co.; this range of limestone extends from Stockbridge through Pittsfield, Lanesborough, &c. to Bennington in Vermont, and is thence probably continued through that state to the Michiscoui river;—in Newbury, about 2 miles from Newburyport, it occurs fine grained, with veins of precious serpentine, amianthus, &c.—In *Maine*, at Brunswick, in beds, which have the direction and inclination of all the stratified rocks in the vicinity, viz. from S. W. to N. E. and inclined at about 45°. The contiguous strata are somewhat variable and uncommon in their composition; sometimes they are composed of hornblende, mica, and limestone, and are perfectly fissile; sometimes of quartz and actynolite, stratified; and sometimes they form a kind of gneiss, which even passes into granite. The limestone is whitish or gray, large grained, and contains actynolite, talc, sulphuret of iron, both common and magnetic, &c.—In Thomaston, Lincoln Co. its beds have the same direction, as those of Brunswick; but the limestone is fine grained, and usually variegated with shades of gray and blue.—It occurs also in the interior of Maine, but has not been examined.

(*Uses.*) This, like other varieties of limestone, may be burnt to lime for preparing mortar, or employed as a flux for certain ores, particularly those, which contain alumine and silex. But it is more peculiarly appropriated to *statuary*, decorations in architecture, and other ornamental works, under the name of *marble*; it is hence sometimes called *statuary marble*; and also *primitive* marble from its geological situation.

In strict propriety the term *marble* should be confined to those varieties of Carbonate of lime, which are susceptible of a polish; including also some minerals, in which Carbonate of lime abounds. Among artists, however, this term is sometimes extended to serpentine, basalt, &c. when polished.

Both granular and compact limestone furnish numerous varieties of marble; but those, which belong to the *former*, exhibit a more uniform color, are generally susceptible of a higher polish, and are hence most esteemed for statuary, and some other purposes. The uniformity of color, so common in primitive marbles, is sometimes interrupted by spots, or veins, or clouds of different colors, arising from the intermixture of hornblende, serpentine, talc, &c. &c.—Of foreign marbles we mention a few.

The *Carrara marble*, found in Tuscany, was highly esteemed by the ancients, and is most employed by the moderns for statuary. It is very white, sometimes veined with gray, and has a grain considerably fine.

The *Luni marble*, found also in Tuscany, is extremely white, and its grain is a little finer, than that from Carrara. Of this marble Dolomieu and indeed most mineralogists suppose the famous Apollo of Belvidere to be made.

The *Parian marble*, obtained from the isles of Paros, Naxos, &c. in the Archipelago, was much employed by the ancients. It is white, but often with a slight tinge of yellow. Its grains are larger than those of Carrara marble. The celebrated Venus de Medicis is of this marble. It is the *Lychnites* of the ancients, its quarries being often worked by the light of a *lamp*.

The *Cipolin marble*, anciently obtained from Egypt, is marked with greenish stripes or veins, composed of talc or mica.

The *Pentelic marble*, from Mount Penteles, near Athens, resembles the Parian, and is sometimes striped, like the Cipolin. Of this was made the statue of Esculapius, and many celebrated works of Athens.

Green antique marble (verde antico of the Italians) is an irregular mixture of this limestone and serpentine. The word *antique* is generally applied to those marbles, whose quarries are now unknown, or not explored.

In the United States are many beautiful and valuable marbles; but the state of the arts has not yet caused them to be extensively quarried, or even sufficiently explored. The following are among those best known.

Philadelphia or Schuylkill marble.[*] Its colors are white, or rather grayish white, either uniform, or variegated with veins or clouds of a darker color, and sometimes bluish. It is, in general, composed of large grains. This marble has been much employed for ornamental work in architecture, &c.

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[*] Notwithstanding the efforts, which the writer has made to obtain information, he has reason to fear, that this account of American marbles is, in some instances, incomplete.

Newhaven marble. The texture of this very beautiful marble is granular, but very fine. Its predominant colors are gray or blue, richly variegated by veins or clouds of white, black, or green; indeed the green often pervades a large mass. It takes a high polish, and endures the action of fire remarkably well. This marble contains chromate of iron, magnetic oxide of iron, and *serpentine;* hence it resembles the *vert antique*, and is perhaps the only marble of the kind hitherto discovered in America. (SILLIMAN.)

Vermont marble. It is, in general, fine grained, and sometimes nearly compact. Its quarries have been opened at Middlebury, Pittsford, &c. The marble from Pittsford is white, either pure, or shaded with gray, &c. It is conveyed by the waters of Otter Creek to Middlebury, where it is manufactured.—The Middlebury marble is sometimes of a pure white, resembling some varieties of Italian marble; but the predominating color is gray of different intensities. This marble receives a good polish, and is manufactured into tombstones, chimney jambs, window caps, &c. During the years 1809 and 1810, 20,000 feet of slabs were cut by one mill, containing 65 saws; and the sales of marble, during the same period, amounted to about 11,000 dollars. (HALL.) Some of the Vermont marbles are as white, as the Carrara marble, with a grain intermediate between that of the Carrara and Parian marbles.

Stockbridge marble, from Berkshire Co. Mass. Its grain is somewhat coarse, and its color is white, sometimes with a slight tinge of blue.—A quarry has also been opened at Pittsfield in the same county.

Thomaston marble, from Lincoln Co. Maine. It is, in general, fine grained, and its colors are often richly variegated. Sometimes it is white or grayish white, diversified with veins of a different color. But, in the finest pieces, the predominant color is gray or bluish gray, interrupted by whitish clouds, which, at a small distance, resemble the minutely shaded parts of an engraving; and, at the same time, traversed by numerous small and irregular veins of black and white. It receives a fine polish, and is well fitted for ornamental works. These quarries, considering their vicinity to navigable water, and the great beauty of the marble, will undoubtedly, in a few years, be extensively worked.

Some of the white marble of Vermont, and that, which may probably be obtained at Smithfield, in Rhode Island, more peculiarly deserve the name of *statuary* marble.

Flexible marble. This has been observed at Pittsford, Rutland Co. in Vermont, and at Pittsfield, &c. Berkshire Co. in Massachusetts, at the latter of which it was first discovered by Dr. Meade. According to the experiments of this gentleman on the Pittsfield marble, its flexibility depends on the presence of a certain quantity of moisture; for, when flexible slabs of this limestone are exposed to heat, they lose their flexibility, but immediately recover it, when plunged in water. All the marble of this quarry is not flexible; those slabs, however, which are so, exhibit this property immediately after being taken from the quarry; but the eye cannot distinguish them without experiment. —On the contrary, the flexibility of certain European limestones, which were probably Dolomites, has been supposed to be *produced* by the action of heat, and the consequent escape of the natural moisture of the mineral. (See Bruce's Min. Jour. v. i. pp. 93, 267.)

Subspecies 3. FIBROUS LIMESTONE.*

It occurs in masses, composed of imperfect crystals or fibres. Sometimes these fibres are coarse, and feebly adhere, or are tapering toward their extremities, and hence appear partly detached from each other. Sometimes they are very delicate, firmly adhere, and thus form solid masses. These fibres, whether straight or curved, are most commonly parallel; and their cross fracture is uneven or undulated, with a resinous lustre. It is more or less translucent, and its usual colors are white or gray, often with shades of yellow, red, or green.

It has also been observed with diverging or radiating fibres; and sometimes in cellular masses, whose fibres are reticulated. *(Bournon.)*—It is harder than fibrous gypsum, which it often resembles.

SATIN SPAR. This is a delicate, fibrous limestone, susceptible of a fine polish, and exhibiting the lustre of satin. Its color, often grayish, is sometimes a pale rose red. It is employed for inlaid, ornamental work.

Very beautiful specimens of satin spar are found in Cumberland Co. England. It sometimes embraces sulphuret of iron.

Fibrous limestone is usually found in veins, or between the strata of other calcareous minerals.

In the *United States*. In *Maryland*, near Baltimore. In *Pennsylvania*, at Cumberland valley, 15 m. from Bedford; it is amber colored and semitransparent. *(Seybert.)* In *Massachusetts*, at Newbury, two miles from Newburyport, near the turnpike, specimens of satin spar have been found.

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* Gemeiner fasriger kalkstein. WERNER. Common fibrous limestone. JAMESON. Chaux carbonatée fibreuse. HAUY. Chaux carbonatée fibreuse massive. BRONGNIART.

Subspecies 4. COMPACT LIMESTONE.[*] *Kirwan.*

The uses and geological characters of this subspecies render it peculiarly interesting. The term *compact*, however, as applied to this mineral, must be received with some latitude; for, although its texture is often very close and compact, sometimes like that of wax, in other instances it is loose and earthy.

It usually occurs in extensive, solid, compact masses, whose fracture is dull, splintery, or even, and sometimes conchoidal. It is sometimes traversed by minute veins of calcareous spar, which reflect a little light; and some compact limestones are also slaty. Its hardness is somewhat variable, and some specimens, containing siliceous particles, give a few sparks with steel. Its spec. gravity usually lies between 2.40 and 2.75.

It is opaque, or translucent at the edges; its more common color is gray, often with shades of yellow, blue, &c. and indeed varying from grayish white to grayish black; it also presents certain shades of yellow, blue, brown, green, and red. These numerous colors are sometimes very lively, and frequently mingled in the same specimen in spots, stripes, veins, clouds, landscapes, &c. It is usually more or less susceptible of a polish.

It is sometimes dendritic; and these dendrites, produced by the filtration of water, containing the black oxide of iron or manganese, may be only superficial, or extend through the mass. In the latter case, the dendrites are best observed by cutting the mineral perpendicularly to the fissures, by which the water entered.

Compact limestone is seldom, perhaps never, a pure Carbonate; but contains from 2 to 12 per cent. of silex, alumine, and the oxide of iron, on the last of which its diversified colors depend. In fact, by increasing the proportion of argillaceous matter, it passes into marl. Some limestones, which effervesce considerably, are still so impure, that they melt, rather than burn to lime.

Var. 1. EARTHY COMPACT LIMESTONE.[†] Its texture is loose and porous, and hence this variety often absorbs a large quantity of water. Its spec. gravity, depending on its texture, is sometimes below 2.00.

Its fracture is dull, earthy or uneven, and, though sometimes fine, is usually coarse grained; indeed the mass seems to be sometimes composed of a kind of calcareous sand. It is sometimes tender and

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[*] Gemeiner dichter kalkstein. WERNER. Common compact limestone. JAMESON. Chaux carbonatée compacte. HAUY. Chaux carbonatée Marbre et compacte. BRONGNIART. La Pierre calcaire compacte commune. BROCHANT.

[†] Chaux carbonatée grossière. HAUY. BRONGNIART.

friable, and sometimes solid. Its more common colors are white and gray, often with shades of yellow, brown, &c. It does not receive a polish.

(*Geological situation.*) It has already been remarked, that granular limestone is almost invariably characterized, as a primitive rock, by its relative situation and freedom from organic remains. As the grain becomes finer, the transparency and crystalline structure gradually diminish, and the mineral passes into a compact limestone; it then associates with a different class of rocks, and begins to contain organic remains or petrifactions.

The *older* varieties of compact limestone are very often found in the vicinity of primitive or transition mountains, sometimes placed against their sides, or even on their summits. They sometimes form whole mountains, or even a chain of mountains, and are often found at a great elevation, as on the summits of the Pyrennees. They occur in beds, often very thick, and usually more or less inclined. They always lie above the primitive rocks, and never alternate with them.

These *older* varieties of compact limestone sometimes contain, in beds or veins, the sulphurets of lead, zinc, iron, and mercury, the oxides of zinc, manganese, and iron, certain ores of copper, &c. They sometimes embrace garnets, steatite, and mica.—Petrifactions do indeed occur in all the varieties of compact limestone, but they usually increase in number and variety, as the deposite becomes more recent.

On the other hand, the *most recent* varieties of compact limestone appear under plains, or constitute hills or low mountains, usually at some distance from primitive mountains. They most commonly contain a great quantity of *shells*,* or other petrifactions.

Hills of compact limestone, seldom of a conical form, are often terminated by plains, or by rounded summits, and their sides are sometimes nearly perpendicular.

We shall describe more particularly three distinct formations; the two former of which fall among the *older* varieties, mentioned in the preceding general remarks.

One of these formations appears to belong to the intermediate or transition class of rocks. The limestone of this formation is always more or less compact, or, if in any degree granular, extremely fine grained. Its fracture is splintery or conchoidal; and its fragments have more translucency at the edges, than those of secondary limestone. Its colors are remarkably variegated; and it often contains

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* The shells, which exist in limestone, may be composed of carbonate of lime; or have a siliceous crust, enveloping the calcareous part; or be entirely siliceous.

white veins of calcareous spar. Its beds, frequently very thick, and indistinctly stratified, are often deposited directly upon argillite or other primitive strata, and sometimes alternate with gray-wacke slate, amygdaloid, hornblende, or greenstone. It sometimes contains organic remains of ammonites, belemnites, corallites, &c.

The formation next to be mentioned is decidedly secondary. It is distinctly stratified; its beds or strata, which vary much in thickness, are seldom horizontal, often greatly inclined, and frequently waved or twisted, still remaining parallel to each other. It often rests upon red sandstone, and is, at the same time, covered by gypsum. It sometimes alternates with clay, marl, or bituminous marlite, impregnated with ores of copper; but is seldom connected with coal.

It contains sulphate of barytes, calcareous spar, and beds of fetid limestone. It also embraces small tuberose masses of hornstone and flint, intimately united with the limestone, and sometimes arranged in beds. Petrified fish, gryphites, ammonites, and other organic remains are common in this formation, but usually less numerous than in *shell* limestone.—In Peru it is often traversed by veins of silver ore.

Another formation of secondary limestone, more recent than the preceding, is called coarse or *shell limestone*. This is found in hills with rounded summits, or resting beneath the surface of a level country. Its strata, sometimes very thin, are commonly horizontal, and not waved, like those of the preceding formation. They frequently alternate with marl, clay, sandstone, and sand, with the last of which they are often contaminated. Hornstone and flint under various forms appear also in this formation.

It is sometimes bituminous; but coal and metallic substances, the oxide of iron excepted, are extremely rare. In some instances it embraces a great variety of shells, belonging to different families, promiscuously intermingled; but frequently, in a succession of different beds, shells of the same family are found together. Sometimes the whole mass is only an aggregation of shells.

Shell limestone sometimes rests on gypsum. In other cases, as in the vicinity of Paris, it rests on a bed of clay, which separates it from chalk; and it is there *covered* by gypsum, belonging probably to the latest known formation of that mineral. In upper Lusatia it alternates with sandstone, and both rest on alluvial earths. (*Jameson.*)

Strata of shell limestone often present rents, fissures, and caverns, which contain calcareous crystals or concretions, or argillaceous oxide of iron. These caverns are particularly remarkable for containing the bones of quadrupeds and other land animals, sometimes belonging to different climates and extinct species. The bones are found on the floor of the cavern, or imbedded in a limestone, which is obviously of more recent formation, than the sides of the cavern. Such caverns are found in Gibraltar, and Dalmatia on the Mediterranean, &c. No human bones, inclosed in minerals, have yet been observed.* (CUVIER.)

(*Localities.*) Of Compact limestone, so abundantly diffused, it is unnecessary to enumerate localities. The shell limestone of England and that of France, bordering on the English Channel, probably belong to the same strata, once continuous.

It is a predominant rock in that section of the *United States*, contained between the Alleghany Mountains, the Lakes, and the Missisippi, as general boundaries.

(*Uses.*) Compact limestone is employed to furnish lime, or marble, or as a building stone. The purest white marble or limestone undoubtedly furnishes the best lime, though but little superior to that, obtained from gray Compact limestone. The calcination of limestone may be effected by wood, coal, or peat, as fuel; but the heat should not much exceed a red heat, unless the stone employed be nearly a pure carbonate.—On this subject, and the preparation of mortar we have room for but few remarks.

Count Rumford, with his usual attention to economy in fuel and in the expense of caloric, has invented an oven for preparing lime. It has the form of a high cylinder with the hearth at the side, and at some distance above the base. The combustible, placed on the hearth, burns with an inverted or reflected flame. The lime is taken out at the bottom, while fresh additions of the limestone are made at the top; and thus the oven is preserved constantly hot.

Limestone, recently dug, and of course moist, calcines more easily, than that, which has become dry by exposure to the air; in the latter case it is found convenient even to moisten the stone, before putting it into the kiln.

(*Mortar.*) This is known to be a mixture of slacked lime and sand, or of some ingredient equivalent to the sand; such as clay, baked hard and reduced to powder. Much depends on a due calcination of the limestone, the fineness of the sand, and a just proportion of water. The addition of small quantities of the oxides of iron

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* Some human skeletons were found a few years since at Guadaloupe in a bed of hard limestone, which closely adheres to the bones. A part of one is now in the hands of *Cuvier*. Another, perfect from the neck to the ancles, was lately transmitted by Sir Alex. Cochrane to the British Muséum. (Christian Observer, Feb. 1814.)

and manganese renders the mortar more solid, and capable of becoming hard under water. Some limestones contain the oxide of manganese, and yield a lime, which becomes brownish by exposure to the air; and is often called *meagre* lime.*

If a suitable quantity of quicklime in powder be added to a mortar, prepared with one part slacked lime and three parts sand, very great solidity will be produced. Similar advantages may be obtained by employing the least possible quantity of water, or by the addition of pounded bricks, or puzzolana, a volcanic product. Indeed most varieties of trap or *greenstone*, when pulverized, having been previously heated red hot and plunged into water, may be employed with great advantage in the preparation of water proof mortar for piers, docks, &c. (*SILLIMAN.*) In constructing the Eddystone lighthouse Mr. Smeaton employed meagre lime 2 parts in bulk, pure sand 3 parts, and *trass*, a pseudo-volcanic product, 1 part. A compact limestone, found near Boulogne, yields lime, capable of being formed into very good mortar without addition; it contains carbonate of lime 73, silex 15, iron 7, alumine 5. (*DRAPPIER.*)

Compact limestone is also an important article of manure, for which purpose the shell limestone is generally preferred. Sometimes the stone is only pulverized; in other cases it is calcined. It has however been found by experiment, that those varieties of limestone, which contain magnesia, are injurious to vegetation, when applied after calcination. These magnesian limestones may generally be known by their slow effervescence in acids.

(*Secondary marbles.*) Compact limestone, more particularly that, which belongs to the older formations, furnishes many beautiful varieties of marble, employed in the arts. Their colors, though sometimes uniformly grey, yellow, red, or black, are usually much variegated.

In addition to the marbles, furnished by granular and compact limestone, there are others composed of a calcareous breccia. Their colors appear in spots, are well defined, and do not pass into each other. In fine, some minerals, which, when polished, are known under the name of marble, appear to be only indurated, calcareous marl.

Black marble is frequently colored by bitumen, which it discovers, when heated or rubbed; it also gives a white lime.

Some marbles contain a large proportion of shells, and to these are indebted for much of their beauty. Of these the most beautiful is the *Lumachella* marble from Bleyberg in Carinthia. The ground is gray

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* Meagre lime, when formed into mortar, requires less sand, than the other varieties. When limestone, containing manganese, is melted with twice its weight of nitre, a *greenish* trace remains on the sides of the crucible.

or brownish; but it contains fragments of shells, having a pearly lustre, sometimes irised, and sometimes reflecting an orange red, or green, or blue light.

Another interesting variety of marble is sometimes called *Florence* marble, from having been found near that city. Its color is usually yellowish gray, marked with various figures of a brownish or darker yellow, which exhibit a representation of houses, towers, and in fact of a city in ruins, with clouds and sky in the back ground. (Marbre ruiniforme. *Haüy.*) All this pleasing illusion, however, depends on the *distance* of the view.

The substances, employed in polishing marble, are, in general, sandstone or emery with water, followed by filings of lead and tin putty, or, if the marble have a light color, by pumice, and a mixture of calcined bones and alum.

White marbles, which have become yellowish or otherwise sullied, may be cleaned by washing them with diluted oxymuriatic acid.

Very few marbles, belonging to compact limestone in the *United States*, are yet known. In *Pennsylvania* at Aaronsburg, in Northumberland Co. is a black marble, containing white specks, like the Kilkenny marble. (*Mease.*)—In *New York*, at Marbletown in Ulster Co. a similar marble is found (Rees' Cyclop.);—also at Granville in Washington Co. a black marble is wrought;—a similar marble, containing shells, is found in the vicinity of Ticonderoga.

Subspecies 5. CHALK.* *Kirwan. Jameson.*

This well known substance is always amorphous, with a dull, earthy fracture. It may always be scratched by the finger nail; it is rough to the touch, soils the fingers, and *writes.* It adheres a little to the tongue. It is opaque and usually white, sometimes with a tinge of yellow; it also occurs gray or brown. Its spec. grav. varies from 2.25 to 2.66.

Chalk is very nearly a pure carbonate of lime, containing minute quantities of alumine and oxide of iron. It seems to have been deposited from a state of suspension, rather than solution in water.

(*Geological situation.*) Chalk is never found associated with primitive earths. It may rise into hills of considerable elevation, or appear many yards below the surface of a level country. It occurs in thick beds, seldom distinctly stratified, in most cases nearly or quite horizontal, but sometimes highly inclined or nearly vertical.

Beds of chalk almost always contain flint in masses of a moderate size, globular, cylindrical, tuberose, vesicular, &c. These mass-

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* Kreide. Werner. Chaux carbonatée crayeuse. Haüy. Chaux carbonatée craie. Brongniart. La Craie. Brochant.

es of flint are not promiscuously scattered, but usually arranged in numerous, parallel beds, in which, however, they do not lie contiguous to each other. The exterior of the flint is usually incrusted, or even penetrated by chalk.

Chalk also contains shells, among which are belemnites, echinites, &c. These shells are very often siliceous, and frequently the cavity itself is filled with a siliceous deposite. A piece of wood, well preserved, has been found in the chalk of Hampshire, Eng. *(Bournon.)*

Chalk is often mixed with sand; but neither coal, nor any metallic substance, excepting the sulphuret or oxide of iron, has been found in it.

In the vicinity of Paris the chalk is situated under shell limestone, from which it is separated by a bed of clay. It contains many organic remains, which are not found in the shell limestone above it; and seems to be peculiarly characterized by the belemnite. When connected with *shell* limestone, the chalk is perhaps always underneath.

In the isle of Wight is an elevated ridge of hills, extending nearly E. & W. and composed of strata of chalk nearly vertical, or forming with the horizon an angle of 60° or 80°; the lower beds do not contain flint. Underneath this chalk is found marl and calcareous sandstone, with subordinate beds of chert, limestone, clay, and carbonized wood. (Webster's paper before the Geolog. Society.)

(Localities.) Chalk is abundant in Upper Normandy, Champagne, and Picardy in France, extending into the Netherlands. In England it prevails in the counties of Kent, Sussex, Hampshire, Berkshire, Wiltshire, &c. It is found in Poland;—also on the islands of Rugen and Zealand in the Baltic.—In Antrim Co. Ireland, it is sometimes covered by basalt. *(Bournon.)*

(Uses.) Its uses are considerably numerous. It furnishes white crayons, and a base for water colors in painting. It furnishes *Spanish White*, to prepare which the chalk is reduced to powder, and agitated in a large quantity of water. When the sand has subsided, the water is poured off and permitted to rest, till the chalk is precipitated.

Subspecies 6. AGARIC MINERAL.* *Kirwan.*

It is composed of very minute particles, feebly cohering, fine or soft to the touch, and soiling the fingers. Its texture is spongy, and

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* Bergmilch. Werner. Rock milk. Jameson. Chaux carbonatée spongieuse. Haüy. Brongniart. Lait de montagne. Brochant.

hence it usually swims for a moment, when placed on water. Its color is white, either pure, or tinged with yellow, &c.—It is a very pure carbonate of lime.

Agaric mineral undoubtedly proceeds from the gradual disintegration of other varieties of carbonate of lime; and is deposited from water in the cavities or fissures of other calcareous rocks.

Var. 1. FOSSIL FARINA.* This variety differs but little from that just described, and has probably a similar origin. It appears in thin, white crusts, light as cotton, and very easily reducible to powder. These crusts are attached to the lateral or lower surfaces of beds of shell limestone, &c.

SUBSPECIES 7. CONCRETED CARBONATE OF LIME.

Calcareous concretions exhibit some diversity of structure, and an uncommon variety of imitative forms, resulting from the peculiar circumstances, under which they have been produced. Their structure is usually more or less crystalline. Sometimes they are compact, or porous. Frequently they appear in the form of a crust, and sometimes they are amorphous. But, in almost all cases, they are more or less obviously composed of a series of successive layers, nearly or quite parallel, whether straight, undulated, or concentric.

Var. 1. OOLITE.† This variety always occurs in globular or spheroidal masses, usually very small, but varying from the size of a poppy seed to that of a pea. These globules appear to be composed of a compact, calcareous nucleus, invested by concentric layers, variable in thickness. These layers, often perceived with difficulty, have in most cases a compact texture. The nucleus is sometimes detached, leaving its place empty. (*BOURNON.*)

The Oolite has a dull fracture, which appears to be splintery. It is nearly or quite opaque, and its color is brown, reddish brown, or yellowish gray.

These globules are almost always united by a calcareous cement; and the beds or masses, thus formed, are found connected with rocks of recent formation, more particularly with shell limestone and calcareous sandstone; sometimes also with compact limestone, or even with gypsum.

(*Remarks.*) The older mineralogists supposed these globules to be the petrified roes of fish; and hence the name *roestone*. Dauben-

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* Chaux carbonateé pulverulente. HAUY. BRONGNIART.

† L' Oolite. BROCHANT. Chaux carb. Oolithe. BRONGNIART. Chaux carbonatée globuliforme. HAUY. Roogenstein. WERNER. Roestone. JAMESON. Oviform limestone. KIRWAN. The name Oolite is derived from the Greek *Ωον*, an egg, and *Λιθος*, a stone.

tion and others suppose them to be limestone, granulated by attrition with water. This opinion, however, is inconsistent with the concentric layers, of which their exterior appears to be composed. The existence of these layers is denied by some, and indeed the closeness of the texture often renders it difficult to distinguish them.

2. PISOLITE.* This variety occurs in globular or spheroidal concretions, usually about the size of a *pea*, though sometimes larger. These concretions are composed of distinct, concentric layers, and almost invariably contain a grain of sand, or some other foreign substance, as a *nucleus*. The Pisolite is nearly or quite opaque, and has a dull fracture. Its color is usually white, often dull, or with a shade of yellow, &c.

These concretions, sometimes detached and scattered, are more frequently united by a calcareous cement. Thus united, they form masses of various sizes, and also continuous beds, which are sometimes covered by alluvial deposites.

The Pisolite has been found chiefly near the warm springs of Carlsbad in Bohemia, and the baths of St. Philip in Tuscany.

(Remarks.) The structure of the Pisolite and the situation, in which it is found, seem to indicate the mode of formation. The particles of sand, or nuclei of these concretions, were probably raised and suspended by an agitated, or rotatory motion of the waters of certain springs or streams, strongly impregnated with calcareous particles. These particles were then deposited around the floating nuclei, which, being thus incrusted with a series of layers, became sufficiently heavy to fall through the fluid.

3. CALCAREOUS SINTER.† This variety embraces most of the imitative forms of carbonate of lime, and may be *stalactical*, tuberose, reniform, globular, cylindrical, tubular, branched, or in large, undulated masses, &c. But, under all its forms, it is composed of a series of successive layers, concentric, plane, or undulated, and nearly or quite parallel. These layers, however, in some cases are not distinct, unless the mass be large.

The structure of these concretions is more or less crystalline, according to the different circumstances, under which they were formed. The fibrous structure most frequently occurs; and the cross fracture of the fibres, though often foliated, is, in some cases,

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* La Pisolite. BROCHANT. Chaux carb. concret. Pisolithe. BRONGNIART. Erbsenstein. WERNER. Peastone. JAMESON. Chaux carb. globuliforme. HAÜY. The term Pisolite is derived from the Greek Πισον, a pea, and Λιθος, a stone.

† Kalksinter. WERNER. Calc sinter. JAMESON. La Stalactite calcaire. BROCHANT.

undulated or uneven. These differences, however, of the cross fracture are united by imperceptible shades.

STALACTITE.* These stalactites, particularly when small, are most frequently conical or cylindrical. But when larger, they become irregular, their surface being tuberose, undulated, &c. and sometimes even branches appear. Their external surface is commonly rough, often coated with minute crystals. In some instances a well defined crystal terminates the stalactite; in other instances a protuberance appears near the extremity, forming a kind of cap, resembling a mushroom, &c. When these conical stalactites are short and large, they unite and appear reniform.

Their fracture, sometimes foliated, is commonly fibrous, with diverging or radiated fibres, having a moderate lustre; sometimes the texture appears compact and the fracture splintery. They are usually more or less translucent; their most common color is white, either pure, or tinged with gray, yellow, or brown; and they occasionally exhibit shades of green, red, blue, &c.

(Mode of formation.) Stalactites are evidently formed by the filtration of water, containing calcareous particles, through pores or fissures in the roofs of those caverns, which are frequent in limestone. The water, having percolated through the roof, there remains suspended in drops. Evaporation commences at the exterior of the drop, and the calcareous particles are deposited on the roof of the cavern in the form of a little ring, which extends by degrees, till a small tube is produced. The bore of this tube is, in most cases, gradually diminished by successive deposites, till it becomes entirely closed, and the stalactite then increases by concentric layers, applied to the *exterior*. Thus cylinders or cones more or less regular are produced, and sometimes so enlarged, that they unite with each other.

Tubular stalactites. Sometimes the initial tube just described does not become obstructed, but passes longitudinally through the axis of the stalactite. Such stalactites sometimes have a uniform thickness, like a quill. Their structure is distinctly foliated; sometimes the laminæ extend through the diameter of the cylinder, but still present the cavity of the tube in the place of the axis.

STALAGMITE.† (Alabaster.) While the stalactite is forming, a part of the water drops from the unfinished stalactite on the *floor* of the cavern, or trickles down the sides, and thus produces those cal-

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[*] The terms stalactite and stalagmite are derived from the Greek Σταλαζω, to drop.

[†] Chaux carb. conoret. Albâtre. BRONGNIART. Chaux carb. concret. stratiforme. HAUY.

careous concretions, called *stalagmites*; and, when large, they often bear the name of *alabaster*. These concretions, when attached to the sides of the cavern, are merely plates or thin crusts. But, on the floor of the cavern, they often form large masses, sometimes rising, till they meet the stalactites, pendent from the roof, and extending in all directions, till the whole cavern is nearly or quite filled.

These deposites are essentially composed of parallel layers, almost always undulated, and conformable to the surface of the soil, on which they rest. Sometimes large protuberances are formed, and indeed a great variety of imitative forms are produced even by the spray or scattered drops from the surface of the growing stalagmite. Hence, with the assistance of a lively imagination, the observer may perceive in these caverns almost any object, which he pleases; hence the glowing and luxuriant descriptions of the travellers, who have entered them, especially with the light of a candle.

These concretions may have a foliated, fibrous, or granular structure; and their parallel layers may, in general, be distinguished by a difference of density, or translucency, or color. Their color is seldom a pure white, but more frequently presents a shade of yellow, red, or brown, arranged in undulating or concentric stripes, or in spots.

(Geological situation.) We hardly need remark, that calcareous sinter is found only in fissures, or in caverns, often very large, which so frequently exist in calcareous rocks. Certain springs, however, whose waters contain carbonate of lime, often form deposites, which may be referred to this variety.

(Localities.) Among the more remarkable foreign localities of calcareous sinter are the grotto of Antiparos in the Archipelago, Bauman's cave in the Hartz, Pool's Hole in Derbyshire, the caves of La Balme in Savoy and of Auxelle in Franche-Comté.

In the *United States* are many caverns of a similar nature. Among these are Madison's cave, on the north side of the Blue Ridge, and Wier's cave, about 15 miles from Staunton, Augusta Co. both in *Virginia*;—also Hughes' cave, in Washington Co. *Maryland.*

(Uses.) When any of these concretions, but more particularly the stalagmite, becomes large and is susceptible of a good polish, it is employed in the arts under the name of *alabaster* or calcareous alabaster. And, although this alabaster and marble are composed of the same ingredients, it is not, in general, difficult to recognise the former by its parallel layers, and the arrangement of its colors already mentioned.

A very singular mode of manufacturing calcareous alabaster has been invented by Dr. Vegni, and employed at the hot baths of St. Philip in Tuscany. This water, impregnated with carbonate of lime, is made to fall, in very minute drops, into hollow moulds, representing various works in bas relief. After a few months a very beautiful, white deposite is produced, sufficiently hard, and faithfully exhibiting the bas relief.

4. CALCAREOUS TUFA.* This substance is depösited from water under circumstances very unfavorable to crystallization; often indeed from water in rapid motion. It is, in fact, chiefly an earthy precipitate, and is sometimes almost destitute of solidity. It is seldom compact, but usually in porous, cellular, or corroded masses, whose surface is often undulated. Its fracture is dull, earthy, or uneven, and seldom gives indications of a foliated or fibrous structure. It is nearly or quite opaque, and usually gray, often with a shade of yellow.— It has a low but variable specif. gravity, and its hardness and solidity are much increased by exposure to the air.

Tufa is impure, and often contains sand, leaves, mosses, and other vegetables, fluviatile shells, and even the horns and bones of animals. It sometimes resembles indurated mortar, or is in branches, &c.

(Geological situation.) Calcareous tufa, though sometimes in large masses, is found in alluvial earths and never at a great depth below the surface. It is sometimes deposited from rain water, which has washed calcareous substances.

A tufa of a fine grain, porous or nearly compact, is sometimes found immediately under the soil, or under beds of clay or marl, in vallies, surrounded by calcareous mountains, whence it has originated. It often contains fluviatile shells, and sometimes marine shells, brought from the mountains.

(Uses.) It is sometimes sufficiently hard to be employed as a building stone. The city of Pasti in Italy is said to be built with a tufa. The *travertino* of the Italians, of which the churches and other monuments of Rome are constructed, is by some supposed to be tufa, while by others it is referred to compact limestone.

CALCAREOUS INCRUSTATIONS.† These are a kind of tufa. They are found investing the exterior of other bodies, and thence derive their form. Among the substances thus incrusted are other minerals, organic bodies, particularly those belonging to the vegetable kingdom, and the interior of tubes or cavities. Hence the interior of certain aqueducts becomes gradually incrusted, and eventually filled by

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* Kalk tuff. WERNER. Calc tuff. JAMESON. Chaux carb. concret. tuf. BRONGNIART.

† Chaux carb. concret. incrustante. HAÜY. BRONGNIART.

calcareous deposites from the water, which passes through them; of which there is a striking example in the waters of Arcueil, near Paris.—Hence in the formation of calcareous *geodes*, the cavity is generally incrusted before the production of those crystals, which often render their interior extremely beautiful.

Vegetables even of the most delicate texture, when immersed in waters, containing carbonate of lime, become incrusted, but still preserve their form perfectly distinct in every branch. Hence the origin of the *osteocolla*, to which has been attributed the property of facilitating the union of a fractured bone. It is in fact the incrusted stem of a vegetable, and somewhat resembles the bone of an animal; for the stem itself becomes decayed, leaving a cavity or blackish line.

Carbonate of lime is sometimes *pseudomorphous*, having been moulded in the cavity of a shell, or some other substance. Of this the *ammonite* (cornu Ammonis) is an example.

Subspecies 8. ARGENTINE.* *Kirwan.*

This mineral has a laminated or rather slaty structure. Its laminæ or layers, often curved or undulated, are seldom perfectly parallel; but their surface has almost always a pearly lustre, somewhat shining. According to Bournon, these laminæ are composed of minute rhombs, whose summits are so deeply truncated perpendicularly to the axis, that only a very thin portion of the rhomb remains. Indeed this mineral sometimes presents the primitive rhomb. It is translucent, at least at the edges; and its color is white, shaded with gray, green, or red. It is easily broken; and its spec. grav. is 2.64. (*Kirwan.*)

It is nearly a pure carbonate of lime, often containing a little oxide of iron or manganese. (*Bucholz.*) Hence, at a red heat, it often becomes reddish brown.

It is found in primitive mountains. In Saxony it exists in limestone, associated with chlorite and the sulphurets of lead and zinc.

1. SILVERY CHALK.† *Kirwan.* This occurs in small masses, more or less friable, composed of lamellæ or scales, shining with a pearly lustre; sometimes its particles scarcely cohere. The scales, which compose this variety, are conjectured by Bournon to be truncated rhombs, similar to those of argentine, but irregularly arranged.

It is soft, or rather like silk, to the touch; opaque; and of a

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* Schiefer Spath. Werner. Slate Spar. Jameson. Chaux carb. nacrée. Haüy. Chaux carb. nacrée argentine. Brongniart. Le Spath schisteux, Brochant.

† Schaum erde. Werner. Foaming earth. Jameson. Chaux carb. nacrée talqueuse. Brongniart. L'ecume de terre. Brochant.

pearly white color, sometimes with a slight tinge of yellow or green. It is found in secondary calcareous mountains in cavities, or adhering to the limestone.

Subspecies 9. MAGNESIAN CARBONATE OF LIME.*

This mineral, while dissolving in nitric acid, produces, *in most cases*, a very moderate effervescence; sometimes indeed scarcely visible, unless the mineral be reduced to powder. And by this peculiarity, in connexion with some of its physical characters, it may generally be distinguished from the other subspecies of carbonate of lime. Some varieties, however, effervesce rapidly in nitric acid; and, in this case, unless some of the physical characters be sufficiently decisive, recourse must be had to some chemical experiment to ascertain the presence of magnesia.—It is harder, than calcareous spar; indeed some of its varieties strike fire with steel, but probably from the presence of quartz.

It presents two varieties, which resemble each other more closely in composition, than in external characters. A crystallized specimen of the common variety from the Tyrol yielded Klaproth carbonate of lime 52, carbonate of magnesia 45, oxide of iron 3. In a specimen of the Dolomite from St. Gothard he found carbonate of lime 52, carbonate of magnesia 46.50, oxides of iron and manganese 0.75; =99.25. It appears that specimens from different localities yield different proportions of the two earths.

Var. 1. COMMON MAGNESIAN LIMESTONE.† (Bitter Spar.) This variety is often in regular crystals, whose primitive and secondary forms are the same, as those of calcareous spar.‡ Most of its crystals, however, are rhombs, sometimes truncated, and sometimes with rounded edges.—It occurs also in amorphous lamellar masses, whose structure sometimes presents granular distinct concretions.

Its fracture is foliated, and its foliæ have a shining or splendent lustre, more pearly than that of calcareous spar. It is very sensibly harder, than calcareous spar, and sometimes scratches even fluate of lime. Its spec. grav. varies from 2.48 to 3.00. (*Bournon.*) It is translucent, at least at the edges, and its crystals are nearly semitransparent. Its usual colors are grayish or yellowish white, pale yellow, or yellowish brown.

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* Chaux carbonatée magnesifère. Hauy. Chaux carbonatée lente. Brongniart.

† Rautenspath. Werner. Rhomb-spar. Jameson. Chaux carb. lente Picrite. Brongniart. Le Spath magnesien. Brochant.

‡ According to Dr. Wollaston the greatest angle of the mutual inclination of the faces of the primitive rhomb in the magnesian carbonate is 106° 25′.

This variety appears to pass by imperceptible shades into the Dolomite, to which it has the same relation, as calcareous spar to granular limestone.

(Geological sit. and Localities.) It is sometimes found in chlorite slate, steatite, serpentine, &c. accompanied by asbestus, tremolite, &c.

The Magnesian limestone of England, which occurs in large masses or even in beds, is, by Bournon, referred to this variety. At Matlock in Derbyshire, Magnesian limestone, sometimes containing shells, is incumbent on horizontal strata of shell limestone. *(TENNANT.)* In the *United States.* In *Pennsylvania*, 13 miles from Philadelphia. In *Connecticut*, near Newhaven, it occurs with asbestus, &c. in serpentine. *(SILLIMAN.)*

MIEMITE. This subvariety, sometimes in crystals, and sometimes in masses with a radiated structure, has a pale, greenish color. It has been found at *Miemo*, in Tuscany.

2. DOLOMITE.* *KIRWAN. JAMESON.* The structure of the Dolomite is always granular. The grains, though a little variable in size, are usually very fine; they differ also very much in their cohesion, the mass being sometimes solid, and sometimes very friable, even between the fingers. In fact, its texture and general appearance often much resemble those of granular limestone with fine grains. Its fracture has a glimmering lustre.—Some varieties are phosphorescent in the dark, both by friction and on a heated shovel.—It is sometimes flexible, when sawn into thin slabs. Its spec. grav. is about 2.85. It is translucent at its edges; and its color is white, either very pure, or tinged with gray, yellow, or red.

As its effervescence in nitric acid is usually feeble, this circumstance will, in such cases, serve to distinguish it from certain granular limestones.

(Geological sit. and Localities.) This variety is often found in primitive or transition mountains, forming large masses, beds, or veins. Hence its beds sometimes alternate with mica slate, or are in contact with fetid limestone. Near Varalla in Italy it exists in a vein, traversing granite. *(NAPIONE.)*

It sometimes contains talc, tremolite, and mica, the last of which often gives it a slaty structure. It also embraces magnetic oxide of iron, and the sulphurets of iron, zinc, arsenic, &c.

In the *United States.* In *New York*, near the city, it occurs large grained, and sometimes with indications of a foliated structure. It is not phosphorescent; and contains tremolite. *(BRUCE.)*—In *Connecticut*, at

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* Dolomit. WERNER. Dolomie. BROCHANT. Chaux carb. magnes. granulaire. HAUY. Chaux carb. lente Dolomie. BRONGNIART.

Washington, Litchfield Co. in very beautiful, white masses, fine grained, and resembling loaf sugar; it is so friable, that it crumbles between the fingers, and may be ground in a common flour mill; it contains the tremolite. This Dolomite effervesces rapidly with nitric acid; and is employed in the manufacture of mineral waters, one quart of its powder yielding a barrel of carbonic acid gas by heat, and two thirds of a barrel by sulph. acid—also at the Milford Hills, near Newhaven, mixed with quartz and tremolite. (SILLIMAN.)

(*Remarks.*) Magnesian limestones, when *calcined* and spread on land as a manure, are injurious to vegetation. This fact was ascertained by Smithson Tennant from observations, made near Doncaster, &c. in England. It does not appear, that this limestone is injurious, when applied before calcination.

SUBSPECIES 10. SILICEOUS CARBONATE OF LIME.*

This mineral, at first view, so much resembles a sandstone, that it has sometimes been called by that name. But its chemical characters and crystalline form establish its claim, as a subspecies of carbonate of lime. It is crystallized in rhombs, or presents itself in mammillary concretions, or in amorphous masses. Although its structure appears granular, its fracture presents shining spots by the light, reflected from its crystallized laminæ. It is sometimes sufficiently solid to give fire with steel, and is sometimes friable. It is opaque, and grayish white; its spec. gravity is 2.6.

In nitric acid, its calcareous part, about one third of the whole, dissolves with effervescence.

(*Geolog. situation and Localities.*) Its crystals are found, either solitary or in groups, in certain cavities, existing in beds of calcareous sandstone. When these cavities, usually filled with sand, are in part empty, it is sometimes the case, that one half of the crystal, in the state of a pure carbonate of lime, projects into the cavity, while the other half of the same crystal is siliceous.—These crystals seem to be formed by the filtration of water, containing carbonate of lime, into the aforementioned cavities. But the particles of sand are merely enveloped by the carbonate of lime, and do not prevent it from assuming one of its proper forms.

This mineral has been found only at Fontainbleau and Nemours in France. In the same vicinity also is a siliceous limestone, which is often cavernous; and the sides of its cavities are sometimes invested with siliceous stalactites, or crystals of quartz.

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* Chaux carbonatée quartzifère. HAUY. BRONGNIART. Sometimes called crystallized sandstone of Fontainbleau.

Subspecies 11. MADREPORITE.[*] *Brochant.*

It is found in large, rounded fragments, composed of numerous, small prisms, nearly cylindrical. These prisms are parallel, or diverge from different centres.[†] Their cross fracture is conchoidal or even, and glistening with a resinous lustre. It is opaque; and its surface is dark grayish brown, but its cross fracture is nearly black.

It contains carbonate of lime 63, silex 13, alumine 10, oxide of iron 11;=97. (*Schroll.*) The same result was obtained at the School of the Mines.

It is found in the valley of Rüssbach, in the Saltzburg, but has never been seen *in situ.*

Subspecies 12. CALP.[‡] *Kirwan.*

This mineral is found in large, compact masses, intersected by veins of white calcareous spar. Its fracture is very fine splintery, even, or a little conchoidal, and dull, excepting where laminæ of the calcareous spar are intermixed. It is opaque; and its color is bluish black, or dark grayish blue; but its streak is white. When moistened by the breath, it exhales an argillaceous odor. Its spec. gravity is 2.68. It is easily divisible into large tabular masses or parallelopipeds.

It effervesces with acids; and, when calcined, becomes yellowish, and falls into thin plates, but does not burn to lime; it even melts at 130° W. into a black glass. It contains carbonate of lime 68, silex 18, alumine 7, bitumen 3, iron 2;=98. (*Knox.*)

It passes into compact limestone and indurated marl. It is very abundant in the vicinity of Dublin, Ireland, where it is employed, as a building stone.

Subspecies 13. FETID CARBONATE OF LIME.[§]

The most striking character of this subspecies is the *fetid* odor, which it exhales, when scraped with a hard, sharp pointed body. This odor, which appears to arise from sulphuretted hidrogen gas, is urinous, or more often like that of putrid eggs. It usually occurs in masses, either compact, or having a granular or foliated structure; its fracture, of course, is various, often earthy, and sometimes fine

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[*] Madreporstein. (De Moll.) Chaux carbonatée Madréporite. Brongniart.

[†] Hence its name, from a supposed resemblance in its structure to certain Madrepores.

[‡] Chaux carbonatée Calp. Brongniart.

[§] Chaux carbonatée fetide. Haüy. Brongniart. Stinkstein. Werner. Stinkstone. Jameson. Swine stone. Kirwan. La pierre puante. Brochant.

splintery, conchoidal, or foliated, at least in certain parts. It is nearly or quite opaque and destitute of lustre. Its ordinary colors vary from gray to grayish black, brown, yellowish brown, &c.

It has also been found in grouped prisms, capable of mechanical division.

Before the blowpipe it loses its odor, and by calcination yields good lime. It is often a little bituminous. (*Bournon.*)

(*Geolog. situation and Localities.*) Its geological characters are similar to those of compact limestone. It forms large beds, or even whole mountains. It is sometimes associated with the oldest formations of secondary gypsum, and is often traversed by veins of calcareous spar.

In the *United States.* In *Maryland*, it is abundant on the Alleghany Ridge.—In *New York*, in Dutchess Co.—also in the vicinity of *Niagara Falls*, and Lake *Ticonderoga.*

Subspecies 14. BITUMINOUS CARBONATE OF LIME.*

This substance is well characterized by the *bituminous* odor, which it exhales, when rubbed or heated. This odor is more offensive, than that of common bitumen, arising perhaps from a mixture of sulphuretted hidrogen, or some animal matter. Its color, which is black or brown, arises from the bitumen. It is sometimes compact with a dull, earthy or conchoidal fracture, and sometimes its structure is foliated. By friction it acquires negative electricity. By the application of heat it loses both its color and odor.

This mineral is found among secondary rocks, and sometimes in small quantities in the vicinity of coal.

(*Localities.*) In the *United States.* In *Connecticut*, near Middletown, it is black, and traversed by veins of white calcareous spar, and satin spar, and presents distinct impressions of fish; when once ignited, it continues to burn with a bright flame. (*Silliman.*) It also occurs in a few other places in the U. States.

(*Uses.*) It is sometimes polished as a marble; indeed it forms most of the black marbles. In Ireland it is sometimes employed, as a combustible. It burns to lime with less fuel, than common limestone.

Subspecies 15. FERRUGINOUS CARBONATE OF LIME.†

Its color is dark gray; but is unequally diffused, the centre of a crystal being often darker than its summits, which are sometimes semitransparent. Its lustre is considerable, but not pearly. It

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* Chaux carbonatée bituminifère. Haüy. Brongniart.

† Chaux carbonatée ferrifère. Haüy.

strongly scratches limpid carbonate of lime, and its spec. grav. is 2.81. Its crystals easily yield the same primitive form, as the pure carbonate, and one of its secondary forms is an acute rhomb, with truncated summits.

It does not blacken by the action of fire, and is fusible by the blowpipe into a black glass, attracted by the magnet. When reduced to powder, it slowly dissolves in nitric acid with a slight effervescence. (*Haüy.*)

According to Vauquelin it contains much oxide of iron and a little silex.

In the environs of Saltzburg it is found in sulphate of lime.

Subspecies 16. BROWN SPAR.* *Jameson.*

This substance is best distinguished by its chemical characters. Its structure and fracture are usually foliated, and the laminæ have a pearly lustre more or less shining, and sometimes almost metallic. The exterior also presents the same pearly appearance, unless prevented by partial decomposition.

Its crystals resemble those of calcareous spar; but their planes are often curved, or their form is lenticular, or their thin edges are sometimes bent up, like those of a hat. Sometimes very minute rhombic crystals are so intimately grouped, that the mineral presents a scaly appearance.

It occurs also in laminated masses, sometimes globular, reniform, or cellular. It has also been observed with a fibrous texture.

It is a little harder than calcareous spar, but seldom so hard, as magnesian limestone. Its spec. gravity varies from 2.83 to 3.00. (*Bournon.*) It is more or less translucent, at least at the edges, and the crystals are sometimes semitransparent. Its color is white or gray, either pure, or tinged with yellow or red; it also presents several shades of red, and is sometimes brownish, &c. The lighter colored varieties best exhibit the pearly lustre; but in proportion as the iron and manganese increase, its colors appear, and its pearly lustre diminishes.

(*Chemical characters.*) Before the blowpipe it becomes yellowish, or dark brown; even exposure to the air darkens its colors in consequence of the combination of oxigen with its metallic ingredients. It undergoes the same changes of color in nitric acid, in which it dissolves, though in most cases with but little effervescence, and produces a yellowish solution.—In this mineral the oxides of iron and man-

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* Braun Spath. WERNER. Chaux carbonatée brunissante. BRONGNIART. Chaux carb. ferro-manganesifère. HAÜY. Sidero calcite. KIRWAN. Le Spath brunissante. BROCHANT.

ganese are always present, but in variable proportions from 4 to 10 or 15 per cent.—By an increase of its metallic ingredients it obviously approaches sparry iron ore, from which it is often difficult to distinguish some specimens of Brown spar.

(Geological sit. and Localities.) Brown spar most frequently occurs in metallic veins, accompanied by quartz, the carbonate and fluate of lime, the sulphurets of lead, zinc, iron, copper, silver, &c. Sometimes it appears in groups of little crystals, attached to other substances.

In the *United States.* In *Pennsylvania,* on Conestoga Creek, 9 miles from Lancaster, with adularia. *(Conrad.)*

Subspecies 17. MARL.[*] *Kirwan.*

It has already been remarked, that compact limestone, by an increase of argillaceous matter, passes into Marl; and hence the same specimens have by different mineralogists been referred both to marl and compact limestone.[†]

Marl is essentially composed of carbonate of lime and clay in various proportions. But some marls are more or less indurated, while others are friable and earthy. In some the argillaceous ingredient is comparatively small, while in others it abounds and furnishes the predominant characters. The calcareous and argillaceous marls unite by imperceptible degrees, and the latter sometimes pass into clay. Marl frequently contains sand, and some other foreign ingredients.

It must hence appear impossible to establish distinct varieties; and accordingly some have divided marls into calcareous and argillaceous; others into *indurated* and *earthy.* For several reasons we adopt the latter division, and shall notice the former under the chemical characters and uses.

Var. 1. INDURATED MARL.[‡] *Kirwan. Jameson.* The hardness of this Marl is inconsiderable. In most cases it may be scratched by the finger nail, and may always be easily cut by a knife. It has a dull aspect, like chalk or clay, often with a few glimmering spots, arising from sand or mica. Its fracture, usually earthy, may also be splintery, conchoidal, or slaty. It is opaque; and its color is commonly gray, often shaded with yellow, brown, or black, &c. Shades of green and yellowish brown are not unfrequent in argillaceous marls. Its spec. gravity usually lies between 2.3 and 2.7.

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[*] Mergel. Werner. Marne. Brongniart. Argile calcarifère. Haüy. La Marne. Brochant.

[†] Some of the *marlites* of Kirwan belong to this intermediate class, while others may be referred to compact limestone.

[‡] Verhærteter mergel. Werner. La Marne endurcie. Brochant.

Compact marls are sometimes traversed by fissures, dividing them into prismatic columns, resembling those of basalt; and, like those, they are sometimes *articulated*. The sides of these fissures are sometimes rendered brown, or even dendritic, by the filtration of metallic oxides.

(Chemical characters.) It is a character of all solid marls to disintegrate or crumble by exposure to the atmosphere, usually in the course of one year, but sometimes a longer period is requisite. This diversity of time depends on the nature of the marl, and its greater or less solidity.—The same changes generally take place in a very short time, when Marl is immersed in water, with which it forms a short paste. It however crumbles more easily, and forms a more tenacious paste, in proportion as it becomes more argillaceous. It is always more or less easily fusible.

All marls effervesce with acids, sometimes very briskly, and sometimes feebly, according to their solidity, and the proportion of carbonate of lime, which may vary from 25 to 80 per cent.; indeed in the argillaceous marls it is often much less. A little mica, as well as sand, is often present.

When the calcareous part of Marl is dissolved by an acid, the residue is composed chiefly of clay; but clay is a compound of silex and alumine in various proportions, and hence the nature of the marl will also vary according as the siliceous or aluminous ingredient of the clay may preponderate.—Marls acquire but little hardness in the fire, unless they are very argillaceous.

Ludus Helmontii. This name is given to orbicular masses of calcareous marl, usually from one to 18 inches diameter, whose interior presents numerous fissures or seams, which divide the mass into irregular prisms. These fissures are usually lined or filled by some crystallized substance, as calcareous spar or quartz, which have undoubtedly entered by filtration.—These masses are usually found in beds of Marl.

Marly Geodes. These are cavities of various forms, whose interior is often garnished with crystals of carbonate of lime. As the walls of these cavities are usually more compact, than the surrounding marl, the geode easily separates.

2. EARTHY MARL.* *KIRWAN. JAMESON.* This variety differs from the preceding by being more or less friable, or even loose; but they gradually pass into each other. Like the indurated marl, it may be either calcareous or argillaceous; it sometimes greatly resembles clay, but may be distinguished by its effervescence in acids.

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* Mergel erde. WERNER. La Marne terreuse. BROCHANT.

(Geol. situation and Localities.) Marl, like clay, belongs both to secondary and alluvial earths, where it occurs in masses, or in beds. Hence it may alternate with compact limestone or gypsum, or with sand or clay. It contains various organic remains, as shells, fish, bones of birds and of quadrupeds; and sometimes vegetables. The organic remains are numerous and extremely interesting in the marly strata, recently examined by Cuvier and Brongniart in the vicinity of Paris.—Earthy marl sometimes lies immediately under the soil, and may, at least in many cases, have resulted from the disintegration of indurated marl.

Marl is found more or less in most countries. In *New Jersey*, it is abundant, particularly in Monmouth and Burlington Counties. In the latter Co. it is greenish, contains sulphate of iron, and shells, and in one instance the entire skeleton of a shark has been found in this marl. *(WOODBRIDGE.)*—In *New York*, in Orange and Ulster Cos. it sometimes contains large fossil bones. *(ARNELL and MILLER.)*

(Uses.) The most general and important use of Marl is that of a manure for the improvement of the soil. The fertility of any soil depends in a great degree on suitable proportions of the earths, it contains; and whether a calcareous or argillaceous marl will be more beneficial to a given soil may be determined with much probability by the tenacity or looseness, moisture or dryness of that soil. It is hence obvious, that to employ marls judiciously, the farmer should be in some degree acquainted with the chemical properties or constituent parts of the marl itself, and with the ingredients of the soil.—He may, in general, determine the existence of marl by its falling into powder, when dried, after exposure to moist air. To ascertain the proportion of its ingredients, the calcareous part may be extracted from a given weight of the marl by solution in acids, and the residue, being dried and weighed, will give the quantity of clay sufficiently accurate.—Some marls do not produce their greatest effect, until several years after they have been applied to the soil.

In England the several varieties of marl are known by the names of stone marl, slaty or flag marl, clay marl, shell marl, &c.

SUBSPECIES 18. BITUMINOUS MARLITE.* *KIRWAN.*

This substance in its composition approaches nearer to marl, than to argillaceous slate. Its fracture is slaty; its layers are straight or curved, and the latter have very sensibly more lustre, than the former. It is opaque, and its colors are grayish or brownish black. Its spec. grav. is about 2.38.

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* Bituminöser mergel schiefer. WERNER. Bituminous marle slate. JAMESON. Le schiste marno-bitumineux. BROCHANT.

It effervesces with acids, in most cases strongly. Before the blowpipe it burns with a small flame, yields a bituminous odor, and melts into a black scoria.

It differs from bituminous shale by its effervescence with acids.

This mineral occurs in secondary mountains. It is sometimes associated with compact limestone and red sandstone of the oldest formation, and contains pyritous copper and other ores of copper so abundantly, that it is worked as an ore of copper; hence sometimes called copper slate.

This marlite frequently contains the impressions or remains of plants and fish. These fish are most commonly in a contorted, unnatural position, those of the same species being usually together, as if collected in shoals; both of which circumstances indicate, that they perished by a sudden irruption or deposition of the mineral, which embraces them. Sometimes the scales only, and sometimes the whole fish has been converted into an ore of copper. Most frequently, however, the fish present a coaly appearance; and the bitumen of this mineral has undoubtedly arisen from the destruction of these marine animals.

Deposites of this substance are found in Italy near Verona, and in Thuringia, &c. in Germany.

Species 8. Arragonite.[*] *Haüy.*

Although this mineral is composed chiefly of lime and carbonic acid, yet there is reason to believe, that other ingredients are essential to its true composition. It differs from pure carbonate of lime in hardness, specific gravity, and crystalline structure. (See remarks under the chemical characters.)

The Arragonite is harder than calcareous spar, and scratches even fluate of lime; and its spec. grav. is equal to 2.91 or 2.94.—One of its most common forms is a six-sided prism, of which two opposite edges contain an angle of about 128° each; its sides are usually striated or channelled longitudinally, and are sometimes concave. The bases of this prism often exhibit lines or projecting edges, which converge towards the centre.—Another of its forms is a six-sided pyramid, elongated and cuneiform. Indeed there are not less than 13 modifications of the primitive form, which, according to Haüy, is an octaedron; but, according to Bournon, who has described 49 forms, depending on 9 modifications of the primitive, the latter is a tetraedral prism with rhombic bases.

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[*] Arragonit. WERNER. L'Arragonite. BROCHANT. Arragone. JAMESON. Arragon spar. KIRWAN. Chaux carb. Arragonite. BRONGNIART. L'Arragonite and Chaux carbonatée dure. BOURNON.

The prismatic crystals present natural joints parallel to their axes, and are divisible into rhomboidal prisms with angles of about 116°, and 64°; whereas those prisms, which result from the division of the cuneiform pyramids, have angles of 128° and 52°. *(Bournon.)*

The Arragonite also occurs cylindrical, fascicular, reniform, coralloidal, or in amorphous, fibrous masses. Its longitudinal fracture is more or less foliated, or fibrous; but the cross fracture is uneven with a vitreous lustre, somewhat shining.

Its colors are milk white, greenish white, gray, pale yellow or violet. Some prisms have a tinge of violet in the middle, while the parts about the extremities are greenish or without color; in this case the greenish or colorless prism is penetrated nearly at right angles by another prism, having a violet color. It is translucent, and sometimes transparent as glass.

(Chemical characters.) In nitric acid it dissolves with effervescence. The analysis of no mineral has ever so much exercised the talents, exhausted the resources, and disappointed the expectations of the most distinguished chemists of Europe, as that of the Arragonite. Vauquelin and Fourcroy obtained lime 58.5, carbonic acid 41.5; and the analysis of Biot and Thenard, conducted with much ingenuity, scarcely differs from this, except in giving a little water. With these both Chenevix and Klaproth agree, in finding the Arragonite to contain lime and carbonic acid in nearly the same proportions, as in the common carbonate of lime.

If these results are correct, it is obvious, that the composition of this mineral is at variance with its crystalline structure, which does not yield a rhomb by mechanical division; thus giving to the crystals of carbonate of lime two primitive forms.

But a gleam of light has recently appeared on this subject. Kirwan in his mineralogy, published in 1794, conjectured that the Arragonite might contain *strontian*; and very recently Professor Stromeyer of Gottingen has discovered in this mineral between three and four per cent. of the carbonate of strontian. This discovery will very probably lead to a solution of the preceding difficulty; but it is important the analysis should be repeated by different chemists.*

Var. 1. FIBROUS ARRAGONITE.† It is in masses, composed of fibres, sometimes parallel, but usually diverging, and, in some instances, terminating in crystals.—It also occurs in reniform or globular masses, striated from the centre to the circumference.

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* Dr. Wuttig, of Russia, has recently announced a mineral under the name *miaszito*, composed of the carbonates of lime and strontian, and most probably a variety of the Arragonite.

† Arragonite fibreux. Hauy.

2. CORALLOIDAL ARRAGONITE.* It occurs in little cylinders, sometimes diverging from each other, and terminating in a point, or a fork, and sometimes branched, like coral. The surface, either smooth, or garnished with little crystalline points, is often very white with a silken lustre. Its texture is fibrous; and the fibres are divergent, and frequently inclined to the axis of the cylinder in an angle of about 30°. This structure clearly indicates a different mode of formation from that of calcareous stalactites.

This variety is often found in cavities in veins of sparry iron, and has hence been called *flos ferri.*

(Geolog. situation and Localities.) The gangue of this mineral is variable. In the province of *Arragon*,† in Spain, where it was first observed, it is disseminated in ferruginous clay.—In the valley of Leogang, in the Saltzburg, it is accompanied with fluate of lime, sulphate of barytes, and calcareous spar. *(De Buch.)* Minute crystals of red ferruginous quartz are implanted in the prisms of Arragonite from the Pyrennees.—At Vertaison, in France, it is in the fissures of a rock, which appears to be a basalt. *(Brongniart.)*

Species 9. Siliceous Borate of Lime.‡

This mineral has recently been discovered by Esmark. It is sometimes in prismatic crystals with ten sides (Pl. III, fig. 23.), having two opposite, solid angles on each base truncated. The primitive form is a right prism, whose bases are rhombs with angles of 109° 28′ and 70° 32′. It also appears in large granular concretions, which frequently discover indications of a prismatic form; also in grains, or amorphous. The surface of the concretions is rough and glimmering.

Its hardness enables it to scratch fluate of lime, and its spec. grav. is 2.98. Its fracture is imperfectly conchoidal, shining, and nearly vitreous. Its color is white, shaded with gray or green, often very delicately.

When exposed to the flame of a candle, it assumes a dull white color, and becomes very brittle, even between the fingers. Before the blowpipe it swells into a milk white mass, and then melts into a pale rose colored glass. It is composed of lime 35.5, silex 36.5, boracic acid 24, water 4. *(Klaproth.)*

Var. 1. BOTRYOLITE.§ This variety occurs in botryoidal masses, composed of concentric layers, reddish at the exterior, but gray or

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* Arragonite coralloïde. Hauy. † Hence its name.

‡ Chaux boratée siliceuse. Hauy. Datholit. Werner. Chaux Datholite. Brongniart.

§ Botryolit. Dunin Borkowski.

yellowish gray within; or its colors alternate in narrow stripes. Its structure is fibrous with diverging and sometimes very delicate fibres.

In this variety Klaproth found lime 39.5, silex 36, boracic acid 13.5, water 6.5, oxide of iron 1;=96.5.

This species has hitherto been found only at Arendal in Norway, where it is associated with quartz, carbonate of lime, talc, magnetic iron, &c.

GENUS IV. *MAGNESIA.*

This genus contains four species, no one of which occurs in any considerable quantity.

Species 1. Sulphate of Magnesia.*

Epsom Salt.

This salt possesses a remarkably bitter taste. Like many other native salts, it appears in efflorescences or concretions, composed of capillary fibres, and sometimes in minute prismatic crystals; also in a loose, mealy powder. Its color is usually grayish white.

It effloresces by exposure to the air, but less rapidly than sulphate of soda. It is soluble in its own weight of water at 60°, from which it may be precipitated by potash or soda; and is hereby easily distinguished from sulphate of soda. Before the blowpipe it dissolves in its water of crystallization, but is not easily fusible. When pure, it is composed, according to Bergman, of magnesia 19, sulphuric acid 33, water 48.

The Haar salz (hair salt) of Werner is probably a mixture of the sulphates of magnesia and of iron. Its taste resembles that of alum.

(Geolog. situation.) Sulphate of magnesia is very seldom found, except in a state of efflorescence, or dissolved in water. These efflorescences sometimes appear on the soil. Sometimes they exist on argillite, gneiss, and other minerals, which contain both magnesia and the sulphuret of iron, the latter of which, by the action of the air on its sulphur, furnishes sulphuric acid, which then unites with the magnesia. It may also arise from the mutual decomposition of the carbonate of magnesia and the sulphates of lime or iron.

It exists in considerable quantities in sea water; and is abundant in many mineral springs, as in those of Epsom, in England, and Sedlitz, in Bohemia.

(Uses.) It is employed in medicine, as a purgative; hence the

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* Magnesie sulfatée. Haüy. Brongniart. Natürliches bittersalz. Werner. Natural Epsom salt. Jameson. Le Sel amer natif. Brochant. Epsom Salt. Kirwan,

value of those mineral waters, which contain it. It is sometimes procured by evaporating such waters.—In other instances it is obtained from minerals, which embrace magnesia and sulphur. The sulphur is acidified by roasting and moistening the mineral; and the sulphate of magnesia, when formed, is extracted by lixiviation.—It exists also in considerable quantities in the *bittern*, which remains after extracting muriate of soda from sea water, from which it may be obtained considerably pure.

Species 2. Carbonate of Magnesia.

A variety of minerals, containing magnesia and carbonic acid, have been observed in different places; but the acid appears to exist in proportions extremely variable, and has very probably been in part, at least, absorbed by the magnesia after exposure to the air; silex also, in greater or less quantities, is usually present. We have, therefore, with Brongniart, referred these substances to the *Magnesite*, a species arranged among the earthy minerals.

If any of these varieties deserve the name of Carbonate of Magnesia, it seems to be that,* discovered by Dr. Mitchell, at Robschütz in Moravia. It is found in masses, sometimes tuberose or cellular, the interior of the cells being rough. Its texture is compact or finely granular; and its fracture dull, earthy, splintery, and also conchoidal. It is soft, a little unctuous, and adheres to the tongue. It is nearly opaque, and has a yellowish gray color with blackish spots, or dendritic figures.

According to Mitchell and Lampadius, it contains magnesia 51, carbonic acid 47.4=98.4. But, according to Wondraschek, it sometimes contains magnesia 33, carb. acid 30, *silex* 8, water 20, lime 0.5, manganese and iron 1.5=93.

This variety was found in serpentine, and accompanied with Keffekil.

Klaproth has also analyzed a mineral from Styria, containing magnesia 48, carb. acid 49, water 3.

This salt is frequently found in mineral waters.

The *magnesia* of commerce is in the state of a sub-carbonate, and is often obtained by decomposing the sulphate of magnesia by an alkaline carbonate.

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* Magnesie carbonatée. Haüy. Magnesie native. Brochant. Reine talkerde. Werner. Native talc earth. Jameson. Magnesite de Mitchell. Brongniart.

Species 3. Borate of Magnesia.*

This mineral has hitherto been observed only in crystals, whose primitive form is a cube; and it usually occurs in cubes, variously modified. In one of its most common forms (Pl. III, fig. 24.) all the edges are truncated. Four of the solid angles, taken alternately, are also truncated, while the other four solid angles are replaced, each by four faces, of which three are usually very small, sometimes scarcely perceptible without a glass. It hence appears, that no two solid angles, viewed as the two extremities of the same axis, passing diagonally through the cube, have the same modification.

In another form all the edges and four solid angles are truncated, while those angles, which, in the former variety, presented four faces, remain entire. It also occurs in dodecaedrons with rhombic faces, four of whose solid angles are sometimes modified by additional faces. Haüy has described 5 secondary forms.

These crystals, though sometimes nearly half an inch in thickness, are usually quite small, with smooth, shining faces; sometimes, however, the surface is rough and apparently corroded.

The most remarkable character of these crystals is the property of becoming electric, by heat, at the eight solid angles, four of which give positive electricity, and the other four, negative. The two extremities or poles of the same axis, passing diagonally through the cube, possess opposite electricities, and differ also in their form or number of faces.—In the first variety, negative electricity appears on the four solid angles, replaced by four faces each.

Their fracture is imperfectly conchoidal; they scratch glass and give fire with steel; their spec. gravity is about 2.56. They are opaque, translucent, or even transparent; and their colors are usually white or gray, sometimes shaded with yellow, green, violet, or black.

Before the blowpipe it is fusible with ebullition into a yellowish enamel. It does not dissolve in cold acids. The transparent crystals are a pure borate of magnesia; but when opaque and of a violet or blackish color, they usually contain 10 or 12 parts of lime and a little silex, alumine, and oxide of iron.

(*Geolog. situation and Localities.*) This is a very rare mineral. It has been found in the mountain Kalkberg, near Lunenburg, in Lower Saxony, imbedded in gypsum.—Also at Segeberg, in Holstein; in the specimens, which the writer possesses, from the latter place, the cubes are imbedded in anhydrous sulphate of lime.

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* Magnesie boratée. Hauy. Brongniart. Boracit. Werner. Boracite. Kirwan. Jameson. Brochant.

SPECIES 4. FLUATE OF MAGNESIA.

This substance is said to have been discovered by Dr. Bruce of New York. Its name was inserted in the Tabular view, with the hope, that the discoverer would have published a description of this new mineral in season to be here inserted.

GENUS V. ALUMINE.

SPECIES 1. MELLATE OF ALUMINE.*

The color of this very rare mineral is almost always honey yellow, sometimes a little tinged with brown. It is crystallized in octaedrons, which are sometimes truncated on all the solid angles, or only on those of the common base, thus forming a dodecaedron with rhombic faces. This octaedron, which is also the primitive form, is composed of two pyramids with square bases, and isosceles triangular faces; and the incidence of any face of one pyramid upon the corresponding face of the other is 93° 22′. It is sometimes in grains or fragments of crystals.

These crystals have smooth, shining surfaces; and their fracture is conchoidal with a strong lustre, somewhat resinous. They are brittle, and easily cut by a knife. They are more or less translucent, or even transparent, and exhibit double refraction in a much higher degree, than they would, if, with equal density, they contained no combustible. By friction they acquire a weak negative electricity, but of short duration, unless the crystal be insulated. Their spec. grav. lies between 1.58 and 1.66.

Before the blowpipe this mineral first whitens, and becomes opaque, then blackish and falls into ashes, but does not melt. It yields neither flame, smoke, nor odor. It is composed, according to Klaproth, of alumine 16, mellitic acid 46, water 38.

It differs from amber in its weak electricity, double refraction, and chemical characters.

This substance has been found chiefly at Artern, in Thuringia, either on the surface, or in the interstices of bituminous wood;—and in Switzerland with asphaltum.

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* Mellite. HAUY. BRONGNIART. Mellilite. KIRWAN. Honigstein. WERNER. Honey stone. JAMESON. La Pierre de miel. BROCHANT.

ORDER IV.

Salts with an alkaline and earthy base.

Species 1. Alkaline Sulphate of Alumine.*

Alum.

No one of the physical characters of this salt, except its astringent and somewhat sweetish taste, is of much use in determining its presence, as found native. When not enveloped in other minerals, it usually appears in efflorescences, composed of capillary crystals or fibres. Sometimes these crystals are white, and silky, parallel to each other, and perpendicular to the surface, on which they stand, and are then often called *plume*, or *fibrous* Alum; sometimes the efflorescence resembles a mould, or is in a loose powder. Native Alum also occurs in concretions or stalactites. Its white color is sometimes contaminated by shades of gray, yellow, or green.

Its crystals, artificially obtained, are usually regular octaedrons.

It is soluble in about $\frac{3}{4}$ its weight of boiling water; and, by the addition of ammonia, yields a white precipitate of alumine. Before the blowpipe it dissolves in its own water of crystallization, and then dries into a white, spongy mass. The mean result of several specimens of the Alum of commerce from different countries, according to the analysis of Vauquelin, is alumine 10.50, potash 10.40, sulphuric acid 30.52, water 48.58. Ammonia is also common in the Alum of commerce, but rare in native Alum, which, however, is usually contaminated by other salts.

Its taste, unless greatly modified by some foreign salt, will distinguish it from sulphate of magnesia; and it does not, like the sulphate of iron, yield a black precipitate on the addition of an infusion of nutgalls.

The Haar salz (hair salt) of Werner, formerly supposed to be a variety of alum, is, according to Klaproth, a mixture of the sulphates of magnesia and iron.

Native Alum is sometimes mingled with clay and oxide of iron.† It occurs in the cavities or fissures of argillaceous slate in soft masses, a little unctuous, and sometimes tuberose or stalactical. It is opaque, and usually has a yellowish color.

(Geological situation and Localities.) Native Alum is usually found in connexion with argillaceous earths or stones, or with volcanic

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* Alumine sulfatée alkaline. Hauy. Alumine sulfatée. Brongniart. Natürlicher alaun. Werner. Natural alum. Jameson. L'Alun natif. Brochant. Alum. Kirwan.

† Berg butter. Werner. Rock butter. Jameson.

products. Sometimes it is diffused through certain earths, turfs, or stones; but most frequently appears efflorescing in the cavities and fissures, or on the surface of certain argillaceous slates, hence called *aluminous* slate.

It is also found on the surface of clays, which embrace the sulphuret of iron.

This salt is not uncommon in volcanic countries, either investing certain lavas, or contained within them. Very fine specimens of fibrous Alum are found in the island of Milo, in the Archipelago, mingled with fibrous gypsum in volcanic rocks. It is found in considerable quantities at the Solfaterra, near Naples, rising in efflorescences on the soil; at La Tolfa in Italy, disseminated in an argillaceous mineral, called Alum stone.

In Scotland, at Hurlett, near Glasgow, the aluminous slate, impregnated with pyrites, constitutes the roof of a coal mine..

In the *United States*, native Alum has been observed in several instances, especially in Tennessee and Pennsylvania.

(Modes of obtaining Alum.) The modes of obtaining this salt are various, and dependant on the nature of the minerals, or Alum ores, from which it is extracted.

When this salt exists, already formed, in earths or friable minerals, it is extracted by lixiviation; but, if the mineral be solid, it must be previously calcined. Thus, if the Alum stone of La Tolfa be merely lixiviated, it yields no salt; but, after calcination, it becomes disintegrated by the gradual action of moisture and the heat of the sun, and then yields its Alum by lixiviation. The calcination and exposure to the atmosphere are not here necessary to acidify the sulphur; for, according to the analysis of Vauquelin, the Alum, united with a large quantity of silex, exists already formed in this stone.

But, more frequently, those minerals, which furnish this salt, are argillaceous substances, which contain pyrites, that is, sulphur united with iron, and sometimes also the potash, requisite to the formation of Alum. The sulphur is acidified either by calcination in a moderate heat, or exposure to the air, or by both methods united. The acid, thus produced, unites with the alumine of the mineral, and forms sulphate of alumine, to which, if potash be not present, either that alkali or ammonia must be added. The alkali is sometimes furnished by the addition of ashes, which contain potash, or of urine, which contains ammoniacal salts.—By the same process also the sulphates of lime, magnesia, and iron may be produced in the same ore.

When the ore or argillaceous mass is sufficiently disintegrated, the Alum is extracted by lixiviation and crystallization.

The differences, which exist between the several varieties of the

Alum of commerce seem to depend chiefly on the greater or less quantity of the sulphate of iron, which they contain. According to Vauquelin the Roman Alum, prepared at La Tolfa, contains the least sulphate of iron; it has usually a rosy tinge. A thousandth part of iron, contained in Alum, produces a sensible effect in dying. (*Thenard.*)

The English Alum, of which there are manufactories in Yorkshire, &c. contains more iron than the Roman, and is often in large masses with a resinous lustre.

Roch Alum appears to have derived its name from Roccho (Edessa), an ancient city of Syria, where a manufactory of this salt was early established.

(*Uses.*) Alum is employed in dying to fix the color, and sometimes to heighten it. It hardens tallow, and increases the adhesive power of common paste. Wood and paper, soaked in its solution, are less combustible. It has other uses in the arts; and is also employed in medicine as an astringent, or, when calcined, as an escharotic.

Species 2. Fluate of Soda and Alumine.*

This very rare mineral has been found only in masses, whose fracture is foliated, with a moderate lustre. It is brittle, and sufficiently hard to scratch sulphate of lime, but is itself scratched by fluate of lime. Its color is white, sometimes grayish or milk white. It is more or less translucent; but when a small fragment is plunged in water, it becomes nearly or quite transparent, and resembles a jelly. Its spec. grav. is about 2.95.

(*Chemical characters.*) Its chemical characters are very remarkable. Before the blowpipe it dissolves in its own water of crystallization, almost as suddenly as ice;† it then dries, and forms a kind of scoria, which is not easily fusible. It is insoluble in water, but dissolves in sulphuric acid with the extrication of white vapors of fluoric acid.

It is composed of alumine 24, soda 36, fluoric acid and water 40. (*Klaproth.*)

It has been found only in Greenland.

Species 3. Glauberite. *Hauy. Brongniart.*

Anhydrous sulphate of soda and lime.

This triple salt occurs in oblique four-sided prisms with rhombic bases. It is limpid, or has a pale yellow color, and retains its trans-

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* Alumine fluatée alkaline. Hauy. Alumine fluatée, Brongniart. Kryolith. Werner. Cryolite. Jameson. Cryolithe. Brochant.

† Hence the name Cryolite, from κρυος and λιθος.

parency in the air, unless it be moistened. It scratches sulphate of lime, but is less hard than carbonate of lime. When immersed in water, it appears milk white and opaque; but, when taken out, an exterior white coat soon falls to powder, and leaves the interior unaltered. Its spec. grav. is 2.73.

Before the blowpipe it splits, decrepitates, and melts into a white enamel. It is composed of anhydrous sulphate of soda 51, anhydrous sulphate of lime 49. (*Brongniart.*)

It has been found near Ocano in New Castile, Spain, disseminated in muriate of soda.

CLASS II.

Earthy compounds, or Stones.

The minerals, which belong to this class, are composed chiefly of earths, sometimes united to an alkali. Indeed a combustible, or even an acid is sometimes present; but, in most cases, the two last mentioned substances are merely accidental. The numerous colors, which these minerals present, almost always arise from some metallic oxide.

In the determination of the species, this class presents many difficulties, arising from the present imperfection of chemical analysis. Of the various ingredients, which chemistry may find in a given mineral, we know not which are essential to the species, and, of course, cannot with certainty distinguish them from those, which are only accidentally present; nor do we know in what *manner* even essential ingredients were united in the mineral before analysis. (See Introd. 180, 189.)

No advantage can arise from forming genera and orders in this class, till such divisions can be established on more scientific principles, than is practicable at present.

It is not perhaps possible, in the present state of mineralogical knowledge, to arrange the species in this class in a very satisfactory manner. The Topaz is here placed first, because in its composition it resembles the preceding class, and ought, perhaps, to be arranged in it. The other species, beginning with alumine nearly pure, as it appears in the sapphire, are thrown into groups, which are determined by a similarity of composition, according to the most recent analyses. The arrangement of the groups also is regulated by the same principle, those, which appear to have the greatest similarity of composition, being, in general, placed contiguous. One advantage at least results from this disposition of the species;—the agreement or disagreement of external characters in those minerals, which appear to have a similar composition, will be easily perceived.

Certain minerals in this class have received the name of gems or precious stones. Their value, as articles of luxury or commerce, depends, in a great degree, on their hardness, transparency, or color. The most important are the sapphire, embracing the oriental ruby, sapphire, and topaz; spinelle; emerald; topaz; and amethyst. Sometimes also the beryl, the garnet, the hyacinth, quartz, &c. are employed in jewelry.

Species 1. Topaz.[*] *Werner. Jameson.*

The Topaz may, in general, be recognised by the eye. It is almost always in prismatic crystals, which, at first view, seem to have only four sides, with rhomboidal bases. Their sides are longitudinally striated, their terminating planes smooth, and their surface has usually a high lustre. They have never been observed under their primitive form, which is an octaedron, according to Haüy, who has described ten secondary forms; from these we select a few of the more common.

The crystal (Pl. III, fig. 25.) is an eight-sided prism, with a four-sided summit. When terminated by pyramids at both extremities, which is rarely the case, the two pyramids differ from each other. Two opposite lateral edges contain each an angle of 93° 6′; two others an angle of 124° 22′; and each of the remaining four edges a very obtuse angle of 161° 16,′ thus giving the crystal the general aspect of a four-sided prism.

Sometimes the pyramid, in the preceding variety, has two additional faces, which stand on the least obtuse edges, and are inclined to each other in an angle of 91° 58′; these two sides sometimes meet in a line and give the termination a cuneiform or bevelled appearance.

Sometimes the six-sided summit of the preceding variety is truncated (Pl. III, fig. 26.) by a plane, perpendicular to the axis of the prism.

Another form (Pl. III, fig. 27.) is an eight-sided prism, one summit having six, and the other ten faces.—Indeed, nearly all its forms may be referred to 8 or 12 sided prisms variously terminated, sometimes even by fifteen faces.

It is sometimes cylindrical, or occurs in laminated, or in rolled masses. Though easily broken, it scratches quartz, but is less hard, than the spinelle. Its fracture, parallel to the base of the prism, is

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[*] Silice fluatée alumineuse. Hauy. Topaze. Brongniart. Brochant.

The name Topaz is derived from the Greek Τοπαζιον; but it is not certain, that the ancients applied this name to the mineral, which is now called Topaz.

foliated, and more or less conchoidal in the direction of the axis. Its lustre is strong and vitreous; its refraction double; and its spec. grav. varies from 3.46 to 3.56.

Some varieties, particularly those found in Brazil and Siberia, acquire electricity by heat; the two summits possess opposite electricities, and have at the same time a different conformation. (See Introd. 138.) The Topaz from Saxony easily becomes electric by friction; and sometimes by heat. (*Haüy.*)

It is commonly transparent, sometimes translucent, and the milk white variety is opaque. It is sometimes limpid as quartz; but its prevailing color is *yellow*, often pale, sometimes tinged with red, orange, or green, and thence passing to red or a pale green, greenish blue, or greenish white, and even to gray and white.

(*Chemical characters.*) Before the blowpipe it is infusible. By the compound blowpipe, in which the flame of burning hidrogen is urged by a stream of oxigen gas, the Saxon Topaz melts with ebullition into a white enamel. (*Silliman.*) The yellow Brazilian Topaz, strongly heated, becomes rose red, but the Saxon Topaz, white. A mean of three analyses by Vauquelin on specimens from Saxony, Siberia, and Brazil, gives alumine 49, silex 29.3, fluoric acid 19; a little iron is sometimes present, and there was a loss of 2 in each analysis. The powder of the Topaz in the course of a few hours changes the vegetable blue to green. Does not this indicate, that its analysis is yet imperfect?

A careful examination of its comparative hardness, its specific gravity, and electric powers, will be sufficient to distinguish it from the sapphire, spinelle, chrysoberyl, and emerald, even when all these substances are deprived of their native form by the lapidary.

PYROPHYSALITHE. *Hisenger* and *Berzelius.* This is probably a variety of the Topaz. It is greenish white, translucid or opaque, and sometimes prismatic. On burning coals it phosphoresces in consequence of the fluate of lime, with which it is mixed.—It has been found near Fahlun, in Sweden, in granite, from which it is separated by a layer of talc.

(*Geolog. situation and Localities.*) The Topaz appears to belong almost exclusively to primitive rocks, and more particularly to the oldest. In Siberia, in the Uralian mountains, it is found in graphic granite, with beryl and quartz.—In Saxony and Bohemia it is found in granite, or in veins, which traverse granite, gneiss, and mica slate, with oxide of tin, apatite, &c. At Schneckenstein, in Saxony, is an aggregate of quartz, schorl, mica, *Topaz*, &c. hence called *Topaz rock.*—The red Topaz of Brazil is sometimes imbedded in quartz.—The Topaz is sometimes found in alluvial earths.

which have proceeded from the disintegration of primitive rocks. In this manner it occurs in Aberdeenshire in Scotland, with rock crystal and beryl. An entire crystal, probably the largest ever seen, has been found in Aberdeenshire, weighing more than 7 ounces troy; and a fragment of another, weighing more than one pound. (*Jameson.*)

(*Uses and Remarks.*) When the Topaz is without flaws and of a pure yellow, it is somewhat esteemed in jewelry. In general, the Saxon Topaz presents a pale yellow; the Brazilian a deeper yellow, sometimes tinged with red, or is entirely red; and the Siberian Topaz is usually colorless, white, pale greenish blue, or greenish white, the last of which is the predominant color of the Topaz of Scotland.*

Subspecies 1. PYCNITE.† *Hauy. Brongniart.*

This mineral, though sometimes in hexaedral prisms, nearly regular, most frequently appears in long, irregular prisms or cylinders, longitudinally striated, and united, parallel to each other, in bundles. It slightly scratches quartz: and is very brittle in a direction perpendicular to the axis of the prisms. Its cross fracture is imperfectly foliated, and its longitudinal fracture more or less conchoidal, with a moderate lustre. Its spec. gravity varies from 3.51 to 3.53; and it is electric by heat. (*Hauy.*)—It is translucent; and its colors are usually yellowish white, straw yellow, greenish or reddish white.

Before the blowpipe it is infusible. It contains, according to Bucholz, alumine 48, silex 34, fluoric acid 17, oxides of iron and manganese 1. Vauquelin found the same ingredients, but less acid, and more alumine.

It differs from the beryl by a greater spec. gravity, and inferior hardness;—from epidote, actynolite, &c. by its infusibility.

The Pycnite has been found chiefly at Altenberg, in Saxony, in a primitive rock, composed mostly of quartz or mica.

Species 2. SAPPHIRE.‡

The minerals, which belong to this species, include some of the most valuable gems, and have been, by some mineralogists, divided into several species. In fact, the several varieties, although agreeing

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* Much confusion has been produced in mineralogy by placing too much reliance on color. Hence the yellow sapphire has been called *oriental Topaz*; the yellow emerald *Siberian Topaz*; yellow quartz, *Bohemian* or *occidental Topaz*; smoky quartz, *smoky Topaz*; and the chrysolite has sometimes exchanged names with the Topaz.

† Schörlartiger berill. WERNER. Schorlous beryll. JAMESON. Schorlite. KIRWAN. Le beril schorliforme. BROCHANT.

‡ From the Greek Σαπφειρος. Corindon. HAUY.

in their essential and specific characters, exhibit a great diversity of external aspect.

Its hardness, greater than that of any other earthy mineral, and inferior to that of the diamond only, is one of its most obvious and distinguishing physical characters. Its specific gravity also is very high, extending from 3.71 to 4.28. It possesses double refraction; and varies from opaque to transparent. Of its numerous colors blue, red, yellow, and gray are the most common.

Though sometimes amorphous, it is very frequently in regular crystals, whose primitive form is a rhomb, slightly acute, each of the plane angles at the summits being 86° 26′. In the opaque crystals the natural joints, parallel to the faces of the rhomb, are usually very obvious; but in most of the transparent crystals, those joints, which are perpendicular to the axis of the rhomb, are the most distinct. Its integrant particles appear to be irregular tetraedrons.

Of the primitive form Haüy has described eight modifications, which, by combining with each other, still farther increase the variety of forms.

It but seldom appears under the primitive form, the summits of which are sometimes truncated perpendicularly to the axis.—Another secondary form is a regular six-sided prism, which is sometimes truncated on three alternate angles at each extremity (Pl. III, fig. 28.)—The same crystal may also be truncated on all its edges, or only on its terminal edges.—Another form is a dodecaedron, or double six-sided pyramid, two corresponding faces of which form with each other, at the common base, an angle of 139° 54′.—Sometimes the summits of this dodecaedron are truncated perpendicularly to the axis (Pl. III, fig. 29.), and, at the same time, three alternate angles at each extremity are also truncated. In fine, nearly all its secondary forms may be referred to a rhomb, a six-sided prism, or a double six-sided pyramid.

It also occurs in laminated, cylindrical, or rounded masses.

The Sapphire, though the hardest earthy substance, appears to be essentially composed of pure alumine; a little silex and oxide of iron being sometimes present. (See results of analysis under the several varieties.) It is infusible by the blowpipe.

Subspecies 1. PERFECT SAPPHIRE.[*]

This subspecies is usually crystallized under some of the forms already mentioned, but sometimes occurs in amorphous or rounded

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[*] Saphir. Werner. Sapphire. Jameson. Le Saphir. Brochant. Corindon-hyalin. Haüy. Corindon Telesie. Brongniart. Perfect corundum. Bournon. Oriental ruby, sapphire, and topaz. Kirwan.

fragments. It is easily broken; and its fracture, though sometimes more or less foliated, is usually conchoidal, splendent, and vitreous. Its hardness is a little superior to that of the following subspecies.—The perfect Sapphire is commonly more or less transparent, but sometimes only translucent. Its colors are blue, violet, red, yellow, and green, which present many intermediate shades; it also occurs limpid, or gray. The same crystal, on different parts, sometimes presents two or three different colors; or it is partly limpid, and partly colored.

The importance of this subspecies permits several subdivisions, founded on color, or the reflection of light.

Var. 1. BLUE SAPPHIRE. (*Oriental sapphire.*) The term Sapphire has, in the arts, been peculiarly appropriated to this variety of color. The finest specimens exhibit an azure or indigo blue. When bluish white, the Germans call it *luchs saphir.* Sometimes one part of the crystal is destitute of color, or different colors are separated by a limpid part. Some blue Sapphires lose their color in the fire; others remain unaltered; and others become still more blue. In one specimen Klaproth found alumine 98.5, oxide of iron 1, lime 0.5.

2. VIOLET SAPPHIRE. (*Oriental amethyst.*) Its color is often very lively.

3. RED SAPPHIRE. (*Oriental ruby.*) It is sometimes a lively and intense red, and sometimes aurora red. A specimen, analyzed by Chenevix, yielded alumine 90, silex 7, oxide of iron 1.2;=98.2.

4. YELLOW SAPPHIRE. (*Oriental topaz.*) This, when exposed to a strong heat, loses its color.

5. LIMPID SAPPHIRE. This, sometimes called white Sapphire, is grayish, or colorless.

CHATOYANT SAPPHIRE. (*Oriental girasole.*) It is sometimes translucid and nearly limpid, reflecting slight tints of blue and red; and sometimes it reflects a pearly light.

ASTERIATED SAPPHIRE. This, when cut, and viewed in certain directions, presents a very peculiar reflection of light in the form of a star, with six radii; this appearance is undoubtedly connected with the edges of the rhombic nucleus.

(*Geolog. situation.*) The Perfect Sapphire has perhaps never been seen in its native situation. It is found in the sand of some rivers, and in alluvial earths, at the foot of primitive or secondary mountains. It is often accompanied by zircon, garnet, magnetic iron, &c. It is also said to have been found in ferruginous clay in the crevices of primitive rocks.

(*Localities.*) The finest Sapphires come from Pegu and Ceylon.

This mineral has also been found in the stream of Expailly, near Puy, in France;—and near Bilin in Bohemia.

(Uses and Remarks.) Beside its well known use, as an article of ornament, it is employed for jewelling the pallets of escapements, and the holes of wheel pivots in astronomical clocks and watches.—The red sapphire is most highly esteemed, its value being sometimes equal to that of a diamond of the same size, and estimated at above 1000 guineas. The blue has the second, and the yellow, the third rank.

Those precious stones, which are employed in jewelry, were formerly distributed into different species, according to their *colors*; hence all red gems, possessing a certain degree of hardness, were called *rubies*; the blue, *Sapphires*; the yellow, *topazes*, &c. But, as the *best* rubies, Sapphires, &c. came from India, they were called *oriental*; while other minerals of inferior value, found in Europe, and erroneously referred to the same species, as the oriental gems, chiefly because they had the *same colors*, were called *occidental*. It appears, however, that most of the *oriental* gems form but one species, presenting various colors, and essentially differ from those called *occidental*; they occur also in other countries than India. Hence the terms *oriental* and *occidental*, as applied to the same species, now designate different degrees of perfection only, without indicating the locality.

SUBSPECIES 2. CORUNDUM.*

The Corundum is sometimes in crystals, whose more common form is a six-sided prism, on the base of which concentric, hexaedral zones of different colors often appear. It also occurs in amorphous masses of a moderate size, sometimes rolled.—Its natural joints are very obvious, at least in two directions, and it is easily divisible into rhomboidal fragments; its fracture is foliated, often with a shining lustre; the cross fracture is uneven, or somewhat conchoidal.

It is opaque or translucent, and sometimes strongly semitransparent. Its colors are neither lively nor numerous; they are commonly greenish gray, flesh or deep red, yellowish, or blue; and sometimes gray, with a pearly or metallic aspect.

Its colors are usually weakened by exposure to heat. Before the compound blowpipe it is immediately fused into a gray globule. (*SILLIMAN.*) A specimen from the carnatic yielded Chenevix alumine 91, silex 5, oxide of iron 1.5;=97.5.

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* Korund. WERNER. Corindon-harmophane. HAUY. Corindon adamantin. BRONGNIART. Imperfect corundum. BOURNON. Adamantine spar. KIRWAN. Le Spath adamantine. BROCHANT.

Its infusibility and hardness, which is but little less, than that of the perfect sapphire, serve to distinguish it from all minerals, which it resembles in external characters.

Var. 1. ADAMANTINE SPAR.* Its color is dark brown, and its internal lustre usually very strong. It comes from China, and almost always contains grains of magnetic oxide of iron. A specimen was found by Chenevix to contain alumine 86.50, silex 5.25, oxide of iron 6.50;=98.25.

(*Geological sit. and Localities.*) The Corundum appears to belong to primitive rocks, and particularly to granite, into the composition of which it sometimes enters; hence scales of mica and particles of feldspar sometimes adhere to its surface. In India, the granite, which embraces Corundum, also contains fibrolite, epidote, talc, garnets, zircon, magnetic iron, &c. It is found also in Malabar, the Carnatic, and other parts of the East.—In Italy it has occurred in mica slate.—The variety, called Adamantine spar, is found in China, in a granitic rock, containing much fibrolite and magnetic iron; the iron is disseminated through its interior, whereas, in the Corundum of India, it is usually confined to the surface.

In the *United States*, it is by some supposed to exist in *Maryland*, near Baltimore;—and in *Connecticut*, at Haddam, in the same granite, which contains chrysoberyl, &c.

It may be employed, like emery, in polishing hard substances.

2. EMERY.† *KIRWAN. JAMESON.* This substance is most probably a compact variety of Corundum. It is well characterized by its great hardness, in which it equals the common Corundum; its powder is, in fact, capable of scratching or wearing down all minerals, except the diamond. Its spec. grav. is about 4.00.

It is always amorphous; its structure finely granular; its fracture uneven or splintery; and its lustre moderate, but sometimes nearly metallic.—It is opaque, or slightly translucent at the edges; and its color varies from a deep gray to bluish gray or grayish black, and is sometimes brownish. It is a conductor of electricity, and often affects the needle.

A specimen from the isle of Naxos yielded Tennant alumine 86.5, silex 3, oxide of iron 4;=93.5. In another from the island of Jersey Vauquelin found alumine 70, iron 30; but the iron appeared to be mechanically mixed, rather than combined. Indeed Emery usually contains foreign substances, which sometimes give the mass a slaty structure.

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* Diamant spath. WERNER. Diamond spar. JAMESON.

† Schmirgel. WERNER. Emeril. BRONGNIART. BROCHANT. Corindon granulaire. HAÜY.

Its hardness sufficiently distinguishes it from jasper, oxide of iron, and some other minerals, which it externally resembles.

(Geolog. situation and Localities.) Emery appears to belong to primitive rocks, but its geological relations are not well known.—In Saxony it is disseminated in a bed of indurated steatite. *(BROCHANT.)* —In the island of Jersey, on the coast of Normandy, it is found in masses, which resemble magnetic iron, and contain small plates of mica; it gives a dark red powder.—In the island of Naxos, in the Archipelago, it exists abundantly in fragments or rolled pieces, at the foot of primitive mountains, and contains mica, magnetic iron, &c. A few other localities have been observed, but the Emery of commerce is chiefly from Jersey and Naxos.

(Uses.) This article is almost indispensable in polishing metals and hard stones. It is previously reduced to a powder by pulverizing it in a steel mill. This powder is agitated in water, in which its particles become suspended, and are then permitted to deposite themselves for a certain length of time; and by repeated washings and by suffering the deposite to go on for 15, 10, 5, &c. minutes, the powder of Emery is obtained of different degrees of fineness.

On metals it is commonly employed with oil, and on stones with water. Certain ores of iron and other substances have, in the arts, received the name of Emery.

SPECIES 3. DIASPORE. *HAUY. BRONGNIART.*

This mineral is but little known. It is composed of laminæ, somewhat curved, easily separable from each other, and possessing a pearly gray color, with considerable lustre. These laminæ, according to the natural joints, which they present, when examined by a light, seem to have separated in the direction of the smaller diagonals of the bases of a rhomboidal prism.—The edges or angles of its fragments are capable of scratching glass. Its spec. grav. is 3.43.

(Chemical characters.) A small fragment, placed in the flame of a candle, almost instantly decrepitates, and is *dispersed* in numerous little spangles. Hence its name, from the Greek *Διασπειρω*. It is composed of alumine 80, water 17, iron 3. *(VAUQUELIN.)*

Nothing is known of its geological situation. Its gangue is a rock, both argillaceous and ferruginous.

SPECIES 4. WAVELLITE.[*] *BRONGNIART.*

This rare mineral is sometimes in extremely minute, prismatic crystals, of an indeterminable form, collected into little tufts, or more

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[*] Hydrargillite. DAVY.

irregularly grouped and resembling down. These tufts are easily reducible to a very white powder.—But more frequently it appears in small, mammillary or rounded masses, often about the size of a pea, and intimately grouped; but each of these nodules or hemispherical masses is composed of fibres, radiating from a centre. The fragments of these masses scratch calcareous spar.

The Wavellite is transparent, or only translucent; its color is white, either pure, or tinged with gray, green, or yellow; and its lustre silky. Its spec. grav. lies between 2.25 and 2.70.

(Chemical characters.) This mineral before the blowpipe loses its hardness and transparency, more than one fourth of its weight, and becomes adhesive to the tongue; but does not melt. When pure, it is soluble in the stronger acids and in alkaline solutions, if assisted by heat. According to Davy it is essentially composed of alumine 70, water 30; but a little silex, lime, or oxide of iron is usually present. It appears also to contain a small portion of fluoric acid, which is sometimes sufficiently abundant, when liberated by sulphuric acid, to corrode glass. In a specimen from Barnstaple, Eng. Klaproth found alumine 71.5, water 28, oxide of iron 0.5.

This mineral is subject to spontaneous decomposition, affecting its lustre, transparency, hardness, spec. gravity, &c. indeed it is sometimes reduced to a substance, resembling clay.

(Geolog. sit. and Localities.) The *Wavellite* was first found by Dr. *Wavell*, at Barnstaple, in Devonshire, in cavities, or forming veins in an argillite.—At St. Stephen's, in Cornwall, it exists in the cavities of granite, adhering in little tufts to the quartz, or forming a stratum on its surface.—In Ireland, near Dublin, at the foot of a hill of siliceous slate, it occurs in small nodules, invested with an earthy crust, but within composed of crystalline spiculæ. (Fitton in Geolog. Trans. v. i.)

Species 5. Spinelle. *Haüy. Brongniart.*

This species, though sometimes in rounded grains, most frequently occurs in crystals, whose primitive form is a regular octaedron, composed of two four-sided pyramids, applied base to base; any two contiguous faces of which meet under an angle of 109° 28′. The Spinelle usually presents its primitive form, which, however, is sometimes more or less modified. Thus the octaedron may be elongated, and its summits cuneiform; or it may be truncated on all its edges, or only on those, which form the common base of the two pyramids. Indeed the octaedron may be so modified by these truncations, as to resemble a tetraedron, or rhomb.—Sometimes it appears in dodecaedrons with rhombic faces, and in hemitrope or double crystals (Pl. I, fig. 99.) with a re-entering angle. (See Introd. 82.) Haüy has described 4 secondary forms. Its integrant particles are regular tetraedrons.

The Spinelle scratches quartz, but is itself scratched by the sapphire, and is a little less hard, than the chrysoberyl. Its structure is usually foliated, with laminæ parallel to the faces of the octaedron.

Before the blowpipe it is infusible; and does not even lose its color. It appears to be essentially composed of alumine and magnesia, having the chromic acid or the oxide of iron, as coloring matters.

SUBSPECIES 1. RUBY.*

It is almost always crystallized in octaedrons, sometimes a little modified. Its color usually presents some shade of red, as scarlet, cochineal, rose, violet, cherry, or yellowish red, but is sometimes dark blue or blackish.† Its fracture, parallel to the sides of the octaedron, is foliated, but its cross fracture is more or less conchoidal; its lustre is vitreous and splendent. It is often translucent, but may be transparent, or opaque. Its spec. grav. varies from 3.57 to 3.76.

It is composed of alumine 82.47, magnesia 8.78, chromic acid 6.18;=97.43. (*VAUQUELIN.*) Its red color is derived from the chromic acid. Before the compound blowpipe it quickly fuses into an elliptical, *red* globule. (*SILLIMAN.*) Its color is therefore retained in the greatest heat.

It resembles some varieties of zircon; but the latter loses its color by heat, and, when both are in octaedrons, the faces of the Ruby are equilateral triangles, and those of the zircon isosceles.—It is less hard, and less heavy, than the red sapphire, and hence may be distinguished, even when cut.—The red topaz, which the Ruby somewhat resembles, is electric by heat, and possesses double refraction.‡

(*Geolog. situation.*) Its geological situation is but little known. It has usually been found in the sand of certain rivers, particularly in those of the island of Ceylon, where it is accompanied by sapphire, zircon, tourmaline, Ceylanite, &c. In some specimens from India it is imbedded in calcareous spar with mica, sulphuret of iron, &c. in others it is contained in feldspar.

(*Use.*) When of good color, it is very highly esteemed in jew-

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* Spinell. WERNER. Spinelle. JAMESON. Spinell and Balass rubies. KIRWAN. Le Spinel. BROCHANT. Spinelle Rubis. BRONGNIART.

† Among lapidaries the scarlet red is sometimes called *ruby spinelle*; the pale or rose red, *balass ruby*; and the yellowish red, *rubicelle*.

‡ Many substances have improperly received the name of Ruby. The red sapphire has been called *oriental Ruby*; the red topaz, *Brazilian Ruby*; a variety of red quartz, *Bohemian Ruby*; red fluate of lime, *false Ruby*; &c.

elry, though of somewhat less value, than the red sapphire *(oriental ruby.)*

Subspecies 2. CEYLANITE.[*] *Jameson.*

The Ceylanite, sometimes in rounded grains, is often crystallized in octaedrons, sometimes with truncated edges; also in dodecaedons with rhombic faces, of which eight solid angles are sometimes truncated. Its spec. gravity varies from 3.76 to 3.79, being a little greater, than that of the ruby; its hardness, however, is somewhat less, but still enables it to scratch quartz. Its structure is rather indistinctly foliated; and its fracture is shining, and conchoidal, with large, smooth cavities.

It is nearly or quite opaque, and its more common color is a very dark blue or black; but its fragments, when held between the eye and the light, transmit a dark greenish light. It also presents other shades of blue, or is purple, or even greenish, or yellowish.

The Ceylanite contains alumine 68, magnesia 12, oxide of iron 16, silex 2 ;=98. *(Descotils.)*

(Geolog. sit. and Localities.) It was first observed in the island of *Ceylon*, in the sand of its rivers, with tourmaline, &c.—At Vesuvius it occurs in greenish crystals in the cavities of certain lavas.—At Monte Somma in rocks, sometimes calcareous, sometimes composed of mica, quartz, feldspar, idocrase, &c. the Ceylanite is in octaedrons dark blue, greenish, &c.

Species 6. FIBROLITE.[†] *Bournon.*

This very rare mineral is composed of minute fibres, intimately united, and often collected into little bundles, crossing each other in various directions. When broken perpendicularly to the fibres, it appears compact and glossy. It is a little harder than quartz; and its spec. gravity is 3.21. By friction, according to Bournon, it phosphoresces with a deep red light. Some of the fibres appear to be rhomboidal prisms. Its color is white, or gray.

It is infusible by the blowpipe. It contains alumine 58.25, silex, 38, iron 0.75 ;=97. *(Chenevix.)*

It accompanies the corundum from the Carnatic, and from China.

Species 7. CYANITE.[‡] *Jameson.*

This mineral is found both massive and in regular crystals. It is

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[*] Zeylanit. WERNER. Spinelle Pleonaste. BRONGNIART. Pleonaste. BROCHANT.

[†] Fibrolite. HAUY. BRONGNIART.

[‡] Cyanit. WERNER. Disthene. HAUY. BRONGNIART. La Cyanite. BROCHANT. Sappare. SAUSSURE. KIRWAN.

frequently in broad or compressed six-sided prisms, with bases a little inclined; two opposite lateral edges, which belong to the primitive form, contain angles of about 103°; and of the other four edges two are about 130°, and two about 127°. Or this crystal may be viewed as a four-sided prism, truncated on two of its lateral edges, diagonally opposite. The wider faces have usually a much stronger lustre, than those, which are narrow.

It has also been observed in eight-sided prisms, with bases either at right angles to the prism, or inclined at an angle of about 106°, or terminated by four-sided pyramids. The primitive form is a quadrilateral prism with inclined bases. The laminæ separate in three directions, and in one, the divisions are very perfect; their surfaces are more or less shining and pearly.

The crystals, often very long, are frequently grouped. Sometimes a double crystal is formed by the union of two crystals in the direction of their length, in such manner, that a cavity or re-entering angle exists in the place of one lateral edge. Sometimes the crystals intersect each other, or are collected into groups, either parallel or diverging.

It scratches glass, when the edges of its laminæ are employed, but is itself scratched by glass, acting perpendicularly to the surface of the laminæ. Its electric powers are remarkable; for the electricity, which it acquires by friction, is sometimes positive, and sometimes negative.

The massive varieties are composed of lamellæ, often very long, sometimes very narrow, sometimes curved and interlaced; and their fracture is frequently fibrous with broad, diverging fibres. Indeed these lamellæ, situated in all directions, are sometimes so intimately united, that the mass appears to be composed of large, granular concretions, or is almost compact. The lustre is always more or less pearly. Its spec. grav. lies between 3.51 and 3.62.

The Cyanite is translucent and sometimes transparent. Its prevailing color is *blue*,* varying from a fine Prussian blue to sky blue, or bluish white; it also occurs bluish green, pale green, yellowish, or even gray or white, and sometimes reddish. In some cases a very intense blue appears in spots or stripes, the remainder of the crystal being a pale blue, or pearly white.

(*Chemical characters.*) It is infusible by the common blowpipe, even when supplied with oxigen gas. But before the compound blowpipe it is instantly fused with ebullition into a white enamel. (SILLIMAN.) A specimen from St. Gothard yielded Laugier alumine 55.5, silex 38.5, lime 0.5, oxide of iron 2.75, water 0.75 ;=98.

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* Hence its name, from the Greek, Κυανος, blue color.

Its laminæ are harder than those of talc, and scarcely unctuous or flexible;—they are not elastic, like those of mica, which they usually scratch.

(*Geolog. situation.*) The Cyanite is found in primitive rocks, especially in talc and mica slate, gneiss, and granite. It is frequently accompanied by garnets, staurotide, quartz, tourmaline, &c. Very fine crystals come from St. Gothard.—In Tyrol it is sometimes red. (*Maclure.*)

(*Localities.*) In the *United States.* In *Maryland*, 20 miles from Baltimore, on the Falls turnpike; its crystals, sometimes 5 inches in length, are usually pale green, rarely blue, and imbedded in a micaceous rock; sometimes in loose masses, composed chiefly of Cyanite, connected by quartz; it is sometimes associated with staurotide, garnets, and magnetic iron;—also on the same road 7 miles from Baltimore both crystallized and massive. (*Gilmor. Hayden.*)—In *Pennsylvania*, in Chester Co. sometimes in masses of united crystals a foot in length, of a pale blue color; (*Woodbridge.*)—also at Darby, in Delaware Co. of a fine blue color, in primitive rocks; (*Conrad.*)—also in Philadelphia Co. near Chesnut hill, in mica slate; (*Seybert.*)—also in Montgomery Co.—In *Connecticut*, at Litchfield and Harwinton, in large and beautiful blue and white crystals, or in crystalline masses, in mica slate;—also in small, imperfect crystals in mica slate near Newhaven. (*Silliman.*)—In *Massachusetts*, at Chesterfield, Hampshire Co. where it was discovered by Dr. Hunt of Northampton; its crystals are sometimes very fine, and its blue color is often remarkably beautiful; it is associated with garnets, quartz, &c.—In *Maine*, at Brunswick, in small quantities, and nearly white, in a micaceous rock.

Species 8. Staurotide.* *Hauy. Brongniart.*

This mineral is always crystallized in prisms, either single, or intersecting each other at given angles. Its primitive form, under which it sometimes appears, is a four-sided prism, whose bases are rhombs, with angles of 129° 30′ and 50° 30′. Its integrant particles are triangular prisms. Of its secondary forms the following are the most common.

A six-sided prism, or the primitive form, truncated on its two acute lateral edges by planes, forming with the contiguous sides angles of 115° 15′. The four planes, which form the two most obtuse lateral edges of this prism, viz. those of 129° 30′, are in general broader, than the other two; sometimes, however, these edges of

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* Granatit. Werner. Grenatite. Jameson. Brochant.

129°30′ are formed by the meeting of one wide and one narrow plane, by which the appearance of the crystal is much altered.

The preceding prism is sometimes truncated at each extremity (Pl. III, fig. 30.) on the two solid angles, which terminate the two most obtuse lateral edges; in some specimens these truncations form a bevelment, or diedral summit.

Two prisms, belonging to either of the preceding varieties, often intersect each other, sometimes at right angles, and sometimes (Pl. III, fig. 31.) at angles of 60° and 120°. In some instances one prism enters or barely traverses the other without actually intersecting it, that is, it projects on one side only.—Sometimes also three prisms decussate each other. The surface of the crystals is sometimes smooth and feebly shining, and sometimes rough and nearly dull.*

The Staurotide feebly scratches quartz, but does not easily give fire with steel. Its fracture is uneven or imperfectly conchoidal, and usually a little foliated, parallel to the axis; its lustre is moderately shining.

It is often opaque, sometimes translucent, especially in the single crystals. Its color is reddish brown, often very dark or even blackish brown, or sometimes grayish. Its spec. grav. is 3.28.

Before the blowpipe it does not melt; but its surface is converted into a kind of black frit. It is composed, according to Klaproth, of alumine 52.25, silex 27, oxide of iron 18.50, oxide of manganese 0.25 =98. In another specimen Vauquelin found alumine 47, silex 30.6, lime 3, oxide of iron 15.3;=95.9. It often contains foreign minerals imbedded.

Its form and infusibility distinguish it from the garnet.

(*Geolog. sit. and Localities.*) The Staurotide has been found only in primitive rocks, and most frequently perhaps in mica slate. It thus occurs at St. Gothard, often accompanied by cyanite; its crystals are often translucid, and have the reddish brown color of the garnet.—In Brittany, it is in a micaceous clay, which appears to be the result of decomposition,

In the *United States.* In *Maryland*, 7 miles from Baltimore, in mica slate, sometimes with cyanite. (DR. BUTTS.)—In *Pennsylvania*, in Montgomery Co, on the Schuylkill, 8 m. from Philadelphia, in rocks abounding with talc; (WISTER.)—also 12 m. from Philadelphia in mica slate. (CONRAD.)—In *Connecticut*, at the notch of the mountain in Bolton, also in East Hartford, and Tolland, in large crystals, often forming the cross, in mica slate with garnets; (SIL-

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* In general, the prisms, which intersect each other, are shorter and more opaque, than the single prisms, and their surface has usually less lustre.

LIMAN.)—also at Harwinton in very perfect crystals in granite with cyanite. (*WOODBRIDGE.*)—In *Maine*, at Winthrop, Sidney, Hallowell, &c. At Winthrop it is very abundant in mica slate; the crystals are opaque and of various sizes, sometimes blackish brown with smooth, glistening surfaces, and sometimes brown or reddish brown with a rough surface; they frequently contain minute garnets or scales of mica. Single prisms, double prisms, crossing at right and oblique angles, and even three prisms, intersecting each other, sometimes all occur in the same small specimen.

SPECIES 9. CHRYSOBERYL.* *KIRWAN. JAMESON.*

This mineral ranks next to the sapphire in hardness. It possesses double refraction; and very frequently exhibits a remarkable reflection of a bluish or milk white light, which seems to play in the interior of the crystal. It often occurs in grains, or small, rounded masses, and sometimes in crystals, whose primitive form is a rectangular, four-sided prism. Its secondary forms are all prismatic. Sometimes it appears in regular six-sided prisms, often so short, that they become six-sided tables. Sometimes these prisms or tables are truncated on their terminal edges, and the crystal then assumes the aspect of an eight-sided prism (Pl. III, fig. 32.), terminated by six-sided summits; sometimes also its summits have each ten faces.

Its fracture is conchoidal or undulated, and splendent; and sometimes foliated, parallel to the axis of the prism. Its spec. grav. extends from 3.60 to 3.79; by friction it easily becoms electric.

It is more or less transparent, or oply translucent. Its color is green of different shades, usually pale, or even greenish white, but, in most cases, more or less mingled with yellow.

It is infusible by the blowpipe. It contains alumine 71.5, silex 18, lime 6, oxide of iron 1.5;=97. (*KLAPROTH.*)

The Chrysoberyl is harder and heavier than the emerald, which it resembles, and sometimes accompanies.—It is not electric by heat, like certain topazes of a similar cclor.

(*Geolog. situation.*) This mineral has been brought from Brazil and Ceylon, but little is known of its original situation in those places.

In the *United States*. In *Connecticut*, at Haddam, on Connecticut river, the Chrysoberyl occurs in granite in six-sided prisms and six-sided tables; its color varies from greenish yellow to yellowish green. The same granite contains garnets, emerald, tourmaline, &c.

(*Use.*) It is sometimes employed in jewelry.

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* Krisoberil. WERNER. Cymophane. HAUY. BRONGNIART. Le Chrysoberil, BROCHANT.

Species 10. GAHNITE.*

It is always crystallized in small, but very regular octaedrons, which are sometimes double, like those of spinelle. Its color is deep green or greenish black, and its fragments are translucent. It scratches quartz, and has an uneven or conchoidal fracture. Its spec. grav. varies from 4.26 to 4.69. It is not a conductor of electricity.

Before the blowpipe it is infusible; but with borax, according to Eckeberg, it gives a green glass, while hot, which becomes colorless, when cold. It contains alumine 60, oxide of zinc 24.25, oxide of iron 9.25, silex 4.75;=98.25. (*Eckeberg.*) According to Vauquelin alumine 42, oxide of zinc 28, oxide of iron 5, silex 4, sulphur 17, insoluble residue 4.

It has been found at the mine of Fahlun, in Sweden, in a rock abounding with talc.

Species 11. GADOLINITE.† *Haüy.*

This very rare mineral has usually occurred in amorphous masses of a black or brownish black color. It slightly scratches quartz, and gives sparks with steel. It is easily broken, and its fracture is conchoidal, and shining with a vitreous lustre. It acts on the magnetic needle; and has a specif. gravity of about 4.04. It is opaque, or a little translucent at the edges.—M. Haüy has an incomplete crystal of Gadolinite, which he conjectures to be a ten-sided prism.

(*Chemical characters.*) Its powder, when thrown into diluted nitric acid and heated, loses its color, and is converted into a yellowish gray jelly. This mineral, when suddenly heated by the blowpipe, decrepitates, and is dispersed in small fragments, which appear inflamed. If cautiously heated, however, it remains entire, but does not melt, except in certain points, which fuse with ebullition. It tinges borax yellow. It contains, according to Klaproth, Ittria 59.75, silex 21.25, oxide of iron 17.5, alumine 0.5, water 0.5;=99.50.

(*Distinctive characters.*) It resembles massive chromate of iron; but the latter is heavier, tinges borax green, and does not form a jelly with acids.—A comparison of its specific gravity and chemical characters with those of the black oxide of uranium and obsidian will prevent its being confounded with those minerals.

(*Geolog. sit. and Locality.*) The Gadolinite, so called from Dr. Gadolin, who discovered in it the new earth, *Ittria*, has been found only at Ytterby, in Sweden. It exists in veins of feldspar,

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* Zinc Gahnite. BRONGNIART. Spinelle zincifère. HAÜY. Automalite. ECKEBERG.

† Gadolinite. JAMESON. BRONGNIART. BROCHANT. Gadolinit. WERNER.

which traverse granite, and are themselves intersected by veins of mica.

Species 12. Zircon. *Hauy. Brongniart.*

This mineral occurs in rounded grains or fragments, or in regular crystals, which sometimes present their primitive form, viz. an octaedron (Pl. III, fig. 33.); its sides are equal and similar isosceles triangles, and inclined to each other at the common base in an angle of 82° 50′. The surface of its crystals is generally smooth, with an oily or resinous lustre. It has nine or ten secondary forms; and its integrant particles are irregular tetraedrons.

The Zircon is a little harder than quartz, and possesses double refraction in a high degree. It is more or less transparent, or only translucent. Its spec. gravity, which generally lies between 4.38 and 4.66, is sometimes 4.70. *(Werner.)*

It is infusible by the blowpipe; but usually loses its color, especially the red varieties. With the compound blowpipe it melts into a white enamel. *(Silliman.)* It is essentially composed of zirconia and silex.

(Distinctive characters.) Its infusibility, spec. gravity, strong double refraction, and the measure of its angles, when crystallized, will serve to distinguish it from the garnet, idocrase, staurotide, &c. indeed some of these characters may be observed, when it is cut and polished.

It presents two varieties, which differ a little in some of their external characters.

1. JARGON.* *Kirwan.* When in distinct crystals, its usual form is a four-sided prism (Pl. III, fig. 34.), terminated by four-sided pyramids, whose faces are inclined to the sides of the prism, on which they stand, at an angle of 131° 25′. All the edges of the prism, and even those of the pyramids are subject to truncation; and the solid angles between the prism and pyramids are often replaced by two faces or bevelled. (Pl. III, fig. 38 and 39.)—It also presents the primitive form. Its fracture is conchoidal, undulated, or uneven, with a strong lustre somewhat resinous. Its colors are numerous; it presents several shades of gray, and green; and is sometimes yellowish, bluish, red, brown, reddish brown, &c. with various intermediate shades, and is even white, or limpid.

In a specimen from Ceylon Klaproth found zirconia 69, silex 26.5, oxide of iron 0.5;=96. In another from Norway he found zirconia 65, silex 33, oxide of iron 1;=99.

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* Zircon Jargon. Brongniart. Zirkon. Werner. Zircon. Jameson. Le Zircon. Brochant.

(Geolog. situation and Localities.) In the island of Ceylon it is found in the sand of rivers with spinelle, tourmaline, &c.—In Norway, at Fredrickswarn, in an aggregate of feldspar and hornblende.—In Galloway, Scotland, in gneiss.

In the *United States.* In *Maryland*, 2 miles from Baltimore, in granite. *(De Butts.)*—In *New Jersey*, near Trenton, in gneiss, with a greenish feldspar; the crystals are small four-sided prisms, terminated by pyramids, with additional faces on their edges or angles; semitransparent and of a deep brownish red color; their length is seldom more than one fourth of an inch. *(Conrad.)*—In *New York*, at Schooley's mountain, in detached masses of granite, consisting chiefly of feldspar; a quadrangular prism, from this mountain, of a dark brown color and almost opaque, measured nearly two inches in length and one fifth of an inch on each side. *(Woodbridge.)*—In *Connecticut*, at Sharon, in detached pieces of quartz; the crystals are four-sided prisms, terminated by pyramids, have a dark brown color, and rarely exceed one half an inch in length. *(Silliman.)* It appears from the preceding details, that the Zircon of the United States belongs to primitive rocks.

(Use.) It is sometimes employed in jewelry, especially in mourning dresses.

2. HYACINTH.[*] *Kirwan. Jameson.* When in distinct crystals its ordinary form is a four-sided prism, terminated by four rhombic planes (Pl. III, fig. 35.), which stand on the lateral edges. Each plane angle at the summit is 73° 44′. It may be truncated on the lateral or terminal edges, or on both. When the sides of the prism are shortened and become rhombs, the crystal resembles the dodecaedral garnet, but differs in the mutual incidence of the faces.

Its structure is more distinctly foliated, and its natural joints, parallel to the primitive octaedron, more obvious, than those of the Jargon. Its fracture, which is foliated, has a high lustre. Its prevailing color is that called hyacinth red, in which the red is more or less tinged with yellow and brown; it is sometimes pale or even grayish.

Before the blowpipe it generally loses its color, but retains its transparency. A specimen from Ceylon yielded Klaproth zirconia 70, silex 25, oxide of iron 0.5;=95.5. In one from France Vauquelin found zirconia 66, silex 31, oxide of iron 2;=99.

(Geolog. situation and Localities.) It has been found in primitive rocks; but is usually taken from the sand of rivers, &c. It is

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[*] Hiazinth. Werner. Zircon Hyacinthe. Brongniart. L'Hyacinthe. Brochant.

thus found in the stream of Expailly, near Puy en Velay, in France, with sapphire, octaedral crystals of magnetic iron, &c.—also in the island of Ceylon, &c.

(Use.) It is sometimes employed in jewelry, even when discolored by heat.*

Species 13. Quartz. *Haüy.*

This extensive and interesting species embraces numerous varieties, differing much in their forms, texture, and other external characters. And it is somewhat remarkable, that, although but few well defined, external characters apply to the whole species, most of its varieties are easily recognised.

It is sufficiently hard to scratch glass, and it always gives sparks with steel more or less plentifully, unless the mass be too brittle to sustain the blow; and in this latter case, its powder will be found rough to the touch, and sufficiently hard to scratch glass or steel. When pure, its specific gravity is about 2.63; but in certain varieties extends both above and below this term, depending on its structure, or the presence of foreign ingredients. Indeed the mean specific gravity of the whole species, derived from the two extremes, is about 2.60.

It is sometimes in amorphous masses, and sometimes in very beautiful crystals, of which the primitive form is a rhomb slightly obtuse, the angles of its faces being 94° 24′ and 85° 36′. This nucleus is seldom easily obtained, unless the crystal be previously heated and plunged into cold water. Haüy has described nine secondary forms, of which the more common is a six-sided prism, terminated by six-sided pyramids. It exhibits double refraction, which must be observed by viewing an object through one face of the pyramid and the opposite side of the prism.

(Chemical characters.) All its varieties are infusible by the blowpipe, and, if pure, it is scarcely softened, even when the flame is excited by oxigen gas. Before the compound blowpipe a fragment of rock crystal instantly melts into a white glass. *(Silliman.)* Quartz is essentially composed of silex, sometimes nearly or quite pure; and sometimes mingled or combined with foreign ingredients, which very materially affect its external characters.

To facilitate description this species is separated into two *Divisions*, each of which is farther divided into subspecies and varieties.

The *first division* embraces those varieties, which are susceptible

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* From a resemblance in color certain sapphires have been called *oriental Hyacinth*; certain topazes, *occidental Hyacinth*; and yellow ferruginous quartz, *Hyacinth of Compostella.*

of crystallization, and have a fracture more or less vitreous. It in fact comprehends all, which some mineralogists include under the species, quartz.

The *second division* contains those minerals, which appear to be composed essentially of silex only, often equally pure, as those of the first division, but which have never been seen crystallized, nor perfectly transparent. Most of the varieties of this division have by Brongniart been collected into one species, bearing the name of silex.*

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* In giving this extent to the species of Quartz, it might perhaps be sufficient to cite the authority of the celebrated Haüy. A few observations, however, may not be inexpedient. In the Introd. art. 177, &c. it was remarked, that identity of composition forms the best specific character of minerals; and that, whenever two minerals are known to be composed of the same ingredient, or ingredients, united in the same proportions, they ought to be referred to the same species, however they may differ in their external characters. According to these principles, we include under this species all those minerals, which appear to be essentially composed of silex only, or whose other ingredients appear to be accidental and foreign to the true composition. Accordingly, when analysis informs us, that the *most perfect* and *best characterized* variety of Quartz contains from 93 to 99 parts of *silex*; that *Amethyst* contains 97.5 parts of *silex*; that *Carnelian* contains 99 parts of *silex*; that *Chrysoprase* contains 96.16 parts of *silex*; that *Opal* contains 98.75 parts of *silex*; and, in fine, that *Flint* contains 98 parts of *silex*; the residue being in all these cases a very little alumine, lime, water, or some metallic oxide; can we, for a moment, doubt whether all these minerals belong to the same species? Is it not evident, that *silex only* is their essential ingredient, and that the other ingredients are merely accidental? It is true, that these adulterating and coloring ingredients sometimes exist in proportions somewhat greater, than in the preceding analyses; but even this circumstance serves to show, that they are merely adventitious; and, if in any instances, they are sufficiently uniform to establish *subspecies*, they cannot consistently be permitted to form specific distinctions, unless we assume *external* characters *only*, as the basis of arrangement.

Further, what two varieties of Quartz are more unlike each other, than are crystallized carbonate of lime and compact limestone, the latter of which is often contaminated with from 3 to 12 per cent. of alumine, silex, and oxide of iron? Still the last two minerals have uniformly been referred to the *same species*. It may indeed be said, that the analysis of minerals, composed of several different earths, does not inform us what is essential to the species. But this remark cannot apply to a mineral, evidently composed of one earth only, as in the case of Quartz. In fine, crystals of Quartz have been found adhering to flint, and imperceptibly incorporating themselves with it, in the same manner, as crystals of carbonate of lime are found attached to compact limestone. (See Introd. art. 176, 197.)

DIVISION 1. Quartz, susceptible of crystallization, and having a fracture more or less vitreous.

SUBSPECIES 1. COMMON QUARTZ.*

This subspecies, though often in amorphous masses, is very frequently in crystals, which, in perfection and beauty, are not exceeded by those of any other mineral. These crystals rarely exhibit their primitive form, which is a rhomb.

The most common form of crystallized quartz is a six-sided prism, terminated by six-sided pyramids, whose faces correspond with the sides of the prism, and form with them an angle of 141° 40′; the mutual inclination of any two opposite faces of the same pyramid being 75° 52′. The sides of the prism are transversely striated; but the planes of the pyramids are smooth and polished. The pyramidal termination frequently appears at one extremity only.—This form is subject to numerous modifications, which greatly affect its general appearance. Sometimes the faces of the pyramids are alternately large and small;—sometimes one face of the pyramid is so much larger, than the others, that it seems to form an oblique base to the prism;—sometimes the prism is broad or compressed, and two opposite faces become so large, that the crystal resembles a table with bevelled edges;—sometimes the sides of the prism are convergent, so that the diameter at one extremity is greater, than at the other.

Not unfrequently some of the solid angles, situated between the prism and each of the two pyramids, are truncated by rhombic planes, (Pl. III, fig. 36.)—Sometimes all the solid angles, situated as aforementioned, are truncated by trapezoidal planes, obliquely placed.

Sometimes the prism is so short, that the two terminating pyramids nearly meet, and the crystal becomes a double six-sided pyramid, with its common base truncated;—or the prism entirely disappears, leaving a double six-sided pyramid (Pl. III, fig. 37.), whose faces are isosceles triangles, inclined at the common base in an angle of 103° 20′. Sometimes only one of the pyramids is distinct;—and sometimes three alternate faces, on each pyramid, are so unduly extended, that the other faces almost disappear, and the crystal appears slightly rhomboidal.

In fine, two or more of the preceding modifications sometimes meet in the same crystal. But, notwithstanding these numerous alterations, arising from the extension of some of the sides or faces at the expense of the others, the angles of mutual incidence remain unaffected.—It has been remarked, that all the specimens from the same

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* Gemeiner quarz—milch quarz—berg kristal. WERNER. Common quartz—milk quartz—rock crystal. JAMESON.

locality usually belong to the same variety of form. In some instances the crystals attain an uncommon size, their prisms having been seen nearly three feet in length and almost two feet in breadth. They are frequently many inches in length.

Quartz is sometimes in stalactical or reniform concretions, sometimes cavernous, corroded, or in plates, &c. It is often in pebbles or rolled fragments, or in amorphous masses more or less large, and sometimes composed of small, granular, distinct concretions.

Its fracture, sometimes imperfectly foliated, is usually more or less conchoidal, undulated, or splintery, and, in some specimens, uneven. Its lustre is vitreous, sometimes splendent, and sometimes only glimmering. Its spec. gravity extends from 2.58 to 2.88. It is sometimes highly transparent, and very frequently translucent, though in some cases only in thin fragments, or at the edges. It is often perfectly limpid; its more common colors are white or gray, often intermixed with yellow, orange, red, green, blue, or black; indeed it presents several distinct shades of red, yellow, green, or blue, and is sometimes black.

By friction it exhales a peculiar odor and some varieties also phosphoresce in the dark.

A specimen, analyzed by Bergman, yielded silex 93, alumine 6, lime 1. In another Gerhard found 99 parts of silex. Its powder renders the tincture of violets green. (*Vauquelin.*) Some colored crystals retain their transparency in a heat sufficient to deprive them of color.

Var. 1. LIMPID QUARTZ. (Rock crystal.*) This, which is only the most perfect variety of Quartz, has, when crystallized, received the name of *rock crystal;* indeed the same name is sometimes extended to colored crystals, when transparent. Limpid quartz is without color, and sometimes as transparent, as the most perfect glass, which it strongly resembles. It is however harder, than glass, and the flaws or bubbles, which it often contains, lie in the same plane, while those in glass are irregularly scattered. (*Brongniart.*)

The finest crystals are found in veins or cavities in primitive rocks, as in granite, gneiss, or mica slate; or in alluvial earths. Savoy, Switzerland, and Madagascar are most celebrated among foreign localities.

In the *United States*, this variety is not uncommon. In *Virginia*, near the North Mountain.—In *Maryland*, in Frederick Co. the crystals are scattered on the surface of the ground; they are perfectly transparent, with a splendent lustre, and the sides of the prisms

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* Berg kristal. Werner. Rock crystal. Kirwan. Jameson.

sometimes so smooth, that the transverse striæ are not perceptible. (*Hayden.*)—In *Pennsylvania*, in many places east of the Blue Ridge.—In *New York*, on an island in Lake George, in very fine crystals. (*Silliman.*)—In *Vermont*, at Grafton, remarkably pure and transparent. (*Hall.*)

(*Use.*) This variety is sometimes employed in jewelry, for watch seals, &c.

2. SMOKY QUARTZ.* Objects, seen through this variety, seem to be viewed through a cloud of *smoke*. Its true color appears to be clove brown. It is sometimes called *smoky* topaz. Fine specimens have been found near Hanover, Lancaster Co. *Pennsylvania*. (*Seybert.*)—In *Maine*, at Topsham, amorphous fragments are not uncommon; and it is sometimes crystallized.

3. YELLOW QUARTZ.† Its color is a pale yellow, sometimes honey or straw yellow. It has been called *citrine*; also *false*, or *Bohemian* topaz.—Good specimens are brought from Carinthia.—It is found in several parts of *Pennsylvania*, east of the Blue Ridge. (*Wister.*)

4. BLUE QUARTZ.‡ Its color is blue, or grayish blue. Its inferior hardness and specific gravity sufficiently distinguish it from the blue sapphire. It has been called *false* or *occidental* sapphire. It comes from Bohemia, Macedonia, &c.—An amorphous blue quartz is found in Chester Co. and near Abington, Montgomery Co. *Pennsylvania*. (*Seybert.*)

5. ROSE RED QUARTZ.§ Its color is rose red of different shades, sometimes with a tinge of yellow. It is seldom more than semi-transparent, and its lustre is often a little resinous. Its color, which is supposed to arise from manganese, is said to be injured by exposure to light.—It has been called *Bohemian* ruby.—In Bavaria it is found in a vein of manganese, traversing granite.—In *Maine*, at Topsham, in loose fragments, scattered among masses of granite and gneiss.

(*Use.*) It is sometimes employed in jewelry, and much esteemed.

6. IRISED QUARTZ.‖ It reflects a series of colors, similar to those of the iris or rainbow. Sometimes this appearance is produced at the surface by a thin coat of some metallic oxide. Sometimes also the colors are reflected from the interior, being caused by numerous small fissures, which traverse the quartz.

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* Quartz hyalin enfumé. Haüy. † Quartz hyalin jaune. Haüy.

‡ Quartz hyalin saphirin. Brongniart.

§ Milch quarz. Werner. Milk quartz. Jameson. Quartz hyalin rose. Haüy. ‖ Quartz hyalin irisé. Haüy.

7. AVENTURINE QUARTZ.* Its predominant color, which may be red, yellow, gray, greenish, blackish, or even white, is variegated by brilliant points, which shine with a silver or golden lustre. These shining points seem to be produced by the reflection of light from numerous fissures, or from disseminated plates of mica, or perhaps from laminæ of Quartz, interspersed through the mass. It is often found in rolled pieces; and, when the fragment is large, the centre usually exhibits very few of those reflections, peculiar to this Quartz. This variety is sometimes employed in ornaments of jewelry.

8. MILKY QUARTZ.† Its color is milk white, in some cases a little bluish; and it is nearly opaque; its fracture has sometimes a resinous lustre. It is sometimes in small crystals, but more often in large masses.—In *Maryland*, it occurs near Baltimore, both crystallized and amorphous.—In *Pennsylvania*, Chester Co. 14 miles from Philadelphia, is found an amorphous, milky quartz, which easily separates into very thin laminæ. (*SEYBERT.*)

9. GREASY QUARTZ.‡ Its colors are various, either light or dark, sometimes reddish, yellowish, &c. but its lustre is peculiar. Its fracture, which may be large splintery or conchoidal, appears as if rubbed with oil. Sometimes its structure is distinctly laminated.

10. RADIATED QUARTZ. It is in masses, which have a crystalline structure, and are composed of imperfect prisms, closely applied to each other, and sometimes terminating in pyramids at the surface. These prisms usually diverge a little, or radiate from a centre, and often separate with great ease.—In *Maryland*, this variety occurs 8 miles from Baltimore in detached masses. (*GILMOR.*)—In *Massachusetts*, at the Lead Mine, near Northampton, where it often constitutes the gangue of the ores.

11. TABULAR QUARTZ. It occurs in plates of various sizes, which are sometimes applied to each other by their broader faces. Sometimes they intersect each other, producing *cells* of various forms. Sometimes their appearance is *pectinated*, or *crested*, like a cock's comb.

In *Maryland*, this variety occurs near Baltimore.

It should, however, be remarked, that the *cellular* appearance of quartz is often produced in a very different manner. In this latter case it presents *impressions*, whose forms may be cubic, tabular, pyramidal, &c. and sometimes the cavities are altogether irregular. But these vacuities proceed from the removal or decomposition of crystals or grains of some metallic sulphuret, &c.—in fact, this decomposition may sometimes be observed, when only partially advanced.

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* Quartz hyalin aventuriné. HAUY. † Quartz hyalin laiteux. HAUY.

‡ Quartz hyalin gras. HAUY.

12. GRANULAR QUARTZ. *Kirwan.* Its structure presents small granular concretions, or grains, which are sometimes feebly united. This variety must be carefully distinguished from certain sandstones, which it sometimes resembles.—It is said to occur at Hinsdale, Berkshire Co. in *Massachusetts*, in large, friable masses, snow white, and much resembling sugar. It may, probably, prove important in the manufacture of glass, and certain kinds of stone ware.

13. ARENACEOUS QUARTZ.* It is in loose grains, coarse or fine, either angular or rounded, and constitutes some varieties of pure sand.—Certain sandstones appear to be composed of this quartz, united by some cement; but they belong not to simple minerals.

14. PSEUDOMORPHOUS QUARTZ.† It appears under regular forms, such as cubes, octaedrons, &c. which do not belong to the species. These false crystals have been moulded in cavities, which real crystals of the fluate, sulphate, or carbonate of lime, sulphate of barytes, &c. once occupied. They are opaque, their surfaces dull, and their edges often blunted.

(Geological situation.) Common Quartz, the subspecies just described, never forms whole mountains. It is sometimes in large masses, or in beds, and frequently in extremely large veins, which, according to Dolomieu, have often been mistaken for beds. Hence are detached those loose, insulated masses, which so often occur. Humboldt mentions a mass in the Andes, supposed to be several thousand feet thick.

Veins or beds of Quartz are usually situated in primitive rocks, as granite, gneiss, mica slate, greenstone; and in the cavities of these veins, or of the rocks, which they traverse, are found the finest crystals of quartz. The whole vein may be composed of Quartz, or it may embrace various other substances. Large masses of Quartz are often traversed by fissures.

Quartz, in the form of crystalline grains, or of irregular masses of various sizes, is abundantly disseminated in granite, gneiss, mica slate, &c. of all which it forms a constituent part. It is sometimes in regular crystals, dispersed through the granite, as at Brunswick, *Maine.* In porphyry also it is sometimes regularly crystallized. It also occurs in carbonate of lime, anthracite, &c. It rarely exists in masses in argillite.

Among secondary rocks Quartz is found forming the greater part of many sandstones; also between strata of compact limestone, of clay, or of marl, or in geodes of marl, or imbedded in sulphate of lime, &c.

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* Quartz hyalin arenacé. Haüy.

† Quartz hyalin pseudomorphique. Haüy.

In alluvial earths it exists in the form of sand.—In fine, stalactites or crystals of Quartz are every day forming by the filtration of water, containing particles of silex, through the pores or crevices of other minerals. Hence stalactites of Quartz have, in certain mines, been found attached even to wood.

Quartz is often associated with the carbonate, and fluate of lime, sulphate of barytes, and feldspar in metallic veins; indeed it exists in almost every metallic vein.

This mineral is sometimes traversed by whitish filaments of sulphate of barytes; or by crystals of actynolite; or by threads of asbestus, which give it a fibrous structure; or it is rendered nearly opaque by the presence of chlorite. It is sometimes penetrated by acicular crystals of titanium or antimony, or by plates or capillary filaments of native copper, silver, or gold.—Hornblende, schorl, epidote, garnet, magnetic iron, &c. are also among the minerals, contained in Quartz. Mica sometimes gives it a slaty structure.

In some rare instances bubbles of air, and even drops of water and bitumen have been found in Quartz.—Although common Quartz never contains any organic remains, it is sometimes crystallized in fossil wood.

(Localities.) Of a mineral so universally diffused, we shall cite but a few localities, in addition to those already mentioned. In *Maryland*, the hills, on which Baltimore is built, present immense quantities of pebbles of Quartz, arranged in beds of various thickness. (GILMOR.)—In *Pennsylvania*, 4 miles from Philadelphia, on the Schuylkill, in prisms terminated by pyramids at both extremities. (CONRAD.)—In *New York*, at Shawangunk mountain, where it passes into Ulster Co. this quartz is used for mill stones; (ARNELL.)—also at Lansinburgh in small, brilliant, well defined crystals;—also at Greenbush in prisms sometimes three inches in diameter with pyramids at both extremities. (WATERHOUSE.)—In *Connecticut*, at Washington, Litchfield Co. was found a mass of transparent Quartz now in the cabinet of Yale College; it appears to be a fragment of an immense crystal, and probably weighs between 200 and 300 pounds. (SILLIMAN.)—In *Rhode Island*, 12 miles north of Providence, is a hill, composed in a great measure of quartz, often crystallized. (SILLIMAN.)—In *Massachusetts*, at the Lead mine in Southampton, Hampshire Co. it forms the greater part of the gangue of this metallic vein, in the cavities of which it appears in crystals usually very regular, sometimes large, and often extremely beautiful; here also occurs the radiated quartz, already mentioned. (SILLIMAN.)—In *Maine* it is abundant, especially in the coarse grained granites, in which it sometimes forms very large masses, is often smoky, and in

some cases beautifully impressed by the contiguous mica, or even alternates with it in very thin layers.

(Uses.) We have already seen, that certain varieties of Quartz are employed in jewelry. It is also used, especially the sandy variety, in the manufacture of glass; also in the preparation of smalt, and certain enamels.—Its appearance is sometimes much altered by introducing metallic solutions into fissures, previously formed by exposure to heat.

SUBSPECIES 2. AMETHYST.* *WERNER. JAMESON.*

The color of the Amethyst is most commonly violet blue, but is seldom of equal intensity through the whole mass or crystal, in some parts of which it often entirely disappears. Sometimes it has a strong shade of red, and sometimes its color passes to brown or gray, or has even a shade of green. Different colors sometimes appear in the same specimen. It most frequently occurs in crystals, whose forms are the same as those of common quartz. It is also found in rolled fragments, or in masses, composed of prismatic, distinct concretions, or rather of imperfect, prismatic crystals. These prismatic concretions exhibit transverse striæ, and at the surface of the mass, often terminate in regular pyramids; they are frequently intersected by lamellar concretions, passing in a zigzag direction. When these prisms are long, small, and very intimately united, the mass has a fibrous appearance. Its other characters are those of common Quartz.

It contains, according to Rose, silex 97.50, alumine 0.25, oxide of iron 0.50, oxide of manganese 0.25 ;=98.50.

(Geolog. sit. and Localities.) It is sometimes attached to the interior of geodes of agate; and is frequently found in metalliferous veins. It also constitutes veins in primitive rocks. The Uralian mountains, Murcia in Spain, and Oberstein in Germany, furnish fine specimens. A greenish variety is found in Silesia.

In the *United States.* In *Pennsylvania,* 40 miles from Philadelphia, in Chester Co. near the Lancaster turnpike, in large, transparent crystals of a rich purple; *(WISTER.)*—also in Delaware and Berks Counties, in transparent crystals.—In *Connecticut,* at Wallingford, Farmington, and Berlin.—In *Massachusetts,* on Mount Tom, near Northampton, in beautiful crystals. *(SILLIMAN.)*—In *New Hampshire,* at Hampton Falls, in rolled pieces.

(Use.) It receives a good polish, and is sometimes employed in jewelry, and for articles of ornament, &c. The *oriental* Amethyst is a sapphire.

* Quartz hyalin violet. HAUY. Quartz hyalin Améthyste. BRONGNIART. L'Amethyste. BROCHANT. From the Greek Αμεθυστος.

SUBSPECIES 3. PRASE.* *JAMESON.*

This subspecies, which is seldom crystallized, possesses all the essential characters of Quartz. Its color, which is uniformly diffused through the mass, is always green, and usually a leek or dark olive green. Its lustre is often a little resinous. When in prismatic concretions, of which its masses are often composed, they are transversely striated. Its specific grav. is 2.58. It is commonly translucent.

Prase appears to be common Quartz, colored by actynolite or epidote. But the uniform diffusion of its color distinguishes it from that quartz, which is colored by chlorite; for the chlorite either adheres, as a crust, or appears to be suspended in the interior.—In Saxony it is found in a metallic bed, accompanied by actynolite, &c.

(Localities.) In the *United States.* In *Maryland,* near Baltimore—also in Washington Co. west side of the Blue Ridge, in masses scattered on the surface. *(HAYDEN.)*—In *Massachusetts,* at Brighton and West-Cambridge, and appears to be colored by epidote. *(GODON.)*

(Use.) It receives a good polish, and is sometimes employed for ornamental purposes.

SUBSPECIES 4. FERRUGINOUS QUARTZ.†

This mineral is opaque, or translucent at the edges only. Its fracture is uneven, or more or less conchoidal, shining and nearly vitreous. It is sometimes in very minute and perfect six-sided prisms, terminated at both extremities by six-sided pyramids; in some cases only three faces of each pyramid are distinct. Its colors, which are usually some variety of yellow or red, and its opacity appear to depend on the oxide of iron, which it contains.

By exposure to the blowpipe, and often to the flame of a candle, it acquires magnetism.

Var. 1. YELLOW FERRUGINOUS QUARTZ. Its color is ochre yellow, sometimes mixed with brown, or with a very slight tinge of green. It is sometimes in distinct crystals; but more often in masses, which appear to be an aggregation of small crystals.

2. RED FERRUGINOUS QUARTZ.‡ Its color is blood or brownish red, or deep brown, or has a tinge of yellow. It occurs in small but very perfect crystals, and in masses, which resemble some varieties

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* Prasem. WERNER. Quartz hyalin vert obscur. HAUY. Quartz Prase. BRONGNIART. Prasium. KIRWAN. La Prase. BROCHANT.

† Quartz rubigineux. HAUY. BRONGNIART. Eisenkiesel. WERNER. Iron Flint. JAMESON.

‡ Quartz rubigineux Sinople. BRONGNIART. Quartz hyalin hematoïde. HAUY.

of jasper; but their fracture, unlike that of jasper, has a vitreous, shining lustre.

When massive, the red variety occurs in metallic veins in primitive mountains, and is sometimes penetrated by the sulphurets of iron, lead, &c. or by native gold.—At Schemnitz in Hungary it contains organic remains. (*De Born.*)—Very perfect crystals of the red variety occur in sulphate of lime near Compostella in Spain, and have been called *hyacinth of Compostella.*

(*Localities.*) In the *United States.* In *Maryland*, in Washington Co. west side of the Blue Ridge, are found small, yellowish, well defined crystals of this quartz.

3. GREENISH FERRUGINOUS QUARTZ.* It occurs in small grains of a greenish yellow color, which becomes darker before the blowpipe. It contains silex 85, oxide of iron .8, water 7. (*Laugier.*) It is found at Cantal, in Auvergne.

Subspecies. 5. FETID QUARTZ.

This quartz is easily recognised by the peculiar odor, which it exhales, when struck with a hammer on its edges or angles. This odor strongly resembles that of sulphuretted hidrogen gas.—The external characters of this mineral are those of common quartz. Its color is usually gray, often marked with spots or stripes of a darker color. It is probably never white, nor perfectly transparent—sometimes faintly translucent. Its lustre is usually a little resinous. It is sometimes crystallized; and in some instances, at least, phosphoresces in the dark by friction.

This fetid property appears to be unequally diffused, even in the same small specimen, and is entirely driven off by exposure to a strong heat.

(*Localities.*) In France, near Nantz, it constitutes an ingredient of a coarse grained granite, or is found in loose masses, and is associated with crystallized feldspar and mica, which are not in the least degree fetid.

In the *United States.* In *Maine*, at Topsham, it exists in loose masses, which often contain very large crystals of feldspar and garnet; it has probably been detached from the coarse granite, which abounds in the vicinity.

DIVISION 2. The minerals, described under this division, have never been seen crystallized, nor perfectly transparent. They appear to be essentially composed of silex, which, in most cases, is equally pure as in the minerals of the first division. With the exception of the Hyalite and Cat's eye, they form the species, which

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* Quartz hyalin granulaire. Haüy.

Brongniart has called Silex. Some of the following varieties scarcely differ except in color, and do in fact pass into each other by imperceptible shades.

Subspecies 6. CAT'S EYE.* *Kirwan. Jameson.*

This very beautiful mineral is highly chatoyant. It reflects, when polished, an effulgent, pearly light, sometimes yellowish or greenish, varying with the position of the eye, and much resembling the reflections, observable in the eye of a cat.† Its usual colors are greenish or yellowish gray, yellowish brown, reddish brown, or grayish white, with intermediate shades. It has been seldom seen in its native state. When brought from India, it is usually cut and polished in specimens not larger, than a hazel nut. Its fracture is imperfectly conchoidal or uneven, and shining. It is more or less translucent, or even semitransparent; and has the hardness of quartz.

The Cat's eye appears to be quartz, penetrated by fibres of asbestus; and from these white and opaque fibres, sometimes distinctly visible, its peculiar reflections arise.

It is composed of silex 95, alumine 1.75, lime 1.50, oxide of iron 0.25;=98.50. (*Klaproth.*)

Its geological situation is unknown; but it comes principally from Ceylon, and the coast of Malabar.

It is employed in jewelry, and is sometimes cut in the form of a plano-convex lens.

Subspecies 7. CHALCEDONY.

Under this subspecies, we include several varieties, which have received distinct names in the arts. They have more or less resemblance in their general characters, and sometimes differ in color only; indeed two or more of them are often intimately united in the same mass.—Chalcedony occurs in small veins, or in cavities of other minerals, and appears to have been formed by the filtration of siliceous matter. It never appears in large, homogeneous masses.

Var. 1. COMMON CHALCEDONY.‡ *Kirwan. Jameson.* This variety is usually characterized by a cloudy or milky appearance, when held between the eye and the light, resembling milk, diluted with water. It is semitransparent, or only translucent in various degrees.

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* Katzenauge. Werner. Quartz agathe chatoyant. Haüy. Quartz hyalin chatoyant. Brongniart. L'Oeil de chat. Brochant.

† Hence its name; and hence the origin of the French term, *chatoyant.*

‡ Gemeiner Kalzedon. Werner. Quartz agathe calcédoine. Haüy. Silex calcédoine. Brongniart. La Calcédoine commune. Brochant. It is said to have been first observed in *Chalcedon*, in Asia.

Though sometimes nearly white, its more common color is gray, more or less shaded with blue, yellow, green, brown, red, &c. Sometimes its colors appear in stripes, veins, circles, clouds, spots, &c. and those, which are very dark, often become blood red, when viewed by transmitted light.

It occurs in amorphous masses, sometimes rolled, but more frequently under some imitative form, as globular, reniform, botryoidal, stalactical, &c. The surface is often rough or uneven.—Its fracture is usually even, though seldom smooth, sometimes a little conchoidal, splintery, or uneven, and nearly or quite dull. Its hardness is, at least, equal to that of flint, and its spec. gravity about 2.65.

The pseudomorphous crystals in prisms, cubes, &c. which it sometimes presents, appear to have been moulded in cavities, once occupied by crystals, or to arise from a thin deposite of Chalcedony about some real crystal.

In a specimen of greenish Chalcedony Klaproth found silex 96.75, water 2.50, alumine 0.25, oxide of iron 0.50. It is sometimes nearly allied to hornstone.

(Geological situation.) Chalcedony, whether amorphous, globular, stalactical, &c. is usually contained in amygdaloid, or porphyry, or in the cavities of these rocks; it sometimes traverses them in veins. The globular masses are often hollow, and have their interior lined with stalactites of Chalcedony, or crystals of amethyst, common quartz, mesotype, &c. and sometimes the central cavity is filled with water. In some instances the globules are not larger, than a pea.

Chalcedony is sometimes invested with crystals of quartz; and, on the contrary, quartz is sometimes covered by a deposite of Chalcedony. In some cases it is accompanied by bitumen, which either rests on its surface, or is even contained in its cavities. It sometimes forms the substance of petrifactions, at least in part.

Chalcedony has also been observed in granite and gneiss, as at Vienne, in France. *(SAUSSURE.)*

(Localities.) Oberstein, in the Palatinate of the Rhine, is one of the best localities of this mineral. It there occurs in an amygdaloidal rock, containing numerous cavities, and liable to decomposition.—Fine specimens are found in the islands of Faroe; Mr. Allan, in his late visit to these islands, observed the remains of a mass of Chalcedony, that had been 4 ft. in length by 2 ft. in its widest part.—It is found also in Vicentino and Iceland. In the latter place Mackenzie observed it in fossil wood.

In the *United States.* In *Maryland,* it is found 4 miles from Baltimore. *(HAYDEN.)*—In *Pennsylvania,* at Little Britain, in Lancaster Co. under various forms and very beautiful; *(CONRAD.)*—

also in Chester Co.—In *New Jersey*, near Trenton.—In *Connecticut*, 4 miles from Newhaven, near Saltonstall's pond, in secondary trap or amygdaloid; it is botryoidal or mammillary, and on one side of the specimen very often appear impressions of crystallized quartz, &c. it is often beautifully invested with crystals of quartz, sometimes forming geodes. Its color is usually yellowish gray, sometimes blue. (*SILLIMAN.*)—It has also been found on the banks of the Missouri.

Chalcedony receives a good polish, acquiring a high lustre, and is much esteemed in jewelry.

2. CACHOLONG.* This is a milk white variety of chalcedony. It is opaque or slightly translucent at the edges. Its texture is seldom sufficiently firm to enable it to give fire with steel, although its particles have the hardness of quartz. Its fracture is even, or conchoidal with large cavities, sometimes dull and sometimes glossy. It often adheres to the tongue.

The Cacholong accompanies common chalcedony, which it often envelopes, the two minerals being united by insensible shades. It also associates with flint and semiopal, with which it is sometimes nearly allied.

It is found loose in the fields on the borders of the river *Cach*,† in Bucharia, in masses, composed of alternate layers of Cacholong and common chalcedony.

It is sometimes set in rings, &c.

3. CARNELIAN.‡ *KIRWAN. JAMESON.* Its prevailing color is red, passing from a deep blood red to flesh red, or reddish white, which has sometimes a feeble tinge of yellow, or is nearly white. Its colors, or their different shades, sometimes appear in spots, or stripes, or gradually pass into each other. It most commonly is semitransparent, sometimes only translucent. Its fracture is perfectly conchoidal, nearly smooth, and has very little lustre. Its spec. gravity is about 2.61. It occurs in rounded or globular masses, or in stalactites; the surface is often rough, or invested with a brownish crust.

Before the blowpipe it loses its color, and becomes less transparent. It contains 99 parts of silex. (*TROMSDORF.*)

Its geological situation is similar to that of common chalcedony, which it often accompanies.—The finest specimens, sometimes called oriental Carnelian, come from Arabia and Hindostan.

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* Quartz agathe cacholong. HAUY. Silex cacholong. BRONGNIART. Var. of common chalcedony. JAMESON.

† *Cholon* in the language of the Calmuchs is said to signify a stone.

‡ Karniol. WERNER. Quartz agathe cornaline. HAUY, Silex cornaline. BRONGNIART. La Cornaline. BROCHANT.

It receives a good polish, and is much employed for seals, bracelets, &c.

4. SARDONYX.* This variety differs from the carnelian in its color only, which is reddish yellow, or nearly orange, sometimes with a tinge of brown. It is scarcely possible to determine, in regard to some specimens, to which of the two varieties they belong.—Werner has applied the name of Sardonyx to those carnelians, whose colors are in alternate bands of red and white, and which, when the stone is cut in certain directions, resemble the flesh seen through the finger nail.—It often occurs in larger masses, than the preceding varieties of chalcedony.

5. PLASMA.† *Werner. Jameson.* Its color usually varies between grass and leek green, presenting different shades, which are often blended in the same specimen in spots, stripes, &c. Sometimes it presents whitish or brownish spots. Its fracture is conchoidal, and has a feeble, resinous lustre. It has the hardness and transparency of common chalcedony.

Before the blowpipe it becomes whitish.—Its color is never apple green, like that of chrysoprase.

This mineral, which was worn by the Romans in ornamental dresses, comes from Italy and the Levant. The green mineral, found at Bojanowitz in Moravia, in rounded masses in serpentine, and accompanied with hornstone and flint, has been referred to Plasma; but Mr. Jameson considers it a common chalcedony.

Subspecies 8. HYALITE.‡ *Kirwan. Jameson.*

This mineral exhibits the usual appearance of a concretion, and differs little from chalcedony, except by possessing a vitreous lustre, and sometimes a very loose texture. Its surface is often shining and polished, like that of gum. It occurs in mammillary or botryoidal masses, in stalactites, in branches with an undulated surface, in grains, crusts, &c. Its fracture is conchoidal, or even, and sometimes foliated, and has a shining, vitreous lustre. Its texture is sometimes loose or porous; and, although the mass is very brittle, its particles have the hardness of quartz. Its color is white, either pure, or tinged with yellow, gray, or blue. It is sometimes opaque, and has a pearly or milky aspect; at other times it is nearly semitransparent. Its spec. gravity, sometimes 2.11, varies with its structure.

(Localities.) These concretions frequently occur in volcanic countries, abounding with hot springs, as in Iceland, the isle of Ischia,

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* Quartz agathe sardoine. Haüy. Silex sardoine. Brongniart.

† Silex plasme. Brongniart. Le Plasma. Brochant.

‡ Hyalit. Werner. Quartz hyalin concrétionné. Haüy. Brongniart.

&c. The siliceous deposite, forming a basin around the celebrated Geyser, in Iceland, belongs to this variety; in the vicinity of this hot spring, even the grass, rushes, and the leaves of the trees become invested with a siliceous crust.—In Tuscany near Sancta *Fiora*, it occurs in stalactites; the *Fiorite* of Thompson.—In Mexico, on veins of opal, traversing porphyry. (*Humboldt.*)—At Francfort, on the Main, in wacke or amygdaloid.—It is sometimes imbedded in basalt or serpentine. (*Kirwan.*)

In the *United States*, it appears to exist in the Buhrstone of *Georgia.*

Subspecies 9. HELIOTROPE.* *Jameson.*

Its color is a deep green, peculiarly pleasant to the eye, and commonly not much differing from a leek green. It is usually variegated by small dots of a bright red; and is more or less translucent. Its fracture is imperfectly conchoidal, or even splintery, and glistening. Its spec. grav. is about 2.63.

Before the blowpipe it loses its color. It is by some supposed to be chalcedony, colored by chlorite or green earth. It differs from jasper by its translucency.

The finest specimens come from Asia. It has been found in Iceland, Bohemia, and Siberia, but of inferior beauty.

Like agates, it is employed by jewellers.

Subspecies 10. CHRYSOPRASE.* *Jameson.*

Its color is commonly apple green, often extremely beautiful; it sometimes passes to a lighter green, and sometimes to leek green. It is translucent, or sometimes semitransparent. Its fracture is dull and even, sometimes a little splintery, and sometimes smooth, especially in the leek green varieties. It occurs in amorphous or tabular masses. Its spec. gravity, according to Klaproth is 3.25, but Kirwan found it about 2.48. Its hardness differs little from that of flint.

Before the blowpipe it loses its color and translucency. It is composed of silex 96.5, alumine 1.5, oxide of nickel 1.00, and a little iron and lime. (*Klaproth.*) Its fine green color arises from the nickel.

(*Locality.*) This mineral has been found only at Kosemütz, in Silesia. It occurs in veins or interrupted beds in serpentine, ac-

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* Heliotrop. WERNER. Heliotropium. KIRWAN. Silex héliotrope. BRONGNIART. Quartz agathe vert obscur et ponctué. HAUY. L'Heliotrope. BROCHANT.

† Krisoprase. WERNER. Chrysoprasium. KIRWAN. Silex Chrysoprase. BRONGNIART. Quartz agathe prase. HAUY. La Chrysoprase. BROCHANT.

companied by chalcedony, opal, quartz, and a peculiar green earth, which contains nickel, and has received the name of *Pimelite.*

It is highly esteemed in jewelry for ring stones, &c.

SUBSPECIES 11. OPAL.*

Those siliceous deposites, which have received the name of Opal, present some diversity in their external characters, and are usually divided into several varieties.

Var. 1. PRECIOUS OPAL.† *JAMESON.* This very beautiful mineral is best characterized by its relations to light. Its proper color is milk white, often slightly tinged with blue, like milk much diluted with water, or yellowish white; but, when viewed by transmitted light, it usually appears reddish or yellowish, sometimes presenting the appearance of flame. It also presents a very lively and irised play of colors, consisting of green, red, blue, yellow, and purple of various shades, and differently assorted, according to the varying position of the mineral. Sometimes only one color is reflected.

This Opal is traversed in all directions by numerous, minute fissures, and on this imperfection in its structure its peculiar beauties depend; for its playful changeability of color is produced by the refraction and reflection of light at these fissures, and is to be explained in the same manner, as the colored rings, between two plates of glass in the experiments of Newton.—It is more or less translucent and sometimes semitransparent, even in a high degree.

It is very easily broken; and its fracture is conchoidal, with a strong lustre, sometimes vitreous, but more often like that of resin recently broken.

It loses its color and transparency before the blowpipe, and by a sudden heat decrepitates. A specimen from Hungary, analyzed by Gerhard, yielded silex 95, alumine 5. Another by Klaproth gave silex 90, water 10.—It is liable to spontaneous decomposition, becoming dull, opaque, adherent to the tongue, and hydrophanous.

(Localities.) The precious Opal occurs in masses of inconsiderable size, sometimes spheroidal, &c. or in veins; and is found in a rock, which is partially decomposed, and appears to be an argillaceous porphyry. It thus occurs at Czerwenitza, in Hungary, which is one of its most remarkable localities.—It has also been found in Saxony, Iceland, France, Mexico, &c.

(Remarks.) The opal is cut and polished for ornamental work in rings, necklaces, &c. It was much esteemed by the ancients, and

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* Quartz résinite. HAUY.

† Edler opal. WERNER. L'Opale noble. BROCHANT. Quartz resinite opalin. HAUY. Silex opale. BRONGNIART.

Nonius, a Senator, is said to have suffered banishment, rather than part with a valuable Opal to Mark Anthony. (*Pliny.*) Large specimens are rare. Jameson mentions one in the imperial cabinet at Vienna 5 inches by 2½ inches. It is sometimes imperfectly imitated by artificial glasses; and substances, which resemble the opal in its play of colors, are said *to opalesce*.

2. COMMON OPAL.* *Jameson.* This, in many of its characters, differs but little from the preceding variety. It does not, however, present that effulgence or play of colors, by which the precious opal is distinguished. Its color is white, shaded with gray, green, or yellow; sometimes milk white; it also presents other shades of green and yellow, and is sometimes brown or reddish. When viewed by transmitted light, the milk white and greenish varieties often change their colors. In its fracture, lustre, and transparency, it differs very little from the precious opal. Its spec. grav. varies from 1.96 to 2.14 in consequence of the fissures, by which it is traversed. It occurs in small masses, amorphous, rounded, reniform, &c.

In a specimen from Kosemütz Klaproth found silex 98.75, alumine 0.10, oxide of iron 0.10;=98.95.

(*Localities.*) It is sometimes in veins or masses, contained in porphyry and amygdaloid.—At Kosemütz in Siberia, it occurs in serpentine with chrysoprase, and appears to be colored green by nickel.—In Iceland, it alternates with chalcedony. (*Jameson.*)—In Saxony, it exists in granite with hornstone and jasper. (*Werner.*)

In the *United States*, on the banks of the Delaware, near Easton in *Pennsylvania*, Opal is found strongly characterized. (*Wister.*)

Appendix.

HYDROPHANE.† This name denotes merely a peculiar property, which some minerals possess, of becoming more transparent in water,‡ and of again returning to their natural state, when removed into a dry air. This property, which depends on a certain structure in the mineral, is most frequently observed in certain varieties of the Opal; sometimes also in the cacholong. The Hydrophane has a porous structure, either originally, or in consequence of partial decomposition. When immersed in water, bubbles of air escape from its pores, while the water enters, and its weight is sensibly increased. But, when the pores are thus filled with water, a less portion of the light is reflected during its passage through the mineral, than if the

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* Gemeiner opal. Werner. L'Opale commune. Brochant.

† Silex hydrophane. Brongniart. Quartz résinite hydrophane. Hauy. Hydrophanes. Kirwan.

‡ Hence the name, from the Greek Υδωρ, water, and φαινω, to show light.

same pores were filled with air; consequently more light is transmitted, and the transparency increased. This explanation may be illustrated by the experiment, in which air and water are successively placed behind a denser medium of glass.

Before immersion it is slightly translucent, or nearly opaque, and often adheres strongly to the tongue. Some varieties become even opalescent by immersion. Hydrophanous opals possess a much stronger lustre, than the cacholong.

A specimen, analyzed by Klaproth, gave silex 93.13, alumine 1.62, water 5.25.

Good specimens are found at Hubertsberg in Saxony, and at Telkobania in Hungary, &c.

GIRASOLE.* This name also designates a particular property, observable in certain varieties of opal. The Girasole is milk white, or bluish white, but, when turned toward the sun,† or any bright light, it constantly reflects a reddish color. It is sometimes strongly translucent; and the finest specimens resemble a translucid jelly.

3. SEMI-OPAL.‡ *JAMESON.* This variety, which is a little harder, than the precious opal, is easily broken; and its fracture is imperfectly conchoidal with large cavities, or nearly even, usually more or less glistening and a little resinous, but sometimes nearly dull. The edges of the conchoidal fracture and those of the fragments are usually very sharp. It is more or less translucent, sometimes only in a slight degree at the edges, and some specimens are semitransparent. Its colors are numerous; white and gray, often shaded with yellow, green, red, or blue, sometimes milk white, and sometimes grayish black; it also presents distinct shades of yellow, green, red, and brown. Its colors are never lively; and, though generally uniform, are sometimes in spots, veins, &c. Its spec. grav. is variable, but does not exceed 2.54.

It is sometimes amorphous, and sometimes tuberose, reniform, stalactical, &c.

Though infusible by the blowpipe, it is often contaminated by foreign ingredients. It is liable to decomposition, and sometimes passes into a substance, resembling porcelain clay.

(Distinctive characters.) Its infusibility distinguishes it from pitchstone, which it often much resembles.—It rarely exhibits the peculiar, opaque, milky whiteness of the cacholong.—Its lustre, or its translucency, or both, will in most cases distinguish it from jasper;

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* Silex girasol. BRONGNIART. Quartz résinite girasol. HAUY.

† Hence its name from the Latin, gyro, to turn, and sol, the sun.

‡ Halb-opal. WERNER. La Demi-opale. BROCHANT. Silex résinite. BRONGNIART. Quartz résinite commune. HAUY.

into which, however, as well as hornstone and cacholong, it gradually passes.—From the common opal it usually differs in lustre, fracture, hardness, and often by the dullness of its colors and inferior translucency.

(Geolog. sit. and Localities.) It occurs in masses, veins, or thin layers in amygdaloid, basalt, porphyry, &c.; also in granite and gneiss, and in veins, which traverse these rocks, especially those veins, which are metalliferous and contain silver. It sometimes constitutes the substance of organic remains of wood, &c.—Near Orleans, in France, it is found in carbonate of lime;—in Auvergne, it is sometimes filled with cavities, and decomposed at the surface.

In the *United States.* In *Maryland,* at the Bare Hills, near Baltimore, it occurs in thin veins in serpentine; its surface is yellowish brown, and carious; its recent fracture, however, is whitish, like chalcedony, but by exposure becomes brown. *(GILMOR.)*—In *Pennsylvania,* at the Falls of the Delaware, near Trenton Bridge, of a bluish gray color in granite; its transparency is much increased by immersion in water;—also in Upper Merian, in Montgomery Co. leek green and opaque, in serpentine. *(SEYBERT.)*

MENILITE.* *JAMESON.* This mineral occurs in small, irregular or roundish masses, often tuberose, or marked with little ridges on the surface. When broken, it appears brown or dark gray, though its exterior is often bluish or striped. It is translucent, often at the edges only. Its structure is a little slaty; its fracture more or less conchoidal or splintery, usually somewhat glistening and resinous. It scratches glass; and its spec. grav. is about 2.18. It is infusible by the blowpipe; and contains silex 85.5, alumine 1, lime 0.5, oxide of iron 0.5. water and carbonaceous matter 11;=98.5 *(KLAPROTH.)*

The *Menilite* has hitherto been found only in France; more particularly at *Ménil*-Montant, near Paris; it is imbedded in a slaty clay, which separates beds of Plaster stone.

SUBSPECIES 12. FLINT.† *KIRWAN. JAMESON.*

Flint is easily broken into fragments with very sharp edges; and its fracture is almost always perfectly conchoidal. A few splinters, however, sometimes appear; and the curvature is often so gradual, that a small portion of the surface, viewed by itself, appears plane. The surface of the fracture has usually a feeble lustre, being smooth and glossy, but is sometimes almost dull. It is translucent, but, in

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* Menilit. WERNER. Silex Menilite· BRONGNIART. Quartz résinite subluisant. HAUY.

† Feurstein. WERNER. La Pierre à feu. BROCHANT. Silex pyromaque. BRONGNIART. Quartz agathe pyromaque. HAUY.

general, only when in thin fragments, or at the edges. Its color is most commonly some shade of gray, either light or dark, sometimes bluish or yellowish gray, or grayish black, wax yellow, yellowish brown, brownish red, &c. The colors are sometimes intermixed in spots, stripes, &c. It is usually a little harder, than common quartz or jasper; but it has been remarked, that the yellowish and lighter colored varieties do not scintillate so plentifully, as those of a dark color, nor do they wear away the hammer of a gun lock so quickly. It, however, always gives lively sparks with steel more or less copiously. Its spec. grav. varies from 2.58 to 2.63.

It occurs most commonly in nodules of a moderate size, often irregular, sometimes globular, elliptical, tuberose, or perforated, and sometimes it is in plates, or in pebbles, or in grains, or is amorphous. It also occurs in pseudomorphous crystals.

When exposed to a strong heat, it loses its color, becomes opake, more brittle, and often decrepitates; but does not melt. It contains silex 98, lime 0.5, alumine 0.25, oxide of iron 0.25, water 1. *(KLAPROTH.)*

(Geological situation.) Flint is almost entirely confined to secondary rocks, or earths, where it occurs imbedded in *chalk*, calcareous marl, or even in compact limestone. The nodules of Flint, various both in size and form, are usually arranged in parallel beds, most commonly horizontal, sometimes oblique; still, however, the nodules of the same bed do not lie perfectly in contact with each other.—It also occurs in thin layers or beds between strata of compact limestone, or in sand.

The nodules of Flint, which occur in chalk, or even in compact limestone, are intimately united with the surrounding mass in such manner, that the calcareous substance often appears to have penetrated the Flint. Hence these flinty nodules, when taken from the quarry, are usually invested with an opaque, white, friable crust, which effervesces with nitric acid, and has been found to contain 10 per cent. of carbonate of lime. If this natural crust be removed, or the Flint be broken, a second, white, opaque, friable, and porous crust will be produced by exposure to the changes of the atmosphere; but it contains no carbonate of lime.—The whitish spots, which sometimes occur in the interior of Flint, contain from 2 to 7 per cent. of carbonate of lime.

In alluvial earths, Flint in the form of pebbles is not uncommon. —It has also been found in rolled pieces in veins, which traverse primitive rocks.

This mineral sometimes contains cavities, lined with crystallized quartz, sulphuret of iron, &c. The crystals of quartz are sometimes united with the Flint by imperceptible shades. Near Poligni in France, the cavities in the interior of Flint contain sulphur.

Masses of Flint, when taken from the earth, contain a great degree of moisture, which often appears on the surface of the fracture.

Flint also forms the substance of various petrifactions, as echinites, madrepores, &c. and sometimes exhibits impressions of leaves and other organic bodies.

It passes into hornstone, chalcedony, and common quartz.

It is difficult to explain the circumstances, under which the nodules of Flint, found in beds of chalk or marl, have been formed. These nodules cannot have received their rounded form from attrition; indeed their peculiar arrangement in beds, &c. forbids the belief, that they have been rolled and transported by water. It has been generally believed, that they were produced by the filtration of water into pre-existing cavities; and these cavities may have been produced by the escape of air, during the deposition of the calcareous strata, or may have once been occupied by animal substances, as mollusci, &c.

(Localities.) This mineral has been found in Denmark, Saxony, Poland, Spain, &c. but more particularly in the north of France, and on the opposite coast of England.

In the *United States.* In *Pennsylvania,* near Easton, Northampton Co. and near Reading, Berks Co. *(SEYBERT.)*—In *New York,* at Black Rock and in the Seneka prairies, imbedded in limestone; *(MITCHILL.)*—also near Saratoga Springs, in globular masses, dark gray, imbedded in limestone. (Lit. and Philos. Reper. v. 2.)—In *Vermont,* on Mount Independence, in Orwell. *(HALL.)*—In *Connecticut,* in detached rolled pieces near Newhaven;—also at Woodbridge in masses, penetrated by white veins and spots of calcareous spar. *(SILLIMAN.)**

(Uses.) Flint is sometimes employed in the manufacture of glass, porcelain, and smalt; but its principal use is for gun flints, of which the manufacture is chiefly confined to France and England. The operation is simple, but requires judgment and dexterity. A small mass of Flint, being held in the hand, or supported on the knee, is divided by a hammer into fragments or splinters, and these splinters are afterward reduced to a proper form and size on the edge of a steel chisel by repeated small blows. A good workman can scale off and finish 1000 flints in three days.—Sometimes only a small number of the nodules, found in any one bed, is suitable for the manufacture of gun flints. The best Flint has a fracture not only

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* May not some of the localities above mentioned belong to *hornstone,* rather than true Flint? The two minerals are often very nearly allied.

conchoidal but smooth, and, in very thin fragments, presents a uniform semitransparence of a greasy aspect. (*Dolomieu.*)*

SWIMMING FLINT.† This mineral occurs in masses, whose texture is spongy, porous, or even cellular. Hence it often *swims* on the surface of water, till it has imbibed a certain quantity. Its powder is rough to the touch, and scratches glass and steel. It is easily broken, and presents a dull, earthy, or uneven fracture. Its color is whitish or gray, often with a tinge of yellow.

It contains silex 98, carbonate of lime 2. (*Vauquelin.*)

It has been found chiefly at St. Ouen, near Paris, in beds of chalk. It frequently contains a nucleus of common flint, with which it is intimately united.

Subspecies 13. HORNSTONE.‡

Its fracture is usually dull, and splintery, often like that of wax;

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* Brongniart, from the observations of Dolomieu, has described a mineral under the name of *Silex Prasien*, which he supposes to be a variety of flint. It is greenish or leek green; and has a dull or glimmering conchoidal fracture.—From the same authority he mentions another substance, to which he gives the name of *silex jadien*. Its color is pale green, and its texture fibrous. But it has neither the hardness, nor fusibility of jade.

† Schwimmstein. Werner. Floatstone. Jameson. Quartz nectique. Haüy. Silex nectique. Brongniart.

‡ Silex corné. Brongniart. Quartz agathe grossier. Haüy.

Infusible varieties of the *Hornstein* of Werner, *Hornstone* of Kirwan and Jameson, and of the *Pierre de Corne* of Brochant.

So much ambiguity of meaning is attached to the word *Hornstone*, that it would be favorable to the interests of mineralogy, if this term could be banished from its nomenclature. It has by some been confounded with *hornblende*, and also with the *roche cornéenne* of Haüy. By others it has been applied to two minerals entirely distinct.

This confusion and obscurity in the use of the word, hornstone, appear to have arisen in part from accidental circumstances. It is asserted by Kirwan, on the authority of Henckel, that this word was originally employed by miners to designate a certain stone, which they found difficult to be cut through, in consequence of its *tenacity*, somewhat resembling that of *horn*. But a certain degree of *translucency* is also a character of horn. Hence, as mineralogists did not observe both these properties to unite in the same mineral, they subsequently applied the term, hornstone, to two distinct minerals, one of which possessed *tenacity* only, while the other was *translucent*, but not remarkably tenacious. Hence the application of the term, hornstone, to the mineral, now called hornblende, which is remarkably tenacious.

On the other hand, the writers of the Wernerian school have not indeed applied the name in question to hornblende, but they include under it two minerals totally distinct in their chemical characters and composition. *One* of them is the mineral here described, composed essentially of *silex*, and absolutely *infusible*; the *other* is always *fusible*, and frequently forms the base of but sometimes it is more or less conchoidal with a very feeble or glimmering lustre. It is more or less translucent, sometimes at the edges only, and sometimes the whole mass, if thin, has the strong translucency of certain horns. It is less hard, than common quartz, and gives sparks rather feebly with steel, unless when it is passing into flint.

Its colors are numerous and usually dull. It is often gray, sometimes nearly white, but more frequently shaded with blue, yellow, black, or green, or it presents distinct shades of red, brown, or green. The colors are sometimes in spots, stripes, clouds, &c. It is usually amorphous, sometimes globular.

(Distinctive characters.) Its infusibility by the blowpipe distinguishes it from petrosilex, and jade.—Its translucency or splintery fracture will, in most cases, serve to separate it from jasper.—It is usually duller than flint, and does not, in general, so freely give fire with steel.—It never possesses the lustre of common quartz.—Some specimens, however, approach very near to flint, chalcedony, jasper, or common quartz, the latter of which is sometimes crystallized in its cavities or interstices.

(Geolog. sit. and Localities.) Hornstone often occurs in veins, especially metallic, in primitive mountains; and sometimes incrusts other minerals. It is also imbedded in rounded or irregular masses in secondary limestone. Sometimes it accompanies amethyst and agates.

In the *United States.* In *Maryland*, Washington Co. west side of the Blue Ridge, in large masses, with a splintery fracture, and constantly containing carbonate of copper;—also near Baltimore with a conchoidal fracture. *(Hayden.)*—In *Massachusetts*, near Boston.—In *Maine*, near Belfast.

Subspecies 14. SILICICALCE.*

This substance occurs in amorphous masses, which present a smooth, dull fracture, either conchoidal or even. It but seldom gives sparks with steel. Its color is gray, or brown, sometimes nearly black. With nitric acid it slightly effervesces; and before the blowpipe melts into a white scoria. It appears to be a mixture of flint, and

porphyry. This latter mineral appears to be included in the *petrosilex* of many French writers, and the *chert* of the English. But the name, petrosilex, almost equally unfortunate with hornstone, has been variously employed; for remarks on which, see that species.

The Roche cornéenne of the French embraces hornblende slate, several varieties of argillite, &c.

* Quartz agathe calcifère. Haüy. Silex silicicalce. Brongniart.

carbonate of lime, and hence its fusibility. Indeed it sometimes embraces fragments of flint.

It exists in thin beds under strata of compact limestone in Provence; and alternates with similar limestone in the Pyrennees.

CONITE. This is supposed by Haüy to be a variety of Silicicalce. Its fracture is uneven or splintery; its color gray; and it is sufficiently hard to scratch glass. Its spec. gravity is 2.83; and it effervesces with nitric acid.

SUBSPECIES 15. BUHRSTONE.* (Millstone.)

The exterior aspect of this mineral is somewhat peculiar. It occurs in amorphous masses, partly compact, but always containing a greater or less number of irregular cavities. Sometimes the mass is comparatively compact, and the cavities small and less frequent, but they always exist even in specimens of a moderate size. These cavities are sometimes crossed by siliceous threads or membranes, much resembling the interior structure of certain bones; and are sometimes lined by siliceous incrustations, or crystals of quartz.

Its fracture is nearly even, sometimes dull, and sometimes smooth, like that of flint. Its color is gray or whitish, sometimes with a tinge of blue, and sometimes yellowish, or reddish.

(Geolog. sit. and Localities.) Near Paris, the Buhrstone occurs in beds, usually horizontal, and seldom more than 9 or 10 feet thick. It contains no organic remains. Its cavities are often crossed by threads, and filled with argillaceous marl or sand; but are very seldom lined by crystals of quartz. It usually rests on clay, and, when near the surface, is covered by ferruginous sand or pebbles. In the order of superposition, it constitutes the ninth of the horizontal beds or formations in the vicinity of Paris, counting upwards from the lowest, which is chalk. It lies over sandstone, containing *marine* fossils; and is covered by a *fresh-water* formation, of which part is calcareous, and part is siliceous, being itself a variety of the Buhrstone. This fresh-water formation contains shells, belonging to lakes and rivers.

In the *United States.* In *Georgia*, the Buhrstone is found near the Carolina line, about 40 miles from the sea. It is said to cover shell limestone. Some of its cavities are those of shells in a siliceous state, and lined by siliceous incrustations, or crystals of quartz. Others are traversed by minute threads, or contain a friable substance somewhat argillaceous.—In *Pennsylvania*, Northampton Co. a Buhrstone or cellular quartz is found; but the writer knows not its characters nor geological situation.

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* Quartz agathe molaire. HAÜY. Silex meulière. BRONGNIART. Var. of Flint of Jameson; and of Pierre à feu of Brochant.

(Uses.) Its hardness, and cavities, when not too numerous, render it peculiarly useful for making millstones. Hence also it is sometimes known by the name of Millstone.

SUBSPECIES 16. JASPER.

Jasper is usually a little less hard than flint, or even common quartz; but it still gives fire with steel. Its fracture is generally more or less conchoidal, sometimes nearly even, and in some instances fine splintery or earthy. In most varieties the surface of the fracture is nearly or quite dull. It is entirely opaque, or sometimes feebly translucent at the edges; and presents almost every variety of color. Its spec. gravity varies from 2.30 to 2.70. It is often a conductor of electricity.

Before the blowpipe it loses its colors, but is infusible, even when the flame is urged by oxigen gas. With the compound blowpipe red Jasper melts into a grayish black slag with white spots. *(SILLIMAN.)* The silex, of which it appears to be essentially composed, is contaminated with alumine and oxide of iron in various proportions.

Several varieties deserve particular notice.

1. COMMON JASPER.* *KIRWAN. JAMESON.* Its most common colors are brown, red, and yellow, of different shades, and variously intermixed. It also occurs green, bluish, violet, or nearly black, and sometimes gray or white. The colors are in some cases arranged in spots or clouds. Green Jasper with red spots differs from heliotrope by its want of translucency.

Common Jasper is found in large amorphous masses, or in detached fragments.

Certain minerals, which are sometimes described, as varieties of red Jasper, although possessing a shining and nearly vitreous fracture, we have already referred to red ferruginous quartz.

2. STRIPED JASPER.† *KIRWAN. JAMESON.* This differs from the preceding variety chiefly in the arrangement of its colors, which are usually some variety of gray, yellow, red, and green; but these colors appear in stripes, veins, rays, in oval spots, or in curved, concentric zones.

This variety occurs in large beds. It is found very beautiful in the Uralian Mountains; sometimes exhibiting red and green stripes, equal and parallel;—and sometimes round or oval whitish spots on a brown or flesh colored ground, and hence denominated *eyed* Jasper.

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* Gemeiner jaspis. WERNER. Jaspe commun. BRONGNIART. Quartz jaspe rouge, &c. HAUY. Le Jaspe commun. BROCHANT.

† Band Jaspis. WERNER. Jaspe rubanné. BRONGNIART. Quartz jaspe onyx. HAUY. Le Jaspe rubanné. BROCHANT.

3. EGYPTIAN JASPER.[*] *Jameson.* It is well characterized by its globular or spheroidal form, sometimes flattened, and by the arrangement of its colors. These colors are brown, yellowish brown, pale yellow, or yellowish gray, always arranged in zones more or less regular, nearly concentric, and sometimes with dots or dendrites of a different color interspersed. In fact, the brown or yellowish brown may generally be considered as forming colored designs upon a paler ground. Its fracture has a feeble lustre.

This variety is found in sand near Suez in Egypt, and the contiguous deserts. It there forms a constituent part of extensive beds of a siliceous breccia, which, by their decomposition, furnish these pebbles in a loose state.—A similar variety, whose colors are red, yellow, or gray, has been found in the Electorate of Baden, in argillaceous oxide of iron.

(*Geological situation.*) Jasper, including the common and striped varieties, is sometimes found in thick beds in the transition, or older secondary rocks; or even forms whole hills. It also occurs in certain veins, especially metallic, which traverse primitive rocks. In the Hartz, beds of Jasper rest on graywacke. Sometimes it accompanies basalt or greenstone. It is also found in masses of a moderate size in amygdaloid, and there accompanies chalcedony, or is disseminated in it, and forms a constituent part of agates; hence sometimes called *agate Jasper.*

It is not uncommon in detached or rolled masses in alluvial earths.

Jasper is often traversed by metallic veins, or by veins of quartz. It sometimes embraces, more especially when in veins, lithomarge, semi-opal, brown spar, garnets, the sulphurets of iron and silver, native bismuth, &c. It is not uncommon in veins, containing certain ores of iron.

According to Bertrand, beds of Jasper sometimes contain fossil shells and marine plants.

Jasper is never porphyritic. The base of that, which has been called jasper porphyry, is fusible, and is either petrosilex or compact feldspar.

In the opinion of many, Jasper has been formed by the filtration of silex into beds of ferruginous clay. It sometimes indeed contains small portions of indurated clay or lithomarge, and, at other times, borders on hornstone, flint, chalcedony, or opal. Jameson has described a mineral under the name of *opal jasper*, which he supposes intermediate between opal and Jasper. Its fracture is conchoidal,

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[*] Egyptischer Jaspe. WERNER. Jaspe Egyptien. BRONGNIART. Egyptian pebble. KIRWAN. Quartz agathe onyx. HAUY. Le Jaspe Egyptien. BROCHANT.

shining, and nearly vitreous. Its colors are some shade of red, brown, or yellow, either uniform, or in spots, veins, &c. It is less hard, than common Jasper. It has been found in porphyry near Tokay in Hungary, &c.

(Localities.) Its foreign localities are numerous. Among these are the Uralian and Altain mountains; in the latter of which its color is sometimes a beautiful white, with black dendritic figures.

In the *United States.* In *Maryland*, the common variety occurs near Baltimore, in detached masses, red, brown, and yellow.—In *New Jersey*, near Trenton and Woodbury of various colors.—In *Connecticut*, near Newhaven in rolled pieces —In *Vermont*, a very beautiful red Jasper has been found.

(Uses.) The high polish, of which Jasper is susceptible, the variety and richness of its colors render it of considerable value and use in the ornamental arts for vases, snuff-boxes, seals, sword handles, &c. The *ceraunite*, or thunder stone, often belongs to Jasper.

Appendix to the species Quartz.

AGATE. This name is usually applied to an aggregate of certain quartzy or siliceous substances, intimately combined, possessing a great degree of hardness, a compact and fine texture, agreeable colors, variously arranged and intermixed, and susceptible of a good polish. The minerals, which most frequently enter into the composition of Agates, are common chalcedony, carnelian, and jasper, to which are sometimes added flint, hornstone, common quartz, amethyst, heliotrope, and opal. The *chalcedony* is however the most common and abundant ingredient, and may frequently be considered the *base* of the Agate; in fact, some agates are composed entirely of chalcedony differently colored. In most cases, only two or three of the aforementioned ingredients occur in the same Agate; but, though variously intermixed, each ingredient usually remains perfectly distinct.

Agates exhibit the colors already mentioned, while describing the simple minerals, which compose them. But these colors are often so arranged, as to present the resemblance of some well known objects. Hence arises much of the beauty of Agates; and hence also most of the distinctive names they have received in the arts. Of these a few will be mentioned.

1. ONYX AGATE;* when the different colors are arranged in distinct parallel stripes or zones. If these zones are straight, it is sometimes called *ribband* Agate; if sinuous, or in a zigzag line, *fortification* Agate.

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* Quartz agathe onyx. HAUY.

2. EYED AGATE; when the colored zones are arranged in concentric curves. This Agate is, in fact, composed of a number of tubercles, each of which consists of concentric layers, enveloping a globular nucleus; this nucleus or pupil is sometimes radiated from the centre to the circumference, and may even be detached from its envelope. The lapidary, by cutting and rounding these Agates in a particular manner, produces a striking resemblance to the eyes of certain animals.

3. DOTTED AGATE;* when many of the colors appear in points or dots. Sometimes these dots are obviously jasper of various colors in a base of chalcedony.

4. MOSS AGATE; in the interior of this appear small filaments, sometimes green, brown, or yellowish, irregularly interwoven, like certain varieties of moss, or the fibres of certain roots. It has indeed been suggested by Daubenton, that these filaments may be really mosses, or some vegetable fibres, enveloped in the Agate at the time of its formation.

5. DENDRITIC AGATE, OR MOCHA STONE;† in the interior of tihs appear brown, reddish brown, or blackish delineations of shrubs, deprived of their leaves. These dendritic appearances are probably produced by the filtration of the oxides of iron and manganese into the fissures of the Agate.

6. SPOTTED OR FIGURED AGATE;‡ when the colors appear in irregular spots, or in figures, bearing more or less of resemblance to *clouds*, *stars*, *landscapes*, *&c.*

7. BRECCIA AGATE; when the mass is composed of fragments of different Agates, united by a siliceous cement.

(Mode of formation.) Agates, though sometimes amorphous, usually occur in nodules, or rounded masses, and rarely in stalactites. They appear to have been formed by the filtration of siliceous particles into pre-existing cavities. It is, however, very remarkable, that the different stripes or zones in Agates should be so perfectly parallel, as we generally observe them; the parallelism extending to every angle, or irregular winding, which exists in the exterior zone, and which undoubtedly received its form from the interior walls of the cavity, in which the Agate was formed. This circumstance also strongly indicates, that such Agates have been formed by successive deposites of thin layers or coats of siliceous earth upon the sides of the cavities, which they now fill entirely or in part. These layers, whether chalcedony, carnelian, &c. are essentially composed of siliceous earth; and their various external characters may arise from the presence of col-

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* Quartz agathe ponctué. HAUY

† Quartz agathe arborisé. HAUY. ‡ Quartz agathe panaché. HAUY.

oring matter, or some other foreign ingredient, or from the various circumstances, under which the deposites were made. The texture of Agates is said to be, in general, coarser near the surface, than toward the centre.

But, if the *exterior coat* was first formed, in what manner could this be penetrated by the siliceous earth to form the *interior* layers? To this it may be replied, that in many Agates, when cut in a certain manner, there appear distinct traces of the canal, by which the solution of silex had entered.

When the cavities have not been filled by the deposite, the Agate remains hollow, forming a geode; and its interior is lined with crystals of common quartz, amethyst, ferruginous quartz, chabasie, &c. The exterior of Agates is frequently invested with a brownish or yellowish crust.

(Localities.) The localities of Agates are, in general, the same as those of chalcedony, which enters so largely into their composition. They are found abundantly at Oberstein in Germany, disseminated in amygdaloid, or porphyry, and usually surrounded by a greenish earth. They are also found in other parts of Europe, in the East Indies, and South America.

In the *United States*, it has been found in *Virginia*, in Greenbriar Co.;—and in *Maryland*, near Baltimore.

(Uses.) Agates are employed both in the useful and ornamental arts; for wheel pivots in watches, for inlayed work, for mortars, boxes, seals, &c. &c. Much of their beauty depends on the art of the lapidary in cutting them in certain directions, in reference to their different structures, and zones of color. Thus, if the Agate be composed of mammillary concretions, a transverse section will exhibit numerous *undulations*.

Agates were much esteemed by the ancients, and many fine specimens of their art of engraving in cameo on these hard substances may be found in mineralogical cabinets and public museums. The term *oriental* is often applied to Agates, chalcedony, carnelian, &c. when very translucent and perfect, but without indicating their locality.

AGATIZED WOOD.[*] This substance appears to have been produced by the process, commonly called the petrifaction of wood. It is essentially composed of siliceous earth, which, it is highly probable, has been gradually deposited, as the vegetable matter was decomposed and removed.

Both its form and texture indicate its origin. Thus it presents,

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[*] Holzstein. WERNER. Woodstone. KIRWAN. JAMESON. Quartz agathe xyloïde. HAUY. Le Bois petrifié. BROCHANT.

more or less distinctly, the form of the trunk, branches, roots, or knots, which once belonged to the vegetable. The surface is rough or longitudinally striated.—Its texture is fibrous, and the fibres often intertwined, like those of wood. Its longitudinal fracture is usually fibrous or splintery, and its cross fracture imperfectly conchoidal with little or no lustre.

Its color is usually gray, either light or dark, or shaded with blue, yellow, &c. sometimes red or brownish. The colors are often in spots, stripes, clouds, &c. It is a little translucent, sometimes at the edges only. Its hardness is nearly that of common quartz; and its spec. gravity sometimes as high as 2.67.

(Localities.) In Europe it occurs in sandy loam or sandstone. Kirwan says "a stump of a tree 6 feet in length, and as many in diameter, with roots and branches thus petrified," has been found near Chemnitz in Saxony.

In the *United States.* On the banks of the Missouri.—In *Maryland*, in Ann Arundel Co.;—in *Delaware*, near Cape Henlopen;—in *New Jersey*, in the pine barrens. *(Seybert.)*

It is susceptible of a good polish.

OPALIZED WOOD.* This, like the preceding, has the form and texture of wood; the vegetable matter having gradually given place to a siliceous deposite possessing the characters of Semi-opal. Its texture is fibrous; its cross fracture conchoidal with a moderate lustre, which is often waxy or resinous. It does not give fire with steel, although it is difficultly scraped by a knife. Its spec. grav. lies between 2.0 and 2.6. Its colors are white or gray, often shaded with yellow or red, and pass into yellow or brown; they are sometimes arranged in spots, circles, &c. It is translucent, at least at the edges, and sometimes opaque.

This substance has been found near Schemnitz, &c. in Hungary.

Species 14. Tripoli.† *Kirwan. Brongniart.*

This useful mineral exhibits no one character remarkably striking. Its general aspect is usually dull and argillaceous, often resembling that of certain clays. Most commonly it occurs in friable or earthy masses, but is sometimes very considerably indurated.

Its powder is very fine, but, at the same time, dry and rough to the touch, and sufficiently hard to scratch metals, glass &c. It does not, like clay, form a paste with water, though it often easily crum-

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* Holz-opal. Werner. Wood-opal. Jameson. Quartz résinite xyloïde. Haüy. Ligniform opal. Kirwan. Opal ligniforme. Brochant.

† Trippel. Werner. Tripoli. Jameson. Le Tripoli. Brochant. Tripoli, et Thermantide tripoléenne. Haüy.

bles in that liquid.—It is sometimes slaty, and sometimes granular, but its texture is seldom compact. Its fracture is dull and earthy, or, in the harder varieties, a little conchoidal. It is opaque, and its color is gray, sometimes very light, often tinged with yellow or red, and even passes into yellow, brown, or red.

Some specimens are very light, and adhere strongly to the tongue.

Before the blowpipe it does not melt, unless contaminated by foreign ingredients. In a strong heat, however, it hardens a little, and often becomes reddish. It sometimes contains a little carbonate of lime, and effervesces with nitric acid.

Although silex must constitute its most essential ingredient, being sometimes in the proportion of 90 per cent. its composition is probably somewhat variable. Indeed Tripoli can hardly be said to constitute a distinct species, as it results from the alteration of other minerals.

Tripoli differs from clay by the roughness and hardness of its powder, and by not forming a paste with water.

ROTTEN STONE. This name, though sometimes extended to the whole species, is usually confined to those varieties, which are most light and friable, and have a very fine grain.

(Geological situation.) Tripoli, so called from a place of that name in Barbary, whence it was formerly brought, appears to be the result of an alteration, produced in certain minerals, by the agency of either *water* or *fire*. In the former case, it appears to be a fine, siliceous sediment, deposited from water, and to have proceeded from the decomposition of certain siliceous minerals; the alumine and iron serving to unite the other particles.—In the latter case, it seems to have resulted from an alteration in sandy clay, or argillaceous slate by the action of fire, either volcanic or proceeding from inflamed coal mines.

It is found among secondary rocks, or in alluvial earths. Thus at Montelimart in France, it is mixed with fragments of basalt, &c.—Near Prague in Bohemia, it is situated between beds of sandstone. *(De Born.)*—Near Rennes, in Brittany, it is covered by sandstone, and contains trunks of trees, converted into Tripoli.—At Postchappel, in Saxony, its beds are in a mountain, containing coal.—In Auvergne are strata of argillaceous slate, black at one extremity, and, at the other, converted into a reddish Tripoli, with intermediate shades in the interval. *(Saussure.)*—It is sometimes in mountains evidently volcanic.

The variety, called Rotten stone, occurs near Bakewell, in Derbyshire, and rests on compact limestone. It usually contains a little carbonate of lime. It is sometimes in nodules, which contain a nucleus of solid limestone, or of very indurated rotten stone.

The *Polishing slate*, Polierschiefer of Werner, appears to be a variety of Tripoli. Its color is white or gray, more or less shaded with yellow. Its structure is slaty; its cross fracture dull and earthy. It is easily reduced to a fine, dry powder. It is very light, and strongly adheres to the tongue. Before the blowpipe it hardens a little, but does not melt.—It is found near Bilin, in Bohemia, where it forms the upper part of a bed, which, at a greater depth, becomes more compact.

(Uses.) It is employed in polishing metals, stones, and glass. The Venetian Tripoli comes from the isle of Corfu, is slaty, yellowish red, and of a very good quality.—That of Derbyshire is highly esteemed.—It may be artificially prepared by calcining some argillites.

Species 15. Porcellanite.* *Kirwan.*

It presents various shades of gray, red, yellow, and blue, as pearl or bluish gray, brick red, &c. and is sometimes brown, greenish, or nearly black. These colors, or their different shades, are sometimes in spots, clouds, &c. and the mineral often resembles a brick, which has undergone a slight vitrification. Its fracture is imperfectly conchoidal or uneven, more or less glistening, and often has the aspect of certain *porcelains.* It is opaque, very brittle, and somewhat less hard, than quartz. It occurs in amorphous masses or fragments, which are often rifted.

Before the blowpipe it melts into a black scoria. A specimen, analyzed by Rose, yielded silex 60.75, alumine 27.25, potash 3.66, magnesia 3.00, oxide of iron 2.50;=97.16. It is most probably an alteration of some variety of argillaceous slate by pseudo-volcanic fires; and of course does not constitute a distinct species.

(Geological situation.) This mineral is not abundant, but appears to have been always found in the vicinity of coal mines, or in places, where such mines have probably once existed. It is sometimes marked with vegetable impressions of a brick red color.—It is found in large masses near the Pitch Lake in Trinidad, slate blue in the interior, but reddish externally. *(Nugent.)*

Species 16. Siliceous Slate.*

This mineral occurs in masses, which are usually amorphous, sometimes rounded, but almost always traversed by numerous small

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* Porzellan Jaspis. Werner. Porcelaine Jasper. Jameson. Jaspe Porcellanite. Brongniart. Thermantide porcellanite. Haüy. Le Jaspe porcelainé. Brochant.

† Kiesel schiefer. Werner. Flinty slate. Jameson. Siliceous schistus. Kirwan. Le Schiste siliceux. Brochant. Jaspe schisteux. Brongniart.

veins of quartz, usually white, sometimes gray or reddish. Its slaty structure is more or less distinct in masses of considerable size, which are also usually fissile; but the fracture of any single layer, or of small specimens, is a little splintery, imperfectly conchoidal, or nearly even, and almost dull. In hardness it differs little from common quartz. Its colors are usually gray, bluish gray, or black, sometimes dark red, and sometimes striped or spotted. It is opaque, or somewhat translucent at the edges. Its spec. gravity lies between 2.59 and 2.64.

Before the blowpipe it is infusible, though some varieties become lighter colored. A specimen, analyzed by Cabal and Chevreuil, yielded silex 55.0, alumine 15.0, potash 8.0, lime 0.5, oxide of iron 10.0, water, carbon, and loss 11.5.

Var. 1. BASANITE.[*] *KIRWAN.* It differs but little from the common variety of siliceous slate. Its color is grayish or bluish black, or even perfectly black; its powder also is black. It is entirely opaque. In small specimens its fracture is usually even, sometimes a little conchoidal, and nearly dull. It occurs not only in amorphous masses, but in rolled pieces, which often incline to a trapezoidal form.

(Uses.) This variety is employed as a test or touchstone to determine the purity of gold; and hence its name, from the Greek Βασανος, the trier. If a bar of gold be rubbed against the smooth surface of the touchstone, a metallic trace is left, by the color of which an experienced eye can form some estimate of the purity of the gold; but the judgment is still farther determined by the changes, produced in this trace by the application of nitric acid, which immediately dissolves those substances, with which the gold may be alloyed. Basalt and some varieties of argillite answer the same purpose. The touchstones, employed by the jewellers of Paris, are composed chiefly of hornblende. Brongniart calls it *Cornéenne Lydienne.* The ancients obtained touchstones from Lydia in Asia.

(Geological situation.) Siliceous slate exists in large masses or in beds, both in primitive and transition mountains. Its beds often occur in argillite, with which it sometimes alternates. It is also found in graywacke slate, or in nodules in mountains of transition limestone. It is sometimes in veins, the strata being parallel to the sides of the veins, and alternating with aluminous slate.

This mineral is perhaps most frequently observed in large insulated rocks, which have probably been detached from mountains or beds of the same substance. It is traversed not only by numerous veins

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[*] Lydischer stein. WERNER. Lydian stone. JAMESON. La Pierre de Lydie. BROCHANT.

of quartz, but by seams or rifts, usually lined with the oxide of iron. Hence the fragments of this substance, which are observable out of place. Thus it occurs in rolled pieces, scattered on plains, or in the beds of rivers.—It sometimes embraces anthracite between its layers; indeed it is probable, that carbon usually enters into its composition.

(Localities.) In the *United States*. In *Massachusetts*, at Topsfield, Essex Co.—In *New Hampshire*, at Northampton, in scattered fragments.—The variety called Basanite occurs in *Pennsylvania*, near Reading and Bethlehem.—In *Maine*, at Topsham, in rolled pieces on the banks of the Androscoggin.

Species 17. Petrosilex.*

This mineral has in general a fine, close texture. When most translucent, it often resembles hornstone or flint. Other varieties, slightly translucent at the edges, more resemble jasper.

Its fracture is usually more or less splintery, sometimes like that of wax, and, at the same time, is often somewhat conchoidal; but in some varieties it is nearly or quite smooth and largely conchoidal, while in others the splinters are so fine, that it appears almost earthy. The surface of the fracture is usually dull, but has sometimes a feeble lustre.

It usually gives sparks with steel, though sometimes with great

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* *Fusible* varieties of the Hornstein of Werner, the Hornstone of Jameson, and the Pierre de corne of Brochant. Pétrosilex agatoïde et jaspoïde. Brongniart. Feldspath compacte céroïde. Hauy.

The term *Petrosilex* has been almost equally unfortunate with that of Hornstone. Kirwan mentions Petrosilex as a synonyme of hornstone. The Abbé Haüy in his Mineralogy appears to include under the name Petrosilex the *fusible* varieties of the hornstone of Werner, the pitchstone of Werner, and some varieties of the compact feldspar of Werner. But in his Tableau Comparatif, since published, he has united Petrosilex to the species feldspar, under the variety feldspath compacte; and this union is sanctioned by the opinions of Dolomieu, Saussure, Lelievre, &c. Brongniart, who has published the latest systematic work on mineralogy, among the French, has a species, bearing the name of Petrosilex; and, according to his own remarks, some of its varieties belong to the compact feldspar, others to the fusible hornstone, and others to the clinkstone of Werner.

It is indeed true, that these three last mentioned minerals do often closely resemble each other. But it is also true, that they differ in several of their characters, especially when extremes are compared, and that their analysis has hitherto received but little attention. We are therefore induced to adopt, for the present, the distinctions of Werner in regard to compact feldspar and clinkstone, and to appropriate the name Petrosilex to the *fusible* varieties of his hornstone. (See note on *hornstone*, the 13 subspecies of quartz.)

difficulty. When in thin fragments, it is often strongly translucent, but varies from this to a very slight translucency at the edges. It exhibits several shades of white, gray, yellow, red, and green, variously intermixed, as reddish white, greenish gray, &c. and is sometimes reddish brown, brown, or nearly black. Its colors are occasionally arranged in spots, veins, &c. Its spec. gravity extends from 2.62 to 2.74.

(Chemical characters.) One essential character of Petrosilex is that of being *fusible* into an enamel, which is usually white, and, when viewed with a glass, often contains numerous bubbles. Some varieties can be melted only in very small fragments, while others fuse without difficulty. It does not effervesce with acids. A specimen of rose colored petrosilex yielded Godon de St. Memin silex 68.0, alumine 19.0, potash 5.5, lime 1.0, oxide of iron 4.0, water with a little loss 2.5.

The *distinctive characters* of Petrosilex are not always easily perceptible in small specimens, more especially, when it is passing into other minerals. Its fusibility sufficiently distinguishes it from that variety of quartz, called hornstone.—From compact feldspar it very often differs by its strong tendency to a conchoidal fracture.—Sometimes it approaches very near to some varieties of argillite or clinkstone.

(Geological situation.) This mineral appears to be confined to primitive or transition rocks, where it occurs in large masses, or veins, or in extensive beds, or even forms whole mountains. Hence it is found associated with argillite, syenite, greenstone, &c.

It often contains crystalline particles of feldspar, quartz, epidote, &c. and, when these crystals of feldspar become sufficiently abundant, it constitutes the base of the hornstein (hornstone) porphyry of Werner. Such porphyries are reddish, greenish, &c. but seldom black.

Petrosilex, whether simple or porphyritic, is liable to decomposition; and hence its surface is frequently invested with an earthy crust, which sometimes adheres to the tongue.

(Localities.) In the *United States*, this mineral is abundant in *Massachusetts*, near Boston, in the towns of Malden, Dorchester, Milton, &c. where it forms beds, or even hills. Sometimes its colors are red and white, arranged in parallel veins or stripes, either straight or curved. At Malden, a dark red variety is diversified by other shades of red in veins. At Milton, it occurs greenish white, and strongly translucent; and some varieties are there marked with flesh-colored spots. Petrosilex, in the vicinity of Boston, is sometimes contiguous to argillite and syenite, and also to another rock, which

is composed of nodules of quartz, argillite, petrosilex, feldspar, &c. and which probably belongs to the grauwacke of Werner. Even when not porphyritic, it very often contains minute particles of quartz, epidote, feldspar, sulphuret of iron, &c. and sometimes, as on Brush hill turnpike, it exhibits dendritic figures of the oxide of manganese. (GODON.)

(*Uses and Remarks.*) Some varieties of Petrosilex are susceptible of a high polish. When homogeneous, the softer kinds may be employed as honestones; indeed, according to B. de Saussure, the Turkey stone often belongs to this species.

According to M. Godon, the vicinity of Boston furnishes Petrosilex perfectly analogous to the Turkey stone; and also a *veined* Petrosilex, which strongly resembles certain antique engraved stones, wrought by the Greeks and Romans in Basso relievo.

SPECIES 18. CLINKSTONE.* *JAMESON.*

This mineral has a structure more or less slaty, and is generally divisible into tabular masses, which are sometimes very thin, like those of argillite. The cross fracture is most commonly splintery, sometimes conchoidal or even. It has only a glimmering lustre.

This mineral is easily broken; and, when struck by a hammer, is *sonorous*, like a metal, especially if in thin tables. Hence its name. Its hardness, which is never less than that of basalt, and often greater, usually enables it to give sparks with steel.

Its color is usually gray, often shaded with dark green, or with yellow, or blue; and, according to Emmerling, it is sometimes green, or grayish black. It is frequently translucent at the edges, sometimes opaque. Its spec. grav. is about 2.57.

It occurs in extensive masses, which are often composed of columnar or tabular distinct concretions, more or less regular.

Before the blowpipe it easily melts into a glass nearly colorless. (*JAMESON.*) It contains silex 57.25, alumine 23.50, soda 8.10, lime 2.75, water 3.00, oxides of iron and manganese 3.50;=98.10. (*KLAPROTH.*) By exposure to the atmosphere its surface is a little decomposed.

Clinkstone sometimes approaches very near to petrosilex, or compact feldspar, and, according to Jameson, it sometimes passes into pitchstone, and basalt.—It is, in general, sensibly harder, than some varieties of argillite, which it may resemble.

(*Geological situation.*) This mineral is usually found among secondary rocks; sometimes in beds resting on basalt. It is some-

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* Klingstein. WERNER. La Pierre sonnante. BROCHANT. Pétrosilex feuilleté. BRONGNIART.

times vesicular, its cavities being lined by very minute crystals. It is frequently rendered porphyritic by crystals of feldspar, and then constitutes Clinkstone porphyry, or the porphir scheifer (porphyry slate) of Werner.

It is also found in transition, and perhaps even in primitive rocks.

Clinkstone is not uncommon in Bohemia and other parts of Germany;—and at Lamlash, in the island of Arran, it occurs in very beautiful, columnar concretions. (*Jameson.*)

Species 19. Pumice.* *Kirwan. Jameson.*

Pumice is rough to the touch, and has a texture more or less spongy or porous; its pores or vesicles are sometimes roundish, and often elongated. It is very light, and often swims on water, having a specific gravity of only .914. In most cases it is too brittle to give sparks with steel, but its powder scratches both glass and steel.

It has usually a fibrous structure, the fibres being sometimes curved and parallel, and sometimes interlaced, or arranged in all directions. When the fibres are large, their lustre is glistening and vitreous, but, when very fine, it is somewhat silken. The cross fracture is uneven or imperfectly conchoidal, and vitreous.

But a fibrous structure is not essential to Pumice. Some varieties appear to be an accumulation of oblong, vitreous bubbles or vesicles; while others are composed of minute flakes or scales, but still sufficiently light to swim on water. Kirwan mentions a variety, in which no fibres are discernible, whose fracture is dull, uneven, and splintery, and whose specif. gravity is the same, as that of water. Indeed Spallanzani asserts, that *visible* pores are not essential to Pumice.

The colors of Pumice are grayish white, or gray, sometimes with a shade of yellow or blue, also brown, reddish brown, or red, greenish, and sometimes grayish black, or black. Spallanzani supposes Pumice to be always black, when ejected from a volcano. In the mass it is opaque, or translucent at the edges, but in minute fragments is often strongly translucent.

(*Chemical characters.*) Pumice is fusible by the blowpipe into a whitish enamel or glass. Its composition is probably a little variable. In a specimen from Lipari Klaproth found silex 77.5, alumine 17.5, potash and soda 3.0, iron 1.75;=99.75.

(*Geological sit. and Localities.*) On the origin of Pumice different and even opposite opinions exist. Some contend, that it is always a volcanic product; others assert, that it is frequently, if not

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* Bimstein. Werner. Ponce. Brongniart. La Pierre ponce. Brochant. Lave vitreuse pumicée. Haüy.

always an aqueous deposite; while others, who admit, that it has been ejected from volcanoes, deny that it has undergone the action of volcanic fires.

That the origin of Pumice is, in many cases, volcanic appears to be supported by evidence perfectly satisfactory. It has a semi-vitrified aspect, approaching more or less to that of glass. It is most frequently found in countries at present volcanic, or which give indications of having formerly been so. It does not, however, occur in all volcanic countries. The fires of Etna and some other volcanoes seem to have seldom or never produced it.

In 1783, flames continued for several months to rise out of the sea about 30 miles from Cape Reikianes, a promontory at the southwest corner of Iceland; during which time vast quantities of *Pumice* washed on shore. (*Mackenzie.*)—At Campo Bianco, in the island of Lipari, Pumice occurs in extensive, distinct beds, nearly horizontal. These beds are not continuous, but are composed of globular masses, feebly united, or entirely distinct, and varying in size from that of a hazel nut to a foot in diameter. If these masses of Pumice were ejected from a volcano, they would assume a globose form, while passing through the air. In some instances the vesicles are elongated, and the fibres extended in the direction of the strata, or supposed current. (*Spallanzani.*) In the same island, Pumice and obsidian are intimately united, or even pass into each other; and both exhibit very strong evidence of having flowed in a current from the crater of a volcano.—Pumice is abundant in the isles of Milo and Santorini, in the Archipelago.—In Teneriffe and Iceland it is found united to obsidian, between which a gradual transition may sometimes be observed. (*Cordier*, and *Mackenzie.*)

It sometimes contains crystals of feldspar, mica, ceylanite, &c.

In Hungary, however, Pumice accompanies pearly obsidian, which alternates with a porphyry, containing crystals of feldspar, quartz, and mica. (*Esmark.*) Sometimes also Pumice alternates with basalt. (*Jameson.*) In the Euganean mountains it is intimately united with pitchstone. (*Spallanzani.*)

But, if Pumice be, in many cases, an imperfect vitrification, it has undoubtedly originated from different substances, in different places. Among these are supposed to be granite, pitchstone, petrosilex, and obsidian; indeed the vitreous obsidian of Hungary, according to Brongniart, may be changed by heat into a substance resembling white Pumice.*

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* The vitreous, capillary filaments, sometimes fine as those of wool, and moveable by the breath, which have been found in the isles of Bourbon and Lipari, appear to be a volcanic glass, rather than Pumice.

(Uses.) It is employed in a state of powder for polishing glass, metals, stones, &c. and in the preparation of parchment. It is also employed, as a building stone, in constructing arches. The Pumice of commerce is obtained chiefly from Lipari.

Species 20. Obsidian.*

This mineral, in its general aspect, resembles certain kinds of glass, or of enamel. Its fracture is *vitreous* or *pearly*; thus constituting two varieties, under which it is more convenient to describe this species, than to collect its characters into one view.

Var. 1. vitreous obsidian.† This variety has a strong resemblance to glass. Its fracture is distinctly conchoidal, with large cavities, and strongly shining with a lustre more or less vitreous. The surface of the fracture often exhibits a waved or striated appearance, and its aspect is sometimes a little unctuous.—It strikes fire with steel, but is brittle, and falls into sharp edged fragments. Most commonly it is translucent at the edges, or opaque; but some varieties are translucent, and, in thin scales, transparent. Its color is black, either deep and pure, or tinged with green, brown, blue, or gray, and sometimes passes to green, brown, or gray, or is even yellow, or red. The darkest colors often discover a tinge of green by transmitted light.—A chatoyement with a silken lustre is sometimes perceived in certain greenish obsidians, when viewed perpendicularly to the direction of their beds, and is probably produced by a great number of little bubbles, very much elongated in the direction of the beds.—Its spec. grav. extends from 2.34 to 2.43, or even to 2.90. It occurs in amorphous masses, or in fragments or grains, often rounded.

(Chemical characters.) Before the blowpipe it intumesces more or less, and melts into an opaque, porous, or spongy enamel, sometimes much larger than the original fragment. This enamel is usually grayish or white; some varieties not only preserve their color during fusion, but even acquire some transparency. It contains silex 78.0, alumine 10.0, potash 6.0, lime 1.0, oxides of iron and manganese 3.6;=98.6. *(Klaproth.)*

It often much resembles pitchstone, but usually differs more or less in lustre and fracture.

2. pearlstone.‡ *Jameson.* This variety appears to have a structure more or less granular, and is traversed by fissures in va-

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* Obsidienne. Brongniart. Lave vitreuse obsidienne. Hauy.

† Obsidienne vitreuse. Brongniart. Obsidian. Werner. Kirwan. Jameson. L'Obsidienne. Brochant.

‡ Perlstein. Werner. Le Perlstein. Brochant. Obsidienne perlée. Brongniart. Lave vitreuse perlée. Hauy.

rious directions. It is hence very brittle, sometimes almost friable. Its fracture is uneven or granular, or sometimes imperfectly conchoidal, shining and *pearly*. It is opaque, or translucent at the edges. Its color is usually some shade of gray, sometimes tinged with blue, green, red, or yellow, or is red, reddish brown, &c.

It scratches glass, even when too brittle to give fire with steel. Its spec. grav. varies from 2.25 to 2.54. When moistened by the breath, it frequently exhales an argillaceous odor.—It is always amorphous, and usually vesicular.

(*Chemical characters.*) Before the blowpipe it intumesces very considerably, but does not melt into a globule. A specimen from Hungary yielded Klaproth silex 75.25, alumine 12.00, potash 4.50, lime 0.50, oxide of iron 1.60, water 4.50;=98.35.

(*Geological sit. and Localities.*) Obsidian is found in grains, or in scattered and insulated fragments, or in beds, or in large masses, which resemble a cooled current of lava.

Beds of Obsidian are variously inclined, and composed of layers, usually parallel, and often separated by a very thin, earthy stratum, whose nature is unknown. They are sometimes traversed by veins of other minerals. Such beds occur in Peru, Iceland, Lipari, &c.—In this last island, Monte Castagna is composed entirely of Obsidian, arranged in beds of variable thickness; this Obsidian often contains cavities, which are sometimes crossed by transparent, delicate threads, resembling glass; its colors are black, greenish, &c. (*Spallanzani.*)—Beds of Obsidian are sometimes nearly vertical.—Some Obsidians are rendered porphyritic by containing crystals of feldspar and quartz.

Obsidian is also found in large masses, which exhibit more or less distinctly the appearance of having once been so fluid, as to flow in currents. Such currents exist in Lipari, where they are intimately connected with pumice; (*Dolomieu.*)—also in Teneriffe, Peru, and Mexico.

Sometimes Obsidian occurs in insulated fragments, often globular, and scattered on the soil; sometimes also it is imbedded in pumice. (*Brongniart.*) In the isle of Ponçe these globular masses sometimes embrace plates of yellow mica, and white, vitreous grains, which appear to be semi-vitrified feldspar. In Iceland, Obsidian occurs not only at the foot of Hecla, but in fragments, scattered over a great part of the island.—Near Okhotsk, on the gulph of Kamschatka, it occurs in little pearly white globules in sand, and is the *Marekanite* of Karsten.

In Peru, Obsidian is found on certain volcanic summits in the Andes, at an elevation of nearly 15,000 feet. In Mexico, it is sometimes contiguous to porphyry; and in Teneriffe to basalt and clinkstone.

The preceding remarks refer chiefly to localities of vitreous Obsidian.

Near Tokay, in Hungary, the pearly Obsidian is mingled with fragments of granite, gneiss, &c. It also occurs in beds, which alternate with those of a porphyry, containing crystals of feldspar, quartz, and mica. In fact, the pearlstone or pearly Obsidian is itself porphyritic or amygdaloidal, and often contains nodules or grains of black, vitreous Obsidian. According to Gerhard, Obsidian is sometimes contained in granitic rocks.—Pearly Obsidian is found also in the island of Egg, one of the Hebrides, and near Sandy Brae in Ireland.

(Origin of Obsidian.) The origin of Obsidian, like that of pumice, is by some attributed to volcanic fire, by others to water. It must be obvious, however, that the vitreous Obsidian is most frequently found in volcanic countries. The apparently semi-vitrified feldspar, which it sometimes contains, its own vitreous texture, and its association with pumice, afford also plausible arguments in favor of an igneous origin. Indeed both varieties undoubtedly pass into pumice.

On the other hand, the association of Obsidian with granite and porphyry, and its arrangement in parallel beds, seem to support the hypothesis of an aqueous origin. It also passes into pitchstone. Its intumescence during fusion, in consequence of the liberation of a great quantity of gas, is also urged as an objection to a previous fusion. But it may be replied, that its first fusion was effected under a pressure, sufficient to prevent the escape of the gas.

Hence some mineralogists have suggested a compromise, by granting a volcanic origin to the Obsidian of Iceland, Italy, &c. and retaining the pearly Obsidian of Hungary, as an aqueous production. But the occurrence of vitreous Obsidian in that, which is pearly, and the extensive masses of pearly Obsidian in Mexico, apparently in currents, suggest new difficulties.

(Uses.) In Mexico and Peru the black, vitreous Obsidian is employed for constructing mirrors, and for various ornamental purposes. It is there manufactured even into knives and razors. It is sometimes called the gallinaceous stone of Peru, and the ***black agate*** of Iceland.

SPECIES 21. PITCHSTONE.* *KIRWAN. JAMESON.*

This mineral, especially when recently broken, has often a strong

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* Pechstein. **WERNER.** La Pierre de poix. **BROCHANT.** Rétinite. **BRONGNIART.**

resemblance to *pitch* or resin in its lustre and texture; and hence its name. Most commonly its fracture is imperfectly conchoidal with cavities either large or small, but sometimes it passes to splintery or uneven. Its lustre, though usually more or less shining and resinous or greasy, sometimes inclines to vitreous.

It is very brittle, and does not readily give fire with steel, though it is not easily scraped by a knife. It is more or less translucid, frequently at the edges only, and is sometimes opaque. Its colors are very numerous, but generally dull and uniform. They are several shades of green; black, mingled with green, brown, or gray; brown, tinged with red, green, or yellow; a few shades of gray and red, and sometimes it is yellowish or bluish. Its spec. grav. varies from 2.29 to 2.64.

It occurs in amorphous masses, which sometimes exhibit granular, prismatic, or lamellar distinct concretions. Hence its structure is sometimes fissile or slaty.

(Chemical characters.) Before the blowpipe it whitens, swells, and melts into a porous, whitish enamel. A specimen from Meissen in Saxony yielded Klaproth silex 73.0, alumine 14.5, soda 1.75, lime 1.0, oxides of iron and manganese 1.1, water 8.50;=99.85. A greater proportion of soda has been found by Klaproth and Bergman in other specimens. Pitchstone is liable to decomposition, by which it is sometimes converted into an argillaceous mass.

(Distinctive characters.) This mineral often much resembles obsidian; but its fracture is less perfectly conchoidal, and it seldom, if ever, possesses that vitreous or pearly lustre, which characterizes obsidian.—From jasper or semi-opal its fusibility easily distinguishes it.

(Geological sit. and Localities.) Pitchstone occurs in very large beds, sometimes forming whole mountains; also in veins, and insulated masses of various sizes. Sometimes it contains crystals of feldspar and quartz, and thus becomes the base of a porphyry.

Near Meissen, in Saxony, Pitchstone alternates with a porphyry, whose base is petrosilex; and this porphyry alternates with gneiss, is connected with syenite, and traversed by metallic veins.—Near Planitz, in Saxony, it forms the mass of the mountain, and embraces a black substance with a feeble silken lustre, which melts into a black glass, and contains 38 per cent. of carbon. *(Brongniart.)* It is found abundantly in Arran and other Scottish isles connected with secondary rocks. *(Jameson.)*—In Teneriffe it is associated with basalt and clinkstone.

Near Dublin, in Ireland, it is in veins, which traverse granite It has a slaty structure, and exhibits lamellar concretions. In the vein, the layers, sometimes ¼ of an inch thick, are perpendicular to the horizon; they divide into rhomboidal fragments. Its spec. grav. is 2.29. (Fitton in Geolog. Trans. v. i.)

In the *United States.* In *Maryland*, it is found at the Bare Hills, 7 miles from Baltimore, in serpentine. (*Hayden.*)—In *Connecticut*, near Newhaven.

(*Remarks.*) The resemblance of Pitchstone to obsidian, into which it sometimes passes, and certain geological circumstances have induced some to suppose its origin volcanic. But, in many cases, its natural associations render its aqueous origin unquestionable. Spallanzani is inclined to suppose it sometimes volcanic, and sometimes aqueous. At Monte Sieva, in the Euganean mountains, he observed Pitchstone, containing a light, fibrous, cellular pumice intimately united with it.

Species 22. Spodumen.* *Werner.*

This mineral has hitherto been observed only in laminated masses, easily divisible into prisms with rhomboidal bases, of about 100° and 80°. These prisms are further divisible in the direction of the shorter diagonals of their bases, and are thus resolved into triangular prisms. All the lateral faces both of the quadrangular and triangular prisms are smooth, shining, and pearly; but the cross fracture is uneven or splintery with very little lustre.

The Spodumen strikes fire with steel, and its spec. grav. is about 3.20. It is very brittle; more or less translucent; and usually greenish white, sometimes apple green.

(*Chemical characters.*) Before the blowpipe it exfoliates into little yellowish or grayish scales, which however are not always equally distinct. These scales then unite and melt into a grayish, transparent globule of glass. When heated in a crucible it also splits into scales, having the two colors already mentioned, but in a few days they all become dark gray. It contains silex 64.4, alumine 24.4, potash 5.0, lime 3.0, oxide of iron 2.2;=99. (*Vauquelin.*)

From adularia, which it somewhat resembles, it differs by its greater spec. gravity, and the results of mechanical division.—It differs from the ichthyophthalmite also in its primitive form, chemical characters, &c.

(*Localities.*) This rare mineral has been found in the iron mine of Uton, in Sweden, associated with reddish feldspar, greasy quartz, and black mica;—also in Norway.

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* Spodumene. Jameson. Triphane. Hauy. Brochant. Brongniart.

Species 23. Lepidolite.[*] *Kirwan. Jameson.*

This mineral, at first view, appears to be composed of small grains, sometimes extremely minute, and has an uneven or splintery fracture, with a moderate lustre. But these grains, among which little pearly scales are often interspersed, are themselves composed of a great number of minute foliæ or spangles, like those of mica. These foliæ also, when separated from the mass, have a glistening, pearly lustre, and are variable in size.

It is moderately hard, and may easily be cut by a knife. It is pulverized with difficulty, and its powder is soft to the touch. The color of the mass often resembles that of the lilac, the violet or purple being sometimes strongly tinged with red; it is also rose red, sometimes nearly white. The single laminæ are usually pearly or silver white. The edges of the mass are translucent. Its spec. grav. varies from 2.81 to 2.85.

(Chemical characters.) Before the blowpipe it intumesces a little, and easily melts into a colorless, translucent globule. With the addition of nitre the globule becomes violet. *(Haüy.)* According to Klaproth, it contains silex 54.5, alumine 38.25, potash 4.0, oxides of iron and manganese 0.75, water with a little loss 2.5. In another specimen Vauquelin found silex 64, alumine 20, potash 14, lime 2.

(Geological sit. and Localities.) Near Rosena, in Moravia, where it was first found, it occurs in large, rose colored foliæ, and in masses of considerable size, disseminated in gneiss, and accompanied by feldspar, quartz, mica, schorl, &c.—In Sweden in a quartzy rock.—In France, near Limoge, in a vein of quartz, traversing a granite, which contains large beryls.—In the isle of Elba, in an aggregate of quartz and feldspar.

Species 24. Mica.[†] *Haüy. Kirwan.*

Mica appears to be always the result of crystallization, but is rarely found in regular, well defined crystals. Most commonly it appears in thin, flexible, elastic laminæ, which exhibit a high polish and strong lustre. These laminæ have sometimes an extent of many square inches, and, from this, gradually diminish, till they become mere spangles, discoverable indeed by their lustre, but whose area is scarcely perceptible by the naked eye. They are usually found united into small masses, extremely variable in thickness, or into crystals more or less regular; their union, however, is so very feeble,

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[*] Lepidolith. Werner. Lepidolithe. Haüy. Brongniart. Brochant. Its name is from the Greek Λεπις, a scale, and Λιθος, a stone.

[†] Mica. Brongniart. Jameson. Brochant. Glimmer. Werner. It is often improperly called isinglass.

that they are easily separable, and may be reduced to a surprising degree of tenuity. In this state their surface becomes irised, and their thickness does not much exceed a millionth part of an inch.

The crystals of Mica are sometimes right prisms with rhombic bases, whose angles are 120° and 60°. This is also the primitive form, in which one side of the base is to the height of the prism nearly as 3 to 8. Its integrant particles have *probably* the same form.—It also occurs in six-sided tables, or six-sided prisms, usually short; and sometimes truncated on their terminal edges.—Also in rectangular laminæ.

The structure of mica is always foliated, but the foliæ may be straight, curved, or undulated; sometimes they appear like broad fibres, parallel or diverging, or are marked with plumous striæ. The surface, whether of the crystals, masses, or separate laminæ, has a shining or splendent lustre, which is usually metallic, sometimes like that of silver or gold; and sometimes like that of polished glass, or a little pearly. The lateral divisions of the laminæ are almost always dull.

It is easily scratched by a knife, and in most cases even by the finger nail. Its surface is smooth to the touch, and *very seldom* slightly unctuous; its powder is dull, usually grayish, and feels soft. In thin laminæ, it is very often more or less transparent; but in other cases it is translucent, sometimes at the edges only. When black and opaque in the mass, the separate laminæ are often semitransparent.—Its colors are silver white, gray, often tinged with yellow, green, or black, or nearly black; also brown, yellow, reddish, green, &c.

Its spec. grav. extends from 2.53 to 2.93; and, when rubbed on sealing wax, it communicates to the wax negative electricity.

(Chemical characters.) It is fusible by the blowpipe, though sometimes with difficulty, into an enamel, which is usually gray or black. The colored varieties are most easily fusible; and black mica gives a black enamel, which often moves the needle. It contains, according to Klaproth, silex 48.0, alumine 34.25, potash 8.75, oxide of iron 4.5, oxide of manganese 0.5;=96. Sometimes the potash is in greater proportion, and in black mica the oxide of iron is sometimes as high as 22 per cent.—Mica is subject to decomposition by exposure to the atmosphere, and is sometimes converted into a kind of steatitic matter.

(Distinctive characters.) Mica differs from talc by its elasticity, its want of unctuosity, and by communicating negative electricity to sealing wax.—It is less hard than diallage, which is not elastic.—It sometimes resembles cyanite, but the latter is harder, not elastic,

and infusible.—It may also resemble the green oxide of uranium, but the latter is brittle, and melts into a black scoria.—It is easily distinguished from micaceous oxide of iron.

The following are its most important varieties.

Var. 1. LAMINATED MICA.* It occurs in large plates, which often contain many square inches. It has been called *Muscovy* glass or talc, being found abundantly in that country.

2. LAMELLAR MICA.† This is the more common variety. It exists in small foliæ, either collected into masses, or disseminated in other minerals. It is sometimes in extremely minute scales, which, when detached from the mass, appear like sand.

Sometimes the lamellæ are convex, and placed one upon another with an increasing extent, so that they form an inverted pyramid.

3. PRISMATIC MICA.‡ This variety is not common. The laminæ are easily divisible, parallel to their edges, into minute prisms, or even into delicate filaments. The edges of the laminæ have usually more lustre, than those of the other varieties.

It occurs in *Connecticut*, at Litchfield;—and in *Maine*, at Topsham.

(Geological situation.) Although mica never occurs in beds, or large insulated masses, there is no substance more universally diffused through the mineral kingdom. It is an essential ingredient in granite, gneiss, and mica slate; and occurs also in syenite, porphyry, and other primitive rocks. Its crystals sometimes appear in the fissures of these rocks, or in the cavities of veins, which traverse them; in these veins also often occur the large plates of laminated mica. Even when disseminated in granite, &c. it is sometimes in perfectly regular crystals. In some cases it constitutes small veins. To limestone, quartz, &c. it often communicates a slaty texture.

Mica occurs also in greenstone, basalt, sandstone, and other secondary rocks; especially in the sandstone and shale, which accompany coal.—It is abundant in the sand of primitive countries, and exists even in that, which is far distant from primitive rocks.—It is often connected with volcanic rocks.

But, notwithstanding this universal diffusion of Mica, it has most probably, in all cases, been formed among primitive rocks. Hence, when found in secondary rocks or alluvial earths, it has undoubtedly arisen from the disintegration of primitive rocks, and been subsequently transported by water.

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* Mica foliacé. HAUY. BRONGNIART.

† Mica lamelliforme—ecailleux—hémisphérique. HAUY.

‡ Mica filamenteux. HAUY. BRONGNIART.

(Localities.) Very fine specimens have been found in Russia, Siberia, &c.

In the *United States*, Mica is very abundant. In *Pennsylvania*, at Germantown, it is crystallized in six-sided tables and prisms. *(*WISTER.*)*—In *Connecticut*, at Woodbury, it is violet.—In *Massachusetts*, at Chesterfield and Goshen, in the granite, which contains the indicolite and green tourmaline; its colors, which are very delicate, are violet, reddish, and yellow.—In *New Hampshire*, in Grafton, 20 m. E. from Dartmouth College, in large laminæ, adhering to quartz;—also near Bellows Falls, in Walpole.—In *Maine*, almost every variety of Mica is found at Topsham, near Bowd. College; it is often in six-sided tables, sometimes equilateral, and sometimes elongated; also in rhomboidal prisms.—In Brunswick, its color is sometimes a very beautiful green.

(Uses.) It has been employed, instead of glass, in the windows of dwelling houses; also in ships of war, because it is not liable to be broken by the concussion, produced by the discharge of cannon. In lanterns it is superior to horn, being more transparent, and not so easily injured by heat.—When in thin, transparent laminæ, sufficiently large, it is useful to defend the eyes of those, who travel, against high winds, and severe storms of snow.—When of suitable color and in minute scales, it is employed to ornament paper, which is then said to be *frosted;* the scales of Mica are made to adhere by a solution of gum or glue.

SPECIES 25. LEUCITE.[*] *JAMESON.*

The Leucite usually appears in regular, well defined crystals, contained under twenty four faces, which are equal and similar trapeziums; or it may be viewed as a double eight-sided pyramid, each of whose vertices is formed by four planes, standing on the alternate edges of the pyramids. They are sometimes elongated. Their primitive form is probably a cube, and their integrant particles irregular tetraedrons.

The surface of perfect and unaltered crystals is smooth, and not striated like that of garnets of a similar form, although they sometimes exhibit seams parallel to the shorter diagonals of the faces. The size may vary from that of a pin's head to an inch in diameter; and the angles and edges are sometimes rounded.—The Leucite occurs also in grains, or fragments of crystals.

Its colors are usually gray, or white, often impure, and sometimes

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[*] Leuzit. WERNER. La Leucite. BROCHANT. Amphigene. HAUY. BRONGNIART. Vesuvian. KIRWAN. The term Leucite is derived from the Greek *Λευκος*, white.

shaded with yellow, or even with red. Some crystals are nearly or quite transparent, others only translucent, and some are opaque.

Its fracture, in certain directions foliated, is in others imperfectly conchoidal or uneven, somewhat shining and vitreous, when the crystal is unaltered.—The Leucite scratches glass with difficulty, and is sometimes almost friable. Its spec. grav. is about 2.47.

(Chemical characters.) Before the blowpipe it is infusible. Its powder converts the vegetable blue to green. It contains silex 53.75, alumine 24.62, potash 21.35 ;=99.72. *(Klaproth.)*

Its infusibility alone is sufficient to distinguish it from the garnet and analcime, which have similar forms; it also differs from them in other characters.

(Geological sit. and Localities.) It is often imbedded in lava and in basalt. In porous or scorious lavas, the crystals are more friable and opaque, than those in more compact lavas, or in basalt. Sometimes, however, it is opaque and earthy, even when perfectly enveloped in lava. Its altered state must, in this case, be attributed to the action of volcanic fire, rather than to that of moisture or sulphurous acid. Its crystals are sometimes united into very considerable masses.

All lavas do not contain crystals of Leucite. They are abundant in the lava of Vesuvius, but seldom or never in that of Etna. They occur in large quantities near Naples and Rome. Leucite is sometimes associated with masses, composed of mica, hornblende, feldspar, &c. which appear to have been ejected from volcanoes, without having undergone the action of fire.

In Bohemia the Leucite is found in basalt.—In the Pyrennees in granite *(Lelievre)* ;—and in Mexico in a gangue, which contains gold. *(Dolomieu.)*

In regard to those Leucites, found in lava, Werner, Dolomieu and others suppose these crystals to have pre-existed in the mineral, which, by its fusion, has produced the lava; and in consequence of their infusibility to have remained more or less unaltered by volcanic fire.

De Buch and others think, that the Leucite has crystallized within the fluid lava. This idea is in part suggested by the fragments of lava, and even of augite, which are often found enveloped in crystals of Leucite. But to this it may be replied, that fragments of basalt, or of whatever produced the lava, might have been originally inclosed in the crystal, and afterwards converted into the state of lava by a degree of heat, insufficient to fuse the surrounding Leucite.

Species 26. Fettstein.* *Werner.*

This mineral has a crystalline structure and foliated fracture in certain directions. It is divisible parallel to all the sides of a rhomboidal prism, and also in the direction of the shorter diagonals of the bases; in other directions its fracture is uneven. Its lustre is shining and *greasy;* and hence probably its name. It is slightly chatoyant.

It scratches glass, and gives fire with steel. It is brittle; and its specific grav. is from 2.56 to 2.61. It is translucid at the edges; and its colors are greenish gray, or sea green, or bluish.

It is fusible by the blowpipe into a white enamel. It contains silex 46.5, alumine 30.25, potash 18.0, lime 0.75, oxide of iron 1.0, water 2.0;=98.50. (*Klaproth.*) The analysis of Vauquelin is nearly the same.

It has been found near Arendal, in Norway, with feldspar and hornblende.

When cut, it sometimes exhibits a play of colors, like the cat's eye.

Species 27. Lapis Lazuli.† *Kirwan.*

This interesting and indeed valuable mineral may generally be recognised by its color, especially with the assistance of a few chemical experiments. When pure, its color is a fine azure blue, a little darker or lighter; sometimes also it approaches sky or smalt blue. It is usually in amorphous or rounded masses of a moderate size, but has recently been observed in dodecaedrons with rhombic faces. Its structure is finely granular, almost compact; and its fracture uneven, sometimes a little foliated; it is dull, or has only a feeble lustre. It is opaque, or a little translucent at the edges.

It scratches glass, but does not easily give sparks with steel, and that only in certain parts. Its spec. grav. in pure specimens is about 2.36, but it is sometimes 2.94.

(*Chemical characters.*) If previously calcined, it loses its color in the mineral acids, and forms with them, when concentrated, a thick jelly. It retains its color at a temperature of 100° W. but may be melted by the blowpipe into a white or gray enamel. In the analysis of this mineral, chemists have obtained very different results; and it is impossible, at present, to say what is its true composition. A part of the difficulty undoubtedly arises from foreign ingredients,

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* Pierre grasse. Haüy. The writer has never seen this mineral; but the above description rests on the authority of Haüy and Count D. Borkowski.

† Lazurstein. Werner. Azure Stone. Jameson. Lazulite. Haüy. Brongniart. La Pierre d'Azur. Brochant. The Arabians call it *Azul.*

which are visibly mingled with it. Clement and Desormes, from Lapis Lazuli of the greatest beauty and much purer than usual, obtained silex 35.8, alumine 34.8, soda 23.2, sulphur 3.1, carbonate of lime 3.1, and in some experiments a little iron; but the two last they do not consider essential. If this analysis be correct, this mineral cannot receive its color from a blue sulphuret, or blue oxide of iron.

(Distinctive characters.) The intensity of its blue, and some other characters will generally distinguish it from the Lazulith of Werner, which we annex as a subspecies.—It also resembles the azure colored ores of copper; but the latter become black in a moderate heat, and communicate to ammonia a blue color.

(Geological sit. and Localities.) When found in place, it appears to have occurred in primitive rocks, especially in granite. It is accompanied with garnets, carbonate of lime, quartz, feldspar, and sulphuret of iron, with some of which it is often intermixed. But it more frequently occurs in scattered, rolled fragments.

It has been found chiefly in China, Persia, and Bucharia. It also exists in Russia, and in Siberia near lake Baikal.

(Uses.) It receives a high polish; and its fine color, often marked by yellow spots or veins of sulphuret of iron, renders it extremely beautiful, and much esteemed for many ornamental works. But its chief use is to furnish the *ultramarine blue*, a pigment remarkable for the durability of its color.—To extract the coloring matter, the mineral, having been repeatedly heated and immersed in vinegar, is reduced to a very fine powder. This powder is formed into a paste with melted resin, wax, and linseed oil; and this paste is ground with warm water, which extracts the coloring matter, and deposites it as a sediment. In this process, the oil is supposed to form a kind of soap with the *soda*; and the particles of the ultramarine, being thus rendered smooth and slippery, escape, by the assistance of the hot water, from the particles of the gangue, which are retained by the wax.—This pigment is employed with oil.

SUBSPECIES 1. LAZULITE.[*]

We subjoin this mineral not without a strong suspicion, that it belongs to another species. Its color is a light indigo blue, but darker than smalt blue. It is opaque, or translucent at the edges. It is sometimes massive, and sometimes in prisms, either hexaedral or tetraedral. Bernhardi says it is often in regular octaedrons with truncated edges, passing to a dodecaedron with rhombic faces. Its fracture is uneven, but in one direction imperfectly foliated, and its lus-

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[*] Lazulith. WERNER. Azurite. JAMESON. Le Lazulithe. BROCHANT. Lazulite de Klaproth. BRONGNIART. Lasulit de Verner. HAUY.

tre is moderate. It scratches glass. Its streak is nearly bluish white. (*BROCHANT.*)

Before the blowpipe it is infusible, but becomes light gray and earthy. With borax it forms a yellowish glass. Its color is not attacked by pure alkalis; and acids have but a feeble action on this mineral. It contains alumine 71.0, silex 14.0, magnesia 5,0, carbonate of lime 3.0, potash 0.25, iron 0.75, water 5.0;=99. (*KLAPROTH.*) Its composition differs much from that of the common Lapis Lazuli.

This mineral occurs massive at Vorau in Stiria with quartz and mica, in a thin vein, traversing mica slate.—In Salzburg it is found crystallized.

SPECIES 28. SCHORL.* *WERNER. JAMESON.*

This mineral is, in general, easily recognised. It most frequently occurs in long, prismatic crystals, more or less regular, whose lateral faces are almost always longitudinally striated. These prisms usually present six, nine, or twelve sides, and are terminated at both extremities by three principal faces. But the edges and solid angles on and around one, and sometimes both, of these triedral summits are variously truncated. Hence, in most cases, the two summits differ from each other in the *number* of their faces, although, in consequence of the smallness of some of these faces, this difference would often escape the eye, without careful observation. Thus the prism has often nine sides with one triedral summit, while the other summit may have five, six, seven, or nine faces. Sometimes the prism has twelve sides with one triedral summit, while the other summit presents five or even nineteen faces.—The prism may have twenty four sides.

Their primitive form, not easily obtained by mechanical division, is an obtuse rhomb (Pl. IV, fig. 1.), of which the plane angle at the summit is 113° 34′. The integrant particles are tetraedrons. Haüy has described seventeen secondary forms, of which we select a few.

A nine-sided prism (Pl. IV, fig. 2.), terminated at one extremity by three faces, and at the other by six, of which three are larger than the others, and stand on those three lateral edges of the prism, each of which contains an angle of 120°. It is sometimes described as a three-sided prism, bevelled on its lateral edges. Indeed this prism frequently appears to have only *three sides*, which however are more or less sensibly convex. Sometimes the edges of the triedral summit are truncated.†

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* Tourmaline. HAÜY. BRONGNIART. Le Schorl. BROCHANT.

† The *Aphrizite*, a variety of Schorl, is sometimes in nine-sided prisms, which exhibit the last mentioned modification of the triedral summit; and sometimes in six-sided prisms.

A nine-sided prism (Pl. IV, fig. 3.), of which one summit has three and the other seven faces.

The prism is sometimes so short, that the two summits almost meet, and the crystal then resembles an obtuse rhomb, truncated on some of its edges.

A six-sided prism, terminated by three faces, which stand on the lateral edges, and are often modified by truncation, on one summit at least.

Sometimes the crystals are cylindrical, and marked with projecting edges or channels; sometimes they are acicular, or even capillary; and sometimes short and very thick.—Schorl also occurs in amorphous masses or fragments.

The electric powers of Schorl constitute one of its most striking characters. By friction it becomes positively electric; but, by exposure to a certain degree of heat, it acquires positive electricity at one extremity, and negative at the other. But in all cases, where the two summits have a different configuration, that summit, which has the greater number of faces, becomes positive. According to Bournon, however, some crystals from Ceylon, perfectly similar at both summits, acquire opposite electricities.

Schorl is very brittle; it scratches glass, and is harder than hornblende, but seldom so hard as quartz. Its fracture is more or less conchoidal, or uneven, and sometimes the cross fracture is slightly foliated. Its lustre is vitreous, and varies from glistening to splendent. Some prisms are articulated. Its spec. grav. extends from 3.05 to 3.36.

It is sometimes opaque, and often translucent, or even transparent. Its most common color is black, but it also occurs green, brown, blue, yellowish, and red of different shades, and sometimes white.

(Chemical characters.) Before the blowpipe it easily melts, and is converted, with ebullition, into a grayish white or brownish enamel, sometimes nearly compact and sometimes vesicular. The red Schorl or rubellite is infusible. A specimen from Eibenstock yielded Klaproth silex 36.75, alumine 34.50, potash 6.0, magnesia 0.25, oxide of iron 21.0;=98.50. Another specimen from Spessart yielded him almost precisely the same results. Sometimes a little lime appears to be accidentally present.

(Distinctive characters.) An attention to the electric powers of Schorl, its vitreous, conchoidal fracture, and fusibility into an enamel, will generally prevent it from being confounded with actynolite, augite, tremolite, chrysolite, emerald, epidote, melanite, and *hornblende*, the last of which it most resembles. (See hornblende.)

Several varieties deserve further notice.

Var. 1. COMMON SCHORL.[*] *JAMESON.* This variety is very common and abundant. It is opaque, or slightly translucent at the edges of thin fragments. Its color is usually a shining, velvet black, but sometimes a little brownish or smoky. Its crystals are often cylindrical or acicular, and very frequently aggregated. Hence this variety often appears in irregular masses, composed of imperfect, prismatic crystals, sometimes parallel and sometimes diverging. When the prisms are very minute, the broken mass exhibits a fibrous or radiated fracture. These aggregated prisms are in general easily separable.—Sometimes masses of Schorl are composed of granular concretions, or of fragments, forming a kind of breccia.

This variety in some cases so abounds with particles of iron, which serve as conductors, that its electric powers are very weak, or even imperceptible.

2. TOURMALINE.[†] *KIRWAN. JAMESON.* This variety includes those Schorls, whose colors are green, brown, yellow, greenish blue, and those, which are white or limpid. The preceding colors present various shades, some of which are so deep, that the crystal, when nearly opaque, appears to be black. It is more or less translucent, and sometimes transparent. It is, however, often the case, that, when a Tourmaline is viewed perpendicularly to the sides of the prism, it is more or less transparent, but, if observed in the direction of the axis, it is opaque, even when the length of the prism is less, than its thickness.—The transparent Schorls generally, but not always, exhibit stronger electrical powers, than those, which are opaque.—The Tourmaline is usually in distinct crystals.

GREEN TOURMALINE.[‡] It presents several shades, varying from leek green to olive green. Some from Brazil are emerald green, and have been called *Brazilian emeralds.*

In the *United States.* In *Massachusetts,* at Chesterfield, in Hampshire Co. it occurs in granite, associated with the indicolite and rubellite; indeed prisms of rubellite are sometimes perfectly *inclosed within* those of the green Tourmaline. Its color varies from a deep to a pale green. The crystals are of various sizes, sometimes four or five inches in length. They are sometimes imbedded in a very beautiful laminated feldspar. (*WATERHOUSE.*)

YELLOW TOURMALINE. It is sometimes honey yellow, or nearly orange.—In the *U. States.* In *Pennsylvania,* at London Grove,

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[*] Gemeiner Schörl. WERNER. Le Schorl noir. BROCHANT. Tourmaline noir. HAUY. Tourmaline Schorl. BRONGNIART. Schorl. KIRWAN.

[†] Tourmalin. WERNER. Tourmaline verte, &c. HAUY. Le Schorl électrique. BROCHANT.

[‡] Tourmaline emeraudine. BRONGNIART.

Chester Co. it exists in transparent crystals with the silico-calcareous oxide of titanium. (*CONRAD.*)

WHITE TOURMALINE. According to Dolomieu, this rare variety, which is found at St. Gothard, &c. exists in granite in the isle of Elba, and is there partly white and partly black.

3. INDICOLITE.* This variety, as its name indicates, has an indigo blue color, sometimes so dark, that it appears almost black, like common Schorl, unless viewed at the edges, and sometimes a light azure or nearly sky blue, or even with a tinge of green. Its crystals have the forms of the species, and are sometimes acicular. It is less easily fusible, than common Schorl; and some specimens scratch quartz.

(*Localities.*) This variety is rare in Europe, but has been found in Sweden.

In the *United States.* It has been found in *New York*, at Haarlem Heights.—In *Massachusetts*, it occurs abundantly at Goshen, in Hampshire Co. in a coarse grained granite, of which the feldspar is white and laminated, or sometimes granular, and the mica yellowish, violet, or rose colored. The crystals are sometimes light azure blue and small, particularly in the granular feldspar; but the blue of the larger crystals is so very deep, that it appears black, except at the edges, which are translucent, and transmit a fine deep blue and sometimes sea green light. Its more common form may be referred to Pl. IV, fig. 2. It is generally opaque, but sometimes translucent, or even transparent. (Bruce's Min. Jour. v. i.)—It occurs also in Chesterfield, an adjoining town, in the same granite, which contains green tourmaline and rubellite.

SUBSPECIES 1. RUBELLITE.† *KIRWAN.*

This mineral resembles Schorl in the form of its crystals, and its power of acquiring opposite electricities by heat; but it sensibly differs in its chemical characters.

Its color is red of various shades, as crimson, pink, or peach blossom red, or violet red, like the lilac, or even darker, and sometimes with a tinge of green. It is transparent, or only translucent. It sometimes slightly scratches quartz; and its spec. gravity is about 3.07.—Its crystals are sometimes cylindrical or acicular, and aggregated in groups.

The Rubellite loses its color and transparency before the blowpipe, but remains infusible. A violet red specimen from Siberia yielded Vauquelin silex 42, alumine 40, soda 10, oxide of manganese and

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* Tourmaline indicolite. BRONGNIART. Tourmaline indigo. HAUY.

† Tourmaline Rubellite. BRONGNIART. Tourmaline apyre. HAUY. Daourite—Siberite—red schorl of others.

iron 7;=99. It is very remarkable, that a mineral of this composition should be infusible.

(Localities.) In the Uralian mountains the Rubellite is found in granite, accompanied with common Schorl.

In the *U. States*. In *Massachusetts*, at Chesterfield, Hampshire Co. it exists in granite, which also contains green Tourmaline, indicolite, and emerald. The crystals are usually translucent, and pink red, often long and slender; and are sometimes embraced in those of the green Tourmaline.

In the cabinet of the late Mr. Greville, which has been purchased by the British Government at 13,727 pounds sterling, and deposited in the National Museum, there is a specimen of Rubellite from the kingdom of Ava, valued at 1000l. *(Jameson.)*

(Geolog. sit. of the species.) Schorl has hitherto been found only in primitive rocks, particularly in granite and gneiss, or in veins, which traverse these rocks. It also occurs in mica slate and argillite. Sometimes it even enters into the composition of rocks. At St. Gothard it occurs in a micaceous Dolomite. It is sometimes found in metallic veins.

(Localities.) Schorl exists in almost every primitive mountain. Madagascar, Spain, and the Tyrol furnish fine specimens. In the *United States*, the localities of several rare varieties have already been noticed. In *Maryland*, at Jones' Falls, near Baltimore, in a vein of granite, the crystals of black Schorl are sometimes more than three inches in circumference. *(Gilmor.)*—In *Maine*, common Schorl is very abundant, particularly in the towns of Hallowell, Gardiner, Litchfield, Bowdoin, and Bowdoinham. At the last mentioned place, the crystals are sometimes uncommonly large, being from one and a half inch even to three inches in their mean diameter, and in some instances nearly one foot in length. The edges, angles, and one termination even of these large crystals are often extremely perfect. They are sometimes imbedded in a very white quartz.—At Brunswick, masses of black Schorl, composed of imperfect, aggregated prisms, sometimes contain fragments of quartz, and also numerous smooth, dull, roundish fragments of feldspar, about the size of shot, or a pea.—At Parker's island in the Kennebec, it is sometimes translucent at the edges, and transmits a brownish light.

(Remarks.) The electrical powers of Schorl are rendered sensible by exposing it to any degree of heat between 100° and 212° Fahr. The crystal may conveniently be held, near the centre of the prism, by a pair of forceps with a wooden or glass handle, and in this state uniformly exposed to hot coals, or the flame of a candle, or plunged in hot water. For the mode of using the electrometer, see Introd. art. 140. Or the crystal, when excited, may be suspended

by a thread of silk; and, on presenting another excited crystal or a stick of excited sealing wax, attraction or repulsion will be observed. Ashes and similar light bodies will be attracted by both poles.

If a crystal of Schorl be heated somewhat above the limit just mentioned, it loses its electricity. By increasing the heat, however, to a certain degree, it again becomes excited, but its electric poles are inverted.

The word Schorl is by some derived from Schorlaw, a village in Saxony, and by others from the Swedish word *skorl*, brittle. But, whatever may be its origin, it has, till recently, been employed in a very loose manner, and applied to a great number of minerals, totally different from each other, and from the mineral, to which it is now limited. Thus the term Schorl, with some modifying epithet, has been applied to epidote, augite, axinite, staurotide, cyanite, actynolite, pycnite, tremolite, and several of the oxides of titanium, &c. &c. &c.

SPECIES 29. ANDALUSITE.* *JAMESON.*

The hardness of this mineral is nearly equal to that of corundum; for it scratches quartz, and sometimes spinelle. Its spec. gravity is 3.16. Its structure is more or less distinctly crystalline. Indeed it sometimes appears in imperfect four-sided prisms, nearly or quite rectangular, and divisible in the direction of one of the diagonals of the bases. Its longitudinal fracture is foliated, and its cross fracture a little splintery. It has usually very little lustre. Its colors are flesh red, reddish white, reddish brown, violet, or grayish black. It is a little translucent, but chiefly at the edges. It sometimes occurs in masses about the size of an egg.

It is perfectly infusible by the blowpipe. It contains alumine 52, silex 38, potash 8, iron 2. (*VAUQUELIN.*)

It differs from feldspar by its greater hardness and its infusibility; and from corundum by its structure and less spec. gravity. Some mineralogists, however, are inclined to believe this mineral to be feldspar, intimately mixed with corundum—and hence its hardness.

(*Geological sit. and Localities.*) The Andalusite has been found only in primitive rocks. In Forez in France, it occurs in a vein of feldspar, traversing granite.—In Spain, in granite and often embraces plates of mica.—In Ireland, in the County of Wicklow, in mica slate. It is usually in grayish black, slender, imperfect prisms, variously aggregated. It is accompanied by an uncommon mineral, resembling indurated talc, in rhomboidal prisms, yellowish gray, faintly translucent, easily cut by a knife, and fusible into a white

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* Andalusit. WERNER. Andalousite. BRONGNIART. Feldspath apyre. HAUY. BROCHANT.

enamel. Of these prisms the Andalusite often forms the axis, from which the talky substance seems to radiate in foliæ. (Fitton in Geolog. Trans. v. i.)

In *U. States*, in *Maine* at Readfield, from which place I have seen only one small specimen; it appears to have been taken from granite.

Species 30. Feldspar.* *Jameson.*

This important and widely distributed mineral has, in most of its varieties, a structure very distinctly foliated. It scratches glass, and gives sparks with steel, but its hardness is a little inferior to that of quartz. When in crystals or crystalline masses, it is very susceptible of mechanical division at natural joints, which, in two directions perpendicular to each other, are extremely perfect; but in the third direction they are usually indistinct.

The primitive form thus obtained is an oblique-angled parallelopiped (Pl. IV, fig. 4.), whose sides are inclined to each other in angles of 90°, 120°, and 111° 28′. The four sides, produced by the two divisions perpendicular to each other, have a brilliant polish, while the other two are dull; this is a distinctive character of great importance. Its integrant particles have the same form, as the nucleus. Its spec. gravity usually lies between 2.43 and 2.70.—It possesses double refraction, which however is not easily observed. It is usually phosphorescent by friction in the dark.

(Chemical characters.) Before the blowpipe it melts into a white enamel or glass, more or less translucent. The results of analysis have not yet been perfectly satisfactory in regard to the true composition of Feldspar. It appears probable, however, that not only silex and alumine, but also lime and potash are essential ingredients.

In a specimen of green Feldspar Vauquelin found silex 62.83, alumine 17.02, potash 13.0, lime 3.0, oxide of iron 1.0;=96.85. In another specimen of common Feldspar Chenevix found silex 64.0, alumine 24.0, lime 6.25, oxide of iron 2.0;=96.25. According to Vauquelin, the variety called Adularia contains silex 64, alumine 20, potash 14, lime 2. But in the same variety Chenevix found silex 68.5, alumine 20.5, lime 7.0, oxide of iron 1.5;=97.50. The variety called Petuntze yielded Vauquelin silex 74.0, alumine 14.5, lime 5.5;=94.

From corundum and chrysoberyl Feldspar may be distinguished by its inferior hardness, less spec. gravity, and fusibility.

Feldspar presents several varieties deserving particular notice.

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* Feldspath. Werner. Hauy. Brochant. Felspath. Brongniart.

Var. 1. COMMON FELDSPAR.* *KIRWAN. JAMESON.* This variety occurs in fragments often rolled, also in grains in sand, but more commonly in masses of a moderate size, forming an ingredient of compound minerals. It is not unfrequently in regular crystals. Of the primitive form already mentioned, Haüy has described twenty modifications.

The crystals of Feldspar, seldom very small, are sometimes *several inches* both in diameter and length; their faces are shining, and their edges sometimes very perfect. Their prevailing form is an oblique prism, whose sides are unequal, and vary in number from four to ten. The terminating faces, of which two are commonly larger than the others, are subject to great variation in number and extent; indeed they often seem to have no symmetry in their arrangement, a circumstance, which arises from the obliquity and irregularity of the primitive form. It is very common to find certain faces unduly extended at the expense of others. The crystals are often grouped, and frequently exhibit hemitropes. We select a few forms for description.

It sometimes presents the primitive form, slightly altered by truncation on two opposite edges.

Also an oblique four-sided prism (Pl. IV, fig. 5.), of which the two bases and two opposite sides are rectangular parallelograms, and the other two sides oblique-angled.

Also an oblique four-sided prism with diedral summits; the terminating faces stand on the obtuse lateral edges, and form with each other an angle of 128° 56′. The lateral edges of this prism, as well as those of the summits, are sometimes truncated. This prism is sometimes so short, and one face of each summit so unduly extended, that the crystal appears to be a rhomb, or a rhombic table.

Also a six-sided prism, terminated by diedral summits; the two edges, on which the terminating faces stand, are usually formed by the four narrower faces of the prism. The crystal is sometimes tabular.

Also a ten-sided prism (Pl. IV, fig. 6.), or rather the preceding six-sided prism, truncated on four of its lateral edges by planes, which form with the contiguous sides an angle of 150°. These prisms are sometimes compressed or have a tabular form; and are very often grouped, two and two, touching by their hexagonal faces.

Another form is a six-sided prism (Pl. IV, fig. 7.), terminated at each extremity by five faces, arranged without symmetry.

In fine, all its forms may be referred to a four or six-sided prism,

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* Gemeiner Feldspath. WERNER. Le Feldspath commun. BROCHANT. Felspath commun. BRONGNIART.

variously truncated and terminated. One of its hemitrope crystals is represented Pl. IV, fig. 8;—they often appear to be rectangular four-sided prisms.

The longitudinal fracture is foliated, and its lustre more or less shining and vitreous, sometimes pearly, especially in certain spots; the cross fracture is uneven or splintery, and nearly dull. It is easily broken, and falls into rhomboidal fragments, which have four polished faces.—The foliæ are sometimes curved, or arranged like the petals of a flower.

It is more or less translucent, sometimes nearly or quite opaque, and presents a great variety of colors. Among these are white, tinged with gray, yellow, green, or red; gray, often with a shade of blue, several shades of red, as flesh or blood red; to which must be added green, yellow, brown, or even black.

This variety is very abundant, and constitutes an essential ingredient of granite, gneiss, syenite, and greenstone. Of granite and syenite it sometimes forms two thirds of the whole mass. It exists also in argillite, porphyry, &c. Its crystals, though sometimes imbedded, are more often found in the fissures or cavities of these rocks, and are sometimes associated with epidote, axinite, chlorite, amianthus, carbonate of lime, quartz, magnetic oxide of iron, &c.

GREEN FELDSPAR. This rare subvariety has an apple green color, varying somewhat in intensity, and sometimes marked with whitish stripes. It scratches green diallage, which it a little resembles.

(Localities.) It was first found in the Uralian mountains.—In the *U. States.* It is found in *Maryland,* near Baltimore, in granite.—In *Maine,* at Topsham, near Bowd. Coll. it appears in imperfect crystals, imbedded in an aggregate of mica and quartz.

2. ADULARIA.* *JAMESON.* This is the most perfect variety of Feldspar, and bears to common Feldspar, in many respects, the relation of rock crystal to common quartz.

Adularia is more or less translucent, and sometimes transparent and limpid. Its color is white, either a little milky, or with a tinge of green, yellow, or red. But it is chiefly distinguished by presenting, when in certain positions, whitish reflections, which are often slightly tinged with blue or green, and exhibit a pearly or silver lustre. These reflections, which are often confined to certain spots, proceed in most cases from the interior of the crystal.

This variety occurs massive, in rolled pieces, and in regular crystals, which are sometimes very large and perfect, exhibiting the

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* Adular. WERNER. Felspath adulaire. BRONGNIART. L'Adulaire. BROCHANT. Moonstone. KIRWAN. Feldspath nacré. HAÜY.

forms already described. It often presents hemitrope crystals, whose structure, when the crystal is cut in a certain direction and polished, is rendered obvious by the laminæ, which are arranged in different directions without crossing each other, in consequence of the inversion of one half of the crystal.—Sometimes even four crystals are grouped.

It passes by imperceptible shades into common Feldspar. From cat's eye it is sufficiently distinguished by its structure.—It does not, like spodumen, exfoliate or split into small lamellæ before it melts; their primitive forms are also different.

(Localities.) It occurs in the fissures and cavities of granite, gneiss, mica slate, &c. associated with quartz, mica, common feldspar, schorl, &c. The finest specimens come from *Adula*, one of the summits of St. Gothard, whence its name is derived.

In the *United States*. In *Maryland*, near Baltimore, it occurs in granite; it is of a pure white, reflecting a light blue. *(Gilmor.)*—In *Pennsylvania*, in the granite of Germantown; it is amorphous and transparent; *(Wister.)*—also on Conestoga creek, 9 miles from Lancaster; it is transparent and associated with brown spar. *(Conrad.)*—In *New York*, in the vicinity of the city, veins of quartz, which traverse limestone, contain small crystals of Adularia. *(Bruce.)*—In *Massachusetts*, at West Springfield.—Also at Southampton in the same granite, which contains galena; it is white, with a slight tinge of yellow, green, or blue. *(Waterhouse.)*

(Remarks.) Adularia is sometimes cut into plates and polished. The *fish's eye*, *moonstone*, and *argentine* of lapidaries come chiefly from Persia, Arabia, and Ceylon, and belong to Adularia, as do also the *water opal* and *girasole* of the Italians.

3. OPALESCENT FELDSPAR.* This very beautiful variety is distinguished by its property of reflecting light of different colors, which appear to proceed from its interior. Its proper color is gray, often dark or blackish gray, or yellowish gray, and some specimens are marked with whitish spots or veins. But, when held in certain positions, in regard both to the eye and the incident light, it reflects a very lively and beautiful play of colors, embracing almost every shade of green and blue, and several shades of yellow, red, gray, and brown. These colors, or their intermediate shades, are usually confined to certain spots, and even the same spot changes its colors in different positions, as from blue to green.

These reflections appear to arise from some alteration in the lam-

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* Feldspath opalin. HAUY. BRONGNIART. Labradorstein. WERNER. Labrador stone. KIRWAN. JAMESON. La Pierre de Labrador. BROCHANT.

ince by decomposition, by which fissures are produced in the direction of the natural joints; hence they suddenly appear or disappear, as the specimen moves.

Its other characters resemble those of common Feldspar.—Its foliated structure distinguishes it from the cat's eye.

(Localities.) It was first found on the island of St. Paul, on the coast of Labrador, in rounded fragments.—Near Petersburg, in Russia, it exists in granite;—and, according to Jameson, it occurs also in greenstone and syenite.

It is much esteemed in jewelry.

4. AVENTURINE FELDSPAR.[*] Its colors are various; but it contains little spangles or points, which reflect a brilliant light, sometimes yellowish from a flesh colored ground, or whitish from a yellowish brown or greenish ground.

It has been found in Siberia with the green Feldspar; and on the border of the White sea, near Archangel.—Also in the *U. States*, in *Maryland*, near Baltimore. *(GILMOR.)*

5. PETUNTZE.[†] This would probably be arranged under the common variety of Feldspar, had it not received some additional importance from its use in the manufacture of porcelain. It appears in fact to be that variety of Feldspar, which the Chinese call *Petuntze.*

It is nearly or quite opaque, and its color is usually whitish or gray. It has in most cases less lustre, than common Feldspar. Its fracture is lamellar, although its masses often have a coarse granular structure.

It most frequently occurs in beds, and usually contains a little quartz. Its powder is said to have a slightly saline taste.

(Uses.) It is employed in the enamel of porcelain ware; and enters, in certain proportions, into the composition of the porcelain itself. Any variety of Feldspar, which contains very little or no metallic oxide, would undoubtedly answer the same purpose.

6. GRANULAR FELDSPAR. This is sometimes merely an alteration of the common variety by partial decomposition;[‡] and then it forms an intermediate step in the passage of common Feldspar to porcelain earth or kaolin. Its fracture is dull or has a feeble lustre, and may be uneven, earthy, or imperfectly foliated. It is nearly or quite opaque. It varies much in hardness, and is sometimes friable even between the fingers.

It is said also to be less fusible, than the common variety, proba-

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[*] Feldspath aventuriné. HAUY. BRONGNIART.

[†] Felspath Pétuntzé. BRONGNIART. Var. of feldspath laminaire. HAUY.

[‡] Aufgelöster feldspath. WERNER. Disintegrated feldspar. JAMESON. Feldspath granulaire? HAUY.

bly in consequence of having lost some of its potash. Crystals of Feldspar, although still retaining their form, are sometimes found in this disintegrated state. Its color is usually white, though sometimes tinged with other colors.

In other cases, the granular structure of Feldspar appears to be the result of a confused crystallization, as in the case of granular limestone. It has sometimes even a saccharoidal aspect, strongly resembling masses of white sugar.

The Feldspar, which occurs in thin layers in gneiss, mica slate, and greenstone, has often a granular structure.

7. COMPACT FELDSPAR.* The mineral, which we place under this variety, occurs in grains or fragments, disseminated in other minerals, or in large amorphous masses. Its texture is compact; its fracture is splintery, but, at the same time, when examined with a glass, it usually exhibits minute grains or foliæ; its lustre is never more than glistening, and often less. It is more or less translucent, but often at the edges only. Its colors are white or gray, often shaded with green or blue; it also occurs green or red.

Before the blowpipe it melts into a whitish enamel.

This compact variety of Feldspar constitutes large masses or beds; and is sometimes the base of certain porphyries. It also enters into the composition of some greenstones, and constitutes the imbedded Feldspar in some porphyries. It is often associated with quartz and mica, and evidently passes into common Feldspar. It occurs in the Alps remarkably well characterized.

Appendix to compact Feldspar.

BLUE FELDSPAR OF STIRIA.† It is very doubtful whether this mineral belongs to Feldspar, from which it differs in specific gravity, fusibility, and composition. Its texture is usually compact with an uneven or splintery fracture, but sometimes a little foliated. Its lustre is feeble. It scratches glass, but is less hard than quartz; and is commonly translucent at the edges only. Its color is sky blue, often pale, or even bluish white. Its specific gravity is 3.06.

Before the blowpipe it whitens and forms a kind of frit, but does not melt into an enamel. It contains alumine 71.0, silex 14.0, magnesia 5.0, lime 3.0, potash 0.25, water 5.0, oxide of iron 0.75; = 99. (*KLAPROTH.*)

This mineral has been found only near Krieglach, in Stiria, where

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* Var. of *dichter feldspath* of Werner; of *compact feldspar* of Jameson; of *feldspath compacte* of Haüy; and of *petrosilex* of Brongniart.

† Feldspath bleu. HAÜY. BRONGNIART. Var. of dichter feldspath. WERNER. Var. of compact feldspar. JAMESON. Var. of Felsite. KIRWAN.

it forms part of an aggregate with quartz and talc. Karsten has united it with the Lazulite of Stiria and Saltzburg.

(Geological sit. of Feldspar.) In addition to what has already been said under the several varieties, we remark, that Feldspar is found chiefly in primitive rocks. It very seldom constitutes large, homogeneous beds. On the contrary, it forms, as we have seen, an ingredient of granite, gneiss, syenite, greenstone, and porphyry. It sometimes constitutes thin beds, or layers, or veins, which traverse gneiss, mica slate, &c. and is often mingled with other minerals in the same vein.

Feldspar is, however, sometimes found in transition or secondary rocks. It is sometimes disseminated in grains or crystals in graywacke, amygdaloid, and basalt. Compact stratified limestone sometimes contains crystals of Feldspar. *(Brochant.)*

It is very common in certain volcanic productions, to which it gives a porphyritic aspect.

Feldspar is almost always accompanied by quartz or mica, or both; and is sometimes colored green by chlorite. It often contains magnetic oxide of iron, which is sometimes so intimately united, that, although imperceptible by the eye, the Feldspar itself is magnetic, and even possesses polarity; for a minute fragment, being made to float on water, will be attracted and repelled by different poles of a magnet.

Feldspar, especially in some of its varieties, is very subject to decomposition by the action of air and moisture. This process, indicated by change of color, diminished lustre and cohesion, may be observed in all stages from sound Feldspar to Kaolin or porcelain earth. It is also attended by the loss of the potash, or some other ingredient, which rendered the Feldspar fusible; for the resulting earth is infusible. (See Kaolin.) This tendency to decomposition is perceptible in the Feldspar, contained in porphyry, as well as in that of granite.

It is unnecessary to enumerate the localities of a mineral so abundant, as is Feldspar in the *United States.* The common variety frequently occurs in extremely beautiful laminated masses in the granite of *Maryland*, *Pennsylvania*, *Massachusetts*, and *Maine.*

Species 31. Jade.* *Brongniart.*

The most striking, general characters of Jade are a great degree of hardness, a remarkable *tenacity*, which renders it difficult to break, a color more or less green, a resinous or oily aspect when polished, and fusibility into a glass or enamel.

Much obscurity, however, pervades many descriptions of this min-

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* Nephrit. Werner. Nephrite. Jameson. Le Nephrite. Brochant.

eral, which have been published. And in fact the several minerals, usually included in this species, differ so much in composition, or in certain chemical characters, that we shall at once subdivide the species for the purpose of description.

Subspecies 1. NEPHRITE.*

The hardness of Nephrite is, in general, at least equal to that of quartz, and sometimes greater. It possesses a peculiar tenacity, which renders it difficult to break, to cut, and to polish. Its surface is a little unctuous to the touch, and, when polished, has an *oily aspect*. Its fracture is splintery and dull, unless rendered glimmering by foreign intermixture. It is sometimes very strongly translucent, and sometimes only at the edges. Its color varies from leek green to greenish white, or almost white, and has sometimes a slight tinge of blue, or yellow. Brochant says its fresh fracture presents a paler green, than that of the surface. Its spec. grav. varies from 2.95 to 3.04. It occurs amorphous, or in rolled masses with a smooth, oily surface.

By the blowpipe it is easily fusible, with some ebullition, into a globule of white semi-transparent glass. According to T. Saussure, it contains silex 53.75, lime 12.75, soda 10.75, potash 8.50, alumine 1.50, oxide of iron 5.0, oxide of manganese 2.0, water 2.25 ;=96.50.

(Localities.) Nothing is known of the geological situation of the Nephrite in India and China, whence it is frequently brought, and has hence been called oriental Jade.

In the *U. States*. In *Pennsylvania*, in Montgomery Co. 10 miles from Philadelphia, it occurs in serpentine. *(Wister.)*—In *Rhode Island*, at Smithfield; it is sometimes in veins, but usually in large nodules, in granular limestone; it is very translucent, of a delicate greenish white, and constitutes a very beautiful mineral. *(Meade.)*

(Uses.) Nephrite does not receive a brilliant polish. But, in consequence of its great tenacity and hardness, it is, in India, cut and polished for certain kinds of jewelry. In Turkey and Poland, it is employed for the handles of sabres, knives, &c. Some very delicate works have been executed with Nephrite, in consequence of its tenacity; it has been formed even into small chains.—It was formerly worn in little plates, &c. as an amulet, attached to the neck, &c. for the purpose of removing nephritic complaints; hence its name.

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* Gemeiner Nephrit. Werner. Common Nephrite. Jameson. Le Nephrite commun. Brochant. Jade nephretique. Hauy. Var. of Jade. Kirwan.

Subspecies 2. SAUSSURITE.*

This differs a little from nephrite in its external characters, and very considerably in its composition. Its specif. grav. is greater, being at a mean about 3.35. It is said to be a little harder, than the nephrite, and it is, at least, equally tenacious; but it receives a higher and less oily polish. Its colors also are green, sometimes deep, and sometimes greenish gray, or white with a slight tinge of green or even of blue. It is usually translucent at the edges. It occurs in rolled pieces, or amorphous masses, and its structure is sometimes a little foliated.

It melts before the blowpipe, like nephrite. It contains silex 44.0, alumine 30.0, soda 6.0, lime 4.0, potash 0.25, oxide of iron 12.5, oxide of manganese 0.05;=96.80. *(T. Saussure.)* An analysis by Klaproth gives silex 49.0, alumine 24.0, lime 10.5, soda 5.5, magnesia 3.75, oxide of iron 6.5;=99.25.

(Localities.) This subspecies belongs to primitive mountains, and sometimes occurs in considerable masses. It was first found by *Saussure* in rolled pieces near the lake of Geneva. It exists also near Turin, on mount Musinet, which is composed chiefly of serpentine; also in Corsica; and in all these localities it is mingled with diallage. At Corsica it contains magnetic oxide of iron.

Subspecies 3. AXESTONE.† *Jameson.*

The fracture of this mineral is more or less splintery and glimmering. The structure of large specimens is a little slaty. Its hardness is less, than that of nephrite; it is more easily broken, and often falls into tabular fragments. It is usually translucent; sometimes at the edges only. Its color varies from a dark or leek green to grass and olive green, or even greenish gray.—It occurs amorphous, sometimes in rolled fragments.

It is less easily fusible, than nephrite or Saussurite, and melts, without effervescence, into a black enamel. *(Brongniart.)* It often appears to be nearly allied to serpentine.

This mineral has been found chiefly in S. America, New Zealand, and the islands of the South Sea.

It receives a tolerable polish; and is employed by the natives of the aforesaid islands for making *hatchets* and other instruments; hence its name.

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[*] Jade de Sauseure. BRONGNIART. Feldspath compacte tenace. HAUY. It is included under the preceding subspecies by Werner, Jameson, Brochant, and Kirwan.

[†] Jade axinien. BRONGNIART. Jade ascien. HAUY. Beilstein. WERNER. La Pierre de hache. BROCHANT.

Species 32. Emerald.*

The Emerald is always crystallized; and almost invariably appears in regular, hexaedral prisms, more or less perfect, and sometimes slightly modified by truncations on the lateral or terminal edges, or on the solid angles. Sometimes the terminal edges are bevelled, and sometimes the truncations on these edges are so deep, that the prism seems to have pyramidal terminations, whose vertices are truncated. Two of the aforementioned modifications are sometimes combined in the same crystal.—The primitive form, of which Haüy has described six modifications, is a regular hexaedral prism, whose sides are squares. The integrant particles are triangular prisms.

The Emerald is a little harder than quartz, which it of course scratches, though not very easily. Its spec. grav. lies between 2.60 and 2.77. It becomes electric by friction, and possesses double refraction in a feeble degree. It is often transparent, sometimes only translucent in various degrees. Its prevailing color is green, sometimes very lively and beautiful, and sometimes pale, or yellowish, or bluish.

(*Chemical characters.*) Before the blowpipe it is fusible, though not very easily, into an enamel or glass, often a little frothy. It appears to be essentially composed of silex, alumine, and glucine; but is sometimes colored by the oxide of *chrome*, and sometimes by that of *iron*. On this difference of coloring matter, usually accompanied by certain differences of external characters, we establish two subspecies, the *precious Emerald*, and *Beryl*. Both have the same essential characters; and it is extremely probable, that they gradually pass into each other by containing *both oxides*.

Subspecies 1. PRECIOUS EMERALD.†

The precious Emerald is, in general, well characterized by that pure and lively green color, which has hence received the name of emerald green. Its color, however, varies a little, sometimes inclining to verdigris or grass green, and sometimes becoming rather pale.

Its crystals are usually small, and short; their lateral faces are shining and smooth, or sometimes longitudinally and feebly striated. Its fracture, sometimes a little foliated, is in most cases imperfectly conchoidal or uneven; its lustre is vitreous and more or less shining.

The precious Emerald contains silex 64.50, alumine 16.0, glucine 13.0, lime 1.60, oxide of chrome 3.25;=98.35. (*Vauquelin.*) The fine color of this Emerald is derived from the oxide of chrome. A specimen from Peru melted before the compound blowpipe into a

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* Emeraude. Hauy. Béril. Brongniart.

† Schmaragd. Werner. Emerald. Kirwan. Jameson. Emeraude verte. Hauy. L'Emeraude. Brochant. Béril Emeraude. Brongniart.

transparent, *green* globule. (*SILLIMAN.*) In one specimen Klaproth found the oxides of both chrome and iron, thus showing, that the two subspecies may pass into each other in regard both to composition and color.

This Emerald may resemble the green tourmaline; but the latter is electric by heat, the former by friction only.

(*Geological sit. and Localities.*) The geological situation of the precious Emerald has not been much observed. It sometimes occurs in the sand of rivers, and other alluvial earths. It has been seen in a gangue of the sulphate and carbonate of lime; but this may not have been the original situation.

The finest Emeralds have been found near Manta in Peru; and in the valley of Tunca, in the province of Santa-Fe, near the mountains of Popayan. Some Emeralds from Peru have been seen six inches in length by two in diameter; but this size is very uncommon. They are found in veins, which traverse argillite, or in cavities of granite; and are accompanied by quartz, feldspar, sulphuret of iron, &c. It exists also in Ceylon, Egypt, and Ethiopia, from the last two of which the ancients are supposed to have obtained Emeralds.

The greater part of the Emeralds, hitherto found in the *United States*, belong to the following subspecies. But it is highly probable, that the precious Emerald has also been observed in the same gangue, which contains the beryl, although analysis has not yet confirmed the indications, which the external characters afford. Thus at Haddam, in *Connecticut*, has been found an Emerald of a deep green, an inch in diameter and several in length, which bears a strong resemblance to the Peruvian Emerald. It is in the cabinet of Col. Gibbs. (Bruce's Min. Jour. v. i.)—So also at Topsham, in *Maine*, have been found several Emeralds, which exhibit a lively and beautiful green, scarcely, if in any degree, inferior to that of the finest Peruvian Emeralds; their surfaces also were nearly or quite free from striæ. Both these localities will be mentioned under the following subspecies.

(*Uses and Remarks.*) When transparent, and of a lively uniform green, the Emerald is extremely pleasant to the eye, and is employed in the most expensive kinds of jewelry.—This name has sometimes been applied to other minerals; thus the green tourmaline has been called *Brazilian emerald;* the green sapphire, *oriental emerald;* and the green fluate of lime, *false emerald.*

SUBSPECIES 2. BERYL.*

Its prevailing color is green of various shades, as mountain or

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* Edler Beril. WERNER. Precious Beryll. JAMESON. Le Beril noble. BROCHANT. Béril Aiguemarine, BRONGNIART. Berryll. KIRWAN. Emeraude

grayish green, &c. but always pale; it also passes through bluish green to sky blue, and through yellowish green to a pale or honey yellow; it is sometimes greenish white, grayish, whitish, or even limpid. It has also been found rose red. Different colors sometimes appear on the same crystal.

Its crystals are usually longer and larger, than those of the precious Emerald. Their size, however, is extremely variable; sometimes they are very long and even acicular, while at other times they are one foot in length by several inches in diameter—and have been observed even one foot in *diameter*. They exhibit all the intermediate sizes. The lateral faces are longitudinally striated, sometimes so deeply, that the edges of the prism are rendered indistinct, or entirely effaced, and the crystal becomes cylindrical.—Two or more of the lateral planes are sometimes so unduly extended, that the prisms appear nearly tetraedral or triedral.—Some prisms are curved, or even geniculated; others are perforated in the place of the axis, and sometimes contain other minerals in the cavity; in fine, they often intersect each other, or are collected into groups of considerable size.—The Beryl also occurs in amorphous, crystalline masses of a moderate size.

Its fracture is imperfectly conchoidal or uneven, and often a little foliated, even more so than that of the precious emerald; its lustre is vitreous, and more or less shining. Its prisms are often traversed by seams, perpendicular to the axis, and in that direction are extremely brittle; sometimes they are articulated, like the prisms of basalt, one surface of the cross fracture being convex and the other concave.

The Beryl contains silex 68, alumine 15, glucine 14, lime 2, oxide of iron 1. (*Vauquelin.*) With the compound blowpipe it melts with ebullition into a globule of bluish, milky white glass. (*Silliman.*)

(*Distinctive characters.*) The Beryl is harder than the apatite, with which it has often been confounded; and the powder of the apatite is phosphorescent on hot coals.—It is harder and less heavy, than the pycnite, which it may also resemble.—From the tourmaline it may be distinguished by its inability of becoming electric by heat.

(*Geological sit. and Localities.*) The Beryl belongs to primitive rocks, more especially to granite. It is often found in graphic granite, or in veins, which traverse this rock.—It is associated with quartz, feldspar, mica, garnets, schorl, topaz, fluate of lime, oxide of tin, and magnetic oxide of iron.

Some of the finest Beryls are found in Dauria, on the frontiers of

limpide, vert-bleuâtre, jaune-verdâtre, &c. Haüy. Aigue marine—Aqua marina of some.

China, in veins, which traverse granite; their gangue is argillaceous. The Beryl occurs also in the Uralian mountains, and other parts of Siberia; and is most frequently in graphic granite.—It is found limpid in the granite of Elba.—Good specimens are brought from Brazil.

In France, near Limoge, it is found in a vein of quartz in granite; it is in whitish green crystals sometimes a foot in length by six inches in diameter, commonly translucid, sometimes yellowish white at the surface.

In the *United States.* In *Maryland,* near Baltimore, in granite; but in most cases the crystals are imperfect. (GILMOR.)—In *Pennsylvania,* on the banks of the Schuylkill, 3 m. above the permanent Bridge; on Chesnut Hill 10 m. from Philadelphia; and in Germantown finely crystallized; in all instances imbedded in granite (WISTER);—also near Chester.—In *New York,* at Sing Sing 35 m. from the city, in granite (MACLURE);—also near the city in veins of granite, which traverse gneiss.—In *Connecticut,* at Brookfield, Huntington, Chatham, &c. in granite. Also at Haddam, on Connecticut river, in granite, which forms a vein in gneiss; the crystals are variable in size, generally light yellowish green, sometimes amber yellow; sometimes also a deep green (see precious Emerald); a crystal in the cabinet of Prof. Silliman measures seven inches in length by nine inches in the diagonal diameter (SILLIMAN and Bruce's Journ. v. i.)—In *Massachusetts,* at Chesterfield, in Hampshire Co. in granite; the crystals vary from a small size to that of a foot in diameter; their color is usually a light green, and they much resemble the French Beryl at Limoge. (Bruce's Min. Jour. v. i.) A *rose* colored Emerald or Beryl one inch in diameter, has recently been found in Chesterfield with the Rubellite, and is now in the cabinet of Col. Gibbs.—The Beryl is also found in the vicinity of Northampton, Goshen, and Boston.—In *Maine,* it is found, more or less constantly, in a coarse grained granite from 5 m. east of Bath in Lincoln Co. to 5 m. west of North Yarmouth in Cumberland Co. an extent of about 30 miles. At Topsham, near Bowd. Coll. it is sometimes imbedded in graphic granite, and often in a brittle, smoky quartz in a large grained granite. This granite constitutes veins in gneiss, and the Beryl sometimes appears in the contiguous gneiss. The crystals are often in well defined hexaedral prisms, transparent, and perfectly resembling the Siberian Beryl; sometimes also nearly opaque. Their colors are pale green, yellowish, bluish, or even whitish. In the same granite are also a few crystals, which present a pure, uniform, and rich green, and obviously belong to the precious Emerald.—Sometimes the Beryls have a corroded aspect, or are perforated longitudinally in the place of the axis, and the cavity in some instances contains plates of mica, &c.—At Bowdoinham in large crystals in graphic granite.

(*Uses and Remarks.*) The Beryl is but little employed in jewelry, as its pale colors, numerous cracks, &c. much diminish its value. The name of Beryl has been sometimes erroneously applied to the apatite, greenish quartz, cyanite, pycnite, epidote, and even to certain topazes.

SPECIES 33. EUCLASE.* *HAUY.*

This very rare mineral has hitherto been seen only in crystals, which, if complete, would present seventy eight faces. Of these, fourteen belong to the prism, which may be viewed as an oblique four-sided prism, bevelled on all its lateral edges, and truncated on two of the edges, produced by the bevelments. Each termination has thirty two faces.

The Euclase yields with uncommon facility to a mechanical division in one direction, parallel to the axis of the prism; and the laminæ, thus separated, have a very strong vitreous lustre. Another division is less easily effected at right angles to the preceding, but still parallel to the axis; thus giving a rectangular four-sided prism for the primitive form. The cross fracture is conchoidal and vitreous.

The Euclase is *remarkably* brittle,† but sufficiently hard to scratch quartz. It is transparent, and possesses a strong double refraction. Its color is a light sea green. Its spec. grav. is about 3.06.

Before the blowpipe it becomes opaque, and melts into a white enamel. It contains, on a mean of two analyses by Vauquelin, silex 35.5, alumine 18.5, glucine 14.5, oxide of iron 2.5;=71. The loss of 29 parts is probably water and an alkali.

Nothing is known of its associations with other minerals. It has been found in Peru only.

SPECIES 34. BASALT.‡ *WERNER. JAMESON.*

This mineral, so interesting in the study of geology, is never crystallized. It occurs, however, not only in large amorphous masses, but also under a columnar, tabular, or globular form. Its most common color is grayish black, sometimes inclining to brownish gray, and sometimes to brownish or bluish black. Some varieties have a tinge of green. The exterior is often brown or reddish brown in consequence of decomposition. The color of its streak is a light gray. It is opaque, or sometimes feebly translucent at the edges.

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* Euklas. WERNER. Euclase. BRONGNIART. BROCHANT. JAMESON.

† Hence its name, from the Greek Ευ, and Κλαζω, to break.

‡ Basalte. BRONGNIART. BROCHANT. Trap. KIRWAN. Lave lithoïde basaltique. HAUY.

Its fracture is usually uneven or fine splintery, sometimes a little conchoidal, earthy, or nearly even. It has no lustre, unless from the presence of foreign substances. It is difficult to break, and frequently sonorous, when struck.

Even when not decomposed, it is always less hard than quartz, but very often gives a few sparks with steel. Its spec. gravity, though somewhat variable, probably lies between 2.87 and 3.00. It usually moves the magnetic needle, and sometimes discovers polarity.

Basalt is by no means always perfectly homogeneous; for it often contains hornblende, olivine, and augite, and sometimes leucite, melanite, feldspar, quartz, mica, magnetic oxide of iron, &c. It sometimes exhibits vesicles or cavities, which, in most cases at least, seem to have been produced by the loss or decomposition of imbedded minerals. These cavities, sometimes empty or filled with water, are often lined or even filled with steatite, calcareous spar, zeolite, chalcedony, clay, &c. and thus give to the mass an amygdaloidal aspect.

(*Chemical characters.*) Before the blowpipe it melts into an opaque, black or grayish black glass, which is often attracted by the magnet. Its melting point is not far from 100° W. and, when *very slowly cooled*, melted Basalt resumes its former *stony* aspect.—From the Basalt of Staffa, Kennedy obtained silex 48, alumine 16, lime 9, soda 4, oxide of iron 16, muriatic acid 1, water 5 ;=99. In the Basalt of Hassenberg, Klaproth found silex 44.5, alumine 16.75, lime 9.5, magnesia 2.25, soda 2.6, oxide of iron 20.0, oxide of manganese 0.12, muriatic acid 0.05, water 2.0 ;=97.77. Without great caution, its analysis must be affected by the imbedded minerals.

It passes by insensible shades into greenstone, wacke, and perhaps clinkstone.

Basalt is more or less subject to decomposition, partly, at least, in consequence of the action of the atmosphere upon its iron, which exists in a low state of oxidation, as is evident by its action on the needle. Hence, the brownish, friable, or even earthy crust, which often invests its exterior. Those Basalts, which seem to approach very near to greenstone, decompose most rapidly. Indeed the whole mass is sometimes converted into an earthy, argillaceous substance; in which the once imbedded crystals of hornblende remain unchanged.

Var. 1. COLUMNAR BASALT.* This is the more common form of Basalt, when not amorphous. But the supposition, that these prisms are real crystals, is rendered altogether inadmissible by the uneven-

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* Figurate Trap or Basalt of Kirwan, which also includes the two following varieties. Basalt prismatique. BRONGNIART.

ness of their sides, the irregularity of their angles, and other circumstances obvious on inspection.

These columns vary in the number of their sides from three to nine; but most frequently have only five or six. Their diameter reaches from three inches to three feet or more; their length also is extremely variable, sometimes only a few inches, and sometimes 40 or 60 feet, or even 100 feet, according to Jameson. They are sometimes jointed or *articulated;* that is, one transverse surface of the prism, at the place of the joint, is *concave,* while the other is *convex,* and accurately corresponds to the concavity, in which it is confined in part by a prolongation of the lateral edges of that portion of the prism, which contains the concavity. Sometimes the distance between the joints is less, than the diameter of the prism.

These basaltic columns, whether straight or curved, are variously grouped. Sometimes they are closely united; in other instances a space intervenes, either empty, or filled by some foreign substance. Sometimes the columns are perpendicular; sometimes inclined, or nearly horizontal, and not unfrequently collected into immense groups with diverging prisms. Those columns, which may be said to belong to the *same series,* often have nearly the same height, while a contiguous series has also a common level, either above or below the former.—It has also been remarked, that, when columns of Basalt touch each other, the contiguous sides have an equal extent, and that a protuberance on one prism has a corresponding depression on the other.—Sometimes the columns are irregular;—and have in a few instances been seen cylindrical. *(FAUJAS.)*

2. TABULAR BASALT. It occurs in masses of a moderate size, and composed of thin layers, which are usually of unequal thickness.

3. GLOBULAR BASALT.* These globular masses are sometimes composed of concentric layers, and contain a nucleus of compact Basalt, or some other substance, as a fragment of shell limestone. Sometimes they consist of prisms radiating from a centre. They vary in diameter from six to thirty inches; and are sometimes compressed or lenticular.

Globular Basalt is usually scattered on the surface of basaltic mountains. Faujas, however, mentions a hill in Scotland, composed entirely of these balls.

4. AMORPHOUS BASALT.† This presents all the essential charac-

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* Basalte sphéroïdal. BRONGNIART.

† Common Trap. KIRWAN. The Ferrilite, and perhaps the Mullen Stone of Kirwan, may be referred to this variety of Basalt. The term, Whin Stone, in Scotland and other parts of Great Britain, is sometimes applied to Basalt, but is also extended to Greenstone, Syenite, &c.

ters of Basalt. It is more frequently porous or cellular, than the other varieties. Its fragments often tend to a quadrangular form.

(Geological situation.) Basalt is a secondary rock, which usually presents itself in beds, or in columns. It sometimes constitutes insulated mountains of a conical form, and considerable altitude, but never by itself forms an extensive chain of mountains.

It is usually incumbent on other rocks, as granite, gneiss, mica slate, argillite, porphyry, greenstone, wacke, compact limestone, sandstone, or on gravel, clay, or beds of coal. It very often appears in large insulated masses, of a conical or tabular form, constituting the summits of mountains, which are composed of materials totally different from Basalt.—It sometimes occurs at a very considerable elevation; thus on the Riesengebirge, in Silesia, it is 4,000 feet above the level of the sea, and near the peak of Teneriffe it is 11,000 ft. above the same level.

The Basalt, which constitutes either entire hills, or only the summits of mountains, almost always occurs in columns, or in beds. It is frequently traversed by rents in various directions; and hence the numerous fragments, which so often cover the sides and bottoms of basaltic mountains.

Beds of Basalt are variable both in thickness and inclination. But, in general, they are not parallel to the strata, on which they rest. Sometimes, however, Basalt is incumbent on wacke, greenstone, and clinkstone-porphyry, into all which it passes by insensible shades. When columnar Basalt rests on wacke, the prismatic divisions sometimes extend into the wacke.

In some instances, beds of Basalt alternate with those of other minerals, or are covered by them. Thus greenstone and clinkstone-porphyry often rest on Basalt.—In Scotland, Basalt sometimes alternates with argillaceous slate, sandstone, limestone, &c.—In the Vicentine, in Italy, twenty beds of Basalt alternate with as many beds of compact limestone. *(Dolomieu.)*—In Graciosa, one of the Canary islands, strata of Basalt repeatedly alternate with those of a yellowish marl, which is itself often divided into irregular prisms, analogous to those of Basalt. *(Humboldt.)*—In Auvergne, it alternates with shell limestone. *(Dolomieu.)*—In Bohemia, the isle of Mull, and other places beds of *coal* lie between those of Basalt. *(Reuss. Jameson.)*—In Teneriffe, it alternates with clinkstone-porphyry, obsidian, and perhaps pitchstone.—In fine, Basalt sometimes contains fragments of sandstone or limestone, or rolled pieces of quartz, &c.

Masses of Basalt are sometimes traversed by walls or perpendicular veins of the same substance; and these walls always possess a different structure from that of the beds, which they traverse. In

Scotland they are called *dikes*, and in Ireland *gaws*. Even these dikes are sometimes intersected by other small veins of Basalt.

The same countries, which contain Basalt in beds or in prisms, sometimes present it also in veins, which may traverse primitive, transition, or secondary rocks. The Basalt of these veins is often divided into little prisms, placed perpendicular to the walls of the vein. In Ireland, near Carrickfergus, is a vein of Basalt, composed of several distinct beds, each of which is differently divided into prisms;—near Ballycastle, a vein of Basalt intersects alternate beds of sandstone and coal. *(Richardson.)*

It is extremely rare to find metallic substances, even in small quantities, connected with Basalt.

The recent formation of Basalt is clearly indicated by the minerals, which it accompanies, and especially by its alternation with beds of shell limestone and coal, and by the organic remains of shells, which the Basalt of Bohemia, the Vicentine, Ireland, &c. sometimes contains.

Basalt is sometimes found in countries decidedly volcanic. But it very seldom occurs near the crater of volcanoes still active; on the contrary, it usually appears near the foot of volcanic mountains, and sometimes almost surrounds them. Hence it is covered by lavas, but probably never rests upon them. Hence it may be often difficult to distinguish amorphous Basalt from the contiguous lava. It is abundant at the foot of Etna, and is found in Iceland, Bourbon, and Teneriffe; while it is rare in the vicinity of Vesuvius.

But, according to Gioeni, basaltic columns exist at the summit of Mount Etna, nearly on a level with the base of its crater. And Spallanzani, the intrepid observer of volcanoes, saw, in the crater of Vulcano, one of the Lipari islands, pentagonal, articulated prisms, sometimes intimately united to the sides of the crater, and sometimes in a great measure detached.—May not, however, the substance observed in both these cases be called *basaltiform lava*, rather than Basalt?

(Localities.) Of these the most remarkable is in the county of Antrim, in the north of Ireland. The Giant's Causeway, near Cape Fairhead, is composed of basaltic columns, usually perpendicular, and closely applied to each other. These columns are mostly hexagonal, sometimes pentagonal, &c. and have distinct and numerous articulations. This causeway projects into the sea, presenting a visible area of about 600 feet in length by 25 feet in breadth, taken on an average, and exclusive of detached columns; but its extent under water is unknown. The height of the columns above the strand is about 40 feet; and they are terminated so nearly on the same level, that one may

walk on them, as on a pavement. The diameter of the prisms is sometimes two feet; and their edges, though so long washed by the sea, appear to be as perfect, as ever.

The small island of Staffa, one of the Hebrides, is composed entirely of Basalt, both amorphous and columnar, and appears to rest on red sandstone. In this island is the celebrated cave of Fingal. The walls of this grotto are composed of columnar Basalt, and support its roof, which also is formed of basaltic prisms, variously inclined, and united by the filtration of various substances into the interstices. This cavern sends forth a remarkable sound, produced by the dashing of the waves against its sides.—The surface of this island is alluvial, consisting of rounded fragments of granite, gneiss, mica slate, quartz, and sandstone, &c. Whence came these fragments of primitive rocks? (*M'Cullock.*)

There appears to be a vast deposite of Basalt, extending northeasterly from the northern parts of Ireland through the Hebrides, and the northwestern parts of Scotland.

Basalt occurs also on the summits of the chain of metalliferous mountains, which separates Bohemia from Saxony. These basaltic summits, either tabular or conical, are almost always insulated. The central parts of the mountains, which compose this chain, are granite, covered by gneiss and argillite. The argillite is covered by wacke, from which it is often separated by gravel, sand, clay, and sometimes coal; and on the wacke the Basalt usually rests. Sometimes also the Basalt is covered by greenstone. It is often columnar, but never contains any metallic veins, although placed on mountains abounding with them.

The mountain Weissenstein, in Hessia, rests on compact limestone, on which are found beds of sand, clay, wacke, and Basalt; this series is three times repeated in the same order, and the lowest series contains lignite or brown coal. (*Jameson.*)—At Scheibenberg, in Saxony, a bed of gravel rests on gneiss; and the gravel is covered by clay, which passes into wacke, and the wacke into Basalt, which rests upon it. (*Brochant.*)—The summit of mount Meisner, in Hessia, exhibits a tabular mass of Basalt more than 300 feet thick, and covered by greenstone. The body of the mountain is composed of inclined strata of compact limestone and red sandstone; on the sandstone is a bed of brown coal with bituminous clay; and on this a thin stratum of wacke, succeeded by beds of Basalt nearly horizontal.

Columnar Basalt is also found near Andernach on the Rhine; and in very fine prisms in Auvergne, &c. &c.

It is extremely doubtful, whether any Basalt, strictly speaking, has yet been observed in the *United States;* although it is said to exist on the Stony Mountains. The columnar and prismatic masses, which exist in various parts of the U. S. are undoubtedly a *secondary, basaltiform greenstone*, which, in some cases, may perhaps be *passing into* Basalt. In all specimens, which the writer has seen, the eye, especially when assisted by a glass, could discover *feldspar*, constituting one ingredient.

(Origin of Basalt.) The opinions of mineralogists on the origin of Basalt may be reduced to three general classes; although the supporters of the same theory may sometimes differ from each other in minor circumstances.

1. All Basalt has been deposited from *water*, like granite, &c. This, which has been called the *Neptunian* theory, has been supported by Bergman, Werner, Kirwan, Jameson, by most of the German mineralogists, and a few among the French.

2. All Basalt is a product of *volcanic fire*. The supporters of this opinion are found chiefly among the French and Italians.

3. Basalt is sometimes of aqueous origin, and sometimes an igneous product. Its locality, &c. must determine the fact in any given instance. This opinion has been supported by Spallanzani, Dolomieu, Fortis, &c.

The limits, assigned to this volume, will permit us barely to recite in a very brief manner the most important arguments in favor of the Neptunian and Volcanic theories, with the replies, which have been made to some of them.

In support of the *aqueous* origin of Basalt it is contended;

1. If there be a series of different minerals, intimately united and gradually passing into each other, the same origin must be attributed to the whole series; and hence, if one member be an aqueous deposite, the whole series must have been produced in the same manner. Now Basalt often forms one member of a series, beginning with gravel, sand, and clay; this clay gradually becomes less sandy and harder, till it passes into wacke, and the wacke is by insensible degrees lost in Basalt. The sand and clay are undoubtedly aqueous deposites; and the conclusion in such cases is obvious.

2. Basalt is frequently found in parallel, horizontal, and sometimes thin beds; and these beds sometimes alternate with sandstone and limestone, which are undoubtedly of aqueous origin.—Further, currents of lava are narrow at their sources, but broad and thick toward their extremities; they never occur in thin, parallel, horizontal beds of uniform density, like Basalt.

3. Basalt sometimes stands on coal, or bituminous *wood, unaltered* by fire, or it even contains beds of coal.

4. Basalt is sometimes intimately united to limestone, or even

contains it in its interior. But this limestone is not calcined; it still retains its carbonic acid, whereas the limestone found in lavas is calcined and friable.

5. Basalt embraces many substances, which are easily fusible, as zeolite, feldspar, hornblende, &c. but these are unaltered and retain their water of crystallization.

To this it has been replied, that these substances may have been formed in Basalt by filtration, since its fusion.

6. Basalt sometimes contains organic remains of both animals and vegetables.

7. Basalt does not exhibit in its texture and internal appearance any marks of previous fusion. The cavities, which it sometimes contains, do not resemble those, which are produced by the ebullition of a melted mass.

But it is replied, that the stony aspect and compact texture of Basalt is no proof, that it has not been fused. For it appears, from the experiments of Sir James Hall and others, that, when melted Basalt is *very slowly cooled*, it reassumes its former texture and appearance; whereas, when rapidly cooled, it remains a vitreous mass.

8. The analysis of Basalt shows, that it contains water in its composition, whereas undoubted lavas contain no water.

9. The Basalt, which is insulated on the summits of certain mountains, cannot have a volcanic origin. For, if each basaltic summit once issued from the mountain, on which it now rests, the interior of that mountain could not exhibit a series of regular beds, traversed in various directions by metallic and other veins, as is found to be the fact. But, if the Basalt, for example, which forms the summits of a chain of primitive mountains in Saxony, already described, has proceeded from one grand current of lava, it may be asked, how could this lava be lodged on these summits, without filling the intervening vallies?

Some of the more direct arguments in favor of the *volcanic* origin of Basalt are the following.

1. Basalt is abundant in the vicinity of many volcanoes; and Sir Will. Hamilton observed some basaltic columns, ejected from Vesuvius in 1779. But Basalt, as well as granite, may be *ejected* from a volcano without previous fusion. Further, Basalt may accompany volcanic mountains, be melted by their fires, and converted into lava; but it is no longer Basalt. The Neptunians do in fact believe, that Basalt is very often the *mother stone* of lava.

2. The black color, porosity, and magnetic polarity of Basalt are circumstances in favor of its volcanic origin.

3. The minerals, which often accompany Basalt, strongly resemble those, found in the vicinity of active volcanoes.

4. The prismatic form, which some Basalts assume, has probably arisen from the sudden cooling and consequent contraction of melted masses of lava in the air or in the sea.

But, in the first place, the prismatic form is common to Basalt and several other minerals, whose origin is undoubtedly aqueous, such as greenstone, granite, porphyry, and marl. And this form may be produced by desiccation as well, as by cooling.

Secondly, it does not appear, that lavas necessarily assume a prismatic form by plunging into water. Spallanzani carefully examined the island of Ischia, whose lavas have entered the sea, but did not find one prismatic column. The lava of Vesuvius, which in 1794 reached the sea, did not divide into columns.

It may be further replied, that melted Basalt, when suddenly cooled, ought to produce a *vitreous* mass. But in answer it is suggested, that the heat of volcanoes is probably insufficient to *vitrify* Basalt; that it merely produces a dilatation of the mass, and, by separating the particles from each other, enables them to move freely among themselves; and that the *flowing* of lava is in part effected by the presence of melted sulphur or bitumen, as earth or mud is made to *flow*, when suspended in water.

Patrin has suggested, that Basalt may have been produced during the muddy eruptions of submarine volcanoes. Hence the sandstone, the unburnt coal, the uncalcined limestone, &c. Hence volcanoes on the surface of the earth cannot produce Basalt.

On the supposition of a *double origin*, the Basalt of Saxony, Ireland, and Scotland would probably be ascribed to an aqueous deposite, and that of Auvergne, Italy, and Sicily to volcanic fires.

The arguments in favor of the aqueous origin of Basalt seem decidedly to preponderate, although difficulties still remain. But it is undoubtedly true, that Basalt often closely resembles real lava; they are sometimes found in contact, or the Basalt is actually enveloped by the lava. Even in this case the Basalt may often be distinguished by the *uncalcined* carbonate of lime, which it contains.

(Uses.) When calcined and pulverized, it may be employed as an ingredient in water-proof mortar. It is sometimes used as a touchstone for metals; or is employed in the manufacture of green glass bottles.—The ancients, and particularly the Egyptians, executed some of their monuments and statues in Basalt. Among these are said to be the statue of Minerva at Thebes, and that of Memnon at the temple of Serapis.

Species 35. Wacke.* *Jameson.*

Its colors are greenish gray, often deep and even passing into blackish green; also gray, brown, or grayish black, sometimes with a shade of yellow or red. It is always opaque.

Its fracture is usually even, sometimes a little conchoidal, or uneven, or nearly earthy; it is dull, or glimmering from foreign intermixture. Its streak has a little lustre.

Its hardness is moderate. It is easily broken, and may be cut by a knife; it is rather soft to the touch. It frequently moves the magnetic needle; and its spec. grav. varies from 2.53 to 2.89.—Wacke is never crystallized; it occurs in amorphous masses, sometimes compact, and sometimes vesicular.

By the blowpipe it melts into an opaque, porous mass. It passes into basalt, between which and clay it appears to be intermediate. It is more easily decomposed than basalt.

(Distinctive characters.) It does not, like common clay, adhere to the tongue, nor form a paste with water.—Its softness to the touch and easy fusibility distinguish it from indurated clay.—It does not, like marl, effervesce with acids.—Careful attention is sometimes necessary to distinguish it from secondary greenstone, partially decomposed.

(Geological situation.) Wacke belongs to secondary rocks. It is sometimes in beds, which are associated with basalt. Very frequently it occurs in veins, which almost always traverse metallic veins, but seldom contain any metallic substances; hence the Wacke is of more recent formation than the veins, which it traverses. Its veins are sometimes found in mica slate and argillite.

Wacke embraces several minerals, which seem to have been enveloped by it at the time of its formation. Among these are basaltic hornblende, native bismuth, magnetic iron, and mica. The mica is disseminated in black, shining laminæ, and is somewhat characteristic of wacke in certain doubtful cases. Sometimes it contains veins of calcareous spar and fragments of primitive rocks; but neither augite nor olivine have been observed.

When the cavities in Wacke are in part or entirely filled with calcareous spar, green earth, zeolite, chalcedony, agates, &c. it constitutes one variety of amygdaloid.

It sometimes contains fossil bones and petrified wood; indeed whole trees have been found in a vein of Wacke at Joachimsthal in Bohemia.

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* Wakke. Werner. La Wakke. Brochant. Wacken. Kirwan. Vake. Brongniart.

This mineral is probably found more abundantly in Germany, than in any other country.

Species 36. Dipyre.[*] *Haüy.*

This mineral appears in minute prisms, either single, or feebly adhering to each other in fascicular groups. The insulated crystals appear to be eight-sided prisms, having natural joints parallel to the sides of a rectangular, quadrilateral prism, and to the diagonals of its bases.

The Dipyre is translucid, grayish or reddish white, and sufficiently hard to scratch glass. Its longitudinal fracture is foliated; its cross fracture conchoidal; its lustre vitreous and shining; and its spec. grav. about 2.63.

Before the blowpipe it melts with ebullition, and its powder on hot coals phosphoresces with a feeble light. It contains silex 60, alumine 24, lime 10, water 2;=96. (*Vauquelin.*)

Its fusibility distinguishes it from the pycnite; and its phosphorescence from the sommite.

It is found near the river Mauleon, in the Pyrennees, in steatite, sometimes mixed with sulphuret of iron.

Species 37. Scapolite.[†] *Jameson.*

This rare mineral, sometimes massive, usually appears in long prismatic crystals, having four or eight sides. The latter form, which may be called a four-sided prism, truncated on its lateral edges, is sometimes terminated by four-sided summits, whose faces are inclined to the alternate lateral planes, on which they stand, at angles of 120°. The primitive form is a four-sided prism, which is very easily divisible, parallel to the diagonals of its bases, which are squares.—The crystals, usually long, sometimes cylindrical or acicular, are often in groups, composed of parallel, diverging, or intermingled prisms.

The longitudinal fracture is foliated; indeed some crystals might be mistaken for a collection of little plates of mica, arranged in the direction of the axis. The cross fracture is often uneven.

The Scapolite presents a considerable diversity of color, lustre, and hardness, which appears to arise in part from a partial decomposition, perhaps the loss of the water of crystallization. Sometimes

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[*] Dipyre. Brochant. Brongniart. Schmelzstein. Werner. Jameson. Its name is derived from the Greek Δυο, two, and Πυρ, fire, indicating the double effect of fire to produce fusion and phosphorescence in this mineral.

[†] Skapolith. Werner. Scapolithe. Brochant. Paranthine. Haüy. Brongniart.

its color is gray, grayish, yellowish, or greenish white, or silver white; and it is then either simply translucent, or has a pearly or almost metallic lustre, like that of mica. Sometimes it is slightly pearly, or has a dull white aspect, as if it had effloresced; and sometimes it is opaque, and of a dull brick red.

When unchanged, it scratches glass; in other cases it scratches carbonate of lime, or is friable. Its spec. grav. varies from 3.68 to 3.71.

Before the blowpipe it intumesces, and melts into a shining, white enamel. It contains, according to Laugier, silex 45.0, alumine 33.0, lime 17.6, soda and potash 2.0, iron and manganese 1.0;=98.6.

An attention to its crystalline form and structure, its specific gravity, and its inability to become electric by heat, or to form a jelly with acids, will, in general, be sufficient to distinguish it from certain varieties of zeolite, stilbite, prehnite, or analcime, which it more or less resembles.

It strongly resembles the Wernerite both in the form of its crystals, and the measure of their angles. Indeed these two species are so similar in composition, that they ought probably to be united.

(Locality.) The Scapolite has been found only in an iron mine, at Arendal in Norway, accompanied with mica, quartz, epidote, feldspar, carbonate of lime, Wernerite, &c.

Species 38. WERNERITE.* *Haüy.*

The Wernerite, a rare mineral, occurs in eight-sided prisms (Pl. IV. fig. 9.), terminated by four-sided summits, whose faces form with the alternate lateral planes, on which they stand, an angle of about 121°. Or it may be called a four-sided prism, truncated on its lateral edges. The primitive form appears to be a quadrangular prism with square bases.—It also occurs in irregular grains.

The Wernerite strikes fire with steel, but is scratched by feldspar. Its fracture is both imperfectly foliated and uneven, with a moderate lustre, a little pearly or resinous. Its spec. grav. is 3.60.

It is usually more or less translucent; and its color is greenish gray, or olive green, and sometimes white. The surface of the crystals sometimes has the lustre and aspect of an enamel.

Before the blowpipe it froths, and melts into an opaque, white enamel. A mean of two analyses by John gives silex 45.5, alumine 33.5, lime 13.22, oxide of iron 5.75, oxide of manganese 1.47;= 99.44.

Its mode of fusion by the blowpipe, and its imperfectly foliated

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* Wernerite. JAMESON. BROCHANT. BRONGNIART. Arktizit. WERNER.

structure may serve to distinguish it from most minerals, which it resembles.

(Localities.) At Arendal, Norway, it exists in an aggregate of red or grayish feldspar and quartz. Sometimes its crystals are contained in laminated masses of scapolite.—It has also been found in Sweden and Switzerland.

Species 39. Axinite.* *Haüy. Brong.*

This mineral is sometimes in tabular masses, but most commonly in crystals, which are easily recognised. The general form of these crystals, certain small faces being neglected, is a very oblique rhomb, or rather four-sided prism, so flattened, that some of its edges become thin and sharp, like the edge of an axe.† The primitive form is a four-sided prism (Pl. IV, fig. 10.), whose bases are parallelograms with angles of 101° 30′ and 78° 30′. The integrant particles are oblique triangular prisms. M. Haüy has described five secondary forms, of which we mention two; viz.

The very oblique four-sided prism above mentioned, truncated on two opposite lateral edges;—also the preceding form with two additional faces (Pl. IV, fig 11.), being truncations on two opposite terminal edges of the prism, and forming with its bases an angle of 153° 26′. Other small faces are sometimes found on the prism.—The crystals have a strong, vitreous external lustre, and the faces not produced by truncation are usually striated.

The crystals are sometimes tabular, and are often so arranged, as to form little cells.

Its hardness is intermediate between that of feldspar and quartz, by the latter of which it may be scratched. It gives fire with steel, yielding an odor like that produced by flint. Its fracture is imperfectly conchoidal, uneven, or splintery, somewhat shining and vitreous. Its spec. grav. varies from 3.21 to 3.30.

Its colors are brown, violet, or brownish violet, gray or whitish, and sometimes green. It is transparent, or translucent, sometimes at the edges only, or is quite opaque.—The green crystals appear to be colored by chlorite, which sometimes renders them opaque. They are generally free from striæ, and better defined, than the violet crystals. Sometimes one part of a crystal is violet and nearly transparent, while the other is green and nearly opaque. Some crystals are merely coated by chlorite.—Most of the violet crystals are electric by heat.

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* Axinit. Werner. Thumerstone. Kirwan. Jameson. La Pierre de Thum. Brochant.

† Hence its name.

(Chemical characters.) Before the blowpipe it easily melts, with ebullition, into a dark gray enamel, which with borax becomes olive green. It contains, according to Vauquelin, silex 44, alumine 18, lime 19, iron 14, manganese 4;=99.

(Geological sit. and Localities.) Axinite is a rare mineral. It is found in primitive rocks, more particularly in fissures or veins, which traverse them. In Dauphiny, it is associated with quartz, feldspar, epidote, and asbestus.—In the Pyrennees, with quartz and limestone.—In Norway, near Arendal, with feldspar and epidote; and near Konsberg it exists in limestone with mica, quartz, &c.—It occurs in lamellar masses near *Thum*, in Saxony, whence the name Thumerstone.

Species 40. Garnet.*

This very common mineral usually occurs in crystals more or less regular. The general aspect of its crystals, even when perfect, is somewhat spherical, in consequence of the great number of their sides, which is never less than twelve, frequently twenty four, sometimes thirty six, sixty, or even eighty four. It presents five or six varieties of form, including the primitive dodecaedron. This dodecaedron is composed of twenty four triangular pyramids, whose vertices unite at the centre, and whose bases are one half of each rhombic face, when divided by the shorter diagonal. These pyramids, whose faces are all equal and isosceles triangles, show the form of the integrant particles.—Its principal forms are the following.

A dodecaedron, its primitive form, with rhombic faces (Pl. IV, fig. 12.), whose plane angles are 109° 28′ and 70° 32′; the mutual inclination of any two contiguous faces is 120°.—Or it may be viewed as a six-sided prism, terminated by three faces, which stand, at each extremity, on alternate, but different lateral edges.—The crystal is sometimes so elongated, that six of its sides become oblique-angled parallelograms.

The preceding dodecaedron is sometimes truncated on all its edges by long, hexaedral faces (Pl. IV, fig. 13.), making with the contiguous faces, which remain rhombs, angles of 150°. This crystal has thirty six faces, of which twelve are rhombs, and twenty four are elongated hexaedrons.—When all the edges between the rhombs and hexaedrons of the preceding form are truncated, the crystal has eighty four faces.

Another form presents twenty four equal and similar, trapezoidal faces (Pl. IV, fig. 14.), which are usually striated in the direction of the longer diagonals. Or it may be described as a double eight-sided

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* Grenat. Hauy. Brongniart.

pyramid, whose summits are formed by four planes, which, at each extremity, stand on alternate, but different lateral edges.—Sometimes twelve of its solid angles are truncated.*

Certain faces of these crystals are sometimes extended, at the expense of others, but still preserve their proper angles of incidence; sometimes also the faces are a little convex. Their average size is that of a pea, but they are sometimes smaller than a pin's head, and sometimes five or six inches in diameter.

Garnet sometimes occurs in fragments or grains, and in amorphous masses, either lamellar or granular.

Its several varieties are not equally hard; they however strike fire with steel and scratch quartz. Its fracture is uneven, more or less conchoidal, and sometimes foliated; its lustre, though variable in degree, is usually vitreous, sometimes resinous. Its spec. grav. extends from 3.55 to 4.23. It is sometimes magnetic.—Its prevailing color is red of various shades; but it is often brown, and sometimes green, yellow, or black. It is usually translucent, sometimes transparent, and often opaque.

(*Chemical characters.*) It is easily melted by the blowpipe into a dull, black enamel, which is often magnetic. The essential ingredients of the Garnet are probably silex, alumine, and lime, although it can hardly be said, that its true composition is known, notwithstanding the numerous analyses, which have been made. Klaproth and Vauquelin have found from 52 to 35 of silex, from 28 to 6 of alumine, from 33 to 2 of lime, and from 41 to 7 of oxide of iron. In one analysis no lime was found, and in a few instances 8 or 10 per cent. of magnesia appeared.

Some of these results, at least in their proportions, have very probably been modified by the gangue, whence the Garnet was taken. Thus the proportion of lime or alumine may be increased by a calcareous or argillaceous gangue; and the magnesia, at least in garnets taken from serpentine, &c. may be accidental.—After all, it is very possible, that the garnet now includes some minerals, which do not belong to the species.

(*Distinctive characters.*) The Garnet sometimes resembles the hyacinth, the leucite, and the idocrase; but the two first are infusible, and the last melts into a shining glass. The uniform incidence of 120° of all the contiguous faces of the dodecaedral variety will also distinguish it from the hyacinth, and several minerals, which approach it in form.—The aplome in rhombic dodecaedrons is striated parallel to the shorter diagonal,

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* The prismatic crystals, described by some writers, are probably some of its other forms elongated.

Var. 1. PRECIOUS GARNET.[*] *JAMESON.* This variety is most commonly in crystals, sometimes in rounded grains. Its color is crimson red, often with a tinge of blue or violet, or sometimes nearly cherry red. Its fracture is sometimes perfectly conchoidal with a strong lustre. Its spec. gravity is almost always above 4.00. Though sometimes translucent, it is often transparent; but frequently impure at the centre.

In one specimen Klaproth found silex 35.75, alumine 27.25, oxide of iron 36.0, oxide of manganese 0.25; =99.25. Another from Bohemia yielded Vauquelin silex 36, alumine 22, lime 3, oxide of iron 41; =102. In one specimen Klaproth found magnesia.

This variety occurs in primitive or even secondary rocks, and sometimes in alluvial earths. Fine specimens are found in India and Bohemia; but it occurs in most countries.

The term oriental, as applied to this variety, indicates not the locality, but merely a great degree of perfection. It is brought from Syrian in Pegu, and hence called Syrian Garnet.

2. PYROPE.[†] *JAMESON. BROCHANT.* It occurs in small masses or grains, often rounded, but never in crystals. Its color is a poppy or blood red, frequently with a tinge of orange, even in the dark blood red, when presented to the light. It is usually transparent with a splendent, vitreous, conchoidal fracture.

It contains, according to Klaproth, silex 40.0, alumine 28.5, magnesia 10.0, lime 3.5, oxide of iron 16.5, oxide of manganese 0.25; = 98.75.

In Bohemia, it occurs in alluvial earths, and at Ely in Scotland in the sand on the sea shore. In Saxony, it is imbedded in serpentine and wacke.

3. COMMON GARNET.[‡] *KIRWAN. JAMESON.* It is sometimes massive, having a lamellar or granular structure, and very frequently crystallized. Considerable masses are sometimes formed by the aggregation of imperfect crystals.—Its fracture is often uneven, sometimes foliated, but never perhaps perfectly conchoidal; its lustre is usually glistening, and less vitreous, than that of the precious Garnet. It is also less hard; and is sometimes extremely brittle.

It is usually more or less translucent, sometimes at the edges only, or is even opaque. Its colors or their shades are numerous;

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[*] Edler Granat. WERNER. Grenat noble. BRONGNIART. BROCHANT. Grenat vermeil, &c. HAUY. Oriental Garnet. KIRWAN.

[†] Pyrop. WERNER. Grenat Pyrope. BRONGNIART. Grenat granuliforme. HAUY. Bohemian Garnet of many.

[‡] Gemeiner Granat. WERNER. Grenat commun. BROCHANT. BRONGNIART. Grenat brun, rougeâtre, &c. HAUY.

among which are brownish, blackish, or yellowish red, &c. leek green, olive green, &c. brown, reddish or yellowish brown, orange yellow, topaz or pale yellow, whitish, greenish or brownish black, &c. Its spec. grav. is usually below 4.00.

It melts a little easier than the preceding varieties. From a greenish yellow specimen Klaproth obtained silex 44.0, alumine 8.5, lime 33.5, oxide of iron 12.0, and a little oxide of manganese. From a red garnet Vauquelin obtained silex 52.0, alumine 20.0, lime 7.7, oxide of iron 17.0;=96.7.

This variety occurs abundantly and extensively. It is found in all classes of rocks, but more particularly in the primitive.

COLOPHONITE.[*] *KARSTEN.* It is distinguished by the glossy, resinous aspect of its fracture. It occurs in small amorphous, granular masses, or in grains, or even in crystals. Its colors are usually orange yellow, reddish, yellowish brown, or deep brown.

A specimen, analyzed by Simon, yielded silex 35.0, alumine 15.0, lime 29.0, magnesia 6.5, oxide of iron 7.5, oxide of manganese 4.75, oxide of titanium 0.5, water 1.0;=99.25.

It has been found in Norway, the Siennese territory, &c.

TOPAZOLITE. *BONVOISON.* We mention this subvariety of Garnet, which has been found in Piedmont, in pale topaz yellow, or nearly olive green dodecaedrons, on account of its analysis, which offers a new earth in the Garnet. It contains silex 37, alumine 2, lime 29, glucine 4, iron 25, manganese 2;=99. (Journal de Physique, Janv. 1807.)[†]

4. MELANITE.[‡] *JAMESON.* This Garnet is opaque, and velvet black, sometimes nearly grayish black. It is always in crystals, which are dodecaedrons, sometimes with truncated edges, or belong to the trapezoidal form. Its fracture is somewhat conchoidal or even foliated; its lustre, especially the external, is often strong.

It contains silex 35.5, alumine 6.0, lime 32.5, oxide of iron 25.25, oxide of manganese 0.4;=99.65. *(KLAPROTH.)*

(Localities.) At Frascati, near Vesuvius, it occurs in a rock, by some supposed to be volcanic, and is accompanied by feldspar, hornblende, and idocrase.—Near Mount Somma, and perhaps in the Py-

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[*] Grenat resinite. HAUY.

[†] The *Succinite* of Bonvoisin, found also in Piedmont, in serpentine, occurs in globular masses about the size of a pea, of an amber yellow, almost transparent, not sufficiently hard to scratch glass, and fusible into a black glass. It is by some referred to the Garnet, by others to the idocrase.

[‡] Melanit. WERNER. Le Melanite. BROCHANT. Grenat noir. HAUY. Grenat Melanite. BRONGNIART. Black garnet of some. Its name is derived from the Greek, *Μελας*, black.

rennees, it exists in calcareous rocks; and in Bohemia in basalt.—In the *U. States*, in *Pennsylvania*, at Germantown, 6 miles from Philadelphia, in gneiss; its crystals are polyedrons with twenty four trapezoidal faces, varying from the size of a pin's head to one inch in diameter; they are opaque, and their color is a shining velvet black; spec. grav. 3.616. (*Wister.*)

Subspecies 1. MANGANESIAN GARNET.*

This mineral is sometimes massive, and sometimes in crystals with twenty four trapezoidal faces, a little translucent at the edges. Its color is a deep hyacinth or brownish red.

It is fusible by the blowpipe; and, when melted with borax and a little nitre, the globule is violet. It contains silex 35, alumine 14, oxide of manganese 35, oxide of iron 14. (*Klaproth.*)

Near Aschaffenberg, in Franconia, it occurs in granite.

In the *U. States*. In *Maine*, at Jones' Eddy, near Bath, it is found massive. Its color is brownish red, its fracture uneven, sometimes conchoidal, and its lustre a little resinous. Its general structure is slaty, or rather the mass seems to be composed of smaller, tabular masses, which, by exposure to the air, become disposed to separate.—It has been analyzed by Vauquelin, and found to contain a large quantity of manganese.—It sometimes embraces magnetic iron, &c.

(*Geological Remarks.*) The Garnet occurs almost always in crystals, grains, or fragments; and indeed it never forms extensive, continuous masses. It is however so abundant in certain compound rocks, that it may almost be said to form their base.

The Garnet, especially the common variety, is abundantly disseminated in primitive rocks, more particularly in mica-slate, granite, gneiss, and greenstone; and often occurs in veins or fissures, which traverse these rocks. It is sometimes imbedded in certain simple minerals, as serpentine, talc, hornblende, lithomarge, &c. It is also associated with ores of iron, lead, &c. in metallic veins or beds. The amorphous variety, mixed with quartz, &c. sometimes constitutes large beds.

The Garnet occurs also in transition or secondary rocks, as in greenstone, compact limestone, sandstone, &c. On the peak of Eredlitz, in the Pyrennees, is a brownish limestone, traversed by white veins, and containing black, white, and red garnets; the black garnets are in the brownish part of the stone, and the white garnets in the white veins. (*Ramond* in Brongniart.)—It has been remarked, that garnets in secondary rocks generally separate from their gangue with more ease, than those imbedded in primitive rocks; a circum-

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* Grenat manganésié. Brongniart.

stance, which indicates, that these garnets existed before they were enveloped by the substance of the secondary rocks.

The garnet is found also in alluvial earths. In Bohemia, near Meronitz, &c. the precious Garnet and Pyrope are found in an alluvial earth, composed chiefly of fragments of serpentine and basalt, united by an argillaceous or marly cement; the same earth contains hyacinth, sapphire, emerald, &c. and even fossil shells. The garnets are brought to view by repeatedly washing this earth.

(Localities.) It is unnecessary to add any further remarks in regard to foreign localities.—This mineral is very common in the *United States*, in the *granite* of which it seems to be more abundant, than in that of many other countries. In the interior of *North Carolina*, Garnets have been found as large, as a child's head. *(Maclure.)*—In *New York*, near Fishkill, they are rose colored.—In *Connecticut*, at Haddam they are sometimes four inches in diameter, have a laminated texture, and are extremely brittle. *(Silliman.)*—In *Vermont*, the precious Garnet is found in Bethel and Royalton, in small but remarkably perfect crystals, imbedded in a steatitic rock. *(Hall.)*—In *New Hampshire*, near Dartmouth College, the precious Garnet exists in dodecaedrons in greenstone. *(Hall.)*—In *Massachusetts*, in Newbury, amorphous garnet is associated with tremolite, epidote, &c. —In *Maine*, at Brunswick, they are sometimes orange red;—at Topsham are found both the precious and common garnet; the crystals are sometimes less than the head of a pin, and sometimes several inches in diameter; they vary in color from an opaque reddish brown to a transparent lively red. The writer has a Garnet, at the centre of which was found a crystal of beryl.

(Uses.) The precious Garnet and the Pyrope are sometimes employed in jewelry; but their color is so intense, that it is sometimes necessary to excavate them on one side. It is very remarkable, that transparent Garnets should be capable of containing 30 or 40 per cent. of iron, and even of moving the needle.—The common variety may be advantageously employed as a flux for iron ores. The powder of the Garnet may also be used in polishing hard bodies.

The *carbuncle* of the ancients was probably a Garnet; according to Pliny, it was sometimes formed into vessels, capable of containing nearly a pint.

Species 41. Aplome.[*] *Haüy.*

This very rare mineral has been observed only in dodecaedrons with rhombic faces, marked by striæ, parallel to the shorter diagonals. This dodecaedron is supposed to be derived from a cube, by

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[*] Aplome. Brochant. Brongniart.

one of the most *simple** laws of decrement, viz. that of a single range of particles, parallel to all the edges of a cube.

The Aplome gives fire with steel, and feebly scratches quartz. Its spec. grav. is 3.44. Its fracture in some parts is uneven and nearly dull, while in others it is shining and slightly conchoidal. Its color is usually a deep brown, sometimes yellowish green. It is usually opaque, but the small crystals often transmit an orange colored light.

It is fusible by the blowpipe into a blackish glass. It is composed of silex 40.0, alumine 20.0, lime 14.5, oxide of iron 14.5, oxide of manganese 2.0, ferruginous silex 2.0 ;=93. (*Laugier.*)

It differs from the garnet in the direction of its striæ, and its inferior spec. gravity.

It has been found in Siberia and Saxony.

Species 42. Epidote.† *Haüy. Brongniart.*

This substance, though recently permitted to form a distinct species, is by no means rare, and exhibits a considerable diversity of external aspect. When in crystals, it is sufficiently well characterized; but some of its amorphous varieties are not easily recognised, especially when they enter into the composition of aggregates.

It is frequently in crystals, of which the primitive form is a right prism, whose bases are parallelograms with angles of 114° 37′ and 65° 23′; the sides of the base and the height of the prism, are nearly as 9, 8, and 5. Its integrant particles have the same form.

The crystals of Epidote occur in prisms, which have usually six or eight sides, and sometimes ten or twelve; but, in almost all cases, the four sides, which belong to the primitive form, are larger, than the others. These prisms are often well defined and variously terminated; they frequently have longitudinal striæ, and are sometimes long and slender.

Of the ten secondary forms, described by Haüy, we select a few.

A six-sided prism (Pl. IV, fig. 15.), terminated at each extremity by two faces, which stand on the two narrowest sides, and form with each other an angle of 110° 06′, and with the sides, on which they stand, an angle of 124° 57′.

Also a six-sided prism (Pl. IV, fig. 16.), each summit having seven faces, of which one is perpendicular to the axis.

Also another six-sided prism (Pl. IV, fig. 17.); each summit presents eleven faces, of which one is at right angles to the axis.

Two of the lateral planes are often so narrow, that the prism ap-

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* Hence its name from the Greek, Απλοος, simple.

† Pistazit. Werner. Pistazite. Jameson. (See Introd. art. 203.)

pears to have only four sides. Indeed these crystals are sometimes described as oblique four-sided prisms, truncated on their lateral edges, and bevelled at their extremities, or otherwise terminated.—Sometimes the crystals are compressed, cylindrical, or acicular, being often collected into groups, in which they diverge, radiate, &c. and the fracture of these groups is often fibrous.

Epidote, more imperfectly crystallized, appears in granular masses, to which, however, distinct crystals are often attached.—It also occurs in grains, forming a kind of sand;—and sometimes in amorphous, compact masses.

It scratches glass, and gives fire with steel; and has a spec. grav. of about 3.45. Its fracture, parallel to the sides of the primitive form, is foliated; its cross fracture uneven; and its lustre usually vitreous and shining.

Its color is commonly some shade of green, varying from yellowish green to blackish or bottle green; also gray, yellowish gray, yellow, greenish yellow, and brown, or even brownish black. It is sometimes opaque, usually translucent, and many crystals are transparent.

(Chemical characters.) Before the blowpipe it melts into a dark brown or blackish scoria; and this property, according to Saussure, is very characteristic. Of the common variety a specimen from near Oisans yielded Descotils silex 37.0, alumine 27.0, lime 14.0, oxide of iron 17.0 oxide of manganese 1.5;=96.5. In another from Arendal Vauquelin found silex 37.0, alumine 21.0, lime 15.0, oxide of iron 24.0, oxide of manganese 1.5, water 1.5.

(Distinctive characters.) The Epidote often much resembles the actynolite; but the latter melts into a grayish enamel, and is divisible into rhomboidal prisms, whose angles are 124½° and 55½°.—Its fusibility into a scoria distinguishes it from certain varieties of greenish asbestus, which melts into an enamel, and yields a soft powder, whereas that of Epidote feels dry.—It often strongly resembles hornblende; but the latter is less hard, its fracture is usually less vitreous, and it melts into a black glass.—Epidote is easily distinguished from the beryl and schorl.

We subjoin a notice of two varieties, which have received distinct names.

Var. 1. ZOISITE.[*] *JAMESON.* It usually occurs in striated, rhomboidal prisms, much compressed, and sometimes rounded. These crystals are commonly incomplete at their extremities, and often aggregated. Its colors are gray, brown, or grayish yellow; and its

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[*] Zoisit. WERNER. From Baron Von Zois, its discoverer.

fracture has somewhat of a pearly lustre. It passes into the common variety.

A specimen from the Alps yielded Klaproth silex 45, alumine 29, lime 21, oxide of iron 3;=98.

It is found in primitive rocks, accompanied by quartz, mica, cyanite, &c. in Carinthia, Tyrol, &c.

2. SKORZA.* *Brochant.* It occurs in grains of various sizes, sometimes very fine, of a yellowish green color, somewhat vitreous in their appearance, and sufficiently hard to scratch glass. Its fusibility into a blackish scoria and its composition show, that it belongs to Epidote; indeed it appears to be nothing more, than a granular Epidote disintegrated.

Klaproth obtained from it silex 43.0, alumine 21.0, lime 14.0, oxide of iron 16.5, oxide of manganese 0.25;=94.75.

(Localities.) This variety has received its name from the inhabitants of Transylvania, where it is found near Muska, on the banks of the river Arangos.—In the *U. States*, in *Maine*, at Brunswick, it occurs on the banks of the Androscoggin between strata of gneiss or of an aggregate of quartz, feldspar, and hornblende.

Subspecies 1. MANGANESIAN EPIDOTE.†

It occurs in acicular, prismatic crystals, foliated in the direction of the axis, and closely applied to each other in groups. It is opaque, and has a violet color.

It contains at least 12 per cent. of the oxide of manganese.—It has been found in Piedmont, in gneiss, accompanied with the oxide of manganese, quartz, asbestus, &c.

(Geolog. sit. of the species.) Epidote is most frequently found in primitive rocks, into the composition of which it sometimes enters, even in very considerable proportions. Its crystals are usually found in the fissures or other cavities of these rocks, or of the veins, which traverse them; and are sometimes disseminated in the minerals, which fill these veins, such as quartz and carbonate of lime. Indeed granular or compact Epidote often constitutes the whole vein, which varies from many inches to less than one tenth of an inch in width. —Epidote is often associated with quartz, garnets, feldspar, hornblende, actynolite, axinite, schorl, asbestus, chlorite, magnetic oxide of iron, &c.

(Localities.) In France, near Oisans, it occurs with amianthus, axinite, crystallized feldspar, &c.—In Norway, near Arendal, with magnetic iron, quartz, garnets, phosphate of lime, &c. Its crystals

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* Epidote Skorza. BRONGNIART. Epidote arenacé. HAUY.

† Epidote manganesifère. HAUY. Epidote violet. BRONGNIART.

are sometimes very large and perfect, being several inches in length with a proportional thickness.—In England, at the Malvern Hills, in Worcestershire, is a rock, composed of nearly equal parts of Epidote and hornblende, with a little mica, and traversed by slender veins of compact Epidote in various directions. *(Horner.)*

In the *United States.* In *Maryland*, at Jones' Falls, near Baltimore, in fine crystals, imbedded in a vein of crystallized feldspar and chlorite. *(Gilmor.)*—In *Pennsylvania*, near Frankford, 5 miles from Philadelphia;—also in Montgomery, Chester, York, and Delaware Counties.—In *New Jersey*, at Trenton, in green six-sided prisms.—In *New York*, near Hudson.—In *Connecticut*, at the Milford Hills, near Newhaven, in primitive greenstone; the Epidote is usually in veins or amorphous masses; but sometimes in radiated crystals in a vein of calcareous spar, traversing greenstone slate. *(Silliman.)* —In *Massachusetts*, near Boston, at Brighton, Dedham, Lynn, &c. in veins, traversing syenite and greenstone, and often entering into their composition; it is usually compact, but sometimes crystallized in cavities; the veins vary in width from that of a sheet of paper to three inches or more *(Godon.)*;—also at Newbury in large crystals in the fissures of a rock, whose base is an amorphous garnet.—In *New Hampshire*, at Franconia, in the iron mine, in light yellow, acicular crystals, interwoven confusedly *(Gibbs.)*;—also at Portsmouth in acicular crystals, radiated in groups in a porphyritic hornblende. *(Maclure.)*—In *Maine*, at Topsham, Brunswick, &c. It is sometimes in crystals, but usually granular or compact, in veins traversing granite, gneiss, greenstone, and other primitive aggregates. Veins of granular Epidote, more than a foot in width, and containing quartz and schorl intermingled, sometimes traverse granite.

Species 43. Cinnamon Stone.* *Jameson.*

This very rare mineral has been subjected to but few observations. In some respects it resembles the garnet, and in composition approaches the idocrase.

It is found in grains or fragments, usually of a yellowish brown, or brownish orange color, with a rough surface. It scratches quartz with some difficulty. Its fracture is imperfectly conchoidal with small cavities, and shining. It is transparent, or only translucent. Its spec. grav. is 3.60.

Before the blowpipe it melts into a brownish black enamel. It contains silex 38.8, lime 31.25, alumine 21.2, oxide of iron 6.5;= 97.75. *(Klaproth.)*

It has been brought from Ceylon, where it is found in sand.

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* Kannelstein. Werner. Haüy.

Species 44. Allochroite.[*] *Hauy.*

This mineral resembles certain varieties of the garnet in some of its physical characters, but more particularly in composition.

It occurs in amorphous masses with a slaty structure. Its fracture is uneven or imperfectly conchoidal, and glistening or dull. It is difficultly broken, gives sparks with steel, and is not easily scratched by quartz. It is opaque, or translucent at the edges; and its colors are yellowish or brownish gray, pale yellow, or reddish yellow. Its spec. grav. varies from 3.50 to 3.73.

It is fusible by the blowpipe, according to Vauquelin, into an opaque, smooth, black enamel. With phosphate of soda and ammonia an enamel is formed, which, by cooling, exhibits several changes of color, passing through reddish yellow and green to yellowish white. It contains silex 37.0, lime 30.0, alumine 5.0, oxide of iron 18.5, oxide of manganese 6.25;=96.75. *(Rose.)* The analysis of Vauquelin closely resembles this.

It was found by Dandrada in Norway, near Drammen, accompanied by carbonate of lime, magnetic iron, and brown garnets; the garnets are sometimes intimately united with the Allochroite.

Species 45. Idocrase.† *Hauy. Brongniart.*

This mineral is sometimes massive, and very often in prismatic crystals, which are usually short, with highly polished and strongly shining surfaces. The primitive form, of which Haüy has described eight modifications, is a four-sided prism with square bases, and one side of the base is to the height nearly as 13 to 14; hence it differs but little from a cube, and is divisible into triangular prisms for the integrant particles.

It has recently been observed under its primitive form.—Sometimes this form is terminated by four-sided pyramids, whose faces correspond to the sides of the prism.—Sometimes the primitive form is converted into an eight-sided prism (Pl. IV, fig. 18.), by truncations on its lateral edges, and is terminated by four-sided summits, whose vertices are truncated by planes, parallel to the bases of the prism; the oblique faces of the summits are inclined to the sides of the prism, on which they stand, in an angle of 127° 06′, and the truncations on the lateral edges form with the contiguous sides an angle of 135°.—Sometimes its crystals appear to be short, rectangular

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[*] Allochroïte. Brochant. Brongniart.

† Vesuvian. Werner. Vesuviane. Jameson. La Vesuvienne. Brochant. The term Idocrase is derived from the Greek Ιδεα, form, and Κρασις, mixture, indicating that its forms are, in some degree, a mixture of the forms of certain other minerals.

prisms, or nearly cubes, truncated on all the edges, both terminal and lateral.—By farther truncations the prism acquires sixteen sides; and one secondary form, if complete, would present ninety faces. The lateral faces are often feebly striated in the direction of their length; and the crystals are sometimes tabular.

Idocrase is somewhat harder than quartz. Its fracture is uneven or a little conchoidal, and more or less shining and resinous.—The massive varieties have sometimes a structure both granular and foliated.

Its colors are green, varying from a pale yellowish or light olive green to blackish green; also brown, yellowish or reddish brown, reddish yellow, or hyacinth red. It is often translucent, sometimes transparent, and sometimes nearly or quite opaque. It possesses double refraction, and varies in spec. grav. from 3.08 to 3.42.

(*Chemical characters.*) By the blowpipe it very easily melts into a yellowish translucent glass, which afterwards becomes black. (BRONGNIART.) From the Idocrase of Vesuvius Klaproth obtained silex 35.5, lime 33.0, alumine 22.25, oxide of iron 7.5, oxide of manganese 0.25;=98.5—and in that of Siberia he found silex 42.0, lime 34.0, alumine 16.25, oxide of iron 5.5, with a trace of manganese;= 97.75.

(*Distinctive characters.*) It sometimes resembles the garnet; but the latter is heavier, its faces are in general less highly polished, it is less easily fusible, and does not yield a translucent glass.—The Idocrase and meionite are sometimes in octaedral prisms, whose lateral faces have the same incidence; but the faces of the tetraedral summits of the Idocrase are inclined to each other at 129° 30′, and those of the meionite at about 136°; and further, the meionite melts with effervescence into a spongy glass.—The chrysolite, olivine, and zircon are infusible.

(*Geological sit. and Localities.*) It is found abundantly in the vicinity of Vesuvius in the cavities of a rock, composed chiefly of quartz, feldspar, mica, talc, and carbonate of lime; and is accompanied by garnet, hornblende, meionite, sommite, zeolite, &c.—At Kamschatka, it exists in a greenish white serpentine.—In Piedmont, on the plane of Mussa, in serpentine, which is also traversed by veins of massive Idocrase. (BONVOISIN.) The crystals from Piedmont sometimes present the primitive form.

The Idocrase is sometimes cut and polished for jewelry.

Species 46. **Meionite.**[*] *Haüy.*

The Meionite occurs in grains, or small crystals, whose more common form is an eight-sided prism, or a four-sided prism, truncated on its lateral edges, and terminated by low four-sided pyramids, whose faces make with the lateral planes, on which they stand, angles of 121° 45′, and are inclined to each other at about 136°.—Sometimes the prism has sixteen sides, and some of the edges between the prism and pyramid admit truncations.—The primitive form is a right prism with square bases, of which one side is to the height of the prism nearly as 9 to 4.

It scratches glass. Its longitudinal fracture is foliated; its cross fracture a little conchoidal; and its lustre shining and vitreous. It is translucent, and sometimes transparent, but traversed by small fissures. It is limpid or grayish white, and sometimes white.

Before the blowpipe it easily melts with a lively ebullition and some noise into a white, spongy glass.

(Distinctive characters.) An attention to the chemical characters, and the measures of the angles or edges about the terminating pyramids will, in general, be sufficient to discover lines of distinction between this species, and the zeolite, idocrase, harmotome, and sommite; especially as the terminating pyramids of the Meionite are lower than those of similar forms in the other minerals.—The Meionite much resembles the Wernerite in the measures of its angles; but the terminating faces of the Wernerite stand on the lateral faces of the primitive form, whereas in the Meionite they correspond to the truncated lateral edges of the primitive form.

The Meionite has been found only at Mount Somma, near Vesuvius; and usually adheres to fragments of carbonate of lime, which are unaltered by fire.

Species 47. Byssolite.[†] *Saussure.*

Little is yet known concerning this rare mineral. It occurs in very delicate filaments, which are usually short; and, though somewhat stiff, are still flexible and elastic. They are attached perpendicularly to the surface of other minerals, sometimes resembling a kind of moss. Their color is olive green, or brownish yellow, and their lustre a little silky.

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[*] Meionit. Werner. Meionite. Brochant. Jameson. Brongniart. Its name is derived from the Greek *Μειων*, less, indicating the lowness of the terminating pyramids, and the consequent shortness of the axis of the primitive form.

[†] Amianthoïde Byssolite. Brongniart. Var. of Amianthoide. Haüy. The name Byssolite appears to be derived from the Greek, Βυσσος, a kind of flax.

It contains, according to Saussure, silex 34, alumine 43, lime 9, oxide of iron 19.

It has been found in the Alps; and near Oisans, in France, where it is attached to gneiss.

Species 48. PREHNITE.* *Haüy.*

This substance appears to be always the result of crystallization. It is sometimes massive, and sometimes in crystals, whose forms are often indeterminable in consequence of their aggregation. The primitive form, which it sometimes presents, is a right prism, whose bases are rhombs with angles of about 103° and 77°. This prism, however, as well as all the distinct crystals of Prehnite, have a tabular form, with four, six, or eight sides.

Its fracture is foliated, parallel to the base of the primitive form, and uneven in other directions; its lustre is moderate and somewhat pearly. It scratches glass, though sometimes feebly, and often gives sparks with steel. Its spec. grav. extends from 2.60 to 2.94. It is electric by heat, but both electric poles seem to have the same configuration, contrary to the usual fact.

A peculiar light green color is somewhat characteristic of this mineral. Its color however varies from apple green to greenish white or nearly white; and sometimes it has a tinge of yellow or is yellowish gray. When partially decomposed, it often assumes a dull white. It is more or less translucent, or even transparent.

(Chemical characters.) It intumesces considerably before the blowpipe, and then melts into a porous slag or enamel, sometimes greenish; but the color, at least in some specimens, appears to depend on the degree of heat. A specimen from the Cape of Good Hope yielded Klaproth silex 43.8, alumine 30.33, lime 18.33, oxide of iron 5.66, water 1.16;=99.28.

(Distinctive characters.) It resembles the stilbite; but the latter is less hard, and its lustre is more pearly.—It does not, like zeolite, form a jelly with acids.—Its mode of fusion distinguishes it from feldspar.

Var. 1. CRYSTALLIZED PREHNITE. The crystals of Prehnite are sometimes in rhomboidal or hexagonal tables, insulated and distinct, with smooth shining surfaces. The hexagons may be viewed as rhomboidal tables, truncated on their two acute edges; and the eight-sided table is sometimes described as a four-sided prism, whose extremities are bevelled, and the edges of the bevelments truncated. These tabular crystals are often grouped. Sometimes the groups are composed of rhomboidal or hexagonal plates a little curved, touching each other

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* Prehnit. WERNER. Prehnite. JAMESON. BRONGNIART. BROCHANT.

in the middle only, and diverging somewhat toward their extremities; hence these groups resemble a fan or a *sheaf.*

2. KOUPHOLITE.* *BROCHANT.* It occurs in minute, rhomboidal plates, of a greenish or yellowish white, translucid, glistening, and a little pearly.

It has been found in the Pyrennees, adhering to carbonate of lime; or grouped, or scattered upon the sides of cavities in a hornblende rock, and mixed with chlorite and epidote.

3. FIBROUS OR MASSIVE PREHNITE.† This variety embraces those crystalline masses of Prehnite, whose texture is usually fibrous or radiated, and sometimes nearly or quite compact. It is often in small globular and tuberose masses, radiated from the centre; many of these masses are sometimes united.—In other cases the fibres are parallel, or but slightly divergent.

Sometimes the mass is composed of small laminæ promiscuously intermingled. In fine, these masses are sometimes so compact, that a fibrous structure is scarcely discernible, or appears only in certain parts.—Fine crystals are found in the cavities of massive Prehnite.

(Geological sit. and Localities.) This mineral was first brought from the Cape of Good Hope by Colonel *Prehn;* and hence its name. It is generally of a purer green than that found in Europe, and sometimes forms considerable masses.—In France, crystallized Prehnite occurs at Oisans, in gneiss and primitive greenstone, and is sometimes impregnated with chlorite, which seems to render its crystals more regular.—In Germany, the fibrous Prehnite is found near Oberstein in globular masses in a porphyry or amygdaloid; it accompanies or even contains carbonate of copper and native copper.—Near Edinburgh and Glasgow, it exists in secondary greenstone, and is sometimes in veins with parallel fibres.—It is often associated with zeolite in greenstone.

In the *United States.* In *Connecticut,* near Newhaven, it exists in secondary greenstone, which also contains zeolite. The Prehnite occurs in veins or in nodules, with a radiated structure, sometimes with crystals on the surface; at the Pine Rock it forms perpendicular veins, rarely more than one fourth of an inch in thickness;—also near Berlin, &c. *(SILLIMAN.)*—In *Massachusetts,* in Brookfield, Watertown, and Charlestown. At the last mentioned place, it occurs in greenstone, and presents rhomboidal or hexagonal tables, or radiated masses, and has the usual colors of Prehnite. *(WATERHOUSE.)*

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* Prehnite Koupholite. BRONGNIART. Prehnite lamelliforme, rhomboïdale. HAUY. From the Greek Κουφος, light, and Λιθος, a stone.

† Prehnite fibreuse—globuliforme radiée—compacte. HAUY. Prehnite compacte. BRONGNIART.

Species 49. ÆDELITE. *Kirwan. Brong.*

The only description of this mineral, hitherto published, is that of Mr. Kirwan, who did not himself possess a specimen.

It occurs in tuberose masses, whose fracture is generally fibrous, sometimes splintery, and nearly dull. It gives fire with steel; and its spec. grav. is 2.51. Its color is light gray, sometimes tinged with red; also brown or green with shades of yellow.

Before the blowpipe it intumesces, and melts into a frothy mass. It contains silex 62 to 69, alumine 18 to 20, lime 8 to 16, water 3 to 4. (*Bergman.*)

It has been found only at Adelfors and Messeberg, in Sweden, in the fissures of greenstone or rocks of hornblende.

Species 50. STILBITE.* *Haüy. Brong.*

This mineral was once associated with zeolite, from which, however, it differs in several important characters.

Its structure and fracture in one direction, which is parallel to two opposite sides of the primitive form, are perfectly foliated, the foliæ being often slightly curved; in other directions its fracture is uneven. Its lustre, except on the cross fracture, is shining, and almost invariably pearly.

The Stilbite scratches carbonate of lime, but scarcely glass. It is translucent, and sometimes transparent. Its color is usually white, either pure, or shaded with gray, yellow, or red; also brown or orange red. It is not electric by heat; and its spec. grav. is 2.50.

The primitive form of its crystals is a four-sided prism, whose bases are rectangular parallelograms, of which the sides and the height of the prism are as the numbers 3, 5, 2; its integrant particles have the same form.

Of the primitive form, which it sometimes presents, Haüy has described five modifications. One of these is a four-sided prism (Pl. IV, fig. 19.), terminated by four faces. The sides are hexagonal, and the summits are sometimes truncated, as in the figure; when the truncation is near the base, the faces of the summits appear like truncations on the solid angles. Sometimes this prism is so compressed, that it becomes a six-sided table, bevelled on four of its edges.—Another form is an oblique four-sided prism (Pl. IV, fig. 20.), truncated on two opposite, lateral edges. Two edges of this prism contain an angle of 130° 24′, and the solid angles, formed by the same edges with

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* Blættriger Zeolith and some varieties of Strahliger Zeolith. WERNER. Foliated Zeolite and some varieties of Radiated Zeolite. JAMESON.

Its name is from the Greek Στιλβω, to shine, alluding to its lustre.

the base, are truncated. This crystal may be called a six-sided prism, and sometimes all its solid angles are truncated.

These crystals have smooth surfaces with a strong lustre; they are often grouped, sometimes in bundles, resembling a fan, and sometimes in globular masses, radiating from the centre.

The Stilbite also occurs in foliated masses, and sometimes its texture becomes nearly or even quite compact, with a diminished lustre.

(Chemical characters.) On hot coals it whitens and exfoliates. Before the blowpipe it intumesces, and melts into a spongy mass. It contains silex 52.0, alumine 17.5, lime 9.0, water 18.5;=97. (*Vauquelin.*) It does not form a jelly with acids.

(Distinctive characters.) It differs from zeolite in not becoming electric by heat, or forming a jelly with acids, and also in its structure.—It is less hard than Prehnite, and undergoes changes on hot coals, which that mineral does not.

(Geological sit. and Localities.) The Stilbite sometimes occurs in the fissures of primitive rocks. It is also associated with zeolite in amygdaloid, greenstone, and other trap rocks; and sometimes with chabasie.—At Strontian in Scotland, it exists in veins of sulphuret of lead, &c.—At Arendal, in Norway, it is brown and still pearly.—In the Tyrol, it appears in little pearly plates of an orange red, or in globular masses with a dull fracture. In the Faroe islands, in trap rocks, finely crystallized in rectangular prisms, which are sometimes one inch in length and three fourths of an inch thick. (*Allan.*) Mr. A. supposes, that he has also found the Stilbite in large cubes, sometimes with truncated angles, in the same islands.

Species 51. Zeolite.*

The Zeolite is sufficiently hard to scratch carbonate of lime, and sometimes the softer kinds of glass in a slight degree. It is electric by heat, one summit of its prisms becoming positive and the other negative; the latter is usually that summit, which was connected with the gangue. Its spec. grav. is about 2.08.

It is usually translucent, sometimes transparent, and exhibits double refraction. Its prevailing color is white, either pure, or with shades of gray, yellow, green, or red; it is also yellow or brownish yellow.

The Zeolite is sometimes in distinct crystals, whose surfaces have a strong lustre, slightly pearly. Their natural joints are parallel to the sides of a quadrangular prism, with square bases, which is the

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* Mésotype. Haüy. Brongniart. Fasriger Zeolith and some varieties of Strahliger Zeolith. Werner. Fibrous Zeolite and some varieties of Radiated Zeolite. Jameson.

primitive form. This form differs but little from a cube; for any one side of the base is to the height of the prism nearly as 9 to 8. Its integrant particles are triangular prisms.

It sometimes presents the primitive form, of which Haüy has described five modifications. Its more common forms are the following.

A four-sided prism, terminated by four-sided pyramids, whose faces make with the lateral planes, on which they stand, angles of 114° 06′. This prism is sometimes truncated on its lateral edges; and sometimes so compressed, that it becomes a six-sided table, bevelled on its four smaller sides.—Sometimes the faces of the summits correspond to the lateral edges of the prism, and the vertices of the summits are also truncated. Certain faces also are sometimes much elongated at the expense of others.—These crystals, sometimes acicular, are variously grouped, and often so closely applied to each other, that the terminations only appear.

Zeolite is very often in small masses, produced by the aggregation of acicular or even capillary crystals.

These masses are often composed of several fascicular groups of minute crystals; and in each group the crystals or fibres diverge or even radiate from one point, and at the surface frequently appear distinct from each other, or exhibit pyramidal terminations.—Sometimes the mass is reniform or globular, with fibres radiating from the centre.—In fine, the fibres are sometimes so minute and intimately united, that the mass appears compact, and its fracture splintery.

The longitudinal fracture of these masses is almost always fibrous. The fibres, usually divergent, are sometimes extremely minute and delicate, and sometimes so broad, that the fracture appears foliated. Its lustre is glistening and more or less pearly or silky. The cross fracture is uneven or imperfectly conchoidal.

Some Zeolites phosphoresce by friction.

(Chemical characters.) Before the blowpipe it melts with very considerable intumescence or ebullition[*] into a whitish, spongy enamel, attended by a little phosphorescence. When reduced to powder, and thrown into nitric acid, it is converted into a jelly in the course of a few hours, unless the quantity of acid be too great. According to Vauquelin, it contains silex 50.24, alumine 29.3, lime 9.46, water 10.0;=99. Pelletier obtained silex 50, alumine 20, lime 8, water 22. But the analysis of Smithson Tennant gives a very different composition. In a crystal of Zeolite, furnished him by Haüy, he found silex 49.0, alumine 27.0 soda 17.0, water 9.5;=102.50.[†] The Zeolite is susceptible of spontaneous decomposition, probably by losing its water,

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[*] Hence its name from the Greek *Ζεω*, to boil, and *Λιθος*, a stone.

[†] If this be correct, the Natrolite is a variety of Zeolite.

(Distinctive characters.) Its power of forming a jelly with acids, and of becoming electric by heat, will, in general, easily distinguish it from the stilbite, analcime, chabasie, and harmotome.—The Prehnite is harder than the Zeolite, and does not form a jelly with acids.

We subjoin a notice of three varieties.

Var. 1. MEALY ZEOLITE.* *JAMESON.* It occurs in opaque, dull, friable masses, with an earthy fracture, and a yellowish or reddish white color. It is very light, and not electric by heat.—It appears to be an alteration of the common Zeolite; and sometimes occurs as a crust on crystallized Zeolite.

2. CROCALITE.† This variety is but little known. Its color is brick red, or orange. It is sometimes in reniform or globular masses, with a radiated texture. It is found in amygdaloid, &c.

At Adelfors, in Sweden, has been found a mineral, which Brongniart refers to the Crocalite. Like the mealy Zeolite, it appears in tender, earthy masses of a brick red color. With nitric acid it forms a jelly, which disappears in a few hours. The same amygdaloid at Adelfors seems to contain both Zeolite and stilbite of a reddish color.

3. NEEDLE STONE. *JAMESON.* This appears scarcely to differ from the common variety, unless in being a little harder. Its crystals are acicular four-sided prisms, terminated by low pyramids. They are often collected into masses, of which the longitudinal fracture is fibrous, and the cross fracture uneven and vitreous. Its color is yellowish white.

This variety has been found in Brittany, and Iceland.

(Geological situation.) Zeolite, which never occurs in large masses, is most frequently found in amygdaloid, basalt, greenstone, and clinkstone porphyry. It sometimes incrusts these rocks, or is disseminated in them, or exists in veins. Its crystals adhere to the sides of fissures or cavities in these rocks, or its globular masses entirely fill these cavities. It is sometimes associated with Prehnite, stilbite, calcareous spar, chalcedony, native copper, &c.

Zeolite also occurs in primitive rocks, as granite, gneiss, and greenstone.

The ease, with which Zeolite is altered by fire, is a strong objection to the volcanic origin of those rocks, in which this mineral is found. Some, indeed, have suggested, that Zeolite may have been formed in volcanic rocks by filtration, during their immersion in water. To this, however, there are strong objections. Others avoid these difficulties by denying the existence of Zeolite in rocks really

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* Mehl Zeolith. WERNER. Mesotype alterèe. HAUY.

† Mesotype Crocalite. BRONGNIART.

volcanic.—It is asserted by Brongniart, that the Zeolites of volcanic countries are never found in recent lavas. Thus, at Etna, Zeolite occurs only in the basalt, which forms the base of the mountain, and has not been observed in the actual products of this volcano.

(Localities.) The Zeolite is found in France, Iceland, the Faroe islands, &c. In the last named islands it occurs in groups of transparent diverging needles from one to two inches long, perfectly well terminated; it sometimes embraces native copper. *(Allan.)*—Near Edinburgh, the Zeolite is sometimes phosphorescent in the dark, even when gently rubbed by the finger.

In the *United States*. In *Maryland*, near Baltimore, at Jones' Falls, in a vein, traversing gneiss; this Zeolite is yellowish with a pearly lustre, in small quadrangular prisms, with pyramidal terminations, and is accompanied by chlorite, feldspar, epidote, &c. *(Gilmor.)* Some of the crystals from this locality appear to exhibit the primitive form of the Zeolite, which by the eye cannot be distinguished from a cube.—In Pennsylvania, on the Schuylkill, 4 miles from Philadelphia, in the fissures of a hornblende rock; it is white with a pearly lustre, in laminæ about one eighth of an inch thick. *(Wister.)*—In *New Jersey*, at Hoboken.—In *Connecticut*, near Newhaven, in horizontal veins in secondary greenstone, or incrusting the surface of the stone; it is in crystals, or radiated masses, or presents the mealy variety. *(Silliman.)*

The name Zeolite has been extended to several different species of minerals. Thus the stilbite has been called *foliated* or *pearly Zeolite*; the analcime, *hard Zeolite*; and both analcime and chabasie, *cubic Zeolite*.

Species 52. Laumonite.* *Haüy.*

This very singular mineral has received its name from that of its discoverer, Gillet Laumont.

In its natural and unchanged state, it exists in laminated masses, composed of prismatic distinct concretions, or in irregular groups of more perfect prismatic crystals. It is, according to Bournon, sufficiently hard to scratch glass. Its fracture is distinctly foliated in two directions, which appear to be parallel to the sides of a rhomboidal prism. Its colors are usually grayish white, or white, which is often tinged with red. It is more or less translucent, or even transparent. Its spec. grav. is 2.23.

Its crystals appear to be four-sided prisms, slightly oblique, sometimes terminated by diedral summits, and sometimes truncated on their lateral edges. Bournon supposes the primitive form to be a

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* Lomonit. Werner. Lomonite. Jameson. Mesotype Laumonite. Brongniart. Zeolithe efflorescente. Brochant.

four-sided prism with rhombic bases. The lateral planes are longitudinally striated.

But, by exposure to air, especially if dry and warm, most of the foregoing characters disappear. The Laumonite, thus exposed, more or less rapidly disintegrates; its laminæ separate, and it falls into irregular, prismatic fragments, whose surfaces are often striated. Indeed, according to Brochant, it is sometimes eventually reduced to a white powder, a little fibrous and glimmering.—With this disintegration other properties change. The mineral becomes opaque, extremely friable, and usually milk white, more or less pearly.

If unchanged specimens are immersed for one or two hours in a strong solution of gum Arabic, they will be defended from the action of the air.

The Laumonite is fusible by the blowpipe with a slight ebullition into a white enamel. It forms a jelly with acids.

(Localities.) This mineral was first observed near the lead mine of Huelgoet in Brittany, attached to the sides of the veins. It has since been observed in the islands of Faroe, and at Paisley in Scotland, &c.—That from Brittany effloresces most rapidly.

In the *U. States.* In *Connecticut*, the Laumonite has been discovered by Prof. Silliman in veins in the greenstone around Newhaven. He remarks, that one specimen effloresced in his hands, and completely crumbled down. The specimen, which Prof. S. has been kind enough to send me, has fallen into small, irregular, prismatic fragments, extremely friable; some of them are whitish and pearly, and in others the white is very slightly tinged with red. Most of the fragments, when thin, retain a small degree of translucency.

SPECIES 53. MELILITE.[*] *HAUY.*

This rare mineral has been seen only in very minute crystals, perfectly regular and well defined, although not larger, than a grain of millet. Their form is cubic or prismatic; and the cube is sometimes truncated on its edges, or passes into a cuneiform octaedron. Their color is usually *honey*[†] yellow, sometimes hyacinth red; but their surface is often coated with a yellow or reddish brown oxide of iron. They are glistening, semitransparent, and sufficiently hard to scratch steel. They are not electric by heat.

Before the blowpipe the Melilite melts without ebullition into a compact, greenish, transparent glass. Its powder in nitric acid forms a transparent jelly; but, if small fragments be thrown in, they merely lose their color, and become less fusible.

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[*] Melilite. BROCHANT. BRONGNIART.

[†] Hence its name from the Greek, Μελι, honey, and Λιθος, a stone.

The preceding characters sufficiently distinguish it from the zeolite, analcime, chabasie, and stilbite.

It has been found in the fissures and cavities of lava near Rome; and is accompanied by the substance called Pseudo-sommite.

Species 54. SODALITE. *THOMPSON.*

This mineral, recently known, occurs massive, or in dodecaedrons with rhombic faces, sometimes so elongated, as to assume the aspect of six-sided prisms, terminated by three-sided summits. It is with difficulty scratched by iron. Its structure is foliated, and its cross fracture conchoidal; its lustre is shining and resinous, except on the cross fracture, where it is vitreous. It is translucent and its color is a light or bluish green. Its spec. grav. is 2.37.

When heated to redness, it becomes dark gray, but is infusible by the blowpipe. It contains, according to Thompson, silex 38.52, alumine 27.48, soda 23.50, muriatic acid 3.0, lime 2.7, volatile matter 2.1, iron 1.0;=98.3. Ekeberg found silex 36.0, alumine 32.0, soda 25.0, mur. acid 6.75, iron 0.25.

It occurs in primitive rocks with garnets, hornblende, augite and sahlite.

Species 55. NATROLITE.[*] *JAMESON. BRONGNIART.*

This substance has usually occurred in small, reniform, rounded, or irregular masses, composed of very minute fibres. The fibres are divergent, or even radiate from a centre; and are sometimes so very minute and close, that the fracture appears almost or quite compact. It has little or no lustre.—Sometimes also it presents minute crystals, especially on the surface of its masses, whose forms appear to be similar to those of the Zeolite.

Its colors are yellowish white, yellowish brown, pale yellow sometimes tinged with red, and whitish. Different colors or shades of color are usually arranged in undulated and parallel stripes. It is translucent at the edges. Its angles feebly scratch glass; and its spec. grav. is 2.16 or 2.20.

Before the blowpipe it easily melts into a white glass, which often contains small bubbles. In nitric acid it is reduced in the course of a few hours, without effervescence, into a jelly somewhat thick. It contains silex 48.0, alumine 24.25, *soda*[†] 16.5, water 9.0, oxide of iron 1.75;=99.5. (*KLAPROTH.*) This result is very similar to that obtained by Smithson Tennant from the Zeolite.

It has been found chiefly at Roegau, in Suabia, near the lake of

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[*] Natrolith. WERNER. Natrolithe. HAUY.

[†] Hence the name Natrolite, derived from Natron.

Constance; and is imbedded in an amygdaloid, whose base is wacke or clinkstone.

Species 56. Analcime.* *Haüy. Brong.*

This mineral is rare, and exhibits but few varieties, which, however, differ considerably in some of their characters. It is generally crystallized; and has hitherto presented only two secondary forms.—One of these is a cube (Pl. IV, fig. 21.), having each solid angle formed by three triangular faces, inclined to the sides of the cube at about 145°.—The other is a solid, contained under twenty four trapezoidal faces, perfectly similar to one of the forms of the garnet, and that of the leucite. Their primitive form, and that of their integrant particles is a cube. The surface has often a strong lustre.

Analcime is also found amorphous, and sometimes in reniform or radiated masses.

It is limpid, or grayish white, also white, or flesh red more or less deep, and sometimes has a tinge of yellow. It is translucent, or even nearly transparent, and sometimes opaque. When the crystal is not opaque, its fracture is undulated or imperfectly foliated; but, if opaque, its fracture becomes uneven; its lustre is shining.

The Analcime slightly scratches glass, and by friction acquires a *weak*† electricity. Its spec. grav. is between 2 and 3.

Before the blowpipe it melts without intumescence‡ into a white semi-transparent glass. It does not form a jelly with acids. It yielded Vauquelin silex 58.0, alumine 18.0, soda 10.0, water 8.5, lime 2.0; =96.5.

(*Distinctive characters.*) It is distinguished from the leucite by its fusibility; and from the garnet by its inferior hardness and specific gravity.—It is not electric by heat, like the zeolite.—It wants the pearly lustre of the stilbite, and its crystals do not, like those of the stilbite, exfoliate, when exposed to a moderate heat.

(*Geological sit. and Localities.*) This mineral is sometimes found in wacke and basalt, attached to the sides of cavities, or even occupying the whole cavity. But it seems to have entered by filtration; for its crystals do not, like those of leucite, impress their forms on the substance, which contains them.

It has been found near Catania and Etna, in Sicily.—The trapezoidal variety is found chiefly near Dunbarton, in Scotland; and the crystals are sometimes more than one inch in diameter.

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* Kubizit. Werner. Var. of Cubic zeolite. Jameson. Var. of zeolithe cubique. Brochant.

† Hence its name from the Greek Αναλκις, weak.

‡ Some mineralogists have observed an intumescence during fusion.

SARCOLITE. *THOMPSON.* This subvariety is found at Mt. Somma in *flesh*-colored cubo-octaedral crystals, nearly transparent.—A similar substance is found also at Castel in the Vicentin, in small flesh-colored masses, or trapezoidal crystals in wacke; it is accompanied by whitish Analcime, into which it seems to pass.

Species 57. Bildstein.* *Werner.*

The Bildstein strongly resembles common steatite in its physical characters, but differs essentially in its composition.

Its texture is very compact. Its fracture is splintery in one direction, and more or less slaty in the other; it is nearly or quite dull. —This mineral is soft, easily cut by a knife, and reducible into a fine unctuous powder. Its surface also is usually very unctuous to the touch.—It is sometimes strongly translucid, and sometimes nearly or quite opaque. Its color is greenish gray more or less deep, sometimes inclining to yellowish gray, or brownish yellow; also reddish white or flesh red. Some specimens are veined or spotted. Its spec. grav. varies from 2.78 to 2.81; and, when rubbed on sealing wax, it communicates positive electricity.

Before the blowpipe it whitens, becomes harder, and is reduced into a kind of enamel. It contains, according to Vauquelin, silex 56, alumine 29, potash 7, water 5, lime 2, oxide of iron 1. In a translucid specimen Klaproth found silex 54.0, alumine 36.0, water 5.5, oxide of iron 0.75;=96.25. It hence appears, that alumine, which sometimes forms the hardest earthy minerals, can also take the place of magnesia in the production of unctuosity.

(Remarks.) Nothing is known of the natural situation or associations of this mineral. It is brought from China, and always under some artificial form; and hence the names Figure or Sculpture stone, or Bildstein, of similar signification. These figures are supposed often to represent the idols or pagods of the Chinese.—The Bildstein is susceptible of a polish.

Species 58. Nacrite.† *Brongniart.*

This mineral occurs in coats or reniform masses, composed of very minute shining scales, or spangles. Their color is pearly gray, or silver white, often with a tinge of green and sometimes of red. It is friable, and, when rubbed between the fingers, feels very unctuous, and leaves on the skin a *pearly* gloss, especially if the mineral be

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* Figure stone. JAMESON. Talc glaphique. HAUY. Steatite Pagodite. BRONGNIART. La Pierre a sculpture. BROCHANT.

† Erdiger Talk. WERNER. Earthy Talc. JAMESON. Le Talc terreux. BROCHANT. Talc granuleux. HAUY. Talcite. KIRWAN. The term Nacrite, from the French, alludes to its pearly lustre.

previously plunged in water for a few minutes. It is very light, and swells a little in water.

The Nacrite is easily fusible by the blowpipe. Water, in which this mineral has been digested for some time, changes the vegetable blue to green; and even precipitates metallic solutions. *(Lucas.)* A specimen, analyzed by Vauquelin, yielded silex 56, alumine 18, potash 8, water 6, lime 3, iron 4;=95.

Its chemical characters sufficiently distinguish it from talc.—It seldom, if ever, presents the green color of chlorite.—It is much more unctuous to the touch, than lepidolite.

It is found in scales, coats, or reniform masses, in the cavities or interstices of primitive rocks, particularly of crystallized quartz.—Piedmont, Freyberg in Saxony, &c. furnish this mineral.

Species. 59. CHABASIE.* *Hauy. Brong.*

This substance, always crystallized, sometimes presents its primitive form, which is an obtuse rhomb, scarcely distinguishable by the eye from a cube, its plane angles being 93° 36′ and 86° 24′.—This rhomb is sometimes truncated (Pl. IV, fig. 22.) on six edges by planes, which unite, three and three, at two opposite angles, while the remaining six angles are also truncated, thus giving a solid with eighteen faces. Even this solid is subject to farther truncations.

The Chabasie scarcely scratches glass. Its fracture is imperfectly foliated; and its spec. gravity 2.71. It is translucent, or sometimes transparent. Its color is white, or grayish white, sometimes with a rosy tinge, which is often only superficial. It is not electric by heat.

Before the blowpipe it intumesces a little, and easily melts into a white, spongy mass. It does not effervesce, nor form a jelly with acids. The analysis of Vauquelin gives silex 43.33, alumine 22.66, soda and potash 9.34, water 21.0, lime 3.34;=99.67.

The preceding characters will easily distinguish the Chabasie from zeolite and carbonate of lime.—Its crystalline forms, though sometimes similar, are still different from those of the Analcime; and the latter does not intumesce before the blowpipe, but melts into a semi-transparent glass.—It cannot be easily confounded with the stilbite.

(Localities.) The Chabasie exists in the fissures and cavities of basalt, and wacke. It is thus found in the north of Ireland.—Near Oberstein in Germany, its crystals are sometimes attached to the interior of geodes of agate.—In the Faroe islands, the stilbite accompanies the Chabasie, whose crystals it sometimes penetrates.

* Schabasit. WERNER. Var. of cubic zeolite of JAMESON; and of Zeolithe cubique of BROCHANT.

Species 60. Allanite. *Thompson.*

This mineral, first noticed as a distinct species by Mr. *T. Allan* of Edinburgh, occurs massive, and in oblique four-sided prisms with angles of 117° and 63°; also in six-sided prisms, terminated by four-sided summits. It scratches hornblende, but not feldspar. Its fracture is conchoidal with small cavities; its lustre shining and resinous, a little metallic. It is opaque, and dark brown, or brownish black. Its powder is greenish gray. Its spec. grav. is between 3 and 4.

Before the blowpipe it froths, and is converted into a scoria. In nitric acid it forms a jelly. It contains silex 35.4, lime 9.2, oxide of cerium 33.9, alumine 4.1, oxide of iron 25.4, volatile matter 4.0. (*Thompson.*)

It is found in Greenland, and associated with mica and feldspar.

Species 61. Yenite. *Hauy. Brong.*

This mineral has recently been made known by M. Lelièvre, who has named it Yenite in commemoration of the battle of *Jena*, changing the initial letter for a particular reason.

It is usually in prismatic crystals, which are sometimes oblique four-sided prisms, with angles of 112° 37′ and 67° 23′, terminated by four-sided pyramids, whose faces are inclined to the lateral planes at about 128° 29′.—Sometimes the prism is nearly rectangular, and terminated by diedral summits, whose faces stand on the obtuse lateral edges, and are inclined to each other at about 113°.—It also occurs in eight-sided prisms, terminated at each extremity by eight faces, four of which are placed on the lateral edges, and four on the lateral planes. Their primitive form is probably an octaedron, of which five or six modifications have been observed.

The Yenite is opaque, and has a black or brownish black color, even when reduced to powder. The lateral faces are longitudinally striated; and, when the color is black, the surface is shining.

It also occurs in masses, composed of diverging fibres or crystals; sometimes the fibres are nearly parallel and very closely united. Its imperfect prisms are sometimes of the size of the finger.

This mineral scratches glass, and gives a few sparks with steel, but is scratched by adularia. Its spec. grav. extends from 3.82 to 4.06. Its longitudinal fracture is a little foliated; its cross fracture conchoidal or uneven; and its lustre resinous.

Before the blowpipe the Yenite is easily fusible into a dull, opaque, black globule, strongly attracted by the magnet. It contains silex 30.0, lime 12.5, oxide of iron 57.5. (*Vauquelin.*) By exposure to the atmosphere, its exterior is converted into an earthy, ochreous crust.

The crystals of Yenite resemble those of dark colored epidote; but they differ in the measure of their angles, spec. gravity, &c.

(Localities.) The Yenite has been found almost exclusively at two places in the island of Elba;—at Rio-la-Marine it occurs in insulated or grouped crystals, disseminated in a green substance, whose nature is not well determined. This green mineral forms a thick bed, resting on granular limestone, and contains also epidote, quartz, arsenical and magnetic iron.

SPECIES 62. SCHAALSTEIN.* *WERNER.*

This substance usually appears in masses, composed of thin laminæ, collected into large prismatic concretions; and sometimes in hexaedral prisms or tables. Its natural joints are parallel to the sides of a prism, slightly rhomboidal. Its fracture is a little imperfectly foliated, shining and pearly. It is easily broken, and, when scraped in the dark with an iron point, is phosphorescent. *(HAUY.)* Its spec. gravity is 2.86.—It is translucent; and its color is grayish or pearly white, sometimes with a tinge of green, yellow, or red.

When immersed in nitric acid, a few bubbles of air escape, and the fragment then separates into grains. *(HAUY.)* It contains silex 50, pure lime 45, water 5. *(KLAPROTH.)*

This substance is very rare, and has been found chiefly at Dognatska, in the Bannat, accompanied by garnets and carbonate of lime.

SPECIES 63. ICHTHYOPHTHALMITE.† *JAMESON.*

This mineral occurs in laminated masses; or in regular crystals, having a strong, and *peculiar* external lustre, which is intermediate between vitreous and pearly.

The primitive form of its crystals, under which it has probably been observed, is a four-sided prism with rectangular bases, whose sides and the height of the prism are as the numbers 14, 18, and 15. Three or four secondary forms have been observed, in which this prism is more or less modified. Sometimes the eight solid angles are truncated by triangular faces. The crystals are sometimes tabular and intersect each other.

It is easily divisible by percussion into laminæ, whose broader surfaces are splendent and somewhat pearly; in other directions it presents a glistening, uneven fracture. Indeed if a fragment of this

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* Schaalstone. JAMESON. Spath en table. HAUY. BRONGNIART. Pierre calcaire testacée. BROCHANT.

† Fischaugenstein. WERNER. Apophyllite. HAUY. BRONGNIART. Ichtyophtalme. BROCHANT. The word Ichthyophthalmite is derived from the Greek, Ιχθυς, a fish, and Οφθαλμος, an eye.

mineral be applied by one of its sides to a hard body, and strongly rubbed, it separates into thin laminæ, like those of selenite. It is very easily broken.

It scarcely scratches glass, and does not give sparks with steel. Its spec. grav. is 2.46. It is often semi-transparent, sometimes only translucent, even at the edges. Its color is yellowish white, or grayish, sometimes with a tinge of red or green.

(Chemical characters.) When exposed to the flame of a lamp, it exfoliates. Before the blowpipe it melts with some difficulty into a white enamel. Its fragments, placed in cold nitric acid, are gradually converted into a whitish, flaky substance; its powder forms a jelly in nitric or muriatic acid. It contains silex 51, lime 28, potash 4, water 17. *(Fourcroy* and *Vauquelin.)*

It is lighter and harder than sulphate of barytes, but much less hard, than adularia, both of which it may resemble.

(Locality.) It has been found in Sweden in the iron mine of Utoe. Its gangue is a reddish, lamellar carbonate of lime, and it is accompanied by hornblende, and a granular oxide of iron.

Species 64. HARMOTOME.[*] *Hauy. Brong.*

This singular mineral is always in crystals, which are, in general, easily recognised. Its single crystals are rectangular four-sided prisms, broad or compressed, and terminated by four-sided pyramids, whose faces stand on the lateral edges, and are inclined to each other at about 121° 58'.—But this mineral is usually found in double crystals (Pl. IV, fig. 23.), composed of two of the preceding crystals, so intersecting each other, that the two broader planes of one prism are perpendicular to the broader planes of the other, throughout their whole length. Hence these intersecting prisms have a common axis, and their terminating faces, taken two and two, coincide in the same plane. In fact, this double crystal may be viewed as a four-sided prism with four-sided summits, and rectangular grooves in the place of its lateral edges.

These crystals are often grouped. Their primitive form is an octaedron, divisible in planes, which pass by the *edges*[†], contiguous to the summits, and through the centre; thus giving tetraedrons for the integrant particles. Only three secondary forms have been observed.

Its color is grayish or milk white, sometimes with a tinge of yellow. It is translucent or opaque, and sometimes nearly transparent.

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[*] Kreutzstein. WERNER. Cross Stone. JAMESON. Staurolite. KIRWAN. Pierre cruciforme. BROCHANT.

[†] Hence its name, from the Greek, *Αρμος*, a joint, and *Τεμνω*, to divide.

It scarcely scratches glass; and its spec. grav. varies from 2.33 to 2.36. Its longitudinal fracture is foliated, and more or less shining, and its cross fracture uneven.

Before the blowpipe it melts with some intumescence into a white, transparent glass. Its powder on hot coals phosphoresces with a greenish yellow light. It contains silex 49, barytes 18, alumine 16, water 15;=98. (*Klaproth.*)

This mineral does not exfoliate, like the stilbite, on hot coals; nor is it electric by heat, like the zeolite.—The prisms of the staurotide cross each other in such directions, that their axes never coincide, like those of the Harmotome.

(*Localities.*) It has been found at Andreasberg, in the Hartz, in metallic veins, with laminated carbonate of lime, the sulphurets of lead, iron, &c.—Also at Strontian, in Scotland, in veins.—At Oberstein, its single crystals are attached to the interior of geodes of agate.

Species 65. Chrysolite.*

The Chrysolite, though harder than glass, is less hard than quartz, by which it may be scratched. Its prevailing color is some shade of green, more or less intermixed with yellow or brown. It is often transparent, sometimes only translucent. It possesses double refraction in a high degree, which may be observed by viewing an object through one of the larger faces of the summits of its crystals, and the opposite side of the prism. Its spec. grav. varies from 3.22 to 3.42. Its fracture is more or less conchoidal, and sometimes a little foliated, parallel to the axis of the crystals.

It occurs sometimes in crystals, sometimes in small amorphous masses or in grains, and sometimes in rolled pieces.

Its crystals have presented six secondary forms, which originate from a four-sided prism with rectangular bases, whose sides are to each other nearly as 11 to 25. All its secondary forms are eight, ten, or twelve-sided prisms, terminated by cuneiform or pyramidal summits, having six, eight, or ten oblique faces, and one face perpendicular to the axis, or this face may be called a truncation of the summit. One of these forms is an eight-sided prism (Pl. IV, fig. 24.), or a four-sided prism, truncated on its lateral edges, and terminated by nine faces, of which eight are oblique and stand on the lateral planes.—Sometimes this prism is terminated by seven faces; of which six are oblique, two of them standing on opposite sides of the prism, and the other four on the faces, produced by the truncation of the lateral edges.

The edges and angles of these crystals are frequently blunted;

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* Peridot. Hauy. Brongniart.

certain faces are often a little convex; and the broader lateral planes are usually striated longitudinally.

Before the blowpipe it becomes brownish, but does not melt. It is essentially composed of silex and magnesia, either of which may be predominant, as appears by the analysis under each variety.

The Chrysolite is harder and heavier than phosphate of lime, which it sometimes resembles.—It is not electric by heat, like the tourmaline of a similar color, from which, as well as from the idocrase, it differs by its infusibility.—This species presents two varieties.

Var. 1. COMMON CHRYSOLITE.* This variety embraces most of the crystals, already described.—It also occurs in small, angular or rounded masses, which almost always have a rough, scaly, or fine splintery surface. The crystals, when uninjured, have a strong lustre.

Its fracture is conchoidal, splendent, and vitreous. It is usually transparent. Its prevailing color is a pistachio or olive green, in which the green is more or less blended with yellow and brown; sometimes also it is grass green or nearly reddish brown.

With borax it melts into a greenish, transparent glass. It contains magnesia 50.5, silex 38.0, oxide of iron 9.5; =98. (*VAUQUELIN.*)

Its geological situation is but little known. The rolled pieces are undoubtedly found in alluvial earths. The Chrysolite, employed in the arts, comes chiefly from the Levant.—It has been found in Bohemia; and in Hungary it is said to be imbedded in serpentine.—It has also occurred in the vicinity of some volcanoes, as in the isle of Bourbon, &c.

(*Uses.*) It is sometimes employed in jewelry, but is not highly esteemed. Werner has suggested, that the yellow chrysolite of the ancients is the modern topaz.—Certain beryls and topazes have been erroneously referred to this variety.

2. OLIVINE.† *JAMESON.* This variety very rarely, if ever, occurs in crystals; but presents itself in grains, or in roundish masses of various sizes, sometimes indeed, according to Faujas, weighing nearly one hundred pounds.

Its structure is sometimes more or less foliated. Its fracture is imperfectly conchoidal or uneven, and its lustre shining and often resinous. Its masses are often composed of granular distinct concretions.—It is generally translucent, sometimes nearly transparent. Its prevailing color differs but little from an *olive* green; and hence its

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* Krysolith. WERNER. Chrysolite. KIRWAN. JAMESON. La Chrysolithe. BROCHANT. Peridot Chrysolithe. BRONGNIART.

† Olivin. WERNER. L'Olivine. BROCHANT. Peridot Olivine. BRONGNIART.- Peridot granuliforme et lamelliforme. HAUY.

name. It also occurs asparagus green, yellowish green, or greenish yellow. It is less heavy than the common Chrysolite.

In nitric acid it loses its color; and with borax melts into a dark green bead. In a specimen from Unkel Klaproth found silex 50.0, magnesia 38.5, lime 0.25, oxide of iron 12.0;=100.75.

The Olivine is subject to decomposition. It gradually becomes friable, yellowish or reddish brown; and is eventually converted into a yellowish brown, ochrey substance.*

(*Geolog. sit. and Localities.*) This mineral is most frequently found in Basalt, and is usually accompanied by Augite. It is abundant in the basalt of Bohemia, France, &c. but all basalt does not contain it.—It is somewhat remarkable, that Olivine has seldom or never been found in wacke and other minerals, which so frequently accompany basalt.

It also occurs in substances ejected from volcanoes; as in the lava of Vesuvius and Hecla, where it is also associated with augite.—In Siberia it has probably been found in a mass of native iron.

SPECIES. 66. LABRADOR STONE.†

This mineral has hitherto been found only in laminated masses. When viewed in the direction of the laminæ, which are usually a little curved, it has a lustre nearly metallic, and its color is a dark copper red, or reddish brown slightly tinged with yellow, and sometimes steel gray; but in other directions it appears brownish, or greenish black. It is opaque, and scratches glass, but scarcely gives fire with steel. Its spec. grav. varies from 3.35 to 3.43.

The result of its mechanical division is a prism with rhombic bases, whose angles are about 100° and 80°; and this prism is further divisible in the direction of the two diagonals of its bases.

It contains silex 54.25, magnesia 14.0, alumine 2.25, lime 1.5, oxide of iron 24.5, water 1.0;=97.5. (*KLAPROTH.*)

It has hitherto been found only on the coast of Labrador, particularly on the island of St. Paul, where it is accompanied by opalescent feldspar.

This mineral has usually been described as a variety of hornblende.

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* The *Limbilite* of Saussure, found in a porphyry, near Brisgaw, has been supposed to be a decomposed Olivine, which it sufficiently resembles in its external characters. But it is fusible into a compact, shining, black enamel; a circumstance, however, which may result from its state of partial decomposition.

† Labradorische Hornblende. WERNER. Labrador Hornblende. JAMESON. KIRWAN. La Hornblende du Labrador. BROCHANT. Hypersthene. HAUY. BRONGNIART.

But, as it obviously belongs to a different species, its name ought not to retain the word hornblende.

Species 67. Tremolite.* *Jameson.*

The Tremolite sometimes occurs in distinct crystals, but more frequently in fibrous or radiated masses, composed of minute, imperfect prisms or fibres. One of its secondary forms is a very oblique four-sided prism, with diedral summits, whose faces are placed on the acute lateral edges; the terminal edge of each summit is oblique to the axis, and contains an angle of 149° 38′; and each obtuse edge of the prism contains an angle of 124.34 —Sometimes this crystal has its acute lateral edges truncated. (Pl. IV, fig. 25.)—Sometimes also the obtuse lateral edges, and even the edges of the summits are truncated.

The *rhombic* surface, brought to view by the transverse fracture of these prisms, is sometimes marked by a *line*, passing diagonally from one acute edge to the other; and hence the name Grammatite, given this mineral by Haüy. The primitive form is an oblique rhombic prism, whose sides are inclined at 124½° and 55½°. It appears to be the same as that of hornblende.

These crystals are seldom regular and well defined. They are often very much compressed or flattened, and sometimes cylindrical. Their sides are longitudinally, and often deeply, striated, and sometimes curved.

The Tremolite sometimes appears in thin, broad bundles, more or less long, and composed of parallel fibres, or minute prisms with rounded edges.—Sometimes its crystals are acicular, delicately fibrous, and collected into groups or masses, in which the fibres may be parallel, diverging, or radiated.—It also occurs in laminated masses.

The longitudinal fracture of these masses of Tremolite is fibrous; but the breadth of these fibres is sometimes imperceptible by the eye, and sometimes so great, that the fracture becomes foliated; its lustre is usually shining or glistening, and often pearly, but sometimes more or less vitreous. Its cross fracture is uneven or undulated with a moderate lustre.

The hardness of Tremolite, examined in mass, often appears variable, in consequence of the brittleness of its fibres. It however always scratches glass; its fibres are stiff, hard, and rough, and, when rubbed on glass with a little water, destroy its polish and wear its surface. Its powder is a little rough to the touch.

The Tremolite is white, often tinged with gray, yellow, green, or

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* Tremolith. Werner. La Tremolithe. Brochant. Grammatite. Brongniart. Var. of Amphibole. Haüy.

red; also gray, sometimes smoky, or even blackish gray. It is sometimes nearly or quite opaque, and often translucent; some crystals are transparent, and, with an increase of transparency, its lustre becomes more vitreous. Its spec. grav. usually lies between 2.92 and 3.20.

The phosphorescence, which most Tremolites exhibit both by heat and friction, sometimes even with a feather, is an accidental property, arising from particles of dolomite, attached to the Tremolite, or contained in its interior. For, when the dolomite is removed by an acid, no phosphorescence appears; and Tremolite, taken from an argillaceous gangue, is never phosphorescent. (Bournon.)

(Chemical characters.) Before the blowpipe it melts into a white glass, full of pores or blebs. Three specimens of white Tremolite from St. Gothard yielded Laugier silex 41 to 28.4, lime 30.6 to 15.0, magnesia 18.0 to 15.25, water and carbonic acid 23. In a common Tremolite Lowitz found silex 52, lime 20, magnesia 12, carbonate of lime 12;=96. In a fibrous Tremolite Klaproth found silex 65.0, lime 18.0, magnesia 10.33, water and carbonic acid 6.5, oxide of iron 0.16;=99.99. The results of the analyses of this mineral seem to depend in an unusual degree on the nature of its gangue. Thus Tremolites taken from dolomite, a compound carbonate of lime and magnesia, generally yield a large proportion of carbonate of lime, and little or no alumine; while others, taken from an argillaceous gangue, have yielded 14 per cent. of alumine. It is probable, however, that only silex, lime, and magnesia are essential to the composition of the Tremolite, and that the carbonic acid is derived from the gangue. Indeed the Tremolite almost always embraces numerous particles of its gangue.

(Distinctive characters.) The electric powers of zeolite and the chemical characters of both zeolite and stilbite form lines of distinction between those minerals and the Tremolite.—The fibrous Tremolite often much resembles some varieties of asbestus; but this latter mineral is less hard, and very seldom scratches glass even slightly, unless it contains some harder foreign substance; its powder is soft to the touch, and frequently agglutinates a little under the pestle.—The results of fusion may serve to distinguish it from actynolite.

The Tremolite is often described under several subspecies or varieties; but the distinctive characters between these varieties are of but little consequence, depending in part on the different breadths of the fibres. These varieties gradually pass into each other, and sometimes two or more of them appear in the same specimen.

Var. 1. COMMON TREMOLITE.* JAMESON. The larger and more

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* Gemeiner Tremolith. WERNER.

distinct crystals belong to this variety; also those masses, whose structure is more or less foliated, or whose fracture presents broad fibres, whether parallel, diverging, or interlaced.

GLASSY TREMOLITE.* *Jameson.* It is sometimes in acicular crystals, or in masses, whose fibres are narrow, and moderately diverging. It is intersected by transverse seams, and is very easily frangible. Its lustre has often more or less of a vitreous aspect.

2. FIBROUS TREMOLITE.† It occurs in masses, composed of fascicular groups of minute, diverging fibres; its fracture is often very delicately fibrous, glistening with a silky lustre. Sometimes the fibres radiate from a centre; and sometimes they proceed in cones from different centres, and intercept each other. It is often very tender. In a few instances it has been seen violet blue.

3. BAIKALITE,‡ *Kirwan.* It occurs in groups of acicular prisms, sometimes very long, and sometimes radiating from a centre. Its color is greenish, often with a shade of yellow; and its lustre sometimes silky. According to Kirwan, its spec. grav. is only 2.20, and it melts into a dark green glass. It contains silex 44, lime 20, magnesia 30, oxide of iron 6. (*Lowitz.*)

It has been found near lake *Baikal*, in Siberia, in foliated limestone.—In Chinese Tartary, it occurs in dolomite. (*Patrin.*)

(*Geolog. sit. and Localities.*) Tremolite occurs most frequently in carbonate of lime, more particularly in dolomite. It is abundant and very beautiful in the vicinity of St. Gothard, usually in dolomite, and associated with mica, talc, &c. Indeed it is said to have been first observed in the valley of *Tremola*, on St. Gothard; and hence its name.—Near Nantz, its fibres are seen radiating on granite, (*Daubuisson.*)—At Cornwall, in a dark green serpentine with asbestus. (*Greg.*)—According to Jameson, it is found near Edinburgh in secondary trap rocks with prehnite.

In the *United States.* In *Maryland*, at several places not far from Baltimore in carbonate of lime. (*De Butts.*)—In *Pennsylvania*, in Chester Co. sometimes with carbonate of lime, asbestus, and serpentine; at London grove it is very beautiful, (*Conrad.*)—In *New York*, at Kingsbridge;—and also near the city in granular limestone; sometimes it seems altogether distinct from the limestone. (*Bruce.*)—Also near Lake Champlain.—In *Connecticut*, at Washington, in Litchfield Co. both in dolomite and granular limestone; it is in flat prismatic crystals, or in very beautiful fibrous and radiated

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* Glasartiger Tremolith. Werner.

† Asbestartiger Tremolith. Werner. Asbestous Tremolite. Jameson. Var. of Amphibole fibreux. Hauy.

‡ Var. of Amphibole aciculaire. Hauy.

masses, with the aspect of white silk; also on Milford Hills, near Newhaven, where all its varieties occur with dolomite and quartz. (*Silliman.*)—In *Massachusetts*, in Newbury, not two miles from Newburyport and near the turnpike, in fibrous, radiated masses; the accompanying minerals are granular limestone, serpentine, asbestus, garnet, &c.

Species 68. Asbestus.*

Asbestus exhibits a considerable diversity of aspect; and sometimes more resembles a product of the vegetable, than of the mineral kingdom.

Its structure is always fibrous; and, although it has never presented distinct crystals, its fibres sometimes appear to be rhomboidal prisms. Its masses are sometimes composed of filaments easily separable, extremely delicate, flexible, and more or less elastic. In other cases, the fibres are stiff, closely adhering, and discover very little flexibility or elasticity. Its lustre is often silky or pearly.

When pure, it is seldom sufficiently hard to scratch glass even in a slight degree; and its fibres have sometimes the softness of cotton. Its powder is soft to the touch, and frequently agglutinates a little under a pestle.

When Asbestus is plunged in water, an absorption takes place, affecting the spec. grav. of the mass, which is also a little softened. It is usually translucent, at least at the edges, but sometimes opaque. Its colors are some variety of white, gray, or green, and sometimes of brown, yellow, red, or even of black.

(*Chemical characters.*) Asbestus, in fragments of a moderate size, is infusible in a common fire. The heat of the blowpipe, however, is sufficient to melt a very minute fragment into a glass or enamel, somewhat variable in color, but in most cases presenting a tinge of green. Its essential ingredients appear to be silex, magnesia, and lime.—This species presents several varieties.

Var. 1. Amianthus.† *Kirwan.* Its masses are composed of delicate filaments, very flexible, and somewhat elastic, often long and resembling threads of silk. The fibres are easily separable by friction, and may often be made to assume the appearance of a silken tuft. Sometimes indeed they occur loose.

The fibres of Amianthus are usually straight, and perhaps always parallel. They have, in most cases, a glistening silky lustre; and are soft to the touch, sometimes like the finest silk. They are nearly

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* Asbest. Werner. Jameson. Asbeste. Hauy. Brongniart. Brochant.

† Amianth. Werner. Jameson. L'Amianthe. Brochant. Asbeste Amianthe, Brongniart. Asbeste flexible. Hauy.

or quite opaque; and their color is white, usually tinged with green or gray; sometimes also silver white, greenish, or reddish. Its spec. grav. varies from .90 to 2·57.

If the extremity of a single filament be presented to the flame of a lamp, it recoils upon itself, and a small, friable globule is formed. But, if a tuft of many fibres be thrown into a fire, it suffers no change. It contains, according to Chenevix, silex 59.0, magnesia 25.0, lime 9.5, alumine 3.0, oxide of iron 2.25;=98.75.

(Localities.) Fine specimens are found in Savoy, where its filaments are sometimes a foot in length.—In Corsica it is so abundant, that Dolomieu employed it for packing his specime[illegible]—It is very abundant in the Pyrennees.

(Uses.) When the filaments are long and very flexible, they may be spun, and woven into cloth, by mixing them with flax, and employing much oil. When this cloth is thrown into the fire, the flaxen fibres are consumed, and a kind of canvas remains. If this cloth be soiled, it may be cast into the fire with safety, and thus restored to its original purity and whiteness. Hence the name of this variety, from the Greek Αμιαντος, unpolluted. The ancients preserved the ashes of their dead by wrapping the body in this cloth before combustion.

Madame Perpenti has succeeded in manufacturing the fibres of Amianthus into cloth without any additional ingredient. Her process consists in softening the Amianthus in water, beating it, rubbing it, and dividing it with a comb, having fine steel points. The fibres, thus obtained, are extremely delicate, but sufficiently strong.

Amianthus has also been manufactured with success into paper; and, could an incombustible ink be prepared, manuscripts might be rendered safe from destruction by fire.

It has also been employed as an incombustible wick for lamps. And it has been suggested, that the *perpetual lamps* of the ancients contained wicks of this kind, constantly supplied with oil. Hence perhaps the name of this species, which is from the Greek Ἀσβεστος, inextinguishable.

2. COMMON ASBESTUS.* The structure of this variety, which passes into the preceding, is always fibrous; but the fibres are stiff and hard, scarcely flexible and elastic even in a slight degree, and strongly adhere together; indeed the adhesion is sometimes so great, that the fracture becomes a little splintery. Its fibres, whether fine or coarse, straight or curved, are usually parallel, but sometimes diverge in fascicular groups, or radiate from a centre. Its lustre is glisten-

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* Gemeiner Asbest. WERNER. Common Asbest. JAMESON. Asbestus. KIRWAN. Asbeste dur. HAUY. BRONGNIART. L'Asbeste commune. BROCHANT.

ing, and often somewhat pearly or resinous. It is translucent, at least at the edges; and its color varies from leek green to greenish gray, and is sometimes olive green, or yellowish gray. It breaks into splintery fragments; and its spec. grav. extends from 2.54 to 3.03.

It is more easily fusible than the other varieties. A specimen, analyzed by Bergman, gave silex 68.9, magnesia 16.0, lime 12.8, alumine 1.1, oxide of iron 6.0;=99.8.

This variety sometimes resembles actynolite or tremolite; but its powder is soft, while that of the other two is dry and harsh.

3. MOU[illegible]IN CORK.* This variety is so light, that it ordinarily swims on water, its spec. grav. usually varying between 0.68 and 0.99. Its structure is fibrous; but the fibres, very seldom parallel, are mingled and promiscuously interwoven, thus leaving numerous pores; hence its low spec. gravity, and its power of absorbing a large quantity of water.

Although its hardness is sometimes considerable, it may usually be impressed by the finger nail; and, when rubbed, it presents a shining streak. It h[illegible]ttle or no lustre; and its fibres are so fine, that its fracture, at [illegible] view, appears compact and uneven. Its more common colors[illegible]ray, grayish or yellowish white, and sometimes yellowish brown, or pale yellow. It is usually opaque.

Its structure often closely resembles that of *cork*. When in thick, spongy masses, it has been called *rock or fossil flesh*. Sometimes it appears in plates or membranes; when these are hard, they have been called *rock or fossil leather*; when thin and flexible, *rock or fossil paper*.

It is less easily fusible, than the other varieties. It contains, according to Bergman, silex 56.2, magnesia 26.1, lime 12.7, alumine 2.0, iron 3.0.

This variety is found in S[illegible]y, France, &c. and sometimes in metallic veins.—Near Alais, in France, it occurs on the surface of the soil, in long whitish masses, resembling human bones.

4. LIGNIFORM ASBESTUS.† *KIRWAN.* The texture of this mineral, under certain points of view, somewhat resembles that of wood. Its structure is irregularly fibrous, the fibres being straight or curved, parallel, interlaced, or a little diverging. They adhere strongly, but are less stiff, than those of the common variety, and usually a little

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* Berg Kork. WERNER. Rock Cork. JAMESON. Suber montanum. KIRWAN. Asbeste tressé. HAUY. Asbeste suberiforme. BRONGNIART. La Liege de montagne. BROCHANT.

† Berg Holz. WERNER. Rock Wood. JAMESON. Asbeste ligniforme. HAUY. BRONGNIART. Le Bois de montagne. BROCHANT.

flexible. It breaks into fragments, which somewhat resemble splinters of wood. Its color is usually brown, sometimes a little reddish or yellowish.

It is with difficulty melted by the blowpipe.—In Europe, this variety is found chiefly in the Tyrol.

5. COMPACT ASBESTUS.* This variety is compact in a comparative sense only. It has a very close texture; but its masses are divisible into filaments more or less delicate, especially after being exposed to moisture. Its color is usually a deep green. It much resembles a fibrous serpentine; and has been found in the Uralian mountains, and in the Pyrennees.

(Geological situation.) Asbestus, which never occurs in large masses, is usually found among the more recent of the primitive rocks. It is sometimes in veins, which traverse granite and gneiss, and often mingled with the various crystallized substances, which fill these veins. It sometimes penetrates quartz or calcareous spar, giving them a silky or fibrous appearance. It is also found in metallic veins.

In the Uralian mountains it exists in small masses, composed of fascicular groups of diverging fibres, in mica slate. *(PATRIN.)* Argillaceous slate is sometimes traversed by veins of Asbestus.

But it more frequently occurs in serpentine or steatitic rocks, constituting whole veins, which vary from a few lines to several inches in breadth.

Asbestus is sometimes associated with talc, magnetic iron, &c. and in some instances its fibres are spread over the surface of crystallized feldspar, like hair.

(Localities.) This mineral is by no means rare. Some of the more remarkable foreign localities have been mentioned under the first variety.

In the *United States.* In *Maryland,* at the Bare Hills, &c. not far from Baltimore, amianthus, common, radiated, and ligniform Asbestus occur in serpentine. *(GILMOR.)*—In *Delaware,* the common variety is very abundant in serpentine, in Christiana Hundred, Newcastle Co. *(CONRAD.)*—In *Pennsylvania,* in Chester and Montgomery Cos. &c. Near Philadelphia soft fibres of amianthus traverse masses of crystallized quartz.—In *New Jersey,* near Hoboken, in serpentine.—In *New York,* 4 miles from the city, is found a rare mineral in radiated masses, which is by some referred to Asbestus; but in the opinion of Prof. Bruce it strongly inclines to Tremolite.—In *Connecticut,* near Newhaven, chiefly in serpentine, and very abundant; the amianthus is sometimes nearly as fine as that of Corsica; the common variety is whitish green, with dolomite and granular

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* Asbeste compacte. BRONGNIART.

limestone adhering, and bitter spar and magnetic iron disseminated; also at New Milford. (*Silliman.*)—In *Massachusetts*, at Brookline, &c. in the vicinity of Boston;—also at Newbury, not 2 miles from Newburyport, near the turnpike, the amianthus and common variety appear in veins, intersecting a very beautiful, precious serpentine.

Species 69. Diopside.* *Brongniart.*

This mineral, yet rare, appears in prismatic crystals, more or less regular. It sometimes presents their primitive form, which, according to Haüy, is an oblique quadrangular prism, with rhombic bases, and in all respects similar to the primitive form of the augite. These quadrangular prisms are often small and elongated, and frequently bent and imperfect. The bases of the primitive form sometimes present pyramidal terminations, and the lateral edges are truncated or bevelled, in some cases producing a twelve-sided prism (Pl. IV, fig. 26.), of which eight sides are usually narrower than the other four; this prism has summits with six faces.

The prisms are sometimes compressed or tabular, sometimes cylindrical and longitudinally striated; they are often aggregated into fibrous or radiated masses. Sometimes also crystals of Diopside are united to massive, granular, or almost compact varieties of the same substance.

Its fracture, parallel to the bases of the primitive form, is more distinctly foliated, than in the direction of the sides. The smaller crystals are often opaque, while the larger are frequently more or less translucent. The colors of the Diopside are green, usually pale or only greenish white, and sometimes yellowish or grayish white. The small four-sided prisms sometimes exhibit a pure, lively green; and the larger crystals are sometimes nearly white. Its spec. grav. is 3.23. It scarcely scratches glass.

It melts by the blowpipe, though with difficulty, into a limpid or grayish glass. It contains silex 57.0, magnesia 18.25, lime 16.5, oxides of iron and manganese 6.0;=97.75. (*Laugier.*)

(*Localities.*) The Diopside in four-sided prisms, associated with granular carbonate of lime, specular oxide of iron, &c. is found in fissures or veins, traversing a black serpentine, on the plain of *Mussa*, in Piedmont; and was hence named *Mussite* by its discoverer, Bonvoisin.—The twelve-sided prisms, usually accompanied by garnets, were discovered by the same mineralogist near the village of *Ala*, in Piedmont; and by him called *Alalite.*

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* Var. of Pyroxene. Haüy.

The variety, first called Mussite, resembles the sahlite; and in fact Haüy considers both Diopside and sahlite as varieties of augite.

SPECIES 70. SAHLITE.* *JAMESON.*

The Sahlite has been observed in four or eight-sided prisms, whose laminæ are sometimes marked by parallel lines. But it more frequently occurs in small laminated masses, or in granular concretions; and the same mass sometimes exhibits both a granular and laminated structure. It easily yields to mechanical division, and the result is a four-sided prism, nearly rectangular, with natural joints parallel to the diagonals of its bases. Its fracture, parallel to the sides of the prism and one of the aforementioned diagonals, is more or less foliated; and the lustre is, in general, moderately shining. Its cross fracture is usually uneven and nearly dull, but sometimes presents foliæ oblique to the axis. Its primitive form, therefore, cannot differ much from that of the augite; and indeed Haüy believes it to be the same.

The Sahlite is soft to the touch, scarcely scratches glass, and may be scraped by a knife. In thin plates it is translucent, but, in thicker masses, at the edges only. Its colors are greenish gray or grayish green, and sometimes pale green. Its spec. grav. is 3.23.

It melts with ebullition by the blowpipe, though not easily, into a porous glass. It contains silex 53, lime 20, magnesia 19, alumine 3, iron and manganese 4;=99. (*VAUQUELIN.*)

This mineral is softer to the touch than Augite; and its internal lustre is usually less lively.

(*Localities.*) It was first found in a silver mine near *Sahla*, in Sweden, by Dandrada; and hence its name. It has also been found in Norway, and in the mountain Odon-Tchelon, in Siberia. At the latter place it is accompanied by mica and beryl, and its crystals present oblique transverse divisions, more shining than usual.—In the *U. States*, it exists near Lake Champlain. (*GIBBS.*)

SPECIES 71. AMIANTHOIDE.† *HAUY. BROCHANT.*

It occurs in tufts, composed of long capillary filaments, flexible and very elastic; more flexible than the fibres of common asbestus, but stiffer and more elastic than those of amianthus. Its color is olive green, sometimes inclining to yellow or brown; and its lustre is somewhat shining and silky.

It melts with difficulty before the blowpipe into a blackish en-

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* Sahlit. WERNER. Malacolithe. BROCHANT. BRONGNIART. Var. of Pyroxene. HAUY.

† Amianthoïde capillaire. BRONGNIART.

amel. It contains silex 47.0, lime 11.3, magnesia 7.3, oxide of iron 20.0, oxide of manganese 10.0;=95.6. (*Vauquelin.*)

At Oisons in France, it is accompanied with epidote, feldspar, quartz, and oxide of manganese.

Species 72. Augite.*

This mineral is not always easily recognised, unless it be in distinct crystals, which is often the case. Its secondary forms, of which nine or ten have been observed, are all six or eight-sided prisms, usually short, and terminated at each extremity by two principal faces. They originate from an oblique prism (Pl. IV, fig. 27.) with rhombic bases, whose sides are inclined to each other at angles of 92° 18′ and 87° 42′; its integrant particles are triangular prisms.

One of its forms is a six-sided prism, of which two lateral edges contain angles of 92° 18′, and the other four, angles of 133° 51′.—This prism is sometimes terminated by diedral summits, whose terminal edges are oblique to the axis, and whose faces, standing on the two least obtuse edges of the prism, are inclined to each other in an angle of 120°. Most commonly two of the lateral planes are broader, than the other four; sometimes the reverse.—Sometimes the preceding crystal is converted into an eight-sided prism (Pl. IV, fig. 28.) by truncations on those lateral edges, on which the terminating faces were placed.—Sometimes the terminal edge of the summit, or only one of its solid angles, is truncated.

Sometimes it appears in hemitrope crystals, in which one extremity has a four-sided summit, and the other presents a re-entering angle. Sometimes its prisms cross each other, but not, like the staurotide, at constant angles.

It also occurs amorphous, or in rounded fragments, or in grains.

The Augite has a foliated structure in two directions, parallel to the sides of the primitive form. It is harder than hornblende or olivine, scratches glass, and gives sparks with steel. Its spec. grav. varies from 3.10 to 3.47.

It is fused with difficulty by the blowpipe; but in small fragments melts into an enamel, which, in the colored varieties, is black. Its essential ingredients appear to be silex, lime, magnesia, and alumine.

Its greater hardness, the results of mechanical division, and its difficult fusibility will, in general, be sufficient to distinguish it from hornblende, which it often resembles.—It cannot easily be confounded with schorl.

It has two varieties.

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* Pyroxene. Haüy. Brongniart.

Var. 1. COMMON AUGITE.* This embraces the distinct crystals of Augite, already described. Their surface is often smooth and shining; and the smaller prisms are frequently very perfect.—It not unfrequently occurs in grains, or small masses, either amorphous or rounded. Its longitudinal fracture is more or less foliated, and its cross fracture uneven; when not in crystals its fracture is often somewhat conchoidal. Its lustre is shining, often strongly, and a little resinous.

Though in general nearly or quite opaque, it is sometimes translucent, and some green crystals are feebly transparent. Very thin fragments of opaque crystals often transmit a greenish light. Its colors are black, greenish black, deep or blackish green, leek or yellowish green, and sometimes brown, gray, or even white. The green shade is often advantageously brought to view by moistening the surface. The color of its powder, except in the whitish varieties, is greenish gray.

In a specimen from Franconia Klaproth found silex 52.0, lime 14.0, magnesia 12.75, alumine 5.75, oxide of iron 12.75, of manganese 0.25, water 0.25;=97.75. In another from Frascati he found silex 48.0, lime 24.0, magnesia 8.75, alumine 5.0, oxide of iron 12.0, of manganese 1.0;=98.75.

The Augite is subject to decomposition, though less so than olivine, and is eventually reduced into a yellowish green, argillaceous mass. (*Brochant.*)

(*Geological sit. and Localities.*) This variety of Augite often exists in volcanic productions, even in recent lava and scoria; indeed some volcanic ejections, as at Stromboli, &c. are in a great degree composed of crystals of Augite. These crystals are very abundant in the scoria of Monte Rosso, near Etna; they also occur loose at the same mountain in a kind of sand, which, according to Spallanzani, consists of triturated scoria.

Many believe, that the Augite, thus found, pre-existed in the stone, from which the lava has originated, having suffered little or no alteration by the fire, which produced the lava. Sometimes, however, the fire has rendered it more brittle, and acid vapours have destroyed its color; indeed white augite sometimes retains its original color in the interior.

Others suppose, that Augite has actually crystallized in the interior of the melted lava. This opinion receives some support from the remark of Mr. Thompson, who asserts, that he saw acicular crys-

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* Augit. WERNER. Augite. JAMESON. L'Augite. BROCHANT. Pyroxene Augite. BRONGNIART.

tals of Augite, *sublimed* and *attached* to the walls of a church, which was enveloped by the lava of Vesuvius in 1794.

This Augite is also common in basalt, accompanied by olivine and basaltic hornblende; its crystals or amorphous masses have usually more lustre, than when found in lava.

Augite sometimes occurs in primitive rocks. Very large crystals are found in the iron mines near Arendal in Norway; and sometimes pass by insensible shades into the coccolite.

In the *U. States*, at the northern extremity of the island of *New York*, white Augite is imbedded in primitive limestone. Its crystals, either small or several inches in length, are eight-sided prisms, of which two sides are often so much larger than the others, that the crystal becomes tabular. The terminations of these prisms, sometimes like those already known, have also presented a new and more complex variety of form. Spec. grav. 3.1. (*BRUCE.*)

2. COCCOLITE.* *JAMESON.* This variety is composed of granular, distinct concretions,† easily separable, often by the finger only, and varying in size from that of a pin's head to that of a pea, or still larger. These concretions are bounded by smooth, but irregular faces, often a little convex; they sometimes present a few well defined edges, and often resemble crystals with rounded angles and edges. Sometimes they pass into laminated masses, which divide very easily into prisms slightly rhomboidal.

Its structure is foliated in two directions, though not always very distinctly; its fracture is sometimes a little conchoidal; its lustre is vitreous and shining. Its spec. grav. lies between 3.31 and 3.37.—Its grains are often translucent, sometimes opaque. Its colors are green of several shades, as grass, olive, or light leek green, also blackish green or black, red, brown, or reddish brown.

It contains, according to Vauquelin, silex 50.0, lime 24.0, magnesia 10.0, alumine 1.5, oxide of iron 7.0, of manganese 3.0;=95.5. It melts before the blowpipe, but not easily.

(*Localities.*) It was first found in the north of Europe, where it exists in primitive rocks. Near Arendal, in Norway, it is associated with magnetic iron, mica, carbonate of lime, &c. The black concretions are sometimes mingled with others of a bright red.

In the *United States*. In *New York*, at West Chester.—In *Vermont*, the Coccolite has been found in several places near Lake Champlain, and probably offers some new varieties of color. It is

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* Kokkolith. WERNER. Coccolithe. BROCHANT. Pyroxene Coccolithe. BRONGNIART. Pyroxene granuliforme. HAUY.

† Hence its name, from the Greek, *Κοκκος*, a grain.

sometimes in masses of a dull black color. But at Charlotte, its masses are composed of easily separable concretions, whose prevailing colors are brownish red, or brown, deep blood red, orange, or pale red; with these, other concretions of a lively green are intermingled. Although some of these concretions from Charlotte seem to be almost prismatic, their structure is, in general, less distinctly foliated, than that of the Coccolite from Norway, and their lustre more vitreous.—At Rodgers Rock, eight miles from Ticonderoga, it forms a mass, weighing a number of tons; its colors are numerous, and its grains very small. (*Hall.* See Lit. & Philos. Repert. v. i. p. 379.)

Species 73. Hornblende.*

This very common mineral may, in general, be easily recognised. Though sometimes in regular and distinct crystals, it is more commonly the result of a confused crystallization; and appears in masses, composed of laminæ, acicular crystals, or fibres, variously aggregated.

When its structure is sufficiently regular, mechanical division is easily effected in a longitudinal direction; and its crystals are found to be composed of laminæ, situated parallel to the sides of an oblique four-sided prism (Pl. IV, fig. 29.) with rhombic bases; the sides of this prism are inclined to each other at angles of 124° 34′ and 55° 26′. The longitudinal fracture, which of course is foliated, usually presents the broken edges of many laminæ extending one beyond another.—Of the five or six modifications of the primitive form, which have been observed, the three following are the most common.

A six-sided prism, of which two opposite lateral edges contain angles of 124° 34′. Each summit is formed by three rhombic faces, standing on alternate, lateral edges, but not on the same edges at both extremities.—The same six-sided prism is sometimes terminated, at one extremity, by four trapezoidal faces (Pl. IV, fig. 30.), corresponding to four of the lateral planes, and, at the other extremity, by two pentagonal faces, standing on two opposite lateral edges.—Sometimes also this prism has, at one extremity, the three-sided summit of the first variety, and, at the other, the diedral summit of the second variety.—Although the two summits of these crystals are often unlike each other, both in the *number* and *arrangement* of their faces, it cannot be inferred, that they ought to become electric by heat; for the summits of the tourmaline differ only by the *addition* of certain faces, at one extremity, to those faces, which are *common to both extremities.*

Hornblende, though less hard than schorl, usually scratches glass,

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* Amphibole. Haüy. Brongniart.

and sometimes with difficulty gives a few sparks with steel. Its powder is dry and not soft to the touch. It is often opaque, sometimes translucent. Its prevailing colors are black and green, often intermixed. Its spec. grav. usually lies between 3.15 and 3.38.

(Chemical characters.) Before the blowpipe it melts with considerable ease; the common hornblende into a black or grayish black glass, and actynolite into a gray or yellowish gray enamel. It yields by analysis silex, alumine, magnesia, and lime, but in variable proportions, arising in part, without doubt, from the nature of its gangue. Its colors are produced by the oxides of iron and of chrome.

(Distinctive characters.) Its laminated structure, its inferior hardness, its inability of becoming electric by heat, and sometimes the results of fusion may be employed to distinguish it from schorl.—It is less hard and more easily fusible than Augite.—It differs from epidote in hardness, and the results of fusion.—Its powder is not soft to the touch, like that of asbestus.

This species admits a twofold division, founded chiefly on a difference of color, produced by the oxides of iron and of chrome.

Subspecies 1. COMMON HORNBLENDE.

This subspecies is much more common and abundant, than actynolite, the following subspecies. It embraces all those minerals, to which Werner has given the name of Hornblende, with the exception of the substance, which he has called Labrador Hornblende.

It is sometimes crystallized under the forms already described; and very often occurs in lamellar or fibrous masses. Its prevailing color is black, sometimes brownish or grayish black, and very frequently more or less tinged with green, or even passes into a deep or blackish green, or dark greenish gray; but the tinge of green is never lively. The color of its streak or fine powder is greenish gray. The black varieties are usually opaque, and the greenish, translucent at the edges.

Its crystals are sometimes perfect and distinct; but very often so aggregated, that it is difficult to perceive their form, although the prisms are sometimes large, and their edges well defined. Sometimes these groups are composed of channelled, cylindrical, or very minute prisms, either parallel or diverging, and sometimes intersecting each other.

Its longitudinal fracture is more or less distinctly foliated with a lustre somewhat shining, or even splendent. Its cross fracture is uneven or a little conchoidal, and has a moderate lustre.

Masses of hornblende, whether fibrous, lamellar, or nearly compact, possess a remarkable tenacity, which renders them tough and difficult to break; indeed a considerable cavity may often be produced by a hammer, before the mass breaks. They exhale, when moistened by the breath, a peculiar, argillaceous odor; and often appear less hard, than the distinct crystals.

A specimen, analyzed by Klaproth, yielded silex 42.0, alumine 12.0, lime 11.0, magnesia 2.25, oxide of iron 30.0, of manganese 0.25, water 0.75;=98.25. In a crystal of basaltic Hornblende from Cape de Gate, Laugier found silex 42.02, alumine 7.69, lime 9.8, magnesia 10.9, oxide of iron 22.69, of manganese 1.15, water 1.92;=96.17. In another crystal from Fulda, Klaproth found silex 47.0, alumine 26.0, lime 8.0, magnesia 2.0, oxide of iron 15.0, water 0.5;=98.5 Hornblende is liable to decomposition at its surface, becomes more friable, and assumes a ferruginous brown color.

We notice several varieties, distinguished by geological considerations, or diversity of texture.

Var. 1. BASALTIC HORNBLENDE.* *JAMESON.* This variety, though found in lava and volcanic scoriæ, is very often in *Basalt;* and hence the term basaltic. It is almost always in distinct crystals, whose color is a pure black, sometimes very slightly tinged with green, or rendered brownish by decomposition. Their surface is sometimes strongly shining, and sometimes dull and invested with a ferruginous crust.

Its structure is more foliated, than that of the other varieties, and its crystals more brittle.—It is also less easily fusible.

This variety is found near Vesuvius, and near Cape de Gate in Spain. It is common in the basalt of Saxony, Bohemia, &c. Sometimes its crystals are found loose in those earths, which have resulted from the decomposition of basalt.

2. LAMELLAR HORNBLENDE.† Its masses are sometimes composed merely of lamellæ, and sometimes of granular concretions of various sizes, having a lamellated structure. Hence the fracture is foliated, but the foliæ are variously inclined or interlaced. Sometimes the lamellæ are continuous and extended; and sometimes the grains are so fine, that the mass appears compact.

3. FIBROUS HORNBLENDE.‡ It occurs in masses, composed of acicular crystals or fibres, either broad or narrow, parallel or interlaced, and sometimes diverging in fascicular groups, or promiscuous-

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* Basaltische Hornblende. WERNER. La Hornblende basaltique. BROCHANT. Amphibole schorlique basaltique. BRONGNIART.

† Amphibole lamellaire. HAUY. BRONGNIART. Gemeiner Hornblende. WERNER. Common Hornblende. JAMESON.

‡ Amphibole fibreuse. HAUY.

ly. Sometimes the fibres are so curved or even curled, that the texture resembles that of knotty wood.

4. SLATY HORNBLENDE, or HORNBLENDE SLATE.* *JAMESON.* This variety scarcely differs from the preceding, except in the slaty structure of its masses. For each individual layer, either straight or curved, is composed of very minute fibres, diverging in bundles or promiscuously, and often interlaced. It presents the usual colors of Hornblende; but its lustre is often moderate.

(*Geological situation.*) Common Hornblende occurs in all classes of rocks, but chiefly in the primitive. It is an essential ingredient in syenite and greenstone. We have already noticed the existence of its crystals in basalt and lava. It often occurs, either crystallized or massive, in granite, gneiss, mica slate, syenite, limestone, &c. or in veins, which traverse these rocks. Sometimes it forms large masses or even beds in gneiss and argillite, and contains magnetic oxide of iron, sulphuret of iron, mica, &c.—Hornblende slate sometimes constitutes large beds in argillite and other primitive rocks. It often contains quartz, feldspar, mica, &c. and, by an increase of these foreign ingredients, it passes into gneiss, or greenstone, or even into chlorite slate. Hornblende is sometimes porphyritic.

(*Localities.*) Of a mineral so very common we mention but one locality; and that for the purpose of noticing an uncommon aggregate, into the composition of which hornblende enters in a large proportion. This aggregate is found at Brunswick in *Maine*, and is contiguous to a bed of primitive limestone. It is stratified, and even fissile, and consists of white granular limestone and fibrous Hornblende, with a little mica intermixed. It sometimes resembles gneiss.

SUBSPECIES 2. ACTYNOLITE.† *JAMESON.*

This mineral possesses all the essential characters of Hornblende. In fact, common Hornblende and Actynolite, separated only by slight differences, when viewed in the extremes, do, in other cases, insensibly pass into each other. The Actynolite has usually a greater translucency, a more lively green color, arising from the chrome, which it contains, and differs also in the result of fusion by the blowpipe.

The Actynolite occurs in prismatic crystals, which are commonly long and incomplete, sometimes extremely minute and even fibrous, and variously aggregated into masses more or less large. Its prevailing color is green, sometimes a pure emerald green, but varying

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* Hornblende Schiefer. WERNER. Amphibole Hornblende schisteux. BRONGNIART. La Hornblende schisteuse. BROCHANT.

† Strahlstein. WERNER. La Rayonnante. BROCHANT. Var. of Amphibole. HAUY. Amphibole Actinote. BRONGNIART.

from a dark or leek green to a pale green, which is sometimes shaded with gray, yellow, or brown. Its colors are liable to change in consequence of decomposition. It scratches glass, but its prisms are often very brittle in a transverse direction. Its cross fracture is often a little conchoidal, and more shining than that of common Hornblende. Its spec. grav. is about 3.30.

It melts by the blowpipe into a gray or yellowish gray enamel. It contains, according to Laugier, silex 50.0, magnesia 19.25, lime 9.75, alumine 0.75, oxide of iron 11.0, oxide of chrome 5.0;=95.75. Its green color is derived from the Chrome, but is often modified by the large quantity of iron, which is present.

It presents but few varieties, and these pass into each other.

Var. 1. COMMON ACTYNOLITE.[*] *JAMESON.* It is sometimes in long hexaedral prisms, or four-sided prisms, truncated on their acute lateral edges, with summits almost always incomplete. Their surface is often splendent, and sometimes longitudinally striated. They are translucent, and sometimes nearly transparent.

It is sometimes in masses, composed of flattened or compressed prisms, more or less broad, and commonly diverging. It has also been observed in fascicular groups of broad prisms, which are often curved; their color is greenish gray with a shining and somewhat pearly lustre.

It sometimes presents lamellated or granular masses, differing from common Hornblende merely in the liveliness of their green color.

GLASSY ACTYNOLITE.[†] *JAMESON.* It is often in masses, composed of slender, compressed, acicular crystals, or of minute fibres. Its prisms are very brittle, being crossed by transverse rents. Their lustre is often strong and vitreous.

2. ACICULAR ACTYNOLITE.[‡] This variety occurs in delicate, capillary prisms or fibres, united in groups, in which the fibres, sometimes parallel, more frequently diverge; and, in some cases, intersect each other, or radiate from a centre. Its lustre is glistening, and somewhat silky or pearly. Its color is usually a paler green, and more mixed with gray, yellow, or brown, than that of the common variety; it is sometimes nearly black. Its masses are often very tender.

FIBROUS ACTYNOLITE.[§] This subvariety may easily be mistaken

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[*] Gemeiner Strahlstein. WERNER. Amphibole hexaèdre. HAUY. Amphibole Actinote hexaèdre. BRONGNIART.

[†] Glasartiger Strahlstein. WERNER.

[‡] Asbestartiger Strahlstein. WERNER. Asbestous Actynolite. JAMESON.

[§] Amphibole fibreuse. HAUY. Amphibole Actinote fibreux. BRONGNIART.

for asbestus. It is composed of delicate, parallel fibres, which easily separate by pressure between the fingers, and are converted into a kind of down; the lustre is a little silky. But these fibres are distinguished from those of amianthus by their stiffness and brittleness. Their color is greenish white or whitish.

(Geological situation.) The Actynolite is found in primitive rocks, or in veins, which traverse them; it is sometimes in metallic beds. It is, perhaps, most common in minerals, which contain magnesia. Its more distinct crystals occur in talc, quartz, and limestone.

(Localities.) It is abundant at Zillerthal in the Tyrol, and at St. Gothard.—In the *United States*, it is not uncommon. In *Maryland*, near Baltimore, all its varieties occur in granite or gneiss. *(Dr Butts.)*—In *Pennsylvania*, at Concord, Chester Co. in large masses of an emerald green color. *(Conrad.)*—In *Connecticut*, near Newhaven, in serpentine; its structure is generally radiated. *(Silliman.)*—In *Maine*, at Brunswick, all its varieties occur, sometimes in granite and gneiss, but more frequently in limestone.

Species 74. Diallage. *Hauy. Brongniart.*

This species has seldom, if ever, been seen in distinct crystals. Its varieties also differ very considerably from each other in some of their external characters; indeed the difference of composition between certain minerals, referred to this species, is so great, that one is compelled to doubt the accuracy of the analysis, or the identity of the minerals.

The Diallage has a foliated structure, and, in *one direction*,* is easily divisible into laminæ with smooth, *polished faces*, sometimes traversed obliquely by cracks or seams. Indeed a rhomboidal prism, with bases nearly square, has been obtained by mechanical division. Its cross fracture is usually uneven with very little lustre. It always scratches carbonate of lime, and sometimes makes a slight impression on glass. Its spec. grav. is about 3.00.

Before the blowpipe it melts with some difficulty into a gray, or grayish green enamel. Its composition will be seen under its varieties.

The Diallage sometimes resembles feldspar; but the latter is harder, and its laminæ easily separate at natural joints in *two* directions.—The same characters will serve to distinguish Diallage from Hornblende.

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* The name Diallage is derived from the Greek Διαλλαγη, difference, alluding to the difference of lustre, &c. between its natural joints.

Var. 1. GRANULAR DIALLAGE.* Its color is a fine grass green, or emerald green. It is opaque, or slightly translucent. It has a shining, foliated fracture in one direction, with a lustre sometimes pearly, or like that of satin. In some specimens the texture is both lamellar and fibrous. Its masses are usually composed of granular distinct concretions, but sometimes appear very compact.

It contains silex 50, alumine 21, lime 13, magnesia 6, the remaining 10 parts being chiefly the oxides of chrome, iron, and copper. (*VAUQUELIN.*)

(*Localities.*) At Mount Musinet, near Turin, and also near the lake of Geneva, it is imbedded in a variety of jade (Saussurite). —In Corsica, it is sometimes connected with the same variety of jade; it also, according to Brongniart, enters into an aggregate of feldspar and petrosilex.—Near the Lizard Point, Cornwall, an aggregate of granular Diallage and feldspar is found between serpentine and gray-wacke. (*BERGER.*)

These aggregates, containing Diallage, are sometimes polished, and employed in ornamental work. Such is the *verde di Corsica* of the Italians.

2. RESPLENDENT DIALLAGE.† This variety occurs in masses of a moderate size, or in laminæ, which, according to Emmerling, are sometimes hexaedral. Its laminæ, sometimes a little curved, have usually a metallic lustre, often strong, and sometimes accompanied with the reflective power of polished metals. When the reflecting surfaces of the laminæ are parallel, or situated in the same plane, as is usually the case, their brilliancy suddenly appears or disappears, as the position of the specimen is changed.

Its color is usually a deep bottle green, or a metallic gray almost silver white; sometimes also olive green, brown, or blackish. Some specimens have a deep brown color, slightly tinged with violet, and a lustre less metallic than usual.—It is somewhat less hard, than the preceding variety; and its spec. gravity is a little below 3.00.

It sometimes passes into granular Diallage, the same natural joint extending itself from one variety to the other. (*HAUY.*)

It contains, according to Drappier, silex 41, magnesia 29, alumine 3, lime 1, water 10, oxide of iron 14; = 98. But, according to Heyer, it contains silex 52.0, alumine 23.33, lime 7.0, magnesia 6.0, iron 17.5; = 105.83.

This variety is usually imbedded in serpentine. Near Turin, it

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* Körniger Strahlstein. WERNER. Granular Actynolite. JAMESON. Diallage verte. HAUY. BRONGNIART. Smaragdite. SAUSSURE.

† Diallage métalloïde. HAUY. Diallage chatoyant. BRONGNIART. Schillerstein. WERNER. Shiller Stone. JAMESON. Spath chatoyant. BROCHANT.

is sometimes associated with jade and granular Diallage. Mica, talc, quartz, garnets, magnetic iron, &c. are among its accompanying minerals.

3. BRONZITE.* Its structure is usually more distinctly foliated, than that of the preceding variety; and its laminæ, though somewhat less shining, still retain a lustre almost metallic. Its lustre does not so suddenly disappear by a slight change of position, as in the preceding variety. Its colors are brass or *bronze* yellow, or tombac brown. In thin plates it is translucid; and its spec. grav. is sometimes 3.20.

It contains silex 60.0, magnesia 27.5, oxide of iron 10.5, water 0.5;=98.5. (*KLAPROTH.*) It is almost infusible.

It is usually found in small masses, disseminated in serpentine.

SPECIES 75. MACLE.† *HAUY. BRONGNIART.*

The Macle has occurred only in crystals, whose different parts are arranged in a very peculiar manner. The form of these crystals is a four-sided prism, whose bases are rhombs, but differ very little from squares. But each crystal, when viewed at its extremities, or on a transverse section, is obviously composed of two very different substances; and its general aspect is that of a black prism, passing longitudinally through the axis of another prism, which is whitish.

The black and white parts of these crystals exhibit some diversity of arrangement, which we shall endeavor to illustrate by one figure (Pl. IV, fig. 31.), in which nearly all the varieties are combined.

Sometimes a black rhomb, whose sides are parallel to those of the crystal, occupies the place of the axis, while four small, black lines pass from each angle of this rhomb to the corresponding angles of the exterior white prism.—Sometimes four other black rhombs appear at the four angles of the white prism, and are joined to the central rhomb by the four black lines already mentioned; the sides of these rhombs are parallel to those of the central rhomb, but are not always well defined.—The preceding crystal sometimes exhibits a considerable number of black lines, parallel to the sides of the black rhombs, as in the figure.—Sometimes four white prisms are so arranged, as to present a cross, still retaining the central rhomb and the four black lines; and sometimes the re-entering angles of this cross contain the four additional black rhombs.—In another variety the whole prism is black, excepting its sides, which are invested with a pearly white coat of Macle.

These crystals, often long, are sometimes very minute; in some instances their edges are rounded.

The term Macle, as the name of a distinct species, applies to the

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[*] Diallage metalloïde. HAUY. BRONGNIART.

[†] Hohl Spath. WERNER. Hollow Spar. JAMESON. Macle. BROCHANT.

whitish prisms only. The black rhombs and lines are an argillaceous substance of the same nature, as their gangue, with a few whitish particles of Macle intermixed.

The crystals of Macle present a considerable number of natural joints, which lead to an octaedron for their primitive form. M. Haüy has remarked, that, if we consider the whole crystal as a prism of Macle, the continuity of whose parts is interrupted by the black substance, all these interruptions are in the direction of some of the natural joints. In some cases, at least, the black central prism is diminished in size, while proceeding from one extremity to the other, being somewhat pyramidal.

The structure of the Macle is sometimes foliated, but, in general, more or less imperfectly, or is even compact; its fracture, which varies accordingly, has a feeble lustre, sometimes a little resinous. It scratches glass, when its structure is distinctly foliated.—Its powder is soft, or a little unctuous to the touch. It is opaque, or sometimes translucent. Its color is white or gray, often shaded with yellow, green, or red.—Its spec. grav. is 2.94; and it communicates to sealing wax negative electricity by friction.

The Macle, or white part of the crystal, melts with difficulty by the blowpipe into a white enamel.

(*Localities.*) The Macle is almost always imbedded in a black argillaceous slate.—It has been found in France, Spain, Portugal, Germany, and England. The variety, in which the black prism is merely invested with a thin coat of Macle, is found in the Pyrennees.

In the *United States*. In *Massachusetts*, Worcester Co. at Sterling, two miles from Lancaster, it occurs abundantly in a dark bluish argillite. Its crystals are of various sizes, and sometimes very perfect. Many of them are often found in the space of a few square inches; and, when only their extremities are visible, as is usually the case, the argillite presents a striking and singular aspect.—In *New Hampshire*, 26 miles from Portsmouth, on the road to the White Hills. (*MACLURE.*)—In *Maine*, at Brunswick and Georgetown, in small quantities.

SPECIES 76. NATIVE MAGNESIA. *BRUCE.*

The structure of this new and interesting mineral is very distinctly foliated; and the foliæ frequently radiate from a centre. Their lustre is more or less shining and pearly; and they are somewhat elastic.

The laminæ, when separate, are transparent; in the mass, only semitransparent; and, by exposure to the weather, their surface becomes dull and opaque.

It is soft, and may be scratched by the finger nail, like talc. It slightly adheres to the tongue; and its spec. grav. is 2.13. Its color is white, often tinged with green; its powder is a pure white.

It becomes opaque and friable before the blowpipe, and its weight is diminished. In diluted sulphuric acid it entirely dissolves without effervescence, and yields a limpid solution extremely bitter to the taste. According to Professor Bruce, to whom we are indebted for a knowledge of this mineral, it is composed of pure magnesia 70, water 30.

It is sufficiently distinguished from talc by its solubility in acids.

(Locality.) It is found at Hoboken in *New Jersey*, in veins from a few lines to two inches in thickness; they traverse serpentine in various directions, and, near the sides of the vein, the serpentine is sometimes intermixed with the foliæ of the magnesia.

(Remarks.) We have been induced to form a distinct species of this mineral, because we have seen no satisfactory evidence, that any of the substances, heretofore called native magnesia, ought to be associated with it. The two varieties of the Magnesite of Brongniart, found at Baudissero and Castella Monte, in Piedmont, are the only foreign minerals, hitherto described, which approach in any considerable degree to native magnesia. They, however, differ materially from the mineral just described; *this* is pure, crystallized magnesia, having a foliated structure—*those* are compact, never pure, and, when analyzed, have always yielded more or less carbonic acid. Indeed their composition is so different, that, were they admitted into this species, they must be arranged as a subspecies.

According to M. Giobert, the magnesian substance, found at Castella Monte, contains no carbonic acid, when in the bosom of the earth, but imbibes it from the atmosphere during an exposure of a few weeks; he believes also, that the variety from Baudissero has derived from the atmosphere the carb. acid, which it contains, even when first removed from the quarry. He therefore is inclined to consider both as native magnesia, contaminated with about 15 per cent. of silex.

Giobert, in his two memoirs on these substances, observes, that the magnesian mineral from Castella Monte does not effervesce with acids, when first taken from the earth; while that from Baudissero always discovers more or less effervescence during solution. Brongniart in his mineralogy remarks, that these Piedmontese magnesites do not effervesce in *concentrated* acids. We might therefore suppose, that the total want of effervescence in the mineral from Castella Monte, as stated by Giobert, arose from the great concentration of his acid, had he not also asserted, that this mineral gave no indication of carb. acid, when exposed to the action of fire.—We conclude these observations with the remark of Haüy in his *Tableau Comparatif*, where he says, it would be singular, if this magnesian earth had absorbed, during its exposure to the air, so great a quantity of carbonic acid, as is sometimes indicated by analysis; for, in the mineral from Castella Monte, 46 per cent. of this acid was found by Morveau.

Species 77. MAGNESITE. *BRONGNIART.*

This species, as its name indicates, embraces those minerals, which contain a greater or less quantity of *magnesia*, and, at the same time, cannot be referred to any other species. This magnesia is sometimes combined with carbonic acid, and always with silex, in variable proportions.

It is hardly possible to give any specific, external characters; for these vary with the composition.—In general, however, its spec. gravity is low, not rising much above 2.00, and sometimes falling below 1.00. It is usually more firm and tenacious than chalk, but varies considerably in hardness, and the cohesion of its parts. Most commonly it is a little unctuous to the touch, and receives a polish from the finger nail. Its colors are white, gray, pale yellow, and reddish white. It does not form a paste with water, unless beaten for a long time.

(*Chemical characters.*) By the action of fire it diminishes in bulk, but does not melt, unless much mixed with other earths. Though frequently containing carbonic acid, it seldom effervesces even with the stronger acids, unless they be diluted. If moistened with a small quantity of sulphuric acid, efflorescences or even minute crystals of sulphate of magnesia appear in the course of a few days. This is one of its most decided characters; and by this it may be distinguished from chalk and certain clays.

Some of its varieties have received distinct names.

Var. 1. KEFFEKIL.* *KIRWAN.* Its color is white or gray, usually tinged with yellow. It occurs in dull, opaque masses, which are a little unctuous to the touch, and have an earthy texture. It is often porous, like tufa; and is very light, sometimes swimming on water, and sometimes its spec. grav. reaches 1.60.

It is infusible by the blowpipe, but hardens by the action of heat. It is partially soluble in acids without effervescence. A specimen, analyzed by Klaproth, yielded silex 50.5, magnesia 17.25, lime 0.5, carbonic acid 5.0, water 25.0;=98.25.

It occurs in masses, and is sometimes disseminated in other minerals, or forms a superficial bed. In Natolia, it fills a vein more than

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* Meerschaum. WERNER. JAMESON. L'Ecume de mer. BROCHANT. Magnesite plastique. BRONGNIART.

six feet wide, traversing compact limestone. Though soft, when taken from the quarry, it hardens and becomes white by the action of the air.

(Uses.) This mineral, being soft and tenacious when recently obtained, is moulded into tobacco pipes and other vessels, and afterward slightly baked. Of this substance the Turkey tobacco pipes are formed.

2. ARGILLO-MURITE.* *KIRWAN.* This variety is exceedingly light, and swims on water, till absorption takes place. Its spec. grav. varies between 1.37 and 0.36. It feels dry and its powder is both very fine and very hard. Its color is grayish white, clouded with yellow.

Its weight and bulk are diminished and its hardness increased by exposure to a porcelain heat, but it does not melt. It does not effervesce in acids; and, according to Fabroni, contains silex 55, magnesia 15, alumine 12, lime 3, water 14, iron 1.

This substance, found near Castel-del-Piano, has been manufactured by Fabroni into bricks, which float on water.

3. *Magnesite of Piedmont.* This is not easily diffusible in water, and is with difficulty formed into a paste. It does not effervesce in *concentrated* acids, and is infusible by the blowpipe. Both its hardness and spec. grav. are variable, and it is sometimes difficult to break.

That, which is found at *Baudissero*, is opaque and very white. It is compact, and has a dull, conchoidal fracture. Though sometimes soft, it is not easily reducible to a very fine powder. Its hardness is sometimes considerable, but is not affected by exposure to the air. It is sometimes mammillary or tuberose.

It contains magnesia 68.0, silex 15.6, carbonic acid 12.0, water 3.0, sulphate of lime 1.6;=100.20. *(GIOBERT.)*

It is found in veins, traversing serpentine.

Another of these Magnesites is found at *Castella Monte.* Its fracture is earthy or slightly conchoidal, and, when recently made, appears white; but, by exposure to the air, it becomes dull, or yellowish. Its thin fragments are translucent. It is unctuous to the touch, adheres to the tongue, and is easily cut by a knife.

It contains magnesia 26.3, silex 14.2, carbonic acid 46.0, water 12.0;=98.50. *(MORVEAU.)* (See remarks on these two Magnesites of Piedmont under the preceding species.)

Both these Piedmontese Magnesites are employed in the manufacture of *porcelain* at Vineuf.

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* Argile legere. BRONGNIART.

4. *Magnesite of Vallecas*, in Spain. It is opaque and grayish white; and has a dull, uneven fracture. When recently obtained, or when moistened, it may easily be cut by a knife. When dry, it swims on water for a short time. It does not diffuse itself in water; but, if beaten for a long time, it forms a paste, which is inferior to that of clay.

It does not effervesce with acids. It does not melt in a porcelain heat, but becomes harder, and diminishes in bulk.

It occurs near Vallecas in Spain, in extensive beds. Flint and cacholong, intimately united with the Magnesite, are found in the fissures of these beds.

This mineral is employed in the manufacture of *porcelain* at Madrid.

5. *Magnesite of Salinelle*, in France. This has a slaty structure. When moist, its thin parts are a little translucent, and its color chocolate brown; but, when dry, it becomes more solid, and its color passes to gray or reddish. It is infusible; but, by exposure to a strong heat, it becomes very white. It contains silex 55, magnesia 22, water 23. (*Vauquelin.*)

6. *Magnesite? of Baltimore*, in the United States. We know not where else to notice this uncommon mineral, till its properties shall have been further investigated. From some experiments it appears to contain magnesia; it effervesces briskly in nitric acid, and is converted by the blowpipe into a light, white powder.

These circumstances have induced us to place this mineral among the Magnesites, from which, however, it differs in most of its physical characters.—Its effervescence in acids seems to exclude it from the preceding species.

It sometimes appears in small, flat prisms with diedral summits, and sometimes in mammillary masses, composed of crystals radiating from a centre, and invested with a yellowish substance. The insulated crystals are white and transparent.

This mineral is found in very narrow veins in serpentine, at the Bare Hills, near Baltimore. (*Hayden* and *Gilmor.*)

(*Remarks.*) It has been seen, that several of the preceding Magnesites are used in the manufacture of porcelain. They may also be advantageously employed in the preparation of sulphate of magnesia (Epsom salt) by the assistance of sulphuret of iron. (*Giobert.*) It should be remembered, that earths, which contain any considerable quantity of magnesia, not saturated with carbonic acid, are injurious to vegetation.

Species 78. Serpentine.* *Kirwan. Jameson.*

This substance, though sometimes strongly resembling other minerals, is, in general, easily recognised. Its grain is more or less fine, and its texture compact. It may always be cut or scraped with a knife, sometimes with difficulty, and often very easily; but it never yields to the finger nail.

Serpentine usually presents some shade of green, varying from a deep green to greenish gray, often intermixed with yellow, and sometimes with red, &c. The color is sometimes uniform, but more frequently different colors appear in spots, stripes, veins, &c. and in polished specimens sometimes resemble the colors of a *serpent*; hence the name. Its colors and their peculiar arrangement are somewhat characteristic.

Its fracture varies even in the same specimen; it is frequently splintery, even, or conchoidal, but sometimes uneven or earthy, or a little slaty. It is dull, or possesses only a feeble lustre. Its surface, which is sometimes glossy, like varnish, is soft to the touch; but its powder is decidedly unctuous. Its spec. grav. usually lies between 2.57 and 2.70. It sometimes moves the magnetic needle, and even possesses polarity.

(*Chem. characters.*) Before the blowpipe it hardens, yet does not melt; but, when impure, is reduced to a frit. A specimen, analyzed by Chenevix, yielded magnesia 34.5, silex 28.0, alumine 23.0, lime 0.5, water 10.5, oxide of iron 4.5; =101. The proportion of magnesia varies from 23 to 36 per cent. But, as Klaproth found no alumine in Serpentine from Saxony, perhaps magnesia and silex are the only essential ingredients. It usually contains the oxide of iron, and sometimes that of chrome. Its analysis, however, must, without great caution, be sensibly affected by the foreign substances, so common in Serpentine.

Serpentine is often nearly allied to the harder varieties of steatite and potstone, and may sometimes resemble even slaty chlorite or certain varieties of argillite.—Its degree of hardness, and its colors, or their peculiar arrangement, are its most distinctive characters in these cases.

It presents two varieties, which sometimes pass into each other.

Var. 1. precious serpentine.† *Jameson.* Its colors are uniform; they are generally leek green or blackish green, often more or less shaded with yellow. It is always translucent, and the transmit-

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* Serpentin. Werner. Serpentine. Brochant. Brongniart. Roche serpentineuse. Hauy.

† Edler Serpentin. Werner. Serpentine noble. Brongniart. Brochant.

ted light has usually a tinge of yellow, even when the reflected light is a deep green; for the same reason the splinters or scales on its fracture are very often yellowish.

Some of the hardest Serpentines belong to this variety. Its fragments often have very sharp edges. Its fracture, though variable, is perhaps most frequently conchoidal or splintery. Its lustre is often more or less glistening and waxy.

2. COMMON SERPENTINE.* *JAMESON.* It presents numerous shades of green, varying from leek green, greenish black, or brownish black to greenish or bluish gray, with much yellow or brown intermixed; it is sometimes yellow or red. These colors, seldom uniform, are arranged in stripes, veins, clouds, spots, dots, &c. Hence a specimen of this Serpentine frequently resembles a compound rock. It is opaque, or translucent at the edges.

Its hardness is often less, than that of precious Serpentine. Its fracture is nearly dull, and presents most of the varieties already mentioned. When moistened, it frequently exhales an argillaceous odor.

(Geological situation.) Serpentine is associated both with primitive and transition rocks; and occurs in masses or beds, which are sometimes extensive, or constitute even whole mountains.

The oldest Serpentine exists in beds in gneiss, mica-slate, and argillite, and is usually accompanied or even mixed with granular limestone, with which indeed its beds sometimes alternate. This formation embraces most of the precious Serpentine, and is much more rare than the following.

A second or more recent formation, consisting chiefly of common Serpentine, occurs in large masses, or extensive beds, or forms even whole mountains. It rests on primitive rocks, or is associated with those of the transition period.

Serpentine, especially the common variety, embraces other minerals, in veins or in beds, or disseminated in masses more or less large. Among these are steatite, talc, asbestus, magnesite, lithomarge, &c. also quartz, garnets, magnetic iron, chromate of iron, &c. It seldom contains metallic substances in sufficient quantity to be explored. At Cornwall, native copper, mixed with steatite, is found in veins, traversing Serpentine; and in Piedmont beds of magnetic iron sometimes alternate with those of Serpentine.

(Localities.) This mineral is not rare. At Zöblitz, in Saxony, it is very abundant, and its quarries have been long explored.—It is very common in Corsica, and very beautiful at Portsoy in Scotland. Humboldt has observed a remarkable Serpentine in the Upper Palatinate.

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* Gemeiner Serpentin. WERNER. Serpentine commune. BRONGNIART, BROCHANT.

It acts on the magnetic needle at the distance of more than twenty feet, although it presents no indications of magnetic iron. The southern parts of this mass possess north polarity, and the northern parts the reverse.—At the Lizard Point in Cornwall, Serpentine is surrounded on all sides by gray-wacke, with which however it is not in contact; in one place a rock, composed of feldspar and diallage, intervenes. (*Berger*)—On the summit of Mount Rose the older Serpentine occurs in horizontal beds. (*Saussure.*)

In the *United States*. In *Maryland*, it occurs at the Bare Hills, near Baltimore, belonging chiefly to the common variety.—In *Pennsylvania*, Serpentine is found in the counties of Montgomery, Chester, &c.—In *New Jersey*, at Hoboken.—In *Connecticut*, near Newhaven, particularly on Milford Hills. The precious Serpentine is imbedded in nodules or irregular masses in primitive limestone, and receives a very high polish. The common variety occurs in extensive beds, connected with limestone, with which it is frequently so blended, as to produce a great variety of figures and colors in slabs, taken from these rocks; its colors are yellow and green. It contains magnetic oxide of iron and chromate of iron, both of which also exist in the limestone. (*Silliman.*)—In *Rhode Island*, near Newport. (*Mease.*)—In *Massachusetts*, near Newburyport, in granular limestone, with which it is often irregularly mingled. The precious Serpentine of this place is often extremely beautiful, and perfectly resembles that of St. Kevens, in Cornwall. Its color is sometimes a deep or even blackish green. It is often traversed by veins of amianthus.

(*Uses.*) Serpentine is easily cut, and the fineness and closeness of its grain render it susceptible of a high polish. It is wrought into little boxes, and various articles for ornamental or even for useful purposes. At Zöblitz in Saxony, several hundred persons are employed in this manufacture.

The aggregate of serpentine and limestone, irregularly mingled, is called *Vert antique*, and constitutes a very beautiful marble.

Species 79. Steatite. (Soapstone.)

Although, in conformity to most mineralogists, Steatite is here separated from talc, it is undoubtedly a variety of that mineral, being the result of a confused crystallization, or of precipitation. (See chemical characters of common Steatite.)

All the varieties of Steatite are so soft, that they may be cut by a knife, and, in most cases, scratched by the finger nail. Its powder and surface are soft and more or less unctuous to the touch. It is seldom translucent, except at the edges. Its fracture is, in general, splintery, earthy, or slaty, with little or no lustre. By friction it communicates to sealing wax negative electricity.

Exposed to heat it becomes harder, but is almost infusible by the blowpipe. It appears to be essentially composed of silex, magnesia, and perhaps alumine.

Var. 1. COMMON STEATITE.* This variety is usually solid, and its texture compact; sometimes it is almost friable, and its texture earthy. Its surface is very often like soap to the touch, and usually receives a polish from the finger nail. It is sometimes so soft, that it may be cut, like soap, and sometimes its hardness approaches that of the softer varieties of serpentine.

In most cases it is translucent at the edges only, and often very feebly. Its color is usually gray or white, seldom pure, but variously mixed with yellow, green, or red, and is sometimes a pale yellow, reddish, or green of different shades. The colors sometimes appear in spots, veins, &c.

Its spec. grav. usually lies between 2.58 and 2.79. When solid, it is somewhat difficult to break. Its fracture is nearly or quite dull, and in most cases splintery or earthy, but sometimes a little slaty, uneven, or conchoidal. When passing into talc, it possesses more or less lustre, sometimes waxy.

Steatite has also been observed in fibrous masses, or in minute threads, traversing more compact varieties, or even other minerals.

It sometimes presents pseudomorphous crystals, which appear to have been moulded in cavities, once occupied by true crystals. Sometimes these crystals have obviously derived their form from hexaedral prisms of quartz, and exhibit even the transverse striæ of these prisms. Sometimes the form is taken from crystals of carbonate of lime.

(*Chemical characters.*) Before the blowpipe it whitens and becomes hard, and is with difficulty reduced into a whitish paste or enamel, often however only at the extremity of the fragment. Vauquelin obtained from a compact, reddish Steatite silex 64, magnesia 22, alumine 3, water 5, iron and manganese 5;=99. A specimen from Bareuth yielded Klaproth silex 59.5, magnesia 30.5, water 5.5, iron 2.5;=98. In the Steatite of Cornwall, he found silex 48.0, magnesia 20.5, alumine 14.0, water 15.5, iron 1.0;=99.

The results of the first two analyses almost perfectly resemble those, which the same chemists obtained from laminated talc, and show beyond a doubt, that Steatite and talc belong to the same species. Further, when compact Steatite is bruised in a mortar or strongly heated, it is, in many cases, obviously composed of very minute foliæ or scales. In fine, Steatite agrees with talc in its composition; and in

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* Speckstein. WERNER. Steatite. JAMESON. Steatite commune. BRONGNIART. BROCHANT. Talc steatite HAUY. Semi-indurated and indurated Steatite. KIRWAN. Soapstone of some.

most of its physical characters, does not so widely differ from laminated talc, as do several varieties of carbonate of lime from calcareous spar. The different electricities, communicated to sealing wax by talc and Steatite, cannot be considered an objection to the identity of the two minerals; for it is well known, that the *kind* of electricity is sometimes determined by very trivial circumstances, as the degree of roughness, friction, &c. in the substances employed.

(*Distinctive characters.*) When Steatite is passing into talc, it is almost impossible to draw a line of distinction; but in most cases the characters already given will be sufficient.—It is sometimes nearly allied to serpentine, and in this case its unctuosity is scarcely perceptible, and it differs chiefly by an inferior degree of hardness.—When friable, like chlorite, it still differs from that mineral by its dullness, greater unctuosity, and infusibility.

(*Geological situation.*) Common Steatite occurs in masses, or veins, or small beds in primitive and transition rocks, more particularly in serpentine. It is sometimes mixed with talc, mica, quartz, and asbestus; or is found incrusting other minerals.—It is sometimes imbedded in wacke; and sometimes occurs in metallic veins.

(*Localities.*) This mineral is not uncommon. That, which is found in Arragon, in Spain, has been called *Spanish chalk*.—In the principality of Bareuth, it occurs in yellowish white pseudomorphous crystals, apparently of the same nature, as the mass of Steatite, in which they are imbedded. The crystals are six-sided prisms, transversely striated; and the same mass contains also crystals of quartz.—The Steatite of Cornwall is impure, and more earthy than usual; it exists in veins traversing serpentine.

In the *United States*. In *Maryland*, at the Bare Hills, near Baltimore, several varieties of Steatite occur in serpentine; it is sometimes fibrous. (*HAYDEN.*)—In *Pennsylvania*, in Montgomery Co. 10 miles from Philadelphia, and other parts of the State.—In *New Jersey*, on the Delaware, opposite Easton; it is white, and suitable for architecture. (*WOODBRIDGE.*)—In *Connecticut*, near Newhaven, &c.—In *Vermont*, the substance, commonly called *soapstone*, is found at Oxford, Grafton, Athens, &c. but the writer knows not, whether it belongs to this variety of Steatite.

2. POTSTONE.* *KIRWAN. JAMESON.* Its hardness is nearly the same, as that of common Steatite; but it is more tenacious, and, though easily cut, it breaks with some difficulty. Its surface is smooth and even unctuous to the touch. Its fracture is uneven, or

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* Topfstein. WERNER. La Pierre ollaire. BROCHANT. Talc ollaire. HAÜY. Serpentine ollaire. BRONGNIART.

earthy, and sometimes slaty or almost foliated; the layers are often undulated. It has usually a moderate lustre, often a little waxy.

It is seldom translucent, except at the edges, and sometimes opaque. Its color is usually greenish gray of various shades, sometimes reddish, or yellowish, or even green; often spotted. Its spec. gravity lies between 2.87 and 3.02; and it usually exhales an argillaceous odor, when moistened by the breath.

According to the analysis of Wiegleb it contains magnesia 38.54, silex 38.12, alumine 6.66, lime 0.41, iron 15.02.

It is often extremely difficult to distinguish this mineral from indurated talc; but, in general, it is less distinctly, foliated, and is less easily broken.

It is usually found in connexion with serpentine; and is sometimes mixed with chlorite, talc, mica, &c. At *Como*, in Italy, is a quarry, which was open in the days of Pliny; hence the name *lapis Comensis.*

(Uses and Remarks.) The substance, employed in the arts under the name of *Soapstone*, usually belongs to Steatite, but sometimes to lamellar or indurated talc. The soapstone of Springfield in Massachusetts, and Francestown in New Hampshire appears to be composed chiefly of talc.—Steatite is not susceptible of a good polish. But its softness and tenacity, in consequence of which it may be cut or turned into articles of various forms, and its property of becoming hard by exposure to heat, render it a useful mineral in the arts. Hence it may be employed for the hearths of furnaces, the sides of fireplaces and stoves, &c. The *potstone* has even received its name from having been manufactured into culinary vessels; and such vessels are in very general use in the country of the Grisons, &c. *(BRONGNIART.)* It resists for a long time the action of the fire.

The common Steatite has even been employed for the purpose of engraving. For, being easily cut, when soft, it may be made to assume any desired form, and afterwards rendered hard by heat; it then becomes susceptible of a polish, and may be variously colored by metallic solutions.

Brongniart supposes, that certain unctuous earths, which savages of the lowest order are known to eat, may be referred to the common Steatite. Thus the inhabitants of New Caledonia employ, as food, a soft, friable, greenish earth, containing magnesia 37, silex 36, iron 17. Humboldt relates a similar fact in regard to a tribe of savages on the banks of the Oronoke in S. America.

SPECIES 80. TALC. BRONGNIART.

The structure of this mineral, sometimes fibrous, is most commonly foliated. The foliæ are more or less flexible, but never elastic. Both its surface and powder are unctuous to the touch. It is so soft, that it may be scratched by the finger nail. When rubbed on cloth, it leaves a whitish trace, often somewhat pearly.

It has always some lustre, which is often strong and pearly, or a little metallic. It is translucent, and in thin plates transparent. Its prevailing colors are green and white with intermediate shades. Its spec. grav. varies from 2.58 to 2.87. When rubbed on sealing wax, it communicates to the wax positive electricity.

Talc is sometimes crystallized in six-sided tables or laminæ, whose primitive form is a prism with rhombic bases.

Before the blowpipe it whitens, its laminæ separate, and their extremities melt into a white enamel. A specimen of common Talc yielded Vauquelin silex 62.0, magnesia 27.0, alumine 1.5, water 6.0, oxide of iron 3.5.

Var. 1. COMMON TALC.* *KIRWAN. JAMESON.* This variety sometimes presents the crystalline form before mentioned; but usually appears in delicate and very flexible laminæ, united, like those of mica, into small masses, and, like those also, easily separable. Its laminæ, sometimes curved or undulated, have usually a shining or even splendent lustre, pearly or metallic; and, when thin, are transparent. Their surface is soft, and, in most cases, very unctuous to the touch. Sometimes, however, the unctuosity of the surface is feeble. Its colors are apple green or greenish white, passing to silver white, and sometimes leek green, reddish or yellowish white.

FIBROUS TALC. The fibres are often large and obviously composed of very narrow, elongated laminæ. Sometimes the mass has the appearance of petrified wood (*ligniform* talc.) Sometimes it resembles coarse fibres of asbestus.

(*Distinctive characters.*) The inferior hardness, want of elasticity, difficult fusibility, and, in most cases, the unctuosity of Talc will distinguish it from mica.—Chlorite and nacrite are fusible; and cyanite, which Talc sometimes resembles, is much harder.

(*Geological sit. and Localities.*) This variety, though not uncommon, is never very abundant. It occurs in primitive or transition rocks; frequently in serpentine. It is often associated with actynolite, limestone, steatite, indurated Talc, &c.

That, which is brought from the mountains of Salzburg and Tyrol

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* Gemeiner Talc. WERNER. Le Talc commune. BROCHANT. Talc laminaire. BRONGNIART. Talc hexagonal et laminaire. HAÜY.

to Venice, is known in commerce by the name of *Venetian Talc.*—In the *United States.* In *Maryland*, it occurs near Baltimore, where it is fibrous, ligniform, &c. and sometimes foliated. (*Hayden.*)—In *Pennsylvania*, Delaware Co. where it is sometimes crystallized. (*Wister.*)—In *Connecticut*, at Haddam, it enters into the composition of granite.—In *Massachusetts*, at Southampton, with sulphate of barytes.—In *Maine*, at Brunswick, in granular limestone with actynolite, and sulphuret of iron; its colors are silver white and apple green.

2. INDURATED TALC.* *Jameson.* It is somewhat harder, less unctuous, and less flexible, than common Talc; indeed its laminæ are sometimes almost destitute of flexibility. Its fracture is foliated, often imperfectly, or almost slaty with curved layers, and sometimes fibrous or radiated; its lustre is somewhat shining and often pearly. Unless in thin plates, it is translucent at the edges only. Its colors are greenish gray, or nearly white, yellowish green, or leek green, and sometimes bluish.

SCALY TALC. Its masses are composed of small scales, rather than continuous laminæ. Its color is pearly white or greenish. It is found in Piedmont; and sometimes called *French Chalk.*

Indurated Talc often strongly resembles steatite, especially the variety called potstone.—It differs from serpentine in its structure, and is also less hard.

(*Geological sit. and Localities.*) It occurs in beds, sometimes considerably extensive, in gneiss, mica slate, argillite, and serpentine, and is accompanied by chlorite, asbestus, &c. At Zillerthal in the Tyrol, it contains tourmaline, staurotide, cyanite, &c.—In the *U. States;* it has been observed near Baltimore in *Maryland*, and at Hoboken, in *New Jersey*, &c.

(*Uses.*) Talc is sometimes used instead of chalk for tracing lines. The common variety forms the basis of the *rouge*, employed by ladies, the Talc being colored by an extract from the Carthamus Tinctorius.

The name Talc is sometimes erroneously extended to mica; and there is indeed sometimes a strong resemblance between the two minerals.

Species 81. Chlorite.† *Brongniart.*

This substance may always be easily cut by a knife, and in most cases it receives an impression from the finger nail. It is sometimes considerably solid, and sometimes friable or earthy. Its masses ap-

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* Verhærteter Talc. Werner. Talc endurci. Brongniart. Brochant.

† Talc chlorite. Haüy.

pear to be composed of minute scales, prisms, or grains, easily separable, sometimes even by friction between the fingers. It is easily reducible to a grayish green powder, which is soft or a little unctuous; its surface also is more or less sensibly unctuous. Its color is almost always some shade of green,* usually very dark. It exhales, when moistened by the breath, an argillaceous odor. By friction it communicates to sealing wax negative electricity. *(HAUY.)*

(Chemical characters.) Before the blowpipe it melts into a scoria or enamel of a gray or blackish color. The results of its analysis are so various, that it is hardly possible to determine what is essential to its composition. Vauquelin obtained silex 26.0, alumine 18.5, magnesia 8.0, oxide of iron 43.0, muriate of soda and potash 2.0, water 2.0 ;=99.50. In another specimen Klaproth found silex 53.0, alumine 12.0, magnesia 3.5, lime 2.5, oxide of iron 17.0, water 11.0; =99. But the results of Hoepfner's analysis are silex 41.15, magnesia 39.47, alumine 6.13, lime 1.50, oxide of iron 10.15, water 1.5; =99.90.

Var. 1. COMMON CHLORITE.† *JAMESON.* It is in masses more or less solid, having an earthy, or very minutely foliated fracture, and a glimmering lustre. These masses are sometimes composed of minute, hexaedral prisms or laminæ, sometimes a little curved. It is opaque; and its color is usually a dark leek green or blackish green, sometimes also mountain or grass green, also brownish, or grayish. Even the paler varieties, when moistened, often exhibit a shade of green.

EARTHY CHLORITE.‡ This subvariety is characterized by the feeble cohesion of its particles; and occurs in friable masses, composed of glimmering scales, or in a loose state.

(Geological situation.) Common Chlorite, whether solid or earthy, is frequently found in primitive rocks, but it never forms very large masses. It occurs in cavities, or in veins, or is disseminated. It is often mixed with quartz, feldspar, carbonate of lime, axinite, &c. sometimes investing or even penetrating and coloring these minerals. Sometimes it forms small beds, containing quartz, feldspar, mica, hornblende, sulphuret of iron, &c. and is often found in metallic veins.—It passes into the following variety.

(Localities.) In the *U. States.* In *Maryland,* near Baltimore, it is abundant.—In *Pennsylvania,* in Chester Co. near the Warwick

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* Hence its name from the Greek, χλωρος, green.

† Gemeiner Chlorit. WERNER. Chlorite commune. BRONGNIART. BROCHANT. Chlorite compacte. HAUY.

‡ Chlorit erde. WERNER. Chlorite earth. JAMESON. Chlorite terreuse. HAUY. BROCHANT.

iron works, it contains sulphuret of iron. *(Seybert.)*—In *Connecticut*, at Brookfield, &c. it is abundant, and near Newhaven it penetrates quartz and calcareous spar. *(Silliman.)*—In *Maine*, at Topsham, in granite, either disseminated, or filling cavities, whose sides are lined with projecting crystals of feldspar.

Common Chlorite is sometimes formed into inkstands, &c. Prof. Silliman has an ancient Indian pipe, made of this substance.

2. SLATY CHLORITE, OR CHLORITE SLATE.* *Jameson.* Its color is blackish green, more or less deep, sometimes mountain green, or greenish gray. It exists in opaque, solid masses, composed of minute scales, like common Chlorite. Its fracture is slaty with layers usually curved or undulated, and glistening. Sometimes its fracture is scaly, or presents small foliæ. Its surface is in some cases very considerably unctuous.

(Geological sit. and Localities.) This variety is found in veins, or thin layers, and sometimes in extensive beds in primitive rocks, especially in argillite. It very frequently contains octaedral crystals of magnetic iron with garnets and quartz.—It exists also in secondary rocks. Sometimes it passes into mica slate, argillite, or greenstone slate.

In the *United States.* In *Pennsylvania,* Montgomery Co. near the Schuylkill, it contains numerous crystals of octaedral iron. *(Seybert.)*—In *Connecticut,* near Newhaven, in thin veins in secondary greenstone; and these veins are divided by still thinner veins of quartz and calcareous spar in the direction of the layers. On the Milford Hills, it appears in layers about one fifth of an inch thick between primitive marble and primitive greenstone; it is soft and unctuous, and not unfrequently stained red by a coloring matter, whose nature is not well known. Near Westhaven, it forms extensive strata, sometimes almost passing into argillaceous slate; but at the beach, one mile below Westhaven, it is decidedly Chlorite slate, and abounds with magnetic oxide of iron. *(Silliman.)* See magnetic iron sand.

3 FOLIATED CHLORITE.† *Jameson.* This Chlorite, which I have never seen, is perhaps a variety of common Chlorite more distinctly crystallized than usual. According to Jameson and Estner, it occurs in six-sided tables a little elongated, and sometimes grouped into cylindrical or conical masses. Its foliæ are usually curved and flexible, shining, and almost opaque. It is nearly blackish green.

At St. Gothard, it is attached to the walls of a vein, traversing mica slate.

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* Chlorit schiefer. Werner. Chlorite Schisteuse. Brongniart. Brochant. Chlorite fissile. Hauy.

† Blättriger Chlorit. Werner.

4. GREEN EARTH.[*] *KIRWAN. JAMESON.* Its color is a pleasant green more or less deep, sometimes bluish or grayish green, and passing to olive or blackish green. Its fracture is dull, and fine grained earthy, or a little conchoidal. It is somewhat unctuous to the touch, and often adheres to the tongue. It is easily reducible to powder. Its spec. grav. is 2.63. *(KIRWAN.)*

It contains, according to Vauquelin, silex 52.0, alumine 7.0, magnesia 6.0, potash 7,5, oxide of iron 23.0, water 4.0 ;=99.5. Klaproth found silex 53, magnesia 2, potash 10, oxide of iron 28, water 6 ;=99. Is it, in fact, a variety of Chlorite ?

(Geological sit. and Localities.) It has usually been found in amygdaloid, porphyry, or basalt, sometimes filling cavities or only lining them, and sometimes investing other minerals. In Bohemia it sometimes forms beds. *(REUSS.)* At Monte Baldo, near Verona, it is explored, as an article of commerce.

In the *United States.* In *New Jersey,* it occurs near Imlaytown. *(SEYBERT.)*—In *New York,* on Hudson's river.—In *Massachusetts,* near Boston, in amygdaloid.

This earth is ground with oil, and employed as a paint.

SPECIES 82. SOMMITE.[†] *JAMESON.*

This mineral, sometimes in grains, is more commonly in small, regular, six-sided prisms, sometimes truncated on the terminal edges ; this six-sided prism is also the primitive form. Its fracture, parallel to the axis, is foliated ; its cross fracture conchoidal ; and its lustre shining. Its angles are sufficiently hard to scratch glass ; and its spec. grav. is 3.27. Its color is grayish white, or greenish gray. It is translucent, and sometimes almost transparent.

By the blowpipe it melts with difficulty into a transparent, homogeneous glass. In nitric acid its transparent fragments become cloudy or partially opaque. It contains silex 46, alumine 49, lime 2, oxide of iron 1 ;=98. *(VAUQUELIN.)*

It does not phosphoresce on hot coals, like certain crystals of phosphate of lime, which it resembles.—It is less hard, than the emerald.

This mineral has been found only in the cavities of lava near Vesuvius, at Mt. *Somma ;* hence its name. It is there associated with mica, hornblende, and idocrase.

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[*] Grün erde. WERNER. La Terre verte. BROCHANT. Talc zographique. HAUY. Chlorite Baldogée. BRONGNIART.

[†] Nepheline. HAUY. BRONG. BROCHANT. Nephelin. WERNER.

SPECIES 83. ANTHOPHYLLITE.* *HAUY. BRONGNIART.*

This substance has been observed only in amorphous masses, whose longitudinal fracture is foliated or radiated, and whose cross fracture is uneven. The lustre of the most perfect laminæ is somewhat metallic. Its natural joints, of which two are much more perfect than the others, are parallel to the faces of a rectangular four-sided prism. —It is rather difficult to break, and strongly scratches fluate of lime, but produces little or no effect on glass. It is feebly translucent at the edges, and its color is brown, tinged with violet. Its powder is whitish, and rough to the touch. Its spec. grav. varies from 3.11 to 3.29.

Before the blowpipe it is infusible. It contains silex 62.66, alumine 13.33, magnesia 4.0, lime 3.33, oxide of iron 12.0, of manganese 3.25, water 1.43. *(JOHN.)*

It is softer, lighter, and has less lustre, than Labrador Stone.—It has been found only at Kongsberg in Norway.

SPECIES 84. PINITE.† *HAUY. JAMESON.*

The Pinite has hitherto been found only in crystals. Their primitive form, and that, which they usually present, is a regular six-sided prism. All its edges are liable to truncation; hence it sometimes appears as a nine or twelve-sided prism, and sometimes four sides are unduly extended at the expense of the others.

These crystals are brittle; their fracture is uneven or splintery, and sometimes more or less foliated, parallel to the sides of the primitive form. Some crystals separate into very distinct layers parallel to their bases. Their lustre, sometimes very feeble, is, on certain parts, glistening, and slightly metallic or resinous.

It is easily scraped by a knife, and sometimes adheres to the tongue. Its powder is unctuous to the touch, and, when moistened by the breath, exhales a strong, argillaceous odor. Its color is brown, tinged with black or red, and sometimes blackish gray. It is nearly or quite opaque, except in the brown varieties, which are a little translucid. Its spec. grav. is about 2.95.

Before the blowpipe it is infusible. A specimen from Saxony yielded Klaproth alumine 63.75, silex 29.5, oxide of iron 6.75. In another from France Drappier found alumine 42.0, silex 46.0, oxide of iron 2.5, loss by calcination 7.0;=97.5.

(Geological sit. and Localities.) It was discovered near Schneeberg, in Saxony, in a mine called *Pini;* hence its name. It is there imbedded in granite.—In Auvergne, France, it is also imbedded in granite; these crystals are sometimes a little translucent, and the

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* Antophyllith. WERNER.

† Pinit. WERNER. Pinite. BRONGNIART. BROCHANT. Micarelle. KIRWAN.

transmitted light has a tinge of green or gray. In the *U. States*. In *Connecticut*, at Haddam, in a micaceous rock ; the crystals are sometimes several inches long and considerably regular. (*Silliman.*)

ARGILLACEOUS MINERALS.

These substances never exhibit crystals, nor even possess a crystalline structure. They appear to be mechanical deposites from water, or the result of decomposition. Although silex and alumine are the predominating ingredients, their proportions are variable, and other earths or even alkalis are occasionally present. By some mineralogists these argillaceous minerals have been unjustly degraded, and their names permitted to appear on the pages of an appendix only, while others, with equal injustice, have exalted them above their just rank, and considered mere varieties as distinct species. We have adopted those divisions, which appeared to be most convenient.

Species 85. Argillaceous Slate.

The minerals, included in this species, have almost always a slaty structure, more or less distinct, with layers either straight or curved. Their hardness is somewhat variable; but they may always be scratched by iron, and frequently by copper. Some varieties are dull, while others possess considerable lustre. Their color is gray, often with shades of blue, yellow, green, red, brown, purple, or black. These colors, always dull, are sometimes uniform, and sometimes in spots, stripes, &c.

They are composed chiefly of silex and alumine; but lime, magnesia, and iron are usually present, and sometimes alkali, carbon, bitumen, manganese, &c.

Var. 1. argillite, or common argillaceous slate.* *Kirwan*. Its longitudinal fracture is slaty; but the layers, either straight or undulated, thick or thin, separate with very different degrees of ease. Sometimes its slaty structure is very indistinct, and the fracture, at least in small specimens, becomes earthy or splintery, and a little conchoidal. It is seldom perfectly dull; frequently its lustre is glistening, sometimes shining, and often a little silky.

Its fragments are usually tabular or splintery. Though a little variable in hardness, it is more or less easily cut or scraped by a knife.

Its streak is grayish white, sometimes with a tinge of red. Its spec. grav. lies between 2.67 and 2.88. It does not adhere to the

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Before the blowpipe it is infusible. It contains silex 62.66, alumine 13.33, magnesia 4.0, lime 3.33, oxide of iron 12.0, of manganese 3.25, water 1.43. *(JOHN.)*

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The Pinite has hitherto been found only in crystals. Their primitive form, and that, which they usually present, is a regular six-sided prism. All its edges are liable to truncation ; hence it sometimes appears as a nine or twelve-sided prism, and sometimes four sides are unduly extended at the expense of the others.

These crystals are brittle ; their fracture is uneven or splintery, and sometimes more or less foliated, parallel to the sides of the primitive form. Some crystals separate into very distinct layers parallel to their bases. Their lustre, sometimes very feeble, is, on certain parts, glistening, and slightly metallic or resinous.

It is easily scraped by a knife, and sometimes adheres to the tongue. Its powder is unctuous to the touch, and, when moistened by the breath, exhales a strong, argillaceous odor. Its color is brown, tinged with black or red, and sometimes blackish gray. It is nearly or quite opaque, except in the brown varieties, which are a little translucid. Its spec. grav. is about 2.95.

Before the blowpipe it is infusible. A specimen from Saxony yielded Klaproth alumine 63.75, silex 29.5, oxide of iron 6.75. In another from France Drappier found alumine 42.0, silex 46.0, oxide of iron 2.5, loss by calcination 7.0 ;=97.5.

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transmitted light has a tinge of green or gray. In the *U. States*. In *Connecticut*, at Haddam, in a micaceous rock; the crystals are sometimes several inches long and considerably regular. (*Silliman.*)

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These substances never exhibit crystals, nor even possess a crystalline structure. They appear to be mechanical deposites from water, or the result of decomposition. Although silex and alumine are the predominating ingredients, their proportions are variable, and other earths or even alkalis are occasionally present. By some mineralogists these argillaceous minerals have been unjustly degraded, and their names permitted to appear on the pages of an appendix only, while others, with equal injustice, have exalted them above their just rank, and considered mere varieties as distinct species. We have adopted those divisions, which appeared to be most convenient.

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They are composed chiefly of silex and alumine; but lime, magnesia, and iron are usually present, and sometimes alkali, carbon, bitumen, manganese, &c.

Var. 1. ARGILLITE, OF COMMON ARGILLACEOUS SLATE.* *Kirwan.* Its longitudinal fracture is slaty; but the layers, either straight or undulated, thick or thin, separate with very different degrees of ease. Sometimes its slaty structure is very indistinct, and the fracture, at least in small specimens, becomes earthy or splintery, and a little conchoidal. It is seldom perfectly dull; frequently its lustre is glistening, sometimes shining, and often a little silky.

Its fragments are usually tabular or splintery. Though a little variable in hardness, it is more or less easily cut or scraped by a knife.

Its streak is grayish white, sometimes with a tinge of red. Its spec. grav. lies between 2.67 and 2.88. It does not adhere to the

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* Thon Schiefer. Werner. Clay Slate. Jameson. Le Schiste argileux. Brochant.

tongue, nor does it always yield an argillaceous odor, when moistened. It is opaque, and its colors are gray, often more or less shaded with blue, green, yellow, red, or black; also grayish black, purplish, reddish, or bluish brown, &c.

It is fusible by the blowpipe into an enamel or scoria. In a variety from Anglesey, Kirwan found silex 38, alumine 26, magnesia 8, lime 4, iron 14. M. Godon, in an Argillite from Roxbury near Boston, which he says was hard and resembled petrosilex, found silex, alumine, lime, potash, soda, and the oxides of iron and manganese.

SHINING ARGILLITE.* Its layers, seldom perfectly straight, are often undulated, sometimes even plaited, and have a lustre more or less shining and silky in one direction. Its colors are gray, yellowish gray, deep bluish gray, &c.

This Argillite is always primitive; and hence never contains organic remains. It abounds with ores. It often much resembles mica slate, into which it passes.

ROOF-SLATE.† In its most perfect state is is characterized by easily splitting into large, thin, and straight layers or plates, which are sonorous, when struck by a hard body. It is dull, or has only a feeble lustre. Its colors are blackish gray, or bluish black, bluish or reddish brown, greenish, &c. It is often sufficiently hard to receive a trace from copper.

It belongs both to primitive and secondary rocks.

(Uses.) This slate, when it possesses the requisite properties, is employed to cover the roofs of buildings. But all roof-slate, mineralogically speaking, is not suitable for the purpose. Some are too solid and do not split easily, or the plates are too thick, or not sufficiently straight; some absorb too much water, and even fall to pieces by the action of moisture and frost; and others contain sulphuret of iron, which hastens their decomposition. Indeed different parts of the same bed seldom furnish slates of equal quality; the upper part is generally too friable, or too much cracked.—Blocks of slate split most easily, when recently taken from the quarry.

When of a dark bluish or grayish black color, and sufficiently soft, it is employed for *writing slates.*

It is also employed for monuments in grave yards. Indeed some varieties of Argillite are used for whetstones and grindstones.

(Geological situation.) Argillite is very abundant in primitive mountains; sometimes also it is associated with transition or secon-

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* Schiste luisant. BRONGNIART.

† Schiste Ardoise. BRONGNIART. Argile schisteuse tabulaire—et tegulaire. HAUY.

dary rocks. It generally appears in extensive strata or beds, seldom perfectly horizontal, often highly inclined, and sometimes even perpendicular. Its beds are sometimes interposed between those of other minerals; and sometimes constitute whole mountains or even chains of mountains.—It has also been observed in veins. (*Werner.*)

Argillite always covers granite, when both occur together; and, when found with gneiss or mica slate, it usually covers them also.

Thus the oldest or shining Argillite usually rests on mica slate, and sometimes alternates with it; it alternates also with gneiss, syenite, and granular limestone. It is sometimes traversed by large veins of other minerals, and abounds with ores, either in beds or veins. The mountains near Potosi and Lima, rich in ores, are said to be composed of this Argillite.

Roof-slate, whether primitive or secondary, is often traversed by layers or thin veins of quartz or carbonate of lime, which divide the strata into rhomboïdal masses.

Argillite sometimes contains beds of novaculite, aluminous and graphic slates, chlorite slate, indurated talc, hornblende, greenstone, &c. It often contains crystals of sulphuret of iron, and other simple minerals.

The organic remains found in secondary Argillite, are chiefly those of the vegetable kingdom, sometimes also of fish and crustaceous animals.

Argillite usually occurs in the vicinity of granite, gneiss, or mica slate. Its mountains have rounded summits with gentle acclivities, and do not present rough and steep cliffs, like those of granite and gneiss; they are generally covered by a fertile soil.

Argillite passes by insensible shades into chlorite slate, petrosilex, gray-wacke slate, &c.

(*Localities.*) Argillite abounds in various parts of the *United States*, but we shall mention only some of the varieties, which have been, or may be, employed as roof-slates. In *Pennsylvania*, Wayne Co. it exists on the banks of the Delaware, about 75 m. from Philadelphia; this slate is of good quality. (*Mease.*)—In *New York*, at New Paltz, Ulster Co.—and at Rhinebeck, Dutchess Co.—In *Vermont*, at Dummerstown, in strata nearly vertical; at Rockingham; and at Castleton, where it is of a pale red. (*Hall.*)—In *Maine*, at Waterville and Winslow on the banks of the Kennebec, about 20 miles above Hallowell; it separates into smooth and regular tables.

2. SHALE.* *KIRWAN.* This variety often differs but little from secondary Argillite, and it is sometimes difficult to distinguish them. It is generally less solid and softer than the Argillite, and is often very easily cut by a knife; its spec. grav. is also usually less, being about 2.64. It adheres somewhat to the tongue, yields an argillaceous odor, absorbs water considerably, and often gradually falls to pieces in that liquid, but never forms a paste.

Its fracture is slaty, sometimes nearly earthy, and is dull, unless rendered glimmering by mica. Its layers are often thick, and its surface is frequently knobby. It is opaque, and its colors are gray, bluish or yellowish gray, grayish black, brown, reddish, or greenish.

It is fusible by the blowpipe.

BITUMINOUS SHALE.† *KIRWAN. JAMESON.* This subvariety is blackish brown, sometimes grayish. Its fracture is slaty. It is usually very soft, a little unctuous to the touch, and its streak has some lustre. Its spec. grav. is about 2.00. *(KIRWAN.)*

This Shale is impregnated with bitumen, and burns with a flame more or less bright. It sometimes very slowly effervesces with acids.

(Geological situation.) Shale is associated with various secondary rocks, with which it often alternates. It very frequently accompanies coal; and indeed the presence of Shale is considered a *very strong indication* of the existence of coal in its vicinity. It often contains mica, and the sulphuret of iron.

The Bituminous Shale is found connected with beds of coal and of the common Shale, into both of which it gradually passes. It sometimes contains impressions of fish.

Shale often exhibits very distinct and complete impressions of vegetables, especially of ferns and reeds. The smaller plants are situated in the direction of the strata; and when the two layers, between which a plant is contained, are separated, one of them presents the impression of the plant, depressed below the surface, and the other bears a corresponding relief. It has, however, been remarked in regard to these plants, that only the upper surface of the leaf is brought to view by the separation of the layers, while the under surface, which bears the parts of fructification, remains attached to the Shale, or, in other words, the relief and the cavity almost always present the same side of the leaf. To explain this, it has been suggested by Brugnières, that the relief or projecting part is composed of the substance of

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* Schiefer Thon. WERNER. Slate Clay. JAMESON. L'Argile schisteuse. BROCHANT. Var. of Schiste argileux. BRONGNIART. Var. of Argile schisteuse. HAUY.

† Brandschiefer. WERNER. Le Schiste bitumineux. BROCHANT. Schiste argileux bitumineux. BRONGNIART.

the leaf, penetrated by carbon, or by particles of Shale, and that the under surface of the leaf, in consequence of its roughness, has contracted with the Shale a stronger union, than the upper surface.

(Localities.) Shale is found in various parts of the *United States*, as in *Virginia* and *Ohio*, where it is connected with coal;—in *Pennsylvania* with coal and anthracite;—in *Rhode Island* with anthracite; and is more or less marked with vegetable impressions.—But one of its most interesting localities is at Westfield, near Middletown, in *Connecticut.* This Shale is highly bituminous, and burns with a bright flame. It abounds with very distinct and perfect impressions of fish, sometimes a foot or two in length, the head, fins, and scales being perfectly distinguishable. A single specimen sometimes presents parts of three or four fish, lying in different directions, and between different layers. The fish are sometimes contorted, and almost doubled. Their color, sometimes gray, is usually black; and the fins and scales appear to be converted into coal. The same Shale contains impressions of vegetables, sometimes converted into pyrites. At this place, where an exploration is now making for coal, the strata, hitherto perforated, are thus described by the proprietor of the mine; viz. a soft, black slate with impressions of fish—a gray slate with vegetable impressions—a reddish slate—sandstone—a hard black and blue slate—white sand—soft, black, bituminous slate with particles of coal and pyrites—and lastly a hard slate, which continues, the lower parts being strongly bituminous. *(SILLIMAN.)*

3. NOVACULITE.* *KIRWAN.* This variety is intimately connected with the argillite; but is usually a little harder, and somewhat translucent at its thin edges. Its general structure is more or less slaty, often very imperfectly, but the fracture of the individual layers or of small specimens is splintery, or splintery and conchoidal, and sometimes uneven. It is dull, or a little glimmering.

It may be cut or scratched by a knife, but is still sufficiently hard to receive a trace from a plane or rounded surface of steel, when rubbed against it; and hence is enabled gradually to wear away this metal. Its colors are usually greenish gray, mountain or oil green, gray, or grayish yellow. It sometimes presents two colors, as yellow and blackish or brownish, arranged in stripes; and the structure of the yellowish part is usually more compact, than that of the other. Its spec. grav. extends from 2.60 to 2.95.

It melts into an enamel, which is usually brownish and porous,

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* Wetz Schiefer. WERNER. Whet Slate. JAMESON. Le Schiste a aiguiser. BROCHANT. Schiste coticulé. BRONGNIART. Argile Schisteuse novaculaire. HAUY. Hone Stone. The name Novaculite is from the Latin, Novacula, a razor or knife.

(Geolog. sit. and Localities.) The Novaculite occurs in primitive rocks; and its beds are usually embraced in those of argillite. This mineral was first brought from the Levant. It is found in several parts of Germany; and the striped variety occurs in the vicinity of Namur.

In the *United States.* In *Maryland,* it is found on the Patuxent river, near the road to Washington. *(HAYDEN.)*—In *Vermont,* at Thetford. *(HALL.)*—In *Massachusetts,* at Dorchester, presenting alternate strata of white and brownish red. *(GODON.)*—In *Maine,* near the Forks of the Kennebec, 80 or 90 miles from Hallowell, where it is abundant.

(Uses and Remarks.) The Novaculite is employed in the arts under the names of hone, oil-stone, Turkey stone, and whetstone. Its power of sharpening the same instruments, by which it may also be cut or scratched, undoubtedly arises from the siliceous particles, which it contains.—It will be remembered, that the argillite and certain sandstones are sometimes employed as whetstones. (See petrosilex.)

4. ALUMINOUS SLATE.* Its colors are bluish or grayish black, sometimes iron black, or nearly gray; they are but slightly altered in the streak. Its structure is slaty, with layers either straight or curved. Its fracture, which of course is slaty in the direction of the strata, is sometimes nearly or quite dull in all directions; and sometimes the longitudinal fracture is considerably shining. In some specimens the fracture becomes uneven or earthy. It is more or less easily cut by a knife; and its spec. grav. varies from 2.33 to 2.49.

(Chemical characters.) It reddens by the action of heat; and, by exposure to the atmosphere, it splits and yields an efflorescence, having a saline and styptic taste. In a specimen from Freyenwald Klaproth found silex 40.0, alumine 16.0, carbon 19.6, sulphur 2.8, sulphates of iron, lime, and potash 1.5 of each, oxide of iron 6.4, water 10.7. By the action of the atmosphere the sulphur is converted into sulphuric acid, which, combining with the alumine and sulphate of potash, produces alum; and the salt, thus formed, is extracted, together with the sulphate of iron, by lixiviation. (See alkaline sulphate of alumine.)

SHINING ALUMINOUS SLATE.† Its lustre is slightly metallic, and more or less shining in the direction of the longitudinal fracture; and its layers are frequently curved. It is usually more rich in alum, than the dull varieties.

(Geological sit. and Localities.) Beds of Aluminous Slate are

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* Alaunschiefer. WERNER. Alum Slate. JAMESON. Le Schiste alumineuse. BROCHANT. Ampelite alumineux. BRONGNIART.

† Gläzaender Alaunschiefer. WERNER. Glossy Alum Slate. JAMESON.

contained in transition or secondary argillite, with which they sometimes unite by insensible shades, and, like that variety, are traversed by veins of quartz, carbonate of lime, and pyrites. They sometimes contain globular masses of the same substance; and in some cases are connected with anthracite.

This slate is not uncommon. In the *United States*, it is found in *Maryland*, in Frederick and Washington Cos. and the east side of the Cotocton range is chiefly composed of it. (*Hayden.*)—In *Pennsylvania* in the western Counties. (*Seybert.*)

(*Uses.*) The name and chemical characters of this mineral sufficiently indicate the important use, to which it may be applied. Other substances, however, embracing the principles of alum, may be employed for the same purpose. This is sometimes the case with bituminous shale, fossil wood, certain clays, &c.

5. GRAPHIC SLATE.* This mineral is opaque, and has a grayish or bluish black color, which is not altered in the streak. When rubbed on paper, wood, &c. it leaves a blackish trace. It is easily cut by a knife; and its surface is smooth, and sometimes even unctuous.—Its structure is usually more or less slaty; but small specimens often appear nearly compact with a fracture somewhat conchoidal. It is dull, or has sometimes a moderate lustre. Its spec. grav. is about 2.14.

When heated, it becomes whitish or reddish; and contains, according to Wiegleb, silex 64.5, alumine 11.25, carbon 11.0, oxide of iron 2.75, water 7.5;=97.

(*Geological sit. and Localities.*) This mineral is found in beds in argillite, more particularly in that, which belongs to transition or secondary formations. It often accompanies aluminous slate, to which it is nearly related, and, like which, it sometimes effloresces with the same salts. It occurs also in the vicinity of coal mines. According to Brongniart, those varieties, which have most lustre, a conchoidal fracture, and a surface a little unctuous, approach the graphite, and belong to primitive argillite.

It is found in Spain, Italy, &c. and in commerce is sometimes called *Italian Stone.*—In the *United States*, it is found abundantly on the Susquehannah. (*Hayden.*)—In *Rhode Island*, it accompanies the anthracite.

(*Uses.*) It is employed by artificers for tracing lines; and, when fine, soft, and pure, is used for black crayons in drawing.

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* Zeichen Schiefer. WERNER. Drawing Slate. JAMESON. Argile schisteuse graphique. HAUY. Ampelite graphique. BRONGNIART. Le Schiste a dessiner. BROCHANT. Black Chalk. KIRWAN.

Species 86. Claystone.* *Jameson.*

This mineral often strongly resembles certain varieties of compact limestone, or calcareous marl. Its texture is sometimes porous, and sometimes compact, or even slaty. Its fracture is dull, and earthy, sometimes splintery or conchoidal. In hardness also it differs little from indurated marl, or the softer varieties of compact limestone, and is sometimes nearly friable. Its particles are sufficiently hard to scratch iron, although its masses may be cut by a knife.

It adheres but slightly to the tongue, and yields an argillaceous odor, when moistened. In water it gradually crumbles, but never forms a ductile paste. It is opaque; and its color is gray, often tinged with yellow or blue; also rose or pale red, brown or brownish red, and sometimes greenish. It very often presents white, brown, or greenish spots nearly round, and is sometimes striped.

It hardens by exposure to heat, but is generally infusible by the blowpipe; some varieties melt at their surface. It does not effervesce with acids; by which it is distinguished from those minerals, which it most resembles.

Claystone seems to approach very near to jasper or petrosilex in a state of decomposition, and sometimes to tripoli.

(Geological sit. and Localities.) It has been usually found in primitive earths, and constitutes veins, masses, or large beds. It forms the basis of one variety of porphyry. Sometimes also it is connected with more recent formations.

Near Chemnitz, in Saxony, it is abundant, and resembles a grayish marl with white and reddish spots.—Between Dresden and Freyberg it has a pale rose color with white, brown, and red spots; this is sometimes called *Fruit-stone.*

Species 87. Clay.

The substances, included under this species, are mixtures of silex and alumine; they sometimes contain other earths, or metallic oxides, by the latter of which some varieties are highly colored. Their hardness is never great; they are easily cut by a knife, may in general be polished by friction with the finger nail, and are usually soft to the touch. When immersed in water, they all crumble more or less readily, and become minutely divided. Many Clays, when moistened, yield a peculiar odor, called argillaceous.

Some varieties, by a due degree of moisture and proper management, are converted into a paste more or less tenacious and ductile;

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* Thonstein. Werner. Indurated Clay. Kirwan. L'Argile endurcie. Brochant. Argilolite. Brongniart.

these constitute the basis of the several kinds of Pottery, and have in the arts received more peculiarly the name of *Clay*.—But other varieties, when immersed in water, are resolved into a loose powder, nearly or quite destitute of ductility; these have in the arts received distinctive names, and are employed as pigments, &c.

Some general remarks on the *ductile Clays*, or those employed in pottery, may with advantage precede a description of their several varieties.

These Clays, when duly moistened and kneaded, constitute a paste, possessing a greater or less degree of unctuosity, tenacity, and ductility, and capable of assuming various forms without breaking. These properties, however, exist in very different degrees in different Clays; and hence the distinction into *long* and *short* pastes.—This argillaceous paste, when dried, becomes in some degree solid and hard, and, by exposure to a sufficient degree of heat, these properties are so increased, that it becomes capable of giving sparks with steel. But, when thus hardened, it loses the property of again forming a paste with water, however minutely triturated.

Clays have a strong affinity for water; hence the avidity, with which they imbibe it; hence also they adhere more or less to the tongue or lip.

Clay, when composed of only silex and alumine in any proportions, is infusible in a furnace; and even when somewhat impure, it resists a great degree of heat without melting. But the presence of other earths, particularly of lime, or of a large quantity of oxide of iron with a little lime, renders Clay fusible. By exposure to heat it hardens, diminishes in bulk, and loses somewhat of its weight by the escape of water.

Although Clay is essentially composed of silex and alumine, these ingredients exist in various proportions. In most cases silex predominates, being in the proportion of two, three, or even four parts to one of alumine; sometimes the proportions are nearly equal, and in some cases the alumine predominates.—The power of alumine to impress its character on the compound, although present in less proportion than the silex, probably arises from the greater minuteness of its particles.

The color of Clay may proceed from oxide of iron, or from some bituminous or vegetable matter. Hence some colored Clays, when exposed to heat, become white by the destruction of their combustible ingredient, while others suffer merely a change of color by the action of oxigen on their iron.—The purer clays are white or gray, and suffer little or no change by the action of fire. Many of its varieties gradually pass into each other.

Var. 1. NATIVE ARGILL.[*] *Kirwan.* It occurs in small, reniform masses, having the hardness of chalk and a dull fracture. When viewed with a microscope, it appears to be composed of very minute, prismatic, transparent crystals. Its color is a pure white.

It does not easily form a paste with water; is soft, but dry to the touch; yields an argillaceous odor; and adheres to the lip.

It is infusible by the blowpipe; and sometimes effervesces with acids. According to Bucholz, it contains alumine 31.0, silex 1.0, sulph. acid 21.5, water 45.0, lime 0.5, iron 0.5; =99.5. It seems to be almost a sulphate of alumine.

At Halle in Saxony, it is found immediately under the soil with sulphate of lime. It is said to have been observed in a few other places; but is extremely rare even at Halle.

2. COLLYRITE.[†] This resembles the preceding in many of its characters. It is white and considerably tenacious. It has a very strong affinity for water, which it absorbs with a hissing noise, and becomes more or less translucent. It dries very slowly in the air, separates into prismatic masses, like starch, and loses about *half* its weight.

It is infusible, and does not effervesce in acids. A specimen from Schemnitz in Hungary yielded Klaproth alumine 45, silex 14, water 41.—In Thuringia it has been observed in veins in sandstone.

3. KAOLIN. PORCELAIN CLAY.[‡] *Kirwan.* This most valuable Clay presents itself in dull, friable masses, composed of fine particles slightly cohering. It is usually dry to the touch, and at the same time rather soft, but in some varieties it is a little unctuous. It adheres very little to the tongue.

It absorbs water with rapidity, and soon falls to powder; but, when pure, it is with difficulty formed into a ductile paste. Its color is white, sometimes shaded with gray, yellow, or red. Its spec. grav. varies from 2.23 to 2.40.

At a porcelain heat it becomes hard; but, if pure, it is infusible, and acquires little or no firmness. When its yellowish or reddish color does not arise from metallic particles, it disappears in the fire; but it is often converted into a kind of gray, by which the value of the clay is diminished.

Kaolin is essentially composed of silex and alumine; the proportions are variable, but the silex usually predominates. A specimen

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[*] Reine Thon erde. WERNER. Pure Clay. JAMESON. Argile native. BRONG.

[†] Argile Collyrite. BRONGNIART.

[‡] Porzellan Erde. WERNER. Porcelain Earth. JAMESON. Argile Kaolin. BRONGNIART. Feldspath decomposé. HAUY. La Terre à porcelaine. BROCHANT. Kaolin of the Chinese.

from near Limoges, well washed, gave Vauquelin silex 55.0, alumine 27.0, lime 2.0, water 14.0, oxide of iron 0.5;=98.5.—In another Kaolin, Rose found silex 52.0, alumine 47.0, iron 0.33;=99.33.—In a specimen from Cornwall, Mr. Wedgwood found silex 20, alumine 60, water 12;=92.—The Kaolin from Monkton, Vermont, yielded Professor Smith and others silex 56, alumine 43;=99. In another specimen of the same Kaolin, Prof. Coxe found silex 60, alumine 37, oxide of iron 3; but he remarks that a part of the oxide proceeded from the muriatic acid, which he used.

When pure Kaolin is employed in the manufacture of porcelain, some ingredient must be added as a flux; but some Kaolins contain lime or magnesia, which renders them sufficiently fusible.

(Geological situation.) Kaolin has been observed only in primitive earths, where it occurs in beds or veins, associated with granite, and sometimes with gneiss. There is, indeed, satisfactory evidence, that Kaolin has in most cases, if not in all, originated from the decomposition of rocks, abounding with feldspar; more particularly from *graphic granite*, which is composed almost entirely of feldspar and quartz. In fact, particles of quartz and mica, two ingredients of all granites, are commonly found in beds of Kaolin; and sometimes the Kaolin itself has the form and lamellated structure of feldspar. These beds are often extensive.

Kaolin is sometimes disseminated in granite or gneiss, and, in this case, is supposed by Jameson to be an original deposition rather, than the result of decomposition.

(Localities.) In France, it is found near Alençon and Limoges, and in both places the Kaolin is covered by beds of a red, friable, micaceous rock, having the texture of gneiss. The Kaolin near Limoges is found in the midst of a granite, composed chiefly of feldspar with a little quartz; and this rock exhibits every intermediate degree of decomposition from the unaltered granite to perfect Kaolin. This Clay is white, sometimes a little yellowish, dry and almost rough to the touch. It sometimes contains large grains of quartz. *(*BRONGNIART.*)*—Near Bayonne also it is found in connexion with graphic granite, exhibiting the various stages of decomposition, and sometimes it retains the lamellar structure of the feldspar.—The Kaolin of Cornwall is white, and very smooth to the touch.—This Clay is found also in Saxony, Bavaria, Silesia, &c.—The Kaolin of China is white, and somewhat unctuous.

In the *United States.* In *Georgia*, it is found about 30 miles N. W. from Augusta. It resembles the Kaolin of Limoges, except that its siliceous particles are much finer and scarcely visible; its colors are said to be white and red. (Lit. and Philos. Repert. v. i.)—In *Connect-*

icut, at Washington, Litchfield Co. in small quantities.—In *Vermont*, at Monkton. The bed appears to be very extensive, and is situated on the east side of a ridge of land, running nearly N. & S. The pure Kaolin is covered to the depth of about 15 feet by loose red earth, quartzy sand, and sandy Kaolin, with fragments of quartz, feldspar, and graphic granite interspersed. This bed affords most convincing evidence, that it has originated from the decomposition of graphic granite, which may in fact be observed in all stages of decomposition. In some cases the thin layers of quartz, belonging to the graphic granite, though very friable, still retain their form, while the intermediate feldspar is converted into porcelain Clay. This Kaolin is white, and retains its color in the fire; it is dry to the touch, and does not, like some Kaolins, contain large grains of quartz. Some specimens have a laminated structure, and, when immersed in water, immediately separate into thin plates; thus affording a strong internal evidence of their origin.—It has been employed with advantage for the same purposes as common putty, and in the manufacture of pots for melting glass. (See Lit. and Philos. Repert. v. i. pp. 64, 375.)

4. CIMOLITE.* *HAUY.* The original color of this Clay is grayish white; but by exposure to the air its surface becomes reddish. Its texture is a little slaty, and small scales may sometimes be separated, leaving a smooth, resinous surface. Though rather difficult to break, it receives an impression from the finger nail. It adheres very considerably to the tongue. Its spec. grav. is 2.00.

Before the blowpipe it eventually whitens, but does not melt. It contains silex 63.0, alumine 23.0, water 12.0, iron 1.25 ;=99.25. (*KLAPROTH.*)

It is found in the Archipelago in the island Argentiera, formerly *Cimolus;* and is probably the Cimolia of Pliny. It possesses the detergent property of Fuller's earth in scouring or cleansing cloths, and was thus employed by the ancients; but it has not the unctuosity of that variety of Clay.

5. ADHESIVE CLAY.† Its structure is, in general, very distinctly slaty, and the layers easily separate by the alternate action of dryness and moisture; sometimes its slaty structure is imperfect, and the layers are undulated or irregular. It has a dull, earthy fracture, and adheres very strongly to the tongue or lip. It is dry to the touch, and very brittle. Its color is usually a pale gray, sometimes nearly white, or with a tinge of red, or green, &c. Its spec. grav. is 2.08.

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* Cimolith. WERNER. Argile Cimolithe. BRONG. La Cimolithe. BROCH.

† Klebschiefer. WERNER. Adhesive Slate. JAMESON. Argile feuilletée. BRONGNIART.

In water it falls to pieces, and may be formed into a paste, by which it is distinguished from argillaceous slate.

In a porcelain heat it is softened, and converted into a kind of scoria. It contains silex 66.5, alumine 7.0, magnesia 1.5, lime 1.25, iron 2.5, water 19.0. (*KLAPROTH.*) A more recent analysis nearly inverts the proportions of alumine and magnesia.

(*Localities.*) It has been found principally in France. At Montmartre it occurs between beds of impure sulphate of lime; its layers are sometimes large and straight, like leaves of pasteboard;—at Menil-Montant it embraces the Menilite.

6. POTTER'S CLAY.* *KIRWAN. JAMESON.* This well known and very abundant mineral is sometimes compact in its texture and considerably solid; in other cases, it is more or less friable. It is smooth or a little unctuous to the touch, and, when dry, receives a polish from the finger nail. Its fracture is dull, earthy, or uneven, and sometimes a little conchoidal. Some varieties have a structure more or less slaty.

It is diffusible in water, with which it acquires a great consistency, and, when duly moistened, forms a ductile and tenacious paste, sometimes called a *long paste.* It adheres more or less to the tongue, and yields an argillaceous odor, when moistened.

It is opaque; but some varieties acquire a little translucency in water. Its colors are gray, grayish white, or nearly white, but frequently the white or gray is shaded with yellow, blue, green, or red; sometimes it is dark gray or brown, and sometimes the shade of yellow, green, or red is considerably deep. Its spec. grav. extends from 1.80 to 2.00. (*KIRWAN.*)

(*Chemical characters.*) The varieties of this Clay differ much from each other in the changes, produced in them by the action of fire. Some are infusible in a porcelain heat, but become very solid; others are more or less fusible in that degree of heat, or even much below it.—Some remain white, while others, previously colored, become white, when exposed to great heats; others acquire a red, brown, or yellowish color more or less deep by the action of fire on their iron. The fusibility of Clay is usually produced by the presence of lime, or of both oxide of iron and lime. In general, the most compact and least friable varieties of Potter's Clay are the least fusible.—A specimen of infusible Clay, nearly white and very tenacious, yielded Vauquelin silex 43.5, alumine 33.2, lime 3.5, iron 1.0, water 18.0;=99.2. From another he obtained silex 63, alumine 16, lime 1, iron 8, water 10;=98.

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* Topferthon. WERNER. Argile glaise. HAUY. Argile à potier. BROCHANT. Argile plastique—et figuline. BRONGNIART.

This Clay appears to result from the decomposition of other minerals, and often contains fragments or pebbles of quartz, feldspar, &c. It sometimes effervesces a little, and, by increasing the proportion of carbonate of lime, it passes into marl. Indeed some argillaceous marls are employed for the same purposes, as Clay, from which however they may be distinguished by their considerable effervescence in acids, their easier fusibility, &c.

PIPE CLAY.* *KIRWAN. JAMESON* This constitutes the purest kind of Potter's Clay. It is gray, grayish white, or nearly white, and sometimes has a tinge of yellow.—It is infusible, but becomes white, when exposed to a great heat, although in a more moderate heat it sometimes assumes a bluish gray color.

It is abundant in Devonshire, whence is obtained much of the Clay, employed in the manufactories of Staffordshire, &c.

VARIEGATED CLAY.† *JAMESON.* This is distinguished by its variegated colors, consisting chiefly of different shades of white, red, and yellow, arranged in spots, stripes, &c. Its structure is sometimes a little slaty. It has the other characters of Clay; but, according to Jameson, it does not form so good a paste, as Pipe Clay.

LOAM.‡ *JAMESON.* This is nothing more than Potter's Clay mingled with sand, and oxide of iron, and sometimes with mica, or carbonate of lime. Its value in agriculture depends much on the proportions of its ingredients. It is sometimes designated as sandy or clayey loam. When mixed with particles of decomposed vegetables, it falls under the denomination of *Mould.*

(Geological situation.) Potter's clay is sometimes found in fissures or veins in primitive rocks. It sometimes constitutes rounded hills, of very moderate elevation and extremely barren, in the vicinity of primitive mountains. Argillaceous hills occur also in the midst of large vallies, surrounded by calcareous minerals, and often contain organic remains. The Clay of these hills is said to be harder and to crumble less easily in water, than that, which is found in the interior of the earth.

Potter's Clay, however, is most frequently found in horizontal beds or irregular masses in alluvial earths, or with the more recent secondary rocks. These beds, often very extensive, seldom appear at the surface of the soil, nor are they often found at a very great depth below. They are often covered by beds of sand; and sometimes by sandstone, shell limestone, chalk, or even buhrstone. Sometimes its beds are interposed between those of muriate of soda, or sulphate of lime, and sometimes they rest on chalk.

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* Pfeifenthon. WERNER. † Bunterthon. WERNER.

‡ Leim. WERNER.

This Clay sometimes contains organic remains of herbaceous plants, or even of trees almost entire; also of large land animals and of marine bodies. Fossils, belonging to the vegetable and animal kingdoms, are sometimes mingled in the same bed, and sometimes are found in distinct strata. The Clay in alluvial earths sometimes embraces shells, the sulphuret and oxide of iron, sulphate of lime, bituminous wood, &c.

The Clay, which is found in volcanic countries, is by some attributed to the decomposition of more solid minerals, and by others to those eruptions of argillaceous mud, which sometimes proceed from volcanic mountains.

To the existence of Clay beneath the soil, we are chiefly indebted for those springs of water, which rise and flow on its surface; for these beds of Clay arrest the progress of those waters, which filter through the loose, superincumbent soil, and compel them to issue in springs from the sides or bottoms of vallies. Sometimes those waters, which exist in the earth underneath these beds of Clay, are hereby prevented from rising to their proper level, till a perforation is effected, when they suddenly rush up, sometimes nearly to the surface of the soil.

(Localities.) In the *U. States* many valuable Clays appear to have been observed. In *Maryland*, south of the granitic ridge, are extensive beds of white and colored Clays, suitable for manufactures.—In *Pennsylvania*, near Philadelphia, &c.—In *New Jersey*, near Burlington and Bordentown, both white and variegated Clay, suitable for glass house crucibles.

(Uses of Clay in general.) Of all earthy minerals Clays contribute most to the wants and conveniences of man. They constitute the basis of almost every kind of pottery from a beautiful, translucid porcelain to the most homely variety of earthen ware. On this extensive subject, we have room to state a few general principles only.

It will be recollected, that all Clays are essentially composed of silex and alumine; and that this mixture, in any proportions, is infusible in a furnace, whose fire is supported by atmospheric air only. So also pure alumine, or a mixture of alumine and lime in any proportions, is equally infusible; but a compound of these three earths becomes fusible, and most easily when the proportions are alumine one part, lime one part, and silex or siliceous sand three parts. If the proportion of silex be greatly increased, the mixture becomes infusible.

The value of many Clays for the manufacture of the finest kinds of pottery or of porcelain is often much diminished by the presence of iron. For, although a very minute quantity of iron does not communicate color to Clay, unless exposed to the action of a strong fire, it then produces a yellowish or reddish tinge.

The most important property of Clay, viz. that of forming with water a tenacious and ductile paste, capable of becoming hard and solid in the fire, depends on the presence of alumine; while, at the same time, *pure alumine* yields only a *short* paste, which cannot be moulded or extended without breaking.

When those Clays, which contain a large quantity of alumine, are permitted to dry, they contract their dimensions, and become deformed by numerous cracks or fissures; and both these effects are produced in a much greater degree by the action of fire. Even when much mixed with other earths, they crack, while drying in large masses, and sometimes split into regular forms. This contraction of Clay, while drying and baking, is productive of very serious evils in the art of pottery; but may be in part prevented by the addition of a certain quantity of silex, or some other substance, not liable to contract by heat.

According to Brongniart, Director of the celebrated manufactory of porcelain at Sèvres, in France, the general process in all kinds of pottery, made with washed Clays, may be reduced to the following six steps; subject to modification in certain varieties.

1. The washing of the Clay by agitation in water. The siliceous sand subsides, while the finer particles of Clay remain suspended in the water, which in this state is decanted; the Clay is then permitted to precipitate.

2. The composition of *the paste*. This paste essentially consists of Clay, which gives it consistency, when moist, and hardness, when baked; but to the clay is added either silex or hard baked Clay in a state of powder, to prevent cracks, while drying and baking, to give firmness and solidity, and to enable the pottery to resist frequent changes of temperature. Sometimes a fusible ingredient is added to the paste.

3. This paste, after remaining some time in water, is beaten and kneaded, to render it ductile and of uniform consistency, and to drive out the air.

4. The forming of the several articles, either on a wheel, or in a mould.

5. When the articles are sufficiently dried, they are baked in a furnace or kiln; but, in most cases, are previously placed in *seggars* or cases, made of infusible Clay. The baking should be slowly conducted; and, as the heat is more intense, the ware becomes more dense and compact, but, at the same time, more liable to injury by alternate exposure to heat and cold.—In this state, when merely bak-

ed, the finer wares are often called Biscuit, and in appearance resemble fine, white marble, or a tobacco pipe.

6. The last step is the application of a coat of glaze or enamel to preserve the ware from soiling, and from absorbing any liquid, it may contain, when employed in the arts of life. This enamel is varied and modified in some degree according to the nature of the ware. It generally consists of some metallic oxide or earth, and, in many cases, is vitrified before its application to the biscuit. The oxide of lead is a very common ingredient in these enamels, being easily fusible and vitrifiable. But its use, when in large quantities, is dangerous, and often injurious to the health, in consequence of the ease, with which it is acted upon by acids or oils.

The enamel or glaze is generally applied by immersing the ware in water, in which the materials of the enamel, very finely pulverized, are held in suspension; for the ware, having been previously baked, either entirely or in part, rapidly absorbs the water, and thus a thin coat of enamel is uniformly deposited on its surface.

Sometimes the same degree of heat is requisite to fuse the enamel and bake the ware; and in this case the ware is only in part baked to render it absorbent, before the enamel is applied. But, when the enamel is easily fusible, the ware is thoroughly baked, before its application.—It is extremely important, that the expansions and contractions of the enamel should correspond with those of the body of the ware.

The various colors, with which porcelain and other hard wares are often painted, consist of metallic oxides mixed with some suitable flux; the mixture is formed into a paste with gum water, &c. applied with a pencil, and then melted.*

We shall close these remarks by a brief notice of some of the different kinds of ware.

1. *Porcelain.* The paste, of which this is made, approaches so near to fusion, that it becomes a little softened during the baking; but is rendered very compact, hard, and more or less translucid. It is composed of Kaolin, mixed with a little petuntze or feldspar, or sometimes with a flux of silex and lime. The petuntze is fusible,

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* The following ingenious mode of applying colored figures to certain kinds of ware has sometimes been employed in Great Britain. The figures are first cut on a copper plate; the coloring matter, mixed with its flux, and ground to a proper consistence in oil, is applied to the plate, and an impression taken on moist paper; the paper, while moist, is applied to the ware, and then, by gentle agitation in water, is made to drop off, leaving an impression of the figures. The ware is then exposed to the requisite heat. (Thompson's Chemistry.)

and is designed to act as a flux on the kaolin, which, when pure, is infusible; but some kaolins are themselves sufficiently fusible without this addition.

This paste is therefore essentially composed of two ingredients, one of which is infusible, and the other fusible. When baked, the fusible ingredient melts, and, enveloping the other, renders the porcelain translucid. Such porcelain will not melt, when afterwards exposed to a violent heat. But, as all white and translucent earthen wares are often called porcelain, we sometimes find porcelains, that are fusible.

The enamel is composed of the same petuntze, and is applied to the ware when only in part baked. The requisite heat is about 140° W.

Manufactories of fine porcelain have been long established in Saxony. The porcelain of Sèvres, in France, is probably more beautiful than any in Europe. Similar establishments exist near Berlin, at Vienna, and Naples, and in several places in England. At Baudissero in Piedmont, and near Madrid in Spain a magnesite is employed in the manufacture of porcelain.

2. *Flint or Stone ware.* This is composed of pipe Clay and flints, reduced to a fine powder. It is often glazed by the fumes of common salt, which is thrown into the furnace, when the ware is sufficiently baked. This ware sometimes possesses the hardness and infusibility of porcelain, but is not translucid.—The same kind of ware is sometimes glazed with a compound of silex, alkali, and oxide of lead.

3. *Queen's ware.* This differs from flint ware merely in the proportions of the materials. Its yellowish color is derived from the oxide of lead, which, with ground flints and sometimes also flint glass, constitutes its glazing. (*NICHOLSON's* Chem. Dict.)

Other colors may be given by the addition of other oxides; thus a little manganese produces a beautiful black.

4. *Poterie de grès* of the French.*. Its materials are a whitish infusible Clay, and a little sand. It somewhat resembles flint ware.

5. *Common Earthen ware.* This is usually composed of fusible Clays, or sometimes even of marl; and of course must be baked in a moderate heat. Its red color is produced by the oxide of iron. It is usually covered with a glaze, consisting chiefly of the oxide of lead; hence its yellowish color. The glaze is sometimes rendered greenish by the addition of the oxide of copper, or black by that of

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* Vauquelin analyzed several kinds of pottery, in all which he found about $\frac{2}{3}$ silex; from $\frac{1}{5}$ to $\frac{1}{3}$ alumine; $\frac{1}{20}$ to $\frac{1}{8}$ lime; and from 0 to $\frac{3}{100}$ oxide of iron. (BROCHANT.)

manganese, or white by that of tin. Galena or sulphuret of lead is sometimes employed. In fine, this glazing frequently consists of an oxide of lead almost pure.

It ought therefore to be known and remembered by every family, that no earthen vessel, glazed with the oxide of lead, can be *safely* employed in the preparation or preservation of any food or drink, in which an *acid* is contained, or in which it may be produced by fermentation or any other process. It is at the risk of health, or even of life, that pickles, apple sauce, &c. are prepared or preserved in such vessels. Oils and fat also act on the oxide of lead.

Crucibles. These vessels are extremely important in many arts, and particularly in chemistry. The Hessian crucibles are composed of a refractory Clay and sand moderately fine.—Others, equally valuable, and, on some accounts preferable, are made by substituting baked Clay, old pots, or crucibles, reduced to a coarse powder, in the place of the sand.—Sometimes plumbago is mixed with the Clay; hence those, which are erroneously called *black lead* crucibles.

Bricks and Tiles. These are usually composed of the common ferruginous Clays, sometimes ground, but very seldom washed. To prevent the absorption of water by bricks, exposed to the weather, a glaze may be applied at a moderate expense, by throwing common salt into the kiln at its greatest heat. (*KIRWAN.*)

Fire bricks, composed of a refractory Clay, are employed for the interior of ovens, furnaces, &c.

The efflorescences, which so often appear on bricks, and destroy their beauty, arise from the mutual action of alkaline and earthy salts, contained in the Clay, or mortar, or in both.

The bricks of ancient Egypt and Babylon appear to have been only dried in the sun.

To the farmer the properties of Clay, loam, and marl are peculiarly interesting.

7. LITHOMARGE.* *JAMESON.* Lithomarge has usually a very fine grain. It is sometimes tender and friable, and sometimes more or less indurated; in the latter case it has often a smooth and stony aspect. It is brittle, and its fracture is dull, very fine grained earthy, conchoidal, or even. It is smooth or even unctuous to the touch, yields a shining streak, and adheres to the tongue. Its colors are white or gray, either pure, or tinged with yellow or red; also yellow, blue, brown, or red of different shades; they are sometimes in spots, clouds, veins, or stripes.

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* Steinmark. WERNER. Argile Lithomarge. HAUY. BRONGNIART. La Lithomarge. BROCHANT. Lithomarga. KIRWAN.

In water it falls to powder, but does not form a paste. The harder varieties crumble slowly, and at first fall into fragments. Its spec. grav. is moderate.

It is infusible by the blowpipe, unless very impure. It appears to be a very fine clay, sometimes containing magnesia.

It differs from Potter's clay by the fineness of its grain and its inability to form a paste with water;—when it resembles Fuller's earth, it still differs by its adhesion to the tongue.—It appears to have been sometimes confounded with claystone, or, more correctly perhaps, certain minerals are intermediate between Lithomarge and claystone.

(Geological sit. and Localities.) It sometimes occurs in fissures or veins, which traverse gneiss, porphyry, serpentine, and other primitive rocks. It is found also in roundish or irregular masses in the cavities of basalt, amygdaloid, &c. and hence probably its name of Lithomarge, or Stone marrow.—It also accompanies metallic substances, as tin and mercury.

At Planitz, in Saxony, it occurs in beds, which rest on coal; it presents various colors, among which a violet blue predominates, and has been called *terra miraculosa*, or wonderful earth.

In the *U. States*, it has been found in *Maryland*, at the Bare Hills, near Baltimore;—and in *Pennsylvania*, Montgomery Co. and in both instances in serpentine.

MOUNTAIN SOAP.* *KIRWAN.* It is smooth and soapy to the touch, and adheres strongly to the tongue. Its streak has a shining, resinous lustre. It writes on paper; and has a black, brownish black, or grayish color. It contains silex 44.0, alumine 26.5, lime 0.5, water 20.5, oxide of iron 8.0;=99.5. *(BUCHOLZ.)*

It has been found in secondary rocks, belonging to the trap formation; chiefly in Poland and the island of Skye. *(JAMESON.)*

8. **FULLER'S EARTH.**† *KIRWAN. JAMESON.* This earth is unctuous to the touch, receives a polish from the finger nail, and has but little and sometimes no adhesion to the tongue. It is often considerably compact, but is very tender, and sometimes almost friable. Its fracture is dull, sometimes earthy or uneven, and sometimes a little conchoidal or splintery. Some varieties have a slaty structure.

In water it readily falls to powder, but is not much diffused; it forms a kind of pap, possessing very little ductility. It does not froth nor lather in water. Its colors are greenish white, greenish gray, olive green, grayish white, yellowish gray, brownish, or reddish,

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* Berg Seife. WERNER. Rock Soap. JAMESON.

† Walker Erde. WERNER. La Terre à foulon. BROCHANT. Argile smectique. HAUY. BRONGNIART.

sometimes marbled or striped. The shade of green is very common, and may often be made more distinct by moisture.

(Chemical characters.) It sometimes blackens, when first exposed to heat, but, by an increase of temperature, it becomes white, thus indicating the presence of a combustible. That from Hampshire, Eng. melts into a brownish, spongy mass; and contains, according to Bergman, silex 51.8, alumine 25.0, carbonate of lime 3.3, carbonate of magnesia 0.7, water 15.5, oxide of iron 3.7. Notwithstanding the presence of these carbonates it does not effervesce with nitric acid. Some clays, containing less alumine than this, still form a ductile paste with water.—It passes into potter's clay.

(Geological sit. and Localities.) It occurs in beds more or less extensive. Some of the best varieties are found in England in Hampshire, in Bedfordshire near Woburn, in Staffordshire, Kent, and Surry; it is often associated with sand, sandstone, and sometimes compact limestone.—In Saxony, it is sometimes near the surface of the soil, and sometimes under greenstone slate.

In the *United States*, it has been found in *Maine*, at Newfield, in the County of York. It is said to occur in veins about 20 feet below the surface of the soil; its colors are greenish gray, brownish, or yellowish. Should it prove to be abundant and of good quality, it may become an important acquisition to the public.

(Uses.) This earth is very important in the fulling of cloth. It deprives the cloth of the grease or oil, which has been employed in its manufacture, and thus enables its fibres to curl and intertwine during the fulling. The cleansing property of this earth depends entirely on its alumine, which readily absorbs the grease.—The essential properties of good Fuller's earth are a susceptibility of being diffused through water without forming a paste, and a great degree of fineness, which is indicated by the high polish it receives, when rubbed by the finger nail. Unless the particles of silex are extremely fine, the cloth would receive injury by friction against them. A mixture of oxide or sulphuret of iron is injurious.

9. BOLE.* *KIRWAN. JAMESON.* This appears to be a fine Clay, often highly colored by iron. Its color is reddish yellow of various shades, often with a tinge of brown, sometimes passing to reddish brown, or flesh red, or yellowish brown, or dark brown. It is opaque, or a little translucid at the edges.

It is compact, and has a dull, conchoidal fracture. It is brittle, feels very smooth, or a little unctuous, and receives a polish from the finger nail. It adheres more or less to the tongue, and yields an ar-

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* Bol. WERNER. BROCHANT. Var. of Argile ocreuse. HAÜY. Var. of Ocre rouge. BRONGNIART.

gillaceous odor, when moistened by the breath. Its spec. grav. extends from 1.40 to 2.00. (*Kirwan.*)

In water it falls to powder, but does not form a paste.

By the action of heat it usually becomes dark red or even blackish, and is rendered magnetic. The Bole of Lemnos melts into a dark colored frothy slag; and contains, according to Bergman, silex 47.0, alumine 19.0, carbonate of magnesia 6.2, carbonate of lime 5.4, water 17.0, oxide of iron 5.4.

Its fusibility and the aggregate of its physical characters will serve to distinguish it from lithomarge.

(*Localities.*) The Boles of Armenia and the island Lemnos in the Archipelago have been most celebrated. That of Lemnos was formerly collected by the priests, washed, formed into pastils, and impressed with the seal of Diana, viz. a stag; hence the name *terra sigillata.* At present it bears the seal of the Grand Seignior or governor of the island.—Near Estremoz in Portugal, where it is made into porous vessels for cooling water or wine, to which it communicates a peculiar taste, particularly agreeable to the females of that country, who sometimes chew this earth.—The Bole of Sienna in Italy adheres strongly to the tongue, becomes brown in the fire, and is not easily fusible.

Boles were formerly employed in medicine as an astringent. They are now used as a pigment. According to Bergman, the Bole of Lemnos is detersive, like Fuller's earth.

10. REDDLE.* *Kirwan. Jameson.* It occurs in opaque masses, having a compact texture. Its color is red of different shades, as brownish red, cherry or blood red, and sometimes nearly brick red. It soils the fingers, and leaves on paper a distinct, lively red trace. Its streak also is usually of a brighter red, than its fracture. Its general structure is slaty, and its cross fracture earthy or conchoidal, and dull.

Its hardness differs but little from that of chalk. It is usually dry or even rough to the touch, adhering rather strongly to the tongue, and yielding an argillaceous odor. Its spec. grav. varies from 3.13 to 3.93. (*Jameson.*) In water it falls to powder, but does not form a paste.

When exposed to heat, it assumes a deeper red or blackish color; and, according to Kirwan, melts at 159° W. This mineral differs from Bole by containing more oxide of iron, and hence its greater spec. gravity. It contains more clay, than red iron ochre, into

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* Roethel. WERNER. Var. of Ocre rouge. BRONGNIART. Le Crayon rouge. BROCHANT. Argile ocreuse rouge graphique. HAUY.

which however it gradually passes, and has even been arranged with the ores of iron, although it is never smelted as such.

It is usually found in small beds or irregular masses in argillite, and particularly in the more recent formations.—This mineral is explored chiefly in Germany and France.

(Uses.) It is employed in making crayons or pencils for drawing. The coarser varieties are used by the carpenter. In making these crayons, the Reddle is sometimes reduced to powder, washed in water, formed into a paste with a solution of gum Arabic, moulded into cylinders, and then slowly dried in the shade. They are improperly called *red lead pencils;* and the mineral itself is often called *Red Chalk.*

11. YELLOW EARTH.* *KIRWAN. JAMESON.* Its color is ochre yellow, either light or dark. It is very soft, and sometimes friable. It soils the fingers, and leaves a trace on paper. It is smooth or a little unctuous to the touch, receives a high polish from the finger nail, adheres very considerably to the tongue, and yields an argillaceous odor. Its fracture is earthy or a little conchoidal, and dull. In water it falls into fragments and eventually into powder, but it does not form a paste.

When sufficiently heated, it becomes *distinctly red,* by which it is distinguished from yellow iron ochre; it melts, according to Kirwan, at 159° W.

It sometimes occurs in thin, horizontal beds between banks of sand, being covered by Potter's Clay or sandstone.

(Localities.) In the *United States,* it occurs in *Pennsylvania,* Northampton Co. near Fort Allen;—and in *New Jersey,* at Batsto. *(SEYBERT.)*

(Uses.) It is sometimes employed in its natural state as a yellow paint; but is more frequently converted into *red* by calcination, and sold under the names of *Prussian red, English red,* &c. Brongniart says, that the English red, used in polishing gold, &c. is a pure oxide of iron.

12. UMBER.† *KIRWAN. JAMESON.* Its color is bistre brown, or brown with a tinge of yellow. Its texture is fine and compact, and its fracture even, or a little conchoidal, and dull. It feels dry, receives a polish from the finger nail, and adheres a little to the tongue.

When slightly heated, it becomes reddish, but, by an increase of heat, is again rendered brown, and at length becomes hard with a black, shining surface. It melts at a very high temperature into a

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* Gelbe erde. WERNER. Argile ocreuse jaune. HAUY. Ocre jaune. BRONGNIART. La Terre jaune. BROCHANT.

† Ocre brun. BRONGNIART. Argile ocreuse brun. HAUY.

dark brown glass. It contains silex 13, alumine 5, oxide of iron 48, of manganese 20, water 14. (*Klaproth.*)—It has been confounded with the earth of Cologne, which is an earthy Lignite, and yields a bituminous odor, when heated.

It is found at Nocera, in Spoletto or *Umbria*; and hence its name. The Umber of commerce comes chiefly from the isle of Cyprus.

It is employed in painting, and sometimes in the coloring of porcelain.

Species 88. Alum Stone.* *Jameson.*

This remarkable mineral has a compact texture, and an uneven or earthy, dull fracture. Its hardness is sometimes nearly equal to that of granular limestone, and sometimes much less. Its color is grayish white or yellowish gray. It is tasteless; and its spec. grav. varies from 2.42 to 2.58.

It is insoluble in water; and contains, according to Vauquelin, alumine 43.92, silex 24.0, sulphuric acid 25.0, sulphate of potash 3.8, water 4.0. In this mineral the alum appears to be so united with silex, as to form an insoluble salt. Hence, in the opinion of Vauquelin, calcination is not necessary to acidify the sulphur, but to render the alum soluble. (See alum.) Klaproth obtained the same ingredients in different proportions.

The Alum Stone is found chiefly in a hill at La Tolfa, near Rome, in veins traversing an argillaceous rock.

APPENDIX;

containing minerals, which have not been analyzed, and concerning most of which very little is known.

Species 89. Bergmanite. *Haüy. Brong.*

Its masses are composed of fibres or little needles confusedly grouped, and often so closely applied to each other, that the texture becomes nearly compact. Some of the needles have a foliated, shining fracture. Its color is a deep gray. Its sharp fragments scratch glass, and even quartz in a slight degree. Its spec. grav. is 2.30. When moistened by the breath, it yields an argillaceous odor.

A fragment, exposed to the flame of a candle, or placed on a hot coal, becomes white and friable. It melts by the blowpipe into a white, translucent glass.

It is found at Frederickswarn, in Norway, with a reddish feldspar.

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* Alaunstein. Werner. La Pierre alumineuse. Brochant.

SPECIES 90. CHUSITE. *BRONG. BROCH.*

This mineral is greenish yellow, and translucid. It is soft, and rather brittle. Its fracture is sometimes granular, and sometimes even, with a resinous lustre.

It is easily fusible by the blowpipe into a translucid enamel, containing a few bubbles. It dissolves in acids without effervescence.

It was first found by Saussure in small masses in the cavities of a porphyry near Limbourg in Germany. He has also found it in indurated clay.

SPECIES 91. FUSCITE. *BRONGNIART.*

It occurs in opaque prisms, having four or six sides and an uneven fracture. Its color is greenish or grayish black; its powder is whitish gray. It is soft, and its spec. grav. extends from 2.5 to 3.0.

It is infusible by the blowpipe, but its surface is rendered shining. It bears some resemblance to the Pinite.

It is found near Arendal in Norway in quartz, accompanied with feldspar and brown spar.

SPECIES 92. GABRONITE. *HAUY. BRONG.*

It is in compact masses, having a very close texture. It scratches glass, but scarcely gives fire with steel. Its fracture is, in general, splintery, sometimes even. Its color is usually bluish or greenish gray; and it is translucent at the edges.

It melts with difficulty by the blowpipe into an opaque, white globule.

It is found in Norway; the bluish variety near Arendal with hornblende, compact feldspar, &c. and the greenish variety near Frederickswarn is disseminated in syenite.

SPECIES 93. HAUYENE.* *GISMONDI.*

This mineral has been observed massive, in grains, and in groups of very small crystals, whose form is indeterminable. It is sometimes blue and opaque, sometimes bluish green and translucid. It is brittle, but sufficiently hard to scratch glass. Its fracture is uneven and moderately shining; its spec. grav. varies from 3.1 to 3.3. It is a conductor of electricity.

It is infusible by the blowpipe; and in nitric acid its powder forms a white transparent jelly. It contains, according to Vauquelin, silex 30.0, alumine 45.0, potash 15.0, sulphate of lime 20.5, lime 5.0, oxide of iron 1.0;=82.5.†

It has been found in Italy near Albano, &c. with mica and green

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* Latialite. HAUY.

† This analysis was observed after the Tabular View was printed.

augite; and at Vesuvius in fragments of rocks, ejected from that volcano.

SPECIES 94. IOLITHE. *HAUY.*

This substance has been found in grains, and in regular hexaedral prisms, whose lateral edges are sometimes truncated. Its primitive form is also a six-sided prism. It scratches glass strongly, and even quartz feebly. Its fracture is uneven or imperfectly conchoidal, and vitreous; its spec. grav. is 2.6. It is usually opaque, sometimes translucent, and its color is violet blue, tinged with black; its powder is bluish gray.

If a translucid fragment be so presented to the light, that the visual ray is parallel to the axis of the primitive form, its color is a very intense blue; but, if the ray be perpendicular to the axis, it appears brownish yellow.

Even when in small fragments, it melts with difficulty by the blowpipe into a pale greenish gray enamel.

It is found near Cape de Gate in Spain in an altered greenstone. Its gangue is a decomposed, argillaceous substance.

SPECIES 95. PETALITE. *BRONG. BROCH.*

Its color is reddish, and sometimes grayish white. Its fracture is foliated; the laminæ are interlaced and have a glistening, pearly lustre. It scratches glass, but is scratched by feldspar; and has a spec. grav. of 2.62. It is brittle, and translucent at the edges.—It is infusible by the blowpipe.

It is found at Uton, Sahla, &c. in Sweden.

SPECIES 96. PSEUDO-SOMMITE.* *HAUY.*

It occurs in very minute, regular hexaedral prisms, sometimes truncated on their terminal edges, and also in transparent, shining needles. It is sufficiently hard to scratch glass.

It melts by the blowpipe with some difficulty. Its powder in nitric acid forms a copious jelly; and it is hereby distinguished from the Sommite, which it somewhat resembles.

It has been observed at Capo di Bove, near Rome, in a volcanic product with the Melilite.

SPECIES 97. SIDEROCLEPTE. *BRONG. BROCH.*

It is yellowish green, translucid, and so soft, that it may be scratched by the finger nail. It occurs in reniform masses, sometimes grouped, and having an even fracture with a feeble resinous lustre.

Before the blowpipe it becomes black and shining, but is scarcely fusible.—It was found by Saussure in Brisgaw.

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* Pseudo-Nepheline. BRONGNIART.

Species 98. Spinellane. *Haüy.*

It occurs in hexaedral prisms, terminated by three-sided summits, whose faces stand on alternate, but different, lateral edges at each extremity; the edges of the summits are sometimes truncated. It scratches glass, and has a blackish brown color.

Before the blowpipe it becomes white, and easily melts into a very porous enamel.

It is found on the banks of the lake Laach, department of the Rhine and Moselle, in a rock, composed chiefly of feldspar with quartz, hornblende, mica, and magnetic iron.

Species 99. Spinthere. *Haüy. Jameson.*

Its color is greenish gray; and its crystals at first view somewhat resemble green axinite. They are small and have a strong lustre; their form is an irregular, double four-sided pyramid, whose summits are obliquely truncated. It has a foliated structure, is translucent at the edges, and too soft to scratch glass.—It is easily melted by the blowpipe.

It has been found in Dauphiny, its crystals being attached to calcareous spar.

CLASS III.

Combustibles.

All the minerals, which belong to this class, combine with oxigen, and undergo combustion. Their physical properties sufficiently distinguish them from metals, which, strictly speaking, are also combustibles.—They are sometimes gaseous, sometimes liquid, and sometimes solid. In general, they have a low specific gravity, and are easily broken. They are seldom crystallized. Their colors, in most cases, depend on the nature of the mineral, are hence few in number, and form important characters; they are usually some shade of black, brown, or yellow.

Carbon, hidrogen, and sulphur, either singly, or in combination with each other, constitute the principal ingredients of these combustibles; a little oxigen, or iron, or some earth is often present.

Species 1. Hidrogen Gas.

This gas is twelve or thirteen times lighter, than atmospheric air. It takes fire on the approach of flame, and burns silently, unless mingled in certain proportions with air or oxigen, in which cases it burns with an explosion. This gas, seldom or never found pure, usually holds carbon or sulphur in solution, thus forming the two following subspecies.

Subspecies 1. CARBURETTED HIDROGEN GAS.

It is lighter than air, but heavier than pure hidrogen gas. The color of its flame is bluish, yellowish white, or white, according to the intensity of the combustion, and the proportion of carbon, &c. When exploded with air or oxigen, the products are water and carbonic acid.—It is composed of hidrogen, carbon, and, perhaps in most cases, of oxigen; and is often mixed with carbonic acid, or common air.

This gas is often disengaged from wet marshes, where vegetables are decomposing; it is found also in caverns in volcanic countries; also in mines, particularly of coal, and is by miners called *Fire damp.*

Subspecies 2. SULPHURETTED HIDROGEN GAS.

This gas is a little heavier than air, and has a peculiar odor, somewhat resembling that of rotten eggs. It burns with a bluish or reddish blue flame, and deposites sulphur on the sides of the vessel. Mixed with about an equal bulk of oxigen gas, it burns with explosion, producing water and sulphurous acid; but with a small quantity of common air it burns without explosion. It is absorbed by water, which hereby acquires the odor of the gas, and a nauseous taste. It precipitates metallic solutions, and tarnishes the white metals; hence it blackens paper, which has been previously dipped in a solution of acetate of lead.—It is composed, as its name indicates, of hidrogen and sulphur.

It is frequently found in places, where pyrites are decomposing, in pits of water, which contain putrid animal substances, and in caverns near beds of volcanic sulphur.

This gas is very abundant in certain mineral waters, and characterizes those, which are called hepatic or sulphuretted waters; such as the Harrowgate water, in Yorkshire, England.—Similar waters exist in many parts of the *U. States*, and are sometimes strongly impregnated with the gas.

Sulphuretted waters often contain saline ingredients. They are drunk as deobstruents, or applied externally in cutaneous diseases.

(Localities.) The two gases just described are most abundant in volcanic countries, or in mines; but they are by no means confined to such situations. Hidrogen gas is disengaged in many places in Italy, particularly in the environs of Modena, Barigazzo, &c.—In France, near St. Barthelemi, department of Isere, a gas issues from a pond and from fissures in the surrounding earth; it has no odor, but takes fire on the approach of a lighted candle, and sometimes continues to burn for several months. It proceeds from a gray, friable,

argillaceous slate, and the mountains in the vicinity are calcareous.—Near the Caspian sea, an inflammable gas issues from the earth in such abundance, that the inhabitants employ it as fuel for preparing their food, or even for burning limestone. (*Brongniart.*)—In Campania, is a spring, whose waters, impregnated with sulphuretted hidrogen, sometimes fail; and the gas then rushes with violence from the earth.

In the *United States.* On the banks of the *Great Kanhaway*, near the mouth of the Elk, is a large mass of soft, black earth, into which a pole may be thrust 10 or 15 feet; and from these apertures often proceeds a stream of hidrogen gas, which will continue to burn for some time. (*Maclure.*)—In *New York*, at Honeoye, Ontario Co. a gas was recently discovered issuing from the earth; and, on removing the earth to the depth of about three feet, the gas was found [illegible] proceed from a fissure in a friable, slaty rock, whose surface was covered with a bituminous substance. This gas has the odor of putrid eggs, takes fire on the approach of a lighted taper, and burns with a bluish flame, yielding a smoke, whose odor is like that of burning coal. The earth above the rock resembles that, on which a coal-kiln has been burned, and, when wet, adheres closely to the shovel, with which it is removed. (Lit. and Philos. Repert. v. i.)—Between Chippewa and Niagara Falls, at Steel's mills, an inflammable gas issues from the earth in several places very abundantly; (Dr. *R. Webster.*)—In the town of North-East, Dutchess Co. is a small lake, from the bottom of which proceeds a very pure inflammable gas. (*Akerly.*)

Species 2. Sulphur.* *Kirwan.*

This mineral is easily recognised. Its usual color is yellow with a shade of green more or less distinct, sometimes lemon or wax yellow; when impure it is often brownish or grayish. It is sometimes opaque, usually translucent, and very rarely transparent. It possesses double refraction in a high degree.

Its spec. grav. is about 2.00; and by friction it acquires negative electricity. It is very brittle, and sometimes friable. Wh[illegible] heated by firmly pressing it in the hand, a crackling noise is distinctly heard[illegible] It is tasteless, and has little or no odor, unless rubbed or heated.

Sulphur most commonly occurs in amorphous, compact masses, whose fracture is uneven, or conchoidal, or a little splintery, with a lustre more or less shining.—Sometimes it appears in small fragments or grains, disseminated in other minerals.—Sometimes also it exists

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* Natürlicher Schwefel. Werner. Natural Sulphur. Jameson. Soufre: Hauy. Brongniart. Le Soufre natif. Brochant.

in the state of a loose or slightly cohering powder in the interior of other minerals, or attached to their surface, particularly to that of lava.—In some instances its masses are radiated; and, when volcanic, it sometimes appears in concretions.

Sulphur occurs also in regular crystals, whose predominant form is an elongated octaedron (Pl. IV, fig. 32.), composed of two four-sided pyramids, whose bases are rhombs, and whose sides are scalene triangles. This is the primitive form; and all its secondary forms, which are no less than eight, are produced by truncations, applied to the summits, edges, or angles of the primitive. One of these forms is represented in Pl. IV, fig. 33, where the truncation on the common base of the two pyramids is so large, that the crystal may be viewed as a four-sided prism, terminated by four-sided summits. Sometimes the octaedron is cuneiform. These crystals, usually small, have in some cases a diameter of five inches; their surface is smooth and shining.

(Chemical characters.) When its combustion is slow, the flame is bluish with a suffocating vapor, which is sulphurous acid. But, when the combustion becomes rapid, the flame is white; there is less odor, and the product is sulphuric acid. Native sulphur is often contaminated with certain earths.

(Geological sit. and Localities.) Sulphur is sometimes found in primitive rocks. Thus at Schwartzwald, in Suabia, it is in veins of pyritous copper, which traverse granite.—In the province of Quito, a bed of quartz, containing sulphur, is found in a mountain of mica slate; and in the same province are two sulphur mines in primitive porphyry. *(Humboldt.)*

But Sulphur, when its origin is *not volcanic*, is found most frequently in secondary rocks, particularly in gypsum, and those minerals, which usually accompany gypsum. It exists in irregular masses, or in crystals, or in veins, and sometimes in beds, varying from a few inches to several yards in thickness. Thus in Sicily, in the vallies of Noto and Mazzaro, it occurs in horizontal beds from two feet to more than ten yards in thickness, alternating with beds of gypsum, and accompanied by sulphate of strontian; here also are found the largest crystals of Sulphur.

Sulphur is almost always accompanied by two or more of the following minerals, viz. gypsum, muriate of soda, marl, or clay; it is thus found at Bex in Switzerland, in the island of Sicily, at Wieliczka in Poland, &c.—Sometimes it is contained in carbonate of lime, or in sandstone. It has, in fact, been observed in most places, where salt mines or salt springs exist. At Poligny, department of Jura, France, Sulphur in a loose or slightly indurated state is embraced in the interior of lenticular masses of flint. It is a little mixed with silex.

Sulphur in crusts or thin beds is sometimes found on the surface of the soil in the vicinity of springs, whose waters contain sulphuretted hidrogen gas, which, when exposed to the air, deposites its Sulphur. In Siberia, such deposites are sometimes worth collection.—It may also proceed from the decomposition of animal substances, or of sulphates.

In volcanic countries Sulphur is very common. It is found in the fissures and cavities of lava near the craters of volcanoes, by the heat of which it has been sublimed. It exists in a state of powder, or in crusts, or in irregular masses, or in crystals, or in concretions globular, stalactical, &c.—Of volcanic sulphur mines that of the Solfa terra near Naples is one of the most remarkable. It is a plain, of which the greatest diameter is about 400 yards, surrounded on all sides by steep rocks, and appears to have been the crater of an ancient volcano. The earth is still warm, and through its crevices Sulphur, muriate of ammonia, &c. are sublimed. Large masses of Sulphur are sometimes attached to the sides of the rocks. M. Brieslak supposes this Sulphur to arise from the decomposition of sulphuretted hidrogen gas, which is here very abundant.—In Iceland, it is found in large masses near the surface of the soil, and the earth, which contains it, is constantly warm.—In the islands of Guadaloupe, Martinique, &c.—In the Souffriere of Montserrat, Sulphur sublimes through the fissures of an argillaceous porphyry. The heat is so great, that water, running on the surface, is rendered boiling hot. *(Dr. Nugent.)*

In the *U. States*, a number of springs have been observed, whose waters deposite sulphur. Such are the Clifton springs in Farmington, Ontario Co. *New York.*

(Mode of obtaining Sulphur.) The Sulphur, employed in commerce, is in part collected from sulphur mines; but is chiefly extracted from pyrites, or the sulphuret of iron or of copper. Different processes are employed. Sometimes pyrites and wood are arranged in alternate layers in the form of a large, truncated, quadrangular pyramid. The roasting is continued for several months, the Sulphur itself supporting the combustion, after the wood is consumed. During this process, the Sulphur sublimes, and is condensed and collected in hollows in the upper part of the pyramid, whence it is removed several times in a day.

In other cases, the pyrites is reduced to a coarse powder, and placed in earthen tubes of a conical form, or in iron retorts, where the Sulphur is disengaged and melted, and thence runs into vessels of water. It is thus obtained in Saxony; and 900 pounds of pyrites yield from 100 to 150 pounds of crude Sulphur, which is further purified by distillation, by which it loses about one eighth of its weight. —It is then melted and cast in wooden moulds into cylinders, known in commerce by the name of sulphur or *roll-brimstone.*—When further purified by sublimation, it is called *sublimed Sulphur* or *flowers of Sulphur*.

The uses of Sulphur in chemistry, medicine, and the arts are numerous, important, and sufficiently well known.

Species 3. Bitumen.*

Bitumen, especially when a little heated, may be recognised by its peculiar odor, which to many persons is not unpleasant. Some varieties are liquid, others soft, and others too hard to receive an impression from the finger nail, but, at the same time, very brittle. The liquid and softer varieties yield more or less odor, even when cold.

The spec. grav. of Bitumen is often below 1.00, and never exceeds 1.20, unless the specimen be impure. By friction it acquires negative electricity. When liquid, it is sometimes yellowish or brownish, and sometimes limpid and transparent; but the more solid varieties are black or brown.

It burns easily, yielding a thick smoke, which has a strong, peculiar odor, but not very pungent. There is sometimes a very small earthy residuum after combustion. The solid varieties are easily melted, but, when cool, they are very brittle. Bitumen yields little or no ammonia by distillation. Its principal ingredients are hidrogen and carbon. It is insoluble in water and alkohol, but combines with fixed and essential oils. (*Murray.*)

Bitumen presents several varieties, most of which evidently pass into each other, proceeding from Naphtha, the most fluid, to Petroleum, which is less fluid, thence to Maltha, which is more or less cohesive, and thence to Asphaltum, which is solid. Hence the characters of some specimens are intermediate between two varieties.

Var. 1. NAPHTHA.† *Kirwan.* This variety is fluid and transparent, a little unctuous to the touch, and constantly exhales a very strong odor. Its colors are grayish or yellowish white, sometimes with a tinge of green. It swims on water, and its spec. grav. varies from 0.71 to 0.84.

It takes fire even on the approach of a lighted taper, and burns with a bluish flame, yielding a thick smoke, and leaving no residue.

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* Bitume. Hauy. Brongniart.

† Var. of Erdöl. Werner. Var. of Mineral Oil. Jameson. Le Naphte, Brochant. Bitume Naphte. Brongniart. Bitume liquide blanchâtre. Hauy.

This is the rarest variety of Bitumen, and is seldom found perfectly pure.

(Localities.) One of its most remarkable localities is in Persia, near Baku, on the western shore of the Caspian Sea. The soil is here sandy and marly, and the surrounding minerals are calcareous. The Naphtha is constantly rising in the state of an odorous, inflammable vapor; hence, by inflaming this vapor, the inhabitants obtain a perpetual fire, which, being concentrated in earthen tubes, is employed for preparing food, &c. The Naphtha is here collected at the bottom of pits, which are dug in the surrounding soil to the depth of several yards. It is yellowish, not perfectly limpid, and requires distillation.—It is found also on Mount Zibio, near Modena, &c. In 1802, near Amiano, in the Dutchy of Parma, a spring was discovered, yielding a yellowish Naphtha very abundantly.

Naphtha is employed in Persia, &c. instead of oil in lamps. It sometimes enters into the composition of certain varnishes.

2. PETROLEUM.* *MURRAY.* This Bitumen is evidently an altered Naphtha; it is less fluid and less transparent; it has sometimes an oily consistence or is almost viscid. It is unctuous to the touch, and exhales a strong and rather unpleasant odor. Its spec. grav. sometimes reaches 0.87. It is translucent or almost opaque. Its colors are blackish brown of various shades, reddish brown, brownish yellow, and sometimes greenish yellow.

It burns easily, but less so than naphtha, and exhales a very dense, black smoke, leaving a small earthy residue. By distillation it yields a liquid resembling naphtha, and the remainder has the consistence of pitch or tar.

(Geological sit. and Localities.) This variety is much more abundant, than the preceding. It is found in secondary rocks, more particularly in the vicinity of beds of coal, in the midst of which or of the accompanying minerals it has sometimes been seen to trickle. It is often found floating on the water of certain springs; and sometimes communicates an irised appearance to water, standing in bogs. Near the base of mount Vesuvius, it has been seen rising in a spring from the bottom of the sea. *(BRIESLAK.)*—At Gabian, in France, Petroleum runs from the earth with a stream of water, on which it floats, and is collected for commerce.—At Beckelbronn, near Weissemburg, it is mixed with sand in the proportion of about ten per cent. Boiling water extracts from this sand a glutinous bitumen, like maltha, from which Petroleum is obtained by distillation.—In It-

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[*] Var. of Erdöl. WERNER. Var. of Mineral Oil. JAMESON. Petrol. KIRWAN. Bitume Pétrole. BRONGNIART. Le Pétrole. BROCHANT. Bitume liquide brun et noirâtre. HAUY.

aly, at Amiano, twelve leagues from Parma, it is extracted from a compact, greenish clay by digging deep pits in the form of an inverted cone; the Petroleum collects at the bottom of these pits, and is drawn up in pails.—At mount Zibio, near Modena, it swims on the surface of certain springs of water, situated at the bottom of a valley; the surrounding soil is composed of a friable rock mixed with clay, limestone, and sand, and disengages large quantities of hidrogen gas.—In Transylvania, it occurs in most of the salt mines.—In the kingdom of Ava, near Rainanghong, it is explored by digging deep pits in a hill containing coal; in this hill are about 500 wells, which yield annually 400,000 hogsheads of Petroleum. (*Phillips.*)

In the *United States*, it is found, sometimes abundantly, in *Kentucky*, *Ohio*, the western parts of *Pennsylvania*, and in *New York* at Seneca Lake, &c. It usually floats on the surface of springs, which, in many cases, are known to be in the vicinity of coal. It is sometimes called Seneca or Gennessee oil.

(*Uses.*) When purified, it is sometimes burnt in lamps. Sometimes also it is employed instead of tar; and in some places is used by external application, as a remedy for rheumatism, chilblains, &c.

Petroleum, by exposure to the air, acquires a greater degree of consistence, and passes into the following variety.

3. MALTHA.* This is still less fluid, than the preceding variety; it is viscid and tenacious, like pitch, and sometimes almost solid, especially when the weather is cold. It is unctuous to the touch, exhales a bituminous odor more or less strong, and has a resinous lustre. It is heavier than Petroleum, but usually swims on water. Its color is black, brownish black, or reddish brown.

When burnt, it yields more smoke and soot than Petroleum, and leaves a greater residue.

(*Localities.*) It is found in nearly the same places as Petroleum; and by exposure to the air is said to pass into Asphaltum. Near Clermont in France, it is mingled with the soil, and attaches itself to the feet of those, who walk over it.

(*Uses.*) It is sometimes employed for the same purposes as tar or pitch on cables, in calking vessels, &c. It enters into the composition of varnishes, designed to protect iron from rust, and sometimes forms an ingredient in black sealing wax. The ancients are said to have employed it as a cement in the construction of walls and buildings.

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* Var. of Erdöl. WERNER. Var. of Mineral Oil. JAMESON. Bitume Maltha. BRONGNIART. Bitume glutineux. HAUY. Le Goudron mineral. BROCHANT. Mineral Tar. KIRWAN.

4. ELASTIC BITUMEN.* *HATCHETT.* This variety seems to be intermediate between the softer and harder Bitumens. It sometimes much resembles caoutchouc or India rubber in its softness and elasticity; and, like that, it removes the traces of plumbago, but, at the same time, soils the paper a little.

Sometimes, however, it possesses but little elasticity, being merely soft; sometimes it is almost dry, and cracked at the surface, and sometimes it has a spongy or corky texture. Indeed the same specimen is sometimes in part elastic, and in part dry. Its lustre is somewhat resinous.—Its color is brown of different shades, reddish brown, or hyacinth red, and has sometimes a tinge of green or yellow. It is translucent at the edges. The softer varieties yield a bituminous odor. Its spec. grav. extends from 0.90 to 1.23.

It burns with a bright flame and bituminous odor, and contains five or six per cent. of foreign matter.

(Locality.) This Bitumen has been found only near Castleton in Derbyshire. It is in veins of sulphuret of lead, traversing compact limestone, &c. and is accompanied by quartz, calcareous spar, fluate of lime, asphaltum, &c.

5. ASPHALTUM.† *KIRWAN.* This Bitumen is dry and solid, and usually very brittle, but often too hard to receive an impression from the finger nail. In some varieties its fracture is more or less conchoidal and shining with a resinous lustre; in others it is earthy‡ or uneven and nearly dull. The earthy variety is less hard, than the others, and seems to be intermediate between Maltha and the harder kinds of Asphaltum.

It is opaque or slightly translucent at the edges; and its color is black or brownish black, sometimes with a tinge of red or gray. It has little or no odor, unless rubbed or heated. Its spec. grav. extends from 1.04 to 1.20.

It burns freely, and leaves but little residue, unless the specimen be impure. It often contains a little Petroleum. *(HATCHETT.)*

(Localities.) In Judea it floats on the waters of the Salt or Dead Sea, sometimes called lake Asphaltites. This Asphaltum, also called *Jew's pitch*, is probably fluid, when it rises to the surface of the water, and there becomes solid. It diffuses through the air a dis-

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* Elastiches Erdpech. WERNER. Elastic Mineral Pitch. JAMESON. Bitume elastique. HAUY. BRONGNIART. Mineral Cahoutchou. KIRWAN. La Poix minerale elastique. BROCHANT.

† Slackiges Erdpech. WERNER. Slaggy Mineral Pitch. JAMESON. Bitume solide. HAUY. Bitume Asphalte. BRONGNIART. La Poix minerale scoriacée. BROCHANT.

‡ Erdiges Erdpech. WERNER. Earthy Mineral Pitch. JAMESON.

agreeable odor.—In the island of Trinidad is the celebrated Pitch Lake about 3 miles in circumference. Its surface is covered with Asphaltum, which is traversed by numerous and sometimes very deep crevices, filled with good water, which the inhabitants use, and in which mullet and other fish are caught. When visited by Dr. Nugent, the surface of this lake had the color of ashes, and did not adhere to the foot, from which, however, it received a partial impression, but not so as to render it dangerous to walk upon it. In other seasons of the year, this Bitumen must be much softer, for pieces of unaltered wood were enveloped in it. This Asphaltum is sometimes black and hard with a dull conchoidal fracture; but, in general, it may be easily cut, and its interior appears oily and vesicular. In the candle it melts like sealing wax, and burns with flame, which ceases, when removed. When mixed with oil, tallow, or tar, it acquires fluidity, and may be used as pitch. In one part of the lake is found Petroleum perfectly fluid. (NUGENT.)—Asphaltum is found in veins at Kamsdorf in Saxony, with calcareous spar, &c. and in Cornwall with the sulphurets of lead, copper, &c.—Near Syrsan, on the Wolga, it occurs in veins or globules in compact limestone.—The earthy variety is found in veins, which traverse gray-wacke in the Hartz, and transition greenstone at Prague. (JAMESON.)

(*Uses.*) The ancients appear to have employed both Maltha and melted Asphaltum as a cement in the construction of buildings, &c. Thus the bricks, of which the walls of Babylon were constructed, were cemented by a Bitumen, which was found abundantly in that vicinity on springs, or floating on the river Is, which falls into the Euphrates. Asphaltum or Maltha, either pure, or mixed with a liquid, extracted from the cedar, was employed by the Egyptians in embalming dead bodies.

(*Geological remarks.*) It appears that Bitumen, though sometimes in veins, traversing primitive or transition rocks, is found most frequently in secondary rocks or earths, and chiefly in those, which are calcareous or argillaceous. Other minerals, as limestone and shale, are often impregnated with Bitumen. The black limestone of Seefield in the Tyrol yields by distillation 40 or 50 per cent. of Petroleum.—Pyrites is sometimes impregnated with Petroleum.—It has been remarked, that those countries, which yield Bitumen most abundantly, usually contain mines or springs of muriate of soda.

It is generally believed, that Bitumen has proceeded from the destruction of vegetables and animals in the interior of the earth.

Naphtha and Petroleum may very probably arise from the decomposition of coal, effected by subterraneous fires, either volcanic, or produced by the combustion of coal, or the decomposition of pyrites;

and these fluid Bitumens, by exposure to the air, may gradually pass into a state more or less solid.

Subspecies 1. RETINASPHALTUM. *Hatchett.*

This substance is opaque, ochre yellow, and very brittle. Its fracture is slightly vitreous, and imperfectly conchoidal. Its spec. grav. is 1.13.

It melts into a brittle, black mass, burns with a bright flame, and yields a fragrant odor, which at last becomes bituminous. It contains, according to Mr. Hatchett, resin 55, asphaltum 41, earth 3;=99. This chemist, who supposes all Bitumens to proceed from vegetable resins, considers this substance an imperfectly mineralized resin.

Species 4. Amber.* *Kirwan. Jameson.*

The claims of this substance to the characters of a mineral are, like those of many other combustibles, of a secondary nature.

Its color always presents some shade or tinge of yellow, but varies from yellowish white† to wax or honey yellow‡, sometimes with a tinge of brown, and sometimes it is reddish yellow or hyacinth red. It is translucent and sometimes transparent. It is sufficiently compact and hard to be turned and polished. By friction it easily acquires negative electricity, and its spec. grav. is about 1.08.—It occurs in grains, or in small irregular masses, which have usually a compact texture, and a conchoidal fracture; its lustre is shining or sometimes only glistening. Some varieties have a slaty structure.

(Chemical characters.) It burns with flame and smoke, and with a little intumescence, but does not become very liquid, if the heat be moderate. It exhales, while burning, an agreeable odor, and leaves but little residue. It is not easily soluble in oils, unless gently roasted. By distillation an empyreumatic oil, and the succinic acid are obtained from Amber.

(Distinctive characters.) Amber is distinguished by its fusibility from the mellate of alumine.—It sometimes perfectly resembles copal in its external characters, but, according to Haüy, may be distinguished by the following experiment. If a fragment of Amber, attached to the point of a knife, be inflamed, it burns with some noise and a kind of ebullition, but without becoming so liquid as to flow, and, if it falls on the table, it rebounds a little; whereas a fragment of copal, in similar circumstances, melts and falls in drops, which become flattened,

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* Bernstein. Werner. Succin. Hauy. Brochant. Brongniart.

† Weisser Bernstein. Werner. White Amber. Jameson.

‡ Gelber Bernstein. Werner. Yellow Amber. Jameson.

(Geological situation.) Amber appears to have been hitherto found only in alluvial deposites of sand, gravel, &c. and frequently on the margin of the sea. It generally occurs in small, detached masses, and is often connected with bituminous wood, brittle lignite, or jet, and sometimes adheres to these substances. It is found also in some coal mines, or in beds of clay, or is associated with pyrites. It is sometimes deposited on the shore by the waves of the sea.

Flies, ants, and other insects, and small portions of vegetables are sometimes embraced in Amber. These insects, however, are sometimes introduced by dealers in Amber to increase the value of the specimen.

(Localities.) This combustible exists in many places, but is seldom abundant. It is obtained chiefly from Prussia, on the shores of the Baltic, and particularly from near Koningsberg, where it is explored by digging through banks of sand, and of clay mixed with rolled pebbles, beneath which lies a thick bed of bituminous wood. The Amber is found in small horizontal veins in the interior of the wood, or in stalactites attached to its surface, or in scattered masses, or underneath the wood.—It is found also in the sandy parts of Poland, even at a great distance from the sea, and sometimes mixed with the products of the fir.—At Coboalles, in Asturia, it occurs in coal, and has a slaty structure.

In the *United States.* In *New Jersey,* on Crosswick's Creek, 4 miles from Trenton, it occurs in alluvial soil. The Amber is both yellow and whitish, and occurs in grains or small masses, seldom exceeding an inch in length; it rests on lignite or carbonated wood, or even penetrates it, and is sometimes connected with pyrites. The stratum of lignite, which contains the Amber, rests on a coarse, ferruginous sand, and is covered by a soft bluish clay, embracing masses of pyrites. Above the clay is a bed of sand. *(Wister and Conrad.)*—Amber exists also near Woodbury, in the same State, in large plates in a bed of marl; also at Camden, opposite Philadelphia, where a transparent specimen, almost white, and several inches in diameter, has been found in a stratum of gravel. *(Woodbridge.)*

(Remarks and Uses.) Most naturalists are induced to believe, that Amber is a resinous juice, which once proceeded from certain trees, but has since been gradually mineralized in the interior of the earth. It occurs in masses, whose weight usually varies from some fraction of an ounce to a few pounds; and its largest masses, which are extremely rare, do not much exceed 20 lbs. The largest mass perhaps ever seen was recently found between Memel and Koningsberg, measuring 14 inches in length by 9¼ in breadth, and weighing 21 lbs. (Month. Mag. Oct. 1811.)

The ancients were acquainted with Amber; and Thales, 600 years before Christ, knew that it could be rendered electric by friction; indeed the term *electricity* is derived from the Greek word, *Ηλεκτρος*, signifying Amber.

It is susceptible of a good polish, and is wrought into various ornamental articles. It was much esteemed by the ancients, and is now more highly valued by Asiatics than by Europeans.—It is employed in the composition of certain varnishes; of this kind is the lacquer varnish, applied to philosophical instruments of brass or copper.—The oil and acid of Amber have been used in medicine.—Jet is sometimes sold under the name of *black Amber.*

SPECIES 5. DIAMOND.* *KIRWAN. JAMESON.*

The most essential character of the Diamond is its extreme hardness, by which it is enabled to scratch the corundum and all other minerals without exception. It is usually more or less transparent, but seldom attains that perfect transparency, which crystallized quartz often exhibits.—Its refraction is simple, but very great in proportion to its density, when compared with incombustibles. Whether rough or polished, it acquires positive electricity by friction.

Although so extremely hard, it is easily broken in the direction of its laminæ, presenting a foliated fracture; or rather it yields to mechanical division in four directions, parallel to the sides of a regular octaedron, which is its primitive form. Its external lustre is variable, but its internal lustre is splendent, and of that peculiar kind, called adamantine; sometimes also it is resinous.

The Diamond is without doubt always the result of crystallization, although its crystalline form is often imperfect, or entirely disappears. It sometimes presents its primitive octaedron. But its general aspect is often spheroidal, arising from the convexity of its faces, and the obtuseness of its edges. One of its secondary forms presents forty eight curvilinear faces (Pl. IV, fig. 34.); in this crystal each face of the primitive octaedron is divided into six similar faces, separated from each other by six edges, which proceed from the centre of the primitive face, three of them to its angles, and three to the middle of its sides.—Sometimes its crystals present twenty four faces, and sometimes only twelve.—In fine, the primitive octaedron is so altered in appearance, that its secondary forms are sometimes described as three-sided pyramids, either single or double, or as double six-sided pyramids, or as hexaedral prisms, variously truncated, bevelled, or terminated.

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* Diamant. WERNER. HAUY. BROCHANT. BRONGNIART. Adamas PLINY. Its name is derived from the Greek *Αδαμας*, invincible, in allusion to its extreme hardness.

The faces of the crystals are frequently convex, and the edges a little curved. Sometimes the faces parallel to those of the primitive form are plane, while the others are convex. All these spheroidal modifications seem to result from a tendency in its crystallization to a regular solid with forty eight faces. The crystals are usually small. The integrant particles are regular tetraedrons.

The Diamond also occurs in cylindrical or in small, amorphous grains.

The Diamond is usually limpid, or presents some shade of gray or white, sometimes tinged with yellow; it also exhibits certain shades of green, yellow, orange, red, blue, or brown. Its spec. grav. extends from 3.50 to 3.60.

(Chemical characters.) The Diamond is combustible without any sensible residue; and begins to burn, according to Mackenzie, at 14° W. Newton observed the strong refractive power of the Diamond in proportion to its density, and suggested that it was a combustible. But its combustibility appears to have been first established by experiment in 1694, in the presence of the Grand Duke of Tuscany. Lavoisier ascertained, that, during its combustion in oxigen gas, it yielded carbonic acid; and the subsequent experiments of Tennant, Guyton, Allen, and Pepys seem to have proved, that the Diamond is composed of *pure carbon.* Like carbon, it unites with iron, and converts it into steel.—The experiments, however, of Sir H. Davy with the galvanic fluid appear to indicate the presence of a very minute quantity of oxigen in the Diamond.

M. Biot has recently made some ingenious calculations on the refractive power of carbon, as it exists in carbonic acid, and finds it to be very small; he hence infers, that the Diamond cannot be composed of pure carbon, but must contain about one fourth its weight of hidrogen, from which it derives its great refractive power. We ought, however, cautiously to admit mere calculation in opposition to chemical experiments, especially as, in this case, it does not appear perfectly obvious, that *carbon* in the carbonic acid must have the same refractive power, as *carbon crystallized* in the Diamond.

(Geological sit. and Localities.) The geological characters of the Diamond are but little known. It is always found in alluvial earths; and is most commonly scattered in sand or gravel, which is often very ferruginous, containing clay and rolled pebbles.—Sometimes the Diamonds occur immediately under the vegetable earth, or even in loam; and sometimes under a kind of sandstone. They also occur in sand, which has been deposited by rivers; and have, without doubt, in all cases, been transported from the mountains, not far from the foot of which they are found.

India and Brazil are almost the only countries, which furnish the Diamond. In India, it is found from Cape Cormorin to Bengal, but chiefly in the provinces of Golconda and Visapour, and at the foot of the Orixa mountains in Bengal. The mines at present most esteemed, and which have furnished the most famous Diamonds, are near the junction of the Kisla and Krishna rivers.—In Brazil, the Diamond is found in the District of Serra-do-Frio in a kind of pudding, or a ferruginous earth or gravel, there called *cascalhão*. At the Diamond works on the river Jigitonhonha, when visited by Mr. Mawe, the cascalhão was in part dug from the channel of the river, which had been diverted from its usual course. The low grounds on each side of the river are also rich in Diamonds. (*Mawe.*)

(*Remarks and Uses.*) Diamonds can be cut and polished only by friction against each other, or rather by means of their own powder. They are sometimes sawed by a delicate iron wire, coated with the powder of the Diamond. This art was unknown till the year 1476; and of course the ancients could not have been acquainted with the great brilliancy of the Diamond, as this in so great a degree depends on the art of the lapidary.

The peculiar lustre and play of colors, which the Diamond presents, arise from the great quantity of light, which is reflected; and this copious reflection results not only from the great refraction and dilatation of the rays of light during their passage through this transparent combustible, but also from the inclination of the faces.—According to Newton, the refractive power of the Diamond is to that of quartz nearly as 8 to 3, whereas the density of the former is to that of the latter as 4 to 3.

The *uses* of the Diamond are well known. Those Diamonds, which cannot be cut and polished, are employed for cutting glass, or to furnish powder for polishing other Diamonds, &c. The value of the Diamond increases in a much greater ratio than its weight, which is usually expressed in *carats*; and the carat is divided into four grains, each of which is one fifth less than the troy grain.—The largest Diamond known is about the size of a pigeon's egg, and was formerly possessed by the Empress of Russia. It is said to have been sold for 416,666 dollars and a pension of 16,666 dollars for life.—It is remarked by Haüy with his usual elegance, that the Diamond, though in most cases *colorless* itself, is still capable of dazzling the eye by its brilliant and playful *colors*, constantly fugitive, but perpetually returning.

SPECIES 6. ANTHRACITE.[*] *HAUY. BRONGNIART.*

This combustible, at first view, strongly resembles coal, from which, however, it materially differs. Its color is black, or rather grayish or iron black, sometimes tinged with blue or brown, and sometimes passing to blackish or steel gray. It perhaps never possesses the pure, deep black of coal. It is perfectly opaque.

The Anthracite is harder than the common slaty coal, but is at the same time very easily frangible. It usually soils the fingers more or less, and leaves on paper a dull, black trace. It is not unctuous to the touch. It is heavier than coal, its spec. grav. usually lying between 1.40 and 1.80; and it is a conductor of electricity.

Its texture, sometimes granular or compact, is more frequently slaty. Its fracture is more or less conchoidal with a metallic lustre, which is sometimes even splendent.

(Chemical characters.) The Anthracite burns slowly and with difficulty, yielding little or no flame, nor smoke, nor any bituminous odor. By combustion it affords carbonic acid, leaving a residue of from two or three to twenty per cent. of grayish ashes. It yields no bitumen by distillation; and the feeble flame, which it sometimes presents, appears to arise from the hidrogen of the water, it contains.—The Anthracite, like the Diamond, appears to be essentially composed of pure carbon, but in a very different state of aggregation; it usually contains also a little silex and alumine, and sometimes oxide of iron. The Anthracite of Kilkenny contains about 97 per cent. of carbon;—that of Rhode Island about 94 or 95. *(MEADE.)* Other varieties contain less.—It is sometimes nearly allied to graphite.

(Distinctive characters.) Anthracite may be distinguished from coal by the difficulty, with which it burns, by its greater spec. gravity, and by its composition.—From graphite it differs by being less heavy; and its trace on paper is dull and blackish, whereas that of graphite is a shining metallic gray; and further, graphite is unctuous to the touch.

Var. 1. SLATY ANTHRACITE.[†] This is the more common variety. Its structure, and of course its fracture in one direction, is more or less distinctly slaty; and it usually divides into layers, whose surface is uneven or undulated, and sometimes striated. Its cross fracture is more or less conchoidal. Sometimes it seems to be

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[*] Glanzkohle. WERNER. Glance-coal. JAMESON. Native Mineral Carbon. KIRWAN. Blind Coal of some. Its name is from the Greek, Ανθραξ, carbon or coal.

[†] Anthracite feuilleté. HAUY. BRONG. Schiefrige Glanzkohle. WERNER. Slaty Glance-coal. JAMESON. La Blende charbonneuse. BROCHANT.

composed of brilliant, crystalline laminæ, arranged in various directions. Indeed the Anthracite has been observed in regular, hexaedral laminæ, and perhaps in acute octaedrons. (*Haüy.*)

2. GRANULAR ANTHRACITE.* It occurs in granular masses, which are friable, and strongly soil the fingers.

3. CONCHOIDAL ANTHRACITE.† Its texture is compact, and its fracture conchoidal, often with a very high metallic lustre. It often breaks into large scales or fragments with undulated or uneven surfaces. It sometimes scarcely soils the fingers.

Anthracite also occurs in small globular masses.

4. COLUMNAR ANTHRACITE.‡ This mineral, which has usually been arranged among the varieties of coal, appears to possess the distinguishing characters of Anthracite. It occurs in masses, composed of thick, columnar concretions, parallel, but a little curved. It is very easily frangible, has an imperfectly conchoidal fracture, and burns without flame or odor, leaving a residue of whitish ashes. (*Jameson.*)

This Anthracite has been found chiefly at Mt. Meissner in Hessia, where it is associated with conchoidal Anthracite, &c. and is covered by basalt and greenstone.§

(*Geological sit. and Localities.*) The Anthracite is sometimes in masses, disseminated in other minerals, sometimes in veins, and sometimes in beds, which usually correspond in their directions and windings to the strata of accompanying minerals.

It most frequently occurs in primitive or transition rocks, as mica slate, argillite, &c. and is sometimes connected with secondary rocks. It is hence obvious, that this combustible has not, at least in many cases, proceeded from the decomposition of vegetable substances, which are not supposed to have existed, when the primitive rocks were formed.—In the Pyrennees, it is in veins, traversing an argillite, which contains the Macle.—Anthracite, crystallized in hexaedral laminæ, has been found in Holland on a granitic rock, which is

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* Anthracite friable. BRONGNIART.

† Anthracite compacte. HAUY. Anthracite ecailleux. BRONGNIART. Muschliche Glanzkohle. WERNER. Conchoidal Glance-coal. JAMESON. La Houille éclatante. BROCHANT.

‡ Stangenkohle. WERNER. Columnar coal. JAMESON. La Houille scapiforme. BROCHANT.

§ The Mineralische Holzkohle (mineral charcoal) of Werner is grayish black, with a fibrous fracture, a glistening silky lustre, and sometimes a ligneous texture; it soils the fingers, is light, and almost friable. It burns without flame.—It is found with coal and lignite, in small tabular or irregular masses.

supposed to have been brought from Norway. (*Fleuriau de Bellevue.*)—In Dauphiny, it occurs in irregular masses in a pudding or gray-wacke, composed of fragments of primitive rocks.—Near Allemont in France, at an elevation of more than 2500 yards, it is found between beds of a black slate, which contains vegetable impressions.—At Mt. Meissner in Hessia, it forms part of a bed of combustibles, lying under basalt.—In the island of Arran and some other places it exists in the Independent coal formation.

In the *United States.* In *Pennsylvania,* Northampton Co. on the river Lehigh, and at Wilkesbarre and other places on the north-eastern branch of the Susquehannah. This Anthracite has a strong lustre, and soils the fingers very little. Its spec. grav. is 1.61. (*Woodhouse.*)—In connexion with the Anthracite on the Susquehannah and at Bethlehem is found in thin veins a black, friable substance, having an earthy texture, and soiling the fingers. It appears to be carbon nearly pure, and in a state of minute division. When washed, it is employed as a substitute for lampblack, and is said to be useful in the manufacture of printers' ink. (*Woodbridge.*)—In *Rhode Island,* at Portsmouth, &c. The color of this Anthracite is black or grayish black with a metallic lustre; its structure is slaty; and it soils the fingers very considerably. Its spec. grav. extends from 1.45 to 1.75. It contains about 94 per cent. of carbon, and is not contaminated with sulphur. This Anthracite, sometimes very near the surface, is covered by argillaceous sandstone and shale, the latter of which exhibits vegetable impressions, and sometimes contains indurated talc and asbestus. The strata are inclined, and belong, according to Dr. Meade, to the Independent coal formation.—Anthracite is found also at Providence and Cumberland in the same State. At the latter place, its structure is more slaty than that of Portsmouth, it soils the fingers more, and approaches graphite. (*Meade.*) —In *Massachusetts,* near Worcester, an Anthracite approaching graphite occurs in beds near the surface; it is used as a pigment, &c. (*Meade.*) In fine, it is the opinion of the mineralogist just mentioned, that Anthracite may be found in many places on a line extending from Rhode Island through Worcester in Mass. to Keene and even Hanover in New Hampshire.—In *Maine,* it is said to exist at Thomaston in small quantities.

(*Uses.*) When once ignited, it burns with a strong and durable heat; and indeed much of the difficulty of kindling it may be avoided by the addition of a certain quantity of charcoal, and by a strong current of air judiciously managed.

As it is composed almost entirely of carbon without bitumen or even sulphur, except from the accidental presence of pyrites, it burns without caking, and is very useful in those operations, where a durable and uniform degree of heat is required. Hence its use in smelting iron ore, and the preparation of steel; in burning limestone; in salt-works, and other processes of evaporation; in distillation, preparing malt, &c. &c. But, as it burns without flame, it cannot be employed in reverberatory furnaces; and, as it does not cake, it cannot be used by the smith for those purposes of the forge, where a *hollow* fire is required. We have already remarked, that it is sometimes employed as a pigment.

SPECIES 7. GRAPHITE.* *HAUY. JAMESON.*

The Graphite is dark steel gray, or nearly iron black. It leaves on paper a well defined, shining trace,† which has very nearly the color of the mass, and consists of minute grains. It is perfectly opaque, easily scraped by a knife, unctuous to the touch, and soils the fingers. It is a conductor of electricity, and, when rubbed on sealing wax, till a metallic trace appears, communicates no electricity to the wax. Its specific gravity varies from 1.98 to 2.26. Its streak is shining and metallic.

Its structure is sometimes foliated, but most commonly granular; it is often also a little slaty. Its fracture is uneven or granular, and often seems to present scales or minute foliæ; its lustre is metallic, and moderately shining.

(Chemical character.) Before the blowpipe it burns, and slowly consumes, leaving a small residue of oxide of iron. It is composed of carbon with a small quantity of iron. The proportions, according to Berthollet, are carbon 91, iron 9;—according to Saussure carbon 96, iron 4;—and according to Allen and Pepys, carbon 95, iron 5. It is sometimes contaminated by clay, pyrites, or quartz.

(Distinctive characters.) The Graphite and sulphuret of molybdena often strongly resemble each other, and leave on *paper* very similar traces. But, if a fragment of Graphite be rubbed on porcelain or any fine, white ware, its trace preserves its usual color, whereas the sulphuret of molybdena, thus rubbed, leaves a greenish or yellowish green trace. And further, sulphuret of molybdena, rubbed on sealing wax, communicates to it positive electricity.—The color of its trace will serve to distinguish it from graphic slate and anthracite.

Var. 1. FOLIATED GRAPHITE.‡ This variety is sometimes in

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* Graphit. WERNER. Graphite. BRONGNIART. BROCHANT. Plumbago KIRWAN. Vulgarly called black lead.

† Hence its name, from the Greek, Γραφω, to write.

‡ Graphite cristallisé et lamelliforme. HAUY. Graphite lamellaire. BRONGNIART.

small, rhomboidal or hexagonal laminæ, which much resemble the sulphuret of molybdena, and often have a similar color. It also occurs in regular, hexaedral prisms, sometimes truncated on the terminal edges or solid angles.

2. GRANULAR GRAPHITE.* It occurs in amorphous masses, or in nodules, which are sometimes very small. The aspect of its fracture varies according to the size of the grains, which are sometimes extremely minute; hence it may appear scaly, or uneven, or may have a very compact texture.

(Geological sit. and Localities.) The Graphite has in most cases been found in primitive or transition rocks, through which it is sometimes disseminated in nodules of various sizes. It also occurs in beds, sometimes considerably large.

In Norway, near Arendal, the foliated variety is found in quartz. —In Greenland, it has been observed in hexaedral prisms.—In France, Spain, &c. Graphite is also found. But the most celebrated mine is at Borrodale, in Cumberland, Eng. This bed is situated in a mountain between beds of argillite, traversed by veins of quartz; the Graphite occurs in nodules often considerably large. Its quality is variable, but much of it is both firm and soft.—In Scotland, Mr. Jameson has found it in the Independent coal formation.

In the *United States.* In *North Carolina.*—In *Pennsylvania,* Buck's Co. in considerable quantity. *(*CONRAD.*)*—In *New Jersey,* Sussex Co. at Sparta, in foliated carbonate of lime. *(*BRUCE.*)*—In *New York,* near the city, in a feldspar-rock, and near Lake George in a micaceous rock; *(*BRUCE.*)*—it occurs also in the vicinity of New York in hexaedral prisms about four tenths of an inch in length, and sometimes truncated on their terminal edges; their gangue is a brownish oxide of iron, embracing hornblende and mica. *(*HAUY.*)*— Also in Ulster Co. in carbonate of lime;—and near Lake Champlain, where it is sometimes in rhomboidal or hexaedral laminæ, with mica and carbonate of lime.—Also in the Highlands, 60 miles above New York, with a structure between lamellar and striated. *(*SILLIMAN.*)*— In *Connecticut,* in many places, as Hebron, &c.—at Sharon it strongly resembles molybdena.—In *Rhode Island.*—In *Massachusetts,* near Worcester? (see anthracite.)—In *New Hampshire,* at Sutton and Chester.—In *Maine,* at Freeport, in a friable granite;—at Brunswick, in limestone, and on the banks of the Androscoggin, brought down by the waters;—at Bath, in granite.

(Uses.) When of good quality, it is manufactured into crayons

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* Graphite granuleux. BRONGNIART. Graphit schuppiger and dichter. WERNER. Graphite scaly and compact. JAMESON. Graphite granulaire. HAUY.

or pencils, improperly called black lead pencils. The Graphite, sometimes previously boiled in oil, is sawed into thin plates, one edge of which is inserted in a groove in one half of the wooden cylinder or case; the projecting part of the plate is removed by a saw, and the two semi-cylinders united. The powder, produced in this manufacture, and the coarser kinds of Graphite are mixed with a solution of gum Arabic or with melted sulphur, and formed into pencils of an inferior kind.—The powder of the Graphite is applied to stoves and other articles of iron to preserve them from rust. Mingled with grease, it is employed to diminish the friction of wheel work, &c.—Mixed and kneaded with clay, it is formed into crucibles, which well endure sudden changes of heat.

Graphite is often artificially formed in iron furnaces.

Species 8. Coal.*

The external characters of this well known mineral are less important, than its properties as a combustible.

Its color is black, which varies a little in its shade, but is almost always shining; its surface is sometimes very beautifully irised with lively colors. It occurs in opaque masses, whose texture is slaty or compact, and whose fracture is generally even or conchoidal.

It is too hard to be scratched by the finger nail; but it is easily broken, and is sometimes friable. Its mean spec. gravity is 1.30. (*Brongniart.*) It is not electric by friction, unless it be insulated.

(*Chemical characters.*) It burns more or less easily with a whitish flame; yielding a black smoke, and a feeble, but not unpleasant, bituminous odor. The products of this combustion are chiefly carbonic acid and water, and a little sulphurous acid. The residue, which is never less than 3 per cent. and sometimes much greater, is generally composed of scoriæ often mixed with ashes. By distillation it yields an empyreumatic oil, ammonia, and carburetted hidrogen.—Coal is essentially composed of carbon and bitumen in variable proportions; the carbon however predominates and often constitutes nearly three quarters of the whole, Small portions of earths and oxide of iron are also present.

(*Distinctive characters.*) This mineral is easily distinguished from anthracite, which burns with difficulty, and does not yield the white flame, black smoke, and bituminous odor of Coal.—It is harder than asphaltum, and does not, when slightly heated, exhale a bitumi-

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* Houille. Haüy. Brongniart. Schwartz Kohle, exclusive of Pech Kohle and Stangen Kohle. Werner. Black Coal, exclusive of Pitch Coal and Columnar Coal. Jameson. Mineral Carbon, impregnated with bitumen. Kirwan.

nous odor.—The several varieties of lignite, which much resemble Coal, yield by distillation an acid liquor.

The different varieties of Coal pass into each other by insensible shades.

Var. 1. CANNEL COAL.* *KIRWAN. JAMESON.* Its color is black, having usually a slight tinge of gray. Its texture is compact, and its fracture even or conchoidal with large cavities; its lustre is resinous and glistening. It is sufficiently solid and hard to be cut and polished, and is the least brittle variety of Coal. Its spec. grav. varies from 1.23 to 1.27.

It contains, according to Kirwan, carbon 75.2, bitumen 21.68, ashes 3.12. It burns, without softening, with a large bright flame of short duration, leaving a sooty substance; and when the combustion is complete, there is an earthy residue of at least 3 per cent. It does not produce a great heat. Its odor is not unpleasant, like that of jet.

It has been found chiefly at Wigan, &c. in Lancashire, England.

It also occurs in Scotland, where an impure variety, whose spec. grav. reaches 1.42, is called Splent Coal.

It is sometimes employed, like jet, for making toys. Its name, according to Kirwan, is derived from the circumstance of its burning like candles, which in Lancashire are called *cannels.*

2. SLATY COAL.† Its color is black, either pure, or with a slight tinge of gray or brown. Its structure is slaty or foliated, and its layers usually divide into prismatic solids, with bases slightly rhomboidal. Its cross fracture is even or a little conchoidal, and sometimes uneven; its lustre is resinous, frequently more or less shining, and on the foliated fracture it is splendent. It is easily frangible; and its spec. grav. varies from 1.25 to 1.38.

It burns easily with a white flame of much longer duration, than that of cannel Coal. It swells and agglutinates, or cakes, as it is usually called, and leaves but little residue, which is more or less a scoria. Several varieties, examined by Kirwan, yielded carbon from 56.8 to 73.5, bitumen from 23.2 to 43.0 and ashes from 1.6 to 5.2.

This variety usually occurs in the first or independent Coal formation, accompanied by shale, sandstone, &c. It frequently embraces pyrites, and sometimes the remains of marine animals.—It is the more common variety of Coal, employed as fuel, and is found abun-

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* Houille compacte. HAUY. BRONGNIART. La Houille de Kilkenny. BROCHANT.

† Schiefer Kohle. WERNER. Slate-Coal. JAMESON. Houille feuilletée. HAUY. Var. of Houille grasse. BRONGNIART. La Houille schisteuse. BROCHANT.

dantly in many countries.—Haüy mentions a subvariety, which is divisible into thin layers, slightly flexible.

3. COARSE COAL.* *JAMESON.* This is a little harder and heavier than slaty Coal. Its structure is usually somewhat slaty, but its cross fracture is coarse grained uneven. Its color is dark grayish black, and its lustre glistening.

It burns less easily than the preceding variety, and does not, like that, swell and agglutinate; it also leaves a more abundant residue.

It is sometimes found in compact limestone, and sometimes associated with slaty coal.

(*Geological situation of Coal.*) The geological characters of Coal are peculiarly interesting; as a knowledge of these may often lead to a discovery of this valuable mineral, when it does not appear at the surface, or assist in exploring its beds.

Coal, though sometimes in irregular masses and rarely in veins, most frequently occurs in beds, having various inclinations and windings. Sometimes the same bed so changes its direction, as to form an acute angle with itself.

The natural associations of Coal with other minerals are remarkably uniform, and in general well determined. The varieties of Coal, described under this species, do not occur in primitive rocks, nor in alluvial earths, nor are they often connected even with the most recent formations of secondary rocks; for we do not include under the name of Coal those combustibles, which often occur in the preceding situations.

Coal, strictly so called, appears to be of the same age as the older secondary rocks, or immediately to follow them. Thus we find it associated with certain secondary rocks, and resting upon them, or, when these are wanting, it rests on older rocks. Sometimes beds of Coal highly inclined are covered by *horizontal* strata of more recent minerals.

Coal has, in a few instances, been observed at a great elevation on the sides of mountains. Thus the Coal mines of Santafe de Bogota in the Cordilleras are elevated more than 4500 yards above the sea. (*BRONGNIART.*) When Coal occurs under plains at a distance from chains of mountains, it is sometimes at a great depth below the surface; as in the vicinity of Namur, where Coal is explored at the depth of nearly 700 yards, and is covered by limestone.

There appears to be several distinct formations of Coal. In the first and most important of these formations, the Independent Coal formation of Werner, we find the following minerals, connected with the Coal.

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* Grob Kohle. WERNER. La Houille grossière. BROCHANT.

1. A friable sandstone, both micaceous and ferruginous, often very coarse grained, and composed of quartz, with mica and feldspar. 2. Shale or argillaceous slate, which is often micaceous, and sometimes bituminous; it presents impressions of vegetables, particularly of ferns and reeds, and sometimes of fish. 3. Beds of marl, compact limestone, and indurated clay. 4. An argillaceous porphyry, often in thick beds, and embracing roots, branches, and even whole trees petrified. 5. Argillaceous iron ore. 6. A pudding stone, composed of rolled pebbles, cemented by a ferruginous clay or sand.

Of the foregoing rocks the friable micaceous sandstone, the shale, and the pudding stone are the most constantly found with Coal. Prof. Jameson has observed greenstone, amygdaloid, and graphite, connected with the preceding series.

The coal of this formation is almost always deposited in a series of beds, which may vary in number from two to thirty or more, and in thickness from a few inches to 10 or 12 yards, or even more. These beds of Coal alternate with one or more of the rocks, belonging to this formation; and sometimes this alternation appears to be *periodical*, so that several successive beds of Coal are repeated with the same accompanying minerals, and have very nearly the same thickness. This fact may be observed in the Coal mines near Newcastle, Eng.

Strata of shale are, in a great number of cases, found contiguous to the upper and lower surfaces of these beds of Coal, constituting the *roof* and the *floor* of the bed; and it has been remarked, that the shale, which covers the Coal, is bituminous, while that, which lies underneath it, has imbibed little or no bitumen. Any of the rocks of this formation may, however, constitute the roof or floor of a bed of Coal.

This formation, which is the most common and embraces the best Coal, constitutes hilly rather than mountainous countries. It is sometimes deposited near the foot of mountains, and sometimes in hollows, having the form of a basin or trough, so that the Coal approaches very near the surface at the extremities of its beds.

A second formation of Coal is found in mountains of secondary trap, composed chiefly of basalt, wacke, and greenstone. This Coal usually occurs in extensive, single beds, which are in most cases thick. These beds of Coal are sometimes intersected by veins of basalt; and the Coal, contiguous to the vein, is incapable of burning with flame, and is sometimes vesicular.—In Auvergne, Mt. Meissner in Hessia, &c. the coal of this formation is covered by basalt; and in the Vicentin it also rests on basalt.

A third formation of Coal is sometimes found in extensive beds, embraced in thick and nearly horizontal beds of compact limestone. This limestone, in the vicinity of the Coal, is frequently blackened by the bitumen it contains, while the shells, which it often embraces, retain their whiteness.

Beds of Coal are often intersected by veins of other minerals, more or less inclined to the horizon. Sometimes a small vein traverses only one bed of Coal; and sometimes the vein is large and traverses all the beds, which belong to the formation. The Coal, in the vicinity of these veins, is more irised and friable, less combustible, and often mixed with the stone, which constitutes the vein.—These veins are productive of much impediment and expense to the miner; but the evil may be diminished by attending to a few geological facts.

When a stony vein is found traversing a bed of Coal, the first object is to pierce the vein perpendicularly both to its direction and inclination. But, as the bed of Coal and its accompanying strata are generally displaced by the vein, the chief difficulty consists in regaining the bed of Coal at a small distance on the other side of the vein. This displacing or change of the strata by the vein is sometimes called a *shift*.

If all the strata, which lie over the Coal, are known to be different from those, which are underneath, it may easily be determined, when the vein is pierced, whether the Coal is above or below.—But there is another geological fact of more universal application.—It is known, that those beds, which form the *roof* or upper side of the vein, almost always appear to have *slidden down*, and hence are found *lower*, than the same beds on the other side of the vein. Hence, if the miner meet the vein on its roof or upper side, he must, after piercing it, regain the bed of Coal by an *ascending* gallery; and the reverse, if he meet the vein on the other side.

Other difficulties appear in exploring Coal mines. Sometimes the roof and floor so approach each other, that the bed of Coal almost entirely disappears. Sometimes the continuation of the bed is broken; and, when the bed reappears, it is found on the right or left of the original direction.

Coal sometimes contains metallic substances, of which sulphuret of iron is by far the most common. Carbonic acid and carburetted hidrogen gases are disengaged in Coal mines, the latter of which produces those dangerous explosions, which so often take place on the approach of a lamp or other flame.

(Localities.) There are but few countries, in which Coal is not found more or less abundantly. It is, however, rare in Italy, Swe-

den, and Norway.—In France, there are many coal mines. Those, which yield the best Coal, are found in the northern and northeastern parts, and belong to the first or proper Coal formation.

England is remarkable for her Coal mines, which appear chiefly in the northern, western, and central parts. The two principal mines are at the northern extremity, near Newcastle on the eastern, and Whitehaven on the western side of the Island; they both belong to the first formation. The mine at Whitehaven has been explored to the depth of about 400 yards, and is extended about seventeen hundred yards under the sea.—Coal is also abundant in some parts of Scotland.—It is an important circumstance, that many of the Coal mines of England and Scotland are connected with ores of iron.—In Germany also, Coal exists in large quantities. In the Coal mine of St. Giles, near Liege, a series of twenty three beds of Coal, lying one above another, has been actually explored. *(BRONGNIART.)*

In the *United States*, Coal has been explored in several districts, and undoubtedly exists in great abundance.—In *Virginia*, near Richmond, is a deposite of Coal about 20 miles in length and 10 miles in breadth; it is accompanied by a whitish sandstone, and shale with vegetable impressions, as is usual in the Independent Coal formation, which here lies over, and is surrounded by primitive rocks. *(MACLURE.)*—In *Pennsylvania*, Coal is found at Chingle-de-Moose, &c. on the west branch of the Susquehannah—in various places west of that branch—also on the Juniata—and on the waters of the Alleghany and Monongahela. Indeed, according to Mr. Maclure, the Independent Coal formation extends from the head waters of the Ohio, with some interruptions, to the waters of the Tombigbee.—In *Connecticut*, a Coal formation, commencing at Newhaven, crosses Connecticut river at Middletown, and, embracing a width of several miles on each side of the river, extends to some distance above Northampton in *Massachusetts*. Coal has been found at Durham, Middletown, Chatham, Enfield, South Hadley, &c. within the limits of this formation; in several instances it is rich in bitumen, and burns with a free flame. *(SILLIMAN.)* See locality of shale at Westfield.

The geographical situation of the Anthracite of Rhode Island and Massachusetts, in relation to the Coal formation just described, is very similar to that of the Anthracite on the Lehigh and at Wilkesbarre, in regard to the Coal on the western waters of the Susquehannah.—There are indications of Coal in *New York*, *New Jersey*, &c.

(Uses.) The uses of Coal are numerous and important; but vary according to the quality of the Coal. For those purposes of the forge, which require a *hollow* fire, the slaty Coal must be employed, as this variety possesses the property of agglutinating, and thus pro-

duces over the iron a kind of arch, which concentrates the heat. But the same property of caking, which depends on its bitumen, disqualifies it for many operations in the arts and in metallurgy. In these cases, it must previously be deprived of its bitumen and sulphur, and thus converted into *Coke.*

The substance called Coke is light, spongy, and of a shining steel gray color. It burns less easily than Coal, but produces a great heat, and does not cake, nor smoke. The preparation of Coke may be conducted in the same manner, as that of charcoal from wood. By this process from 700 to 1100 lbs. of Coke are obtained from one ton of Coal; but the volatile products, consisting of bitumen or *Coal tar* and ammonia, are thus lost. For collecting these, a plan has been contrived by Lord Dundonald, and successfully executed. The Coke is prepared in ovens or stoves, almost close; and from 120 tons of Coal are collected about 3½ tons of tar, and a quantity of ammoniacal salt. (Nicholson's Chem. Dict.)

Coal has been used with success in baking stone ware; but neither Coal nor Coke has hitherto been employed for baking hard porcelain. *(Brongniart.)*—When it contains any considerable quantity of pyrites, it is rendered more or less unfit for use, in consequence of the sulphurous acid, produced during its combustion. Sometimes also the heat, liberated by the decomposition of the pyrites, is sufficient to inflame the Coal; and hence the spontaneous combustion of many Coal mines;—such Coal is also easily disintegrated.

According to the experiments of Kirwan, the quantity of carbon in Coal may be ascertained with sufficient accuracy for common purposes by detonation with nitre, which is supposed to consume the carbon, while it acts very little on the bitumen;—and, if the quantity of ashes be ascertained by combustion, the proportion of bitumen may be inferred. (See Kirwan's Min. vol. ii.) Different varieties of Coal produce different degrees of heat.

(Origin of Coal.) Most geologists are induced to believe, that Coal has originated from the decomposition of vegetable substances in the interior of the earth. And this opinion seems to be supported by the remains of vegetables, which accompany coal, and by the products, which chemistry obtains, and which are chiefly carbon and hidrogen. It has however been objected, that vegetables scarcely decomposed are sometimes found in beds of Coal.*

But it appears to be certain, that Coal has been formed subsequently to the existence of organized bodies; and that previously to its production, its particles must have existed in a liquid or minutely

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* Vegetable impressions are rare in strata *between* beds of Coal.

divided state, whether the solvent were water, or caloric acting under a partial compression. Hence its structure is sometimes almost crystalline;—hence it is often mingled with portions of contiguous minerals.

The circumstances, under which beds of Coal are found in most countries, and their accompanying minerals, are remarkably uniform. And further, the cause, which has produced the Coal, appears to have been many times repeated; hence the great number of beds of Coal, which are often found in the *same mine*, under circumstances altogether similar.

The leaves of vegetables, impressed on the shale, which accompanies Coal, are almost always fully expanded, thus indicating a state of rest in the fluid, from which the Coal was deposited.—Jameson, on the authority of Habel, mentions a petrified trunk of a tree, one foot in diameter at one extremity, and forty feet in length, rising through rocks of the Coal formation.

SPECIES 9. LIGNITE. *BRONGNIART.*

The several varieties, included under this species, exhibit some diversity of external character; but they have all unquestionably originated from wood,* which has been buried in the interior of the earth; indeed they frequently exhibit a ligneous texture more or less distinctly. But, although in some varieties this texture may entirely disappear, the Lignite still differs very considerably from Coal.

Most of its varieties burn with flame, but they do not swell nor cake, like coal; the odor, which they exhale, is also sensibly different from that of burning coal or bitumen, and is usually unpleasant, sometimes sharp, or fetid. Like wood, they leave a residue of ashes, but often more abundant. They further differ from coal by yielding, when distilled, a peculiar acid liquor. Their color, sometimes black, is more frequently brown.

The varieties of Lignite are almost invariably found in alluvial earths, or connected with rocks of the most recent formation, as sandstone, shell limestone, or basalt. It is in many cases obviously of more recent formation than coal.—By some, these ligneous substances are viewed as an imperfect coal, as wood not yet mineralized, or passed into the state of coal; while others doubt the transition of Lignite into coal.

Many of its varieties gradually pass into each other.

Var. 1. JET.† *KIRWAN.* The color of Jet is a pure and deep

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* Hence its name from the Latin, Lignum, wood.

† Jayet. HAUY. Lignite Jayet. BRONGNIART. Pech Kohle. WERNER. Pitch-Coal. JAMESON. La Houille piciforme. BROCHANT.

black, sometimes with a tinge of brown. It occurs in opaque, compact masses, so solid and hard, that they are susceptible of being turned on a lathe and highly polished. Its fracture is conchoidal or undulated, shining or even splendent, and has a resinous lustre. Its spec. grav. varies from 1.25 to 1.30. By friction it acquires a weak electricity even when not insulated.

It sometimes presents the form of branches of trees, and exhibits traces of a ligneous texture.

It burns with flame, often a little greenish; but it does not melt, like solid bitumen. It exhales, while burning, a strong, and sometimes aromatic odor, sensibly different from that of coal or bitumen.

(Geological sit. and Localities.) Jet most frequently occurs in detached masses of a moderate size in beds of sandstone, marl, &c. It is also connected with formations of coal, particularly that, which is found in secondary trap.—It is also associated with other varieties of Lignite.

Good specimens of Jet are found in Gallicia, &c. in Spain;—near Wittemberg in Saxony; and in the department of Aude in France, where it sometimes contains amber.

(Uses and Remarks.) It is sometimes employed for fuel; but is more frequently cut and polished for ornamental purposes. In the department of Aude, before mentioned, more than 1000 persons are employed in the manufacture of Jet into buttons, bracelets, snuff boxes, &c.—It has also been called Gagat—and black amber. Some mineralogists consider it intermediate between coal and bituminous wood.

2. BRITTLE LIGNITE.* This variety may be distinguished from jet and some other combustibles, which it resembles, by its very great *brittleness*. Its surface is always cracked, and it is very easily divisible into cubical fragments. Its color is black with a shade of brown, and less shining than that of jet.

The longitudinal fracture sometimes brings to view a ligneous texture; its cross fracture is even, or a little conchoidal; and its lustre is moderate.

This variety burns easily, emitting a disagreeable odor. By long exposure to the air it often bursts, and falls to pieces.

(Geolog. sit. and Localities.) It is sometimes in horizontal beds of considerable magnitude; and occurs in alluvial earths, composed of sand, argillaceous marl, &c. or is connected with sandstone, basalt, &c.—It passes into the brown and earthy Lignites.—It is abundant in Bohemia and the south of France.

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* Lignite friable. BRONGNIART. Moor Kohle. WERNER. Moor Coal. JAMESON. La Houille limoneuse. BROCHANT.

It is not used in the forge, but may be employed for burning lime, &c.

3. BITUMINOUS WOOD.* *Jameson.* Its form is that of the roots, branches, or trunks of trees somewhat compressed; and its texture is perfectly ligneous. The longitudinal fracture is fibrous with but little lustre; the cross fracture has more lustre, is sometimes a little conchoidal; and often discovers the concentric, annual rings of the wood. It is opaque, more friable than wood, gives a shining streak, and is very light. Its color is brown, either dark or light, and sometimes nearly brownish black, or with a shade of blue or red.

It burns with a clear flame, yielding an odor, which is very different from that of coal, and is generally rather unpleasant. Its ashes, at least in some instances, contain potash.

(*Geological sit. and Localities.*) This substance, which is found in alluvial earths, or connected with rocks of the most recent formation, sometimes constitutes masses or beds of very considerable extent and thickness. Thus in Hanover, near Munden, it forms two beds, of which one is more than ten yards thick; the two beds are separated by a thin, stony layer.—In Iceland, where it is called *Surturbrand*, it is abundant, and very distinctly exhibits the compressed trunks of trees; it is sometimes but little mineralized, and is even employed as timber.—In England it is abundant at Bovey, near Exeter.

It is, however, most frequently found in detached masses, or in small beds. It is often associated with other varieties of Lignite, into many of which it gradually passes.—The same tree is sometimes carbonated in one part, while the other remains in the state of wood.

Its fissures sometimes contain carbonate or sulphate of lime, quartz, chalcedony, arsenical sulphuret of iron, amber, &c.

When sufficiently abundant, it is employed as fuel.

4. BROWN LIGNITE.† This substance, in many of its properties, resembles bituminous wood, like which it sometimes, but less frequently, exhibits the texture of wood on its longitudinal fracture; or this texture, according to Fabroni, may be brought to view by boiling the specimen in diluted nitric acid.

Its general structure is often a little slaty; its cross fracture is even or conchoidal, with a resinous lustre somewhat shining. It is brittle, and varies in spec. grav. from 1.40 to 1.55.

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* Bituminöses Holz. Werner. Le Bois bitumineux commun. Brochant. Lignite fibreux. Brongniart. Ligniform carbonated wood. Kirwan.

† Gemeiner braun Kohle. Werner. Common brown Coal. Jameson. La Houille brune. Brochant. Bovey Coal, or compact carbonated Wood. Kirwan.

It burns with a weak flame, often bluish, and exhales an odor, which is usually disagreeable. A specimen from Bovey yielded Hatchett water mixed with an acid and some bitumen 30.0, thick oily bitumen 10.5, charcoal 45.0, carbonic acid a[illegible]retted hidrogen 14.5.

Its *geological situation* is similar to that of bituminous wood, into which it passes. It sometimes contains pyrites, amber, mellate of alumine, and retin-asphaltum.—It is abundant [illegible] Exeter, at Bovey, in England.—Small quantities have been observed in the alluvial earths of the *U. States*.

5. EARTHY LIGNITE.* Its color is nearly black or blackish brown, or a lighter brown, and sometimes with a tinge of red. It has very little solidity, and is often perfectly friable. Its fracture is dull, fine grained earthy, but sometimes exhibits a ligneous texture. It acquires some lustre in the streak; and is but little heavier than water.

It burns, like tinder, with little or no flame, and yields an odor, which, like that of bituminous wood, is often unpleasant.

This variety differs but little from bituminous wood, except in its friability; indeed the two gradually pass into each other.

(Localities.) This Lignite most frequently occurs in alluvial earths, and is sometimes connected with secondary rocks in the vicinity of coal.—It is explored near Cologne, where it forms beds from 20 to 30 feet thick, which rest on white clay, and are covered by a bed of pebbles of quartz, jasper, &c. It contains trunks of trees, imbedded without order, usually compressed, of a black or reddish color, and burning very well; also fragments and fruits of a species of palm tree. The ashes of this Lignite are a little alkaline.

(Uses.) It is employed as fuel in cases, where a great heat is not requisite; and for this purpose it is often moistened and formed into small, regular solids. Its ashes constitute a good manure.—The variety, found near Cologne, and sometimes called Cologne earth, or umber improperly, is employed by painters, either as a water color, or with oil.

When it contains pyrites, it affords alum, and passes into the following subvariety.

ALUMINOUS EARTH. This scarcely differs in its external characters from the Earthy Lignite just described. It has usually a sharp taste.

It burns with some flame, and, when exposed in large masses to a moist air, it becomes warm, and sometimes takes fire.

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* Erd Kohle. WERNER. Earth Coal. JAMESON. Bois bitumineux terreux. BROCHANT. Lignite terreux. BRONGNIART.

Like the other Lignites, it is found in alluvial earths; and sometimes forms extensive beds, which often embrace bituminous wood.

By lixiviation it affords alum.

SPECIES 10. PEAT.*

This homely, but valuable and well known combustible, has a loose texture, more or less porous, or even spongy. When recently dug, it forms a viscid, slimy mass, which, by exposure to the air, becomes dry, [illegible] and more or less light and brittle in different varieties. Its color is brown, sometimes yellowish or reddish, or a dull black.

Peat consists essentially of vegetable matter in various states of decomposition; but is more or less mixed with earths and salts. It appears to differ from vegetable earth by retaining nearly *all* the principles of the vegetable, though these principles may have formed combinations, which did not exist in the living plant.

This substance burns with different degrees of ease, but sufficiently well to be employed as fuel. It leaves an abundant residue of very light ashes.

We notice two varieties of Peat, depending chiefly on the degree of decomposition in the vegetable.

Var. 1. FIBROUS PEAT.† This variety, sometimes called Turf, is composed chiefly of vegetable fibres, variously interlaced, and united by a slimy, vegetable matter in a more advanced state of decomposition. Its texture is of course very loose. Hence we perceive the roots, stems, and leaves of the various plants, which grow in swamps, bogs, marshes, or heaths; indeed it sometimes seems to be composed almost entirely of leaves.‡ When dry, it is lighter and more elastic, than compact Peat, and its color is usually less dark.

2. COMPACT PEAT.§ When recently dug, it forms a very slimy mass, soft to the touch, and sufficiently tenacious to be cut or moulded into small regular solids, like a brick. When dry, its texture becomes more or less firm and compact, and it exhibits an earthy fracture. It is harder, heavier, and blacker, than the first variety. It embraces few or no visible remains of the organic parts of vegetables, and seems to have originated chiefly from aquatic plants. In some rare instances, its fracture is glossy, like resin.

The two preceding varieties pass insensibly into each other, and frequently occur in the same bed. In this case, the upper part of

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[*] Tourbe. BRONGNIART. It is often called Moss in Europe.

[†] La Tourbe fibreuse. BRONGNIART. Turf. KIRWAN.

[‡] La Tourbe papyracée. BRONGNIART.

[§] La Tourbe limoneuse—et piciforme. BRONGNIART. Peat. KIRWAN.

the bed is loose and fibrous, having undergone only a partial decomposition; but, on approaching the lower parts, the remains of the vegetable fibre gradually disappear, and the Peat becomes more compact, in consequence of the more complete decomposition of the vegetable, and of the pressure of the superincumbent mass.

(Geological situation.) This combustible is found in swamps, marshes, bogs, and low grounds, which have been, or are still covered with stagnant water. Its beds, always horizontal, are sometimes many yards thick, and either appear at the surface, or are covered by a stratum of vegetable earth. These beds, the lower part of which must once have been the bottom of ponds or small lakes, are, of course, extremely variable in extent; they are sometimes homogeneous, and sometimes contain layers of mud, sand, or clay.

Beds of Peat exhibit some peculiar characters, by which their existence may often be discovered. They possess a remarkable degree of elasticity, especially when moist; so that, if a heavy blow be impressed on one point, the bed is perceived to tremble for a considerable extent on all sides. When impregnated with water, they often swell, and their surface becomes a little convex. In this state they become so soft, that it is difficult to walk upon them, and they gradually absorb, sometimes to a great depth, any heavy body, which is placed on the surface.

Marshes or bogs, which contain Peat, are usually covered, or at least impregnated with water, for some part of the year. But, unless covered with vegetable earth, they are incapable of cultivation, and yield only coarse grasses, and certain aquatic plants.—In fine, beds of Peat sometimes rest on the surface of water, or even form small floating islands.

Beside clay, sand, and fresh water shells, other substances are occasionally found in Peat. Whole trees sometimes occur in beds of Peat, many of them lying in the same direction, and near their stumps, which appear to have been cut at nearly the same height. These facts have been observed in the Peat of Holland, Scotland, and Ireland.

Beds of Peat also embrace remains of animals, among which are deer's horns, and the bones of oxen; indeed timber, axes, and other implements of labor are sometimes found in these beds; and in the Peat of Kincardine, in Scotland, whole causeways have been observed.

(Localities.) Although Peat is found more or less in all countries, it is much more abundant in cold or temperate regions, than in those, which are warm. When found in warm climates, it exists at a very considerable elevation, and has seldom been observed in trop-

ical regions.*—In Ireland, Scotland, and Holland it occurs in large quantities.—It appears also, that, in certain parts of Holland, Peat is sometimes composed entirely of marine plants.—In many parts of the *U. States*, this valuable combustible exists abundantly.

(*Uses and Remarks.*) This substance is cut and taken from its bed by instruments, contrived for that purpose. Sometimes a long, narrow spade, from one side of which, near the bottom, a sharp knife projects at right angles, is employed. The Peat is of course cut in two directions at once, and is taken out in solid masses of convenient length and size. The compact variety, especially when taken from water, is often moulded into the form of large bricks.—In all cases, however, the utmost care should be employed to render the Peat perfectly dry.

Peat is extensively employed as fuel in those countries, where it abounds, and where wood and coal cannot be easily obtained. This is peculiarly the case in Holland.

The compact is generally superior to the fibrous variety, as it produces a stronger and more durable heat; it also burns with a brighter flame, and a darker colored smoke. Some varieties contain much bitumen.

Peat may also be employed in several kinds of manufactures, as in burning limestone, bricks, &c.

Some varieties do not answer well for culinary purposes, in consequence of the empyreumatical oil, which they yield, while burning. Other varieties contain pyrites, and, during combustion, afford more or less of sulphurous acid gas.—Its ashes sometimes contain sulphate of iron.

(*Origin of Peat.*) A concurrence of circumstances, all of which are not perfectly well understood, is necessary to the formation of Peat. It is obvious, however, that stagnant water, impregnated with the astringent and antiseptic juices of certain plants, and a low temperature, by which many of the ingredients of vegetables are prevented from escaping in the form of gas, are among the circumstances, favorable to the production of Peat. It has been remarked, that the stagnant water of Peat-grounds does not become putrid, and is less unhealthy, than that of marshes, which do not produce Peat. It is however very difficult to say, why certain marshes and bogs should be capable of converting into Peat the vegetables, which they produce, while other marshes, equally abounding with vegetables, and apparently under similar circumstances, should be incapable of yielding this combustible. Hence different opinions have been expressed on

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* Essays on the Natural History and Origin of Peat by R. Rennie.

the origin of Peat; and hence some have supposed, that it depends on the presence of a particular vegetable; but they do not agree in regard to the vegetable itself.—It appears to be well ascertained, in many cases at least, that those ditches, from which Peat has been removed, will again become filled with the same combustible; but the period, requisite for this change, will vary, according as the circumstances are more or less favorable.

CLASS IV.

Ores.

The minerals, which belong to this class, generally present more definite and more uniform characters, than those of the preceding classes. Hence, in almost every systematic arrangement, the same minerals have been referred to this class. Most of the species are well defined. In a few cases, however, where several different metals are combined, it may be difficult to distinguish between those, which are essential to the species, and those, which are accidentally present.

Metals, as presented by nature, are sometimes pure, or combined with each other only, and are said to exist in a *metallic state.* But more frequently they are combined with oxigen, sulphur, &c. by which their peculiar, metallic properties are more or less disguised; in this case the metal is said to be *mineralized*, and the oxigen or sulphur is called a *mineralizer.*

These two general states, in which metals are found, may conveniently be subdivided into five particulars.

1. *Native metals.* In this case the metal is pure, or alloyed with only a minute quantity of some other metal or metals.

2. *Alloys.* In this case also the metals alloyed are in a metallic state. Thus silver and antimony are found united. Sometimes more than two metals enter into the same compound. The alloy often differs much from each of its component parts in color, hardness, malleability, spec. gravity, &c.

3. *Oxides.* Most of the metals sometimes occur in this state, and often abundantly. Sometimes the oxides of two metals are united.

4. *United with a combustible.* This division is chiefly composed of those various, native compounds, called *sulphurets*, in which the sulphur is commonly united with the metal, sometimes with its oxide.

5. *Metallic salts.* Here the metal always exists in the state of an oxide, united to some acid, of which the sulphuric, muriatic, carbonic, and phosphoric are the most common.

Metals, existing in the state of an oxide, or a salt, or united with a combustible, are called *ores;* and this term is by analogy extended to the native metals and alloys.

The earthy, stony, saline, or combustible substance, which contains the ore, or is only mingled with it, without being chemically combined, is called the *gangue* or matrix of the ore. Hence an obvious distinction between the gangue and mineralizer; for the latter is always *combined* with the metal, while the former is only *mixed* with it.

Sometimes the same mass contains two or more different metals, and has hence been referred to, different places in the class, according as its generic character is derived from the metal predominant in quantity, or from that, which is most rare or valuable. Hence, in a systematic arrangement, some ores may not be found under that metal, for which they are worked. Thus all ores, from which silver is extracted, are not strictly silver ores.

Metals, and their ores are sometimes disseminated in other rocks; sometimes they form irregular masses of various sizes, and sometimes they constitute beds; but more frequently they are found in veins, either filling the whole vein, or mixed with various saline and earthy minerals. They appear to be the production of every period, but more frequently exist in primitive and transition, than in secondary rocks, or than in alluvial earths.

The relative ages of the metals may be determined in a very satisfactory manner by the nature of the gangue, and by the relative position of different metallic veins. For these veins undoubtedly were once open fissures, which have since been filled by the substances, which they now contain. Hence those veins, which are most frequently intersected by others, must be older, than the veins, which intersect; and, on the other hand, those veins, which intersect all the others, must be considered the most recent. According to these principles, molybdena and tin are among the most ancient metals, while lead, copper, &c. belong to later formations. Iron is a production of every period.

The term *mine* is usually applied to those places, whence the ores of metals are, or may be, extracted in considerable quantities, but is sometimes extended to deposites of combustibles, salts, or even of earthy minerals.

We shall now briefly describe the physical properties of metals in a state of purity.

1. *Density*, or *specific gravity.* The spec. gravity of metals, if we exclude those recently discovered by Sir H. Davy, is always greater than that of the minerals, which compose the preceding class;

es; tellurium, the lightest metal, being above 6.0, while the heaviest earthy body is less than 5.0.

2. *Opacity.* Metals are almost perfectly opaque. Hence the thinest layers of gold, which are applied to the surface of porcelain, remain opaque; still, however, this metal, when in leaves extremely thin, transmits a feeble light.

3. *Lustre.* Metals, especially when polished, reflect light very copiously, and hence possess that peculiar kind of lustre, which is called *metallic.* Even when reduced to a coarse powder, they retain more or less of their lustre. The metallic lustre, which some earthy minerals possess, is confined to the surface.

4. *Color.* Each metal, when pure, uniformly presents its proper color; the light being reflected from the integrant particles, and not from any foreign mixture. Their general color is some shade of white, gray, or yellow.

5. *Malleability.* It is in consequence of possessing this property, that some metals may be extended into very thin leaves, either by beating them with a hammer, or pressing them between rollers. All the metals are not sensibly malleable; and those, which are so, exhibit this property in very different degrees.

6. *Ductility.* By this property metals are rendered capable of being drawn into wires, more or less fine. But, although the ductile metals are also malleable, yet these two properties do not always correspond in the same metal. Thus iron is ductile in a much higher degree, than it is malleable.

7. *Tenacity.* The two preceding properties must, in fact, ultimately depend on the *tenacity* of the metal; and this seems to arise from the power, which certain metals possess, of permitting their particles to move among themselves without being forced beyond the limits of their mutual attraction. The *tenacity* of metals, however, is usually estimated by the strength of their wires; and different metals may be compared in this respect, by taking wires of a given diameter, and gradually adding weights to one of their extremities, till the wires break.

8. *Hardness.* This property is possessed in only a moderate degree by most of the metals, but may be increased by artificial processes. When the ductility and softness of metals have been removed, they may be restored by heating the metal, and permitting it to cool slowly.

9. The *elasticity* of metals follows very nearly the same order as their hardness, and may be artificially increased in the same manner. —The peculiar *sound,* which some metals yield, after being struck, is connected with their hardness and elasticity.

10. Although the metals are well known to be the best *conductors of*

electricity, yet, it appears from the experiments of Haüy, that, when insulated, they acquire a feeble electricity by friction with cloth.

11. Some of the metals possess a slight degree both of *taste* and *odor*.

12. Several of the metals, when melted, may be regularly crystallized. The process consists in permitting the melted mass to cool at the surface; and the solid crust being pierced, the internal, liquid part is poured out, leaving crystals attached to the sides of the cavity.

Action of Caloric. The metals are all expansible by caloric, and the degree of expansion appears to be nearly in the order of their fusibilities.—The scale of fusibility extends from mercury, which becomes fluid at about 40° below zero on Fahr. to iron, which melts at about 158° W. and thence to platina, which can be melted by the most intense heat only.—Melted metals, if the quantity be small, assume a globular form; and a metal, thus purified by fusion, was formerly called a *regulus.*

Many, and perhaps all, of the metals may be volatilized by heat; but, in general, they must be previously melted; arsenic, however, is volatilized at a lower temperature, than its melting point.

The more valuable metals may be arranged in nearly the following order in regard to their most important physical characters; beginning in each case with the metal, which possesses the property in the highest degree.

Spec. gravity.	*Lustre.*	*Malleability.*	*Tenacity.*	*Hardness.*	*Fusibility.*
Platina.	Iron or steel.	Gold.	Iron.*	Iron.	Mercury.
Gold.	Silver.	Silver.	Copper.	Platina.	Tin.
Mercury.	Platina.	Platina.	Platina.	Copper.	Lead.
Lead.	Mercury.	Copper.	Silver.	Silver.	Silver.
Silver.	Gold.	Iron.	Gold.	Gold.	Copper.
Copper.	Copper.	Tin.	Tin.	Tin.	Gold.
Iron.	Tin.	Lead.	Lead.	Lead.	Iron.
Tin.	Lead.				Platina.

GENUS I. *GOLD.*

This metal, when pure, has a fine yellow color, slightly tinged with red, and acquires, when polished, a high lustre. In malleability it is superior to all the other metals. Its ductility is also very great. It is softer than silver, and may easily be cut by a knife. Its specific gravity is about 19.3.

Gold is not oxidated by exposure to air or moisture; nor is this

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* According to the experiments of Sickengen. Ann. de Chimie. t. xxv.

effect produced by caloric, unless at a very high temperature, such as that produced by electricity. It also burns in the flame of a united stream of oxigen and hidrogen gases. It melts at about 32° W. Nitro-muriatic acid is its proper solvent.

(Uses and Remarks.) The uses of Gold in jewelry and the ornamental arts are too numerous and too well known to be here enumerated. When employed in the arts or for coin, it is alloyed, sometimes with silver, but more frequently with copper, or with a mixture of copper and silver, to increase its hardness. The best proportion for the alloy appears to be that, in which the copper, or the compound of copper and silver, constitutes one twelfth part. This is the standard Gold of England and the U. States. Copper heightens the orange tinge of Gold; silver in the proportion of about one fifth part renders it greenish; and the addition of a little iron gives it a bluish tint.

The purity of gold coin, &c. is estimated by supposing a given mass divided into 24 equal parts, called *carats*; and hence, if this mass be alloyed with 2 parts of copper or silver, it is said to be 22 carats fine.—The purity of Gold may also be determined with considerable accuracy by means of the touchstone. (See basanite.)—The purple oxide of Gold communicates to glass or enamel a rich red or purplish tinge; as appears in the painting of porcelain.

Species. 1. Native Gold.* *Kirwan. Jameson.*

Native Gold is very seldom, if ever, perfectly pure; but is alloyed with minute quantities of other metals, which sometimes considerably affect its color. When the Gold contains very little alloy, its color scarcely differs from a pure gold yellow;† but it thence varies, according to the nature and quantity of the alloy, to brass yellow,‡ greenish yellow, and even passes to grayish yellow,§ which sometimes inclines to steel gray; sometimes also the yellow has a tinge of brown.

Native Gold appears under various forms. It is sometimes crystallized in cubes or octaedrons, either of which may be its primitive form; sometimes in cubes with truncated edges; also in dodecaedrons with rhombic faces, and in solids with twenty four trapezoidal faces. The crystals are usually small and imperfect.—It also presents various imitative forms, as dendritic, ramous, capillary, reticular, filiform, like moss, or in leaves, or membranes; in fine, it very often occurs in spangles or grains,‖ or small masses, variable in size,

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* Gediegen Gold. Werner. Or natif. Haüy. Brongniart. Brochant.

† Gold-yellow native Gold. Jameson.

‡ Brass-yellow native Gold. Jameson.

§ Grayish yellow native Gold. Jameson.

‖ These are often called *Gold Dust.*

and often flattened. These grains or masses are frequently loose and insulated, and sometimes disseminated in other minerals.

It is malleable, easily cut by a knife, and has a metallic lustre. Its spec. grav. varies from 12.0 to 19.0, according to the proportion of alloy.

(Chemical characters.) Native Gold is soluble in the nitro-muriatic acid; and from this solution, which is yellowish and tinges the skin purple, the Gold is precipitated in a metallic state by the green sulphate of iron. The metals, by which native Gold is alloyed, are silver, copper, iron, palladium;* and even platina is said to exist in some Gold. The alloy sometimes consists of two or more of the preceding metals. A specimen from Bohemia yielded Lampadius Gold 96.9, silver 2.0, iron 1.0.

Native Gold may be distinguished from sulphuret of iron and pyritous copper by its malleability and greater spec. gravity—and from platina by the metallic precipitate, which it affords with sulphate of iron.

Gold, in small quantities, is often so completely enveloped in other minerals, that it is invisible by the eye, but may still be worth the labor of extraction. In this case, the mineral, supposed to contain it, may be triturated with mercury, which dissolves the gold; and the mercury is then to be evaporated to dryness. If Gold be present, but in too small quantity to be visible to the eye, the residue, after evaporating the mercury, may be dissolved in nitro-muriatic acid; and a yellowish solution, capable of tinging the flesh purple, will be obtained. Sometimes it is expedient to roast the ore before trituration.—Among those ores, which often contain small quantities of metallic Gold in a state of mixture, and which may be extracted, as already mentioned, are the sulphurets of iron, lead, zinc, and mercury, pyritous copper, and native tellurium; and in most of these minerals it is almost impossible to determine the presence of the Gold by any external character.

(Geological situation.) Gold is sometimes in veins; sometimes disseminated in rocks or ores of other minerals, or in leaves or ramifications attached to their surfaces; and sometimes in loose grains or masses in alluvial earths. The veins, which contain it, are, in most cases, composed chiefly of quartz, and may traverse granite, gneiss, mica slate, &c. It occurs also in metallic veins in porphyry, hornblende, greenstone, and limestone; and sometimes in veins, which traverse gray-wacke and other transition rocks.—In addition to

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* The existence of palladium in Gold was first discovered by Mr. J. Cloud of Philadelphia, in some ingots from Brasil; deposited in the Mint of the United States.

quartz, other minerals, as jasper, feldspar, carbonate of lime, sulphate of barytes, &c. sometimes constitute the gangue of Gold.—The ores, which most frequently accompany Gold, are the sulphurets of iron, silver, lead, and antimony, pyritous copper, red silver ore, and arsenical iron.

In a few instances Gold has been observed in minerals of secondary formation.

But much of the Gold of commerce is found in grains or small masses, disseminated in those alluvial deposites of sand, gravel, and pebbles, which constitute certain plains, or form the margin or the bed of rivers.

Auriferous sands, whether siliceous or argillaceous, are almost always ferruginous. Hence their color is usually reddish or blackish. Hence also the opinion, that the Gold in ferruginous earths has proceeded from the decomposition of sulphuret of iron, containing Gold.

The Gold, which exists in the sands of certain rivers, does not, in most cases at least, appear to have been detached by the waters from those ores or rocks, over which they may have passed during their course. Several facts strongly support this opinion. In almost all rivers, whose sands are auriferous, the Gold is confined to a limited, and often comparatively small, part of the course of the river; and, instead of becoming more abundant, as the river is ascended toward the supposed source of the Gold, it diminishes in quantity, and at length often disappears. Thus the Rhine furnishes less Gold near Basle, than toward Strasburg, although the former is nearer to the mountains, whence the river proceeds. Thus also the sands of the Danube contain no Gold, while this river is traversing a mountainous country in the bishopric of Passau; but in the plains below Efferding its sands become auriferous.

It may indeed be said, that the rapidity of the current prevents any deposite of Gold, till a river reaches a level country, and becomes more tranquil. But in this case, when a river traverses broad vallies, and thereby loses much of its velocity even in mountainous countries, the Gold, which it transports, ought to be deposited. This does not, however, appear to be often the case. Further, the river Tesino has no auriferous sand till it has passed through the lake Maggiore; but whatever Gold this river might have brought from the mountains of Switzerland would undoubtedly have been deposited, while traversing this lake, where its current is comparatively slow. (*BRONGNIART.*)

It appears exceedingly probable from the preceding and similar examples, that the Gold, which exists in the sand of many rivers, has been washed from the plains, which they traverse. In fact, the sand of these plains is known in many instances to contain Gold; and the sand of rivers and brooks is usually more auriferous immediately after storms, during which much water and sand must have passed from the plains into the contiguous streams. The sand of the river Nera, in Hungary, is even less auriferous, than that of the plain, contiguous to the river.—Still it must be admitted, that the Gold of these plains may have been deposited by some ancient alluvion of a different nature, perhaps, and more extensive, than that of rivers; and hence may originally have preceeded from primitive mountains.

The Gold is usually most abundant in the re-entering angles of rivers; and, if 100 pounds of sand contain but a few grains of Gold, they are worth the labor of *washing*, by which process this precious metal is extracted from them. The largest masses of alluvial Gold, hitherto found, have not much exceeded thirty pounds.

(*Localities.*) Gold is very abundantly diffused, although in most countries it is found in small quantities only.

Spain and Greece appear to have furnished the ancients with considerable quantities of Gold;—but the mines of the former have been abandoned since the discovery of America.

Many of the rivers of France contain auriferous sand. This is the case with certain portions of the Rhine, the Rhone, the Garonne, &c.

In Germany, Gold mines are explored in the mountains, which traverse the Saltzburg.

In Ireland, in the county of Wicklow, it is found in a quartzy, ferruginous sand, and also in a stream, which runs over argillaceous slate, traversed by veins of quartz. This Gold contains from $\frac{1}{15}$ to $\frac{1}{6}$ its weight of silver.

Hungary, however, is the only country in Europe, whose mines and auriferous sands yield any considerable quantities of Gold. Their annual produce is estimated at about 1700 lbs. Troy. (BRONGNIART.)—In Transylvania, are the Gold mines of Nagyag and Offenbanya, where this metal is united with tellurium, lead, and silver.

In Siberia, are valuable mines of Gold, whose annual produce is estimated at about 4500 lbs. Troy. These mines exist at Schlangenberg, Beresof, &c. and at the latter place is found auriferous sulphuret of iron partially decomposed.

Africa, which furnished the ancients with much Gold, still abounds with this precious metal; and there is reason to believe, that most of it proceeds from alluvial earths. The mines of Kordofan are situated between Darfoor and Abyssinia.—Other Gold mines are found in the western part of Africa, south of the great desert Zaara, near the foot of those mountains, which contain the sources of the Senegal, and Gambier. The sands of these rivers are also auriferous.—Much Gold is also obtained from the kingdom of Bambouk, northwest of the mountains just mentioned, where it is found in grains or spangles in a ferruginous earth.—The country of Sofala, on the southeast coast of Africa, appears also to furnish much Gold. This is by many supposed to be the Ophir, whence Solomon obtained Gold in such abundance.

But America, particularly South America, contains the most valuable Gold mines; of which the most important are found in Brazil, New Grenada, Chili, New Spain, and Peru.

The annual produce of the Gold mines of S. America and New Spain is probably between 35,000 and 40,000 lbs. Troy; of which more than one third is furnished by Brazil, where it is obtained chiefly by washing auriferous sands. Gold is, in fact, found at the foot of the Andes through almost their whole extent.—The Gold of Peru is sometimes in a gangue of quartz;—that of Brazil is sometimes found in carbonate of lime;—and a great proportion of the Gold of Mexico occurs in veins of silver ores.

In the *United States;* in *North Carolina,* in Cabarras Co. on Meadow Creek, &c. The Gold occurs in grains or small masses in alluvial earths, and chiefly in the gravelly beds of brooks in the dry season. (*Gibbs.*)—According to Mr. Ayres, one mass, weighing 28 lbs. has been discovered.—The Gold of Cabarras is alloyed with silver and a little copper. When purest, it is 23 carats fine, and is superior in quality to the Gold coins of England and the U. States. In 1810, upwards of 1341 ounces of this Gold, equal in value to 24,689 dollars, had been received at the mint of the U. States. (Bruce's Min. Jour. v. i.)—It is said also to have been found on the upper branches of James' River.

It appears from the preceding details, that most of the Gold of commerce is obtained from auriferous sands. When thus found, it is extracted by the simple process of washing the sand. When enveloped in other minerals, it is extracted by amalgamation with mercury.

(*Remarks.*) According to Humboldt,* the annual produce of the Gold mines of S. America and New Spain is in value but little short of 11 millions of dollars; of which Brazil furnishes about 4½ millions, New Grenada about 3 millions, Chili about 1⅔ millions, New Spain about 1 million, Peru and Buenos Ayres the remainder. The *quantity* of silver, annually furnished by the same countries, is between 40 and 50 times greater than that of Gold. The same author has

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* Political Essay on New Spain.

also estimated the value of the whole quantity of ***Gold*** and ***Silver***, extracted from the same mines, between the years 1492 and 1803, at 5,706,700,000 dollars.

GENUS II. *PLATINA.*

Platina has a grayish white color, approaching that of silver, but with less lustre. Its hardness is somewhat inferior to that of iron. When fused and hammered, its specific gravity lies between 20 and 22, but varies according to the process, by which it has been purified, and the degree of hammering, it has undergone.

It is a slow conductor of caloric; and, with the same degree of heat, expands considerably less than steel, like which it may be rendered very elastic. Like iron also, it softens so much below its melting point, that it is capable of being *welded.*

Platina is infusible by itself in the best furnaces; but may be melted in the focus of a powerful mirror, or even by the blowpipe with the aid of oxigen gas. (*Henry.*) Before the compound blowpipe it is melted and volatilized with strong ebullition. (*Silliman.*) It is not oxidated by exposure to the air, nor by a very strong heat; nor is its lustre changed by boiling nitric acid. It is soluble in nitromuriatic acid, yielding a muriate of Platina, from which muriate of ammonia throws down a yellow precipitate, consisting of muriate of Platina and ammonia. A solution of muriate of Platina, so diluted as to resemble water, is made to assume a bright red color by the addition of a few drops of recent muriate of tin.

The various processes of purifying native Platina, proposed by De Lisle, Jeannety, Tilloch, and Count Poushkin, may be found in most systems of chemistry.

(*Uses.*) The physical characters of pure Platina, particularly its hardness, infusibility, and resistance to the action of air and moisture, indicate the important uses, to which it may be applied. Thus it is employed for crucibles, spoons, evaporating vessels, pendulums, pyrometers, &c. It is also well adapted to the construction of reflecting mirrors for telescopes, as it strongly reflects light, and does not tarnish by exposure to the air. It may also be employed for the pendulum-springs of watches. The little expansion, which it undergoes by exposure to heat, renders it an excellent standard of measures of length. Rods of this metal were employed by Delambre and Mechain in the measurement of the base of a series of triangles to determine the length of an arc of the meridian. It has also been used in the painting of porcelain; and, by alloying it with gold, different shades of color may be produced.

SPECIES 1. NATIVE PLATINA.* JAMESON.

This metal occurs in grains, which are usually flattened, and sometimes in small masses, the largest of which are about the size of a pigeon's egg. Its color is a light steel gray, with a shining metallic lustre. It is less hard than iron; malleable, and, in thin plates, flexible. When in grains, its spec. grav. is but little above 15.

(Chemical characters.) These grains are soluble in nitro-muriatic acid, leaving a blackish residue of about 3 per cent. consisting of iridium and osmium; the solution, when concentrated, has a deep reddish brown color, and yields, on the addition of muriate of ammonia, a yellowish precipitate. Native Platina is not pure, being in fact alloyed with small quantities of eight or nine other metals, viz. iron, copper, lead, chrome, and also four other metals, unknown till they were discovered in Platina. These new metals are iridium, osmium, rhodium, and palladium.

Among the grains of Native Platina are some, which are harder and heavier than the others, not malleable, and scarcely soluble in nitro-muriatic acid; these, according to Wollaston, are an alloy of iridium and osmium.

(Geological sit. and Localities.) Nothing is known of the original situation of Platina. It has hitherto been obtained chiefly from a few districts in South America, in alluvial deposites. In the districts of Novita and Citara, in the province of Choco, Peru, the Platina is mixed with magnetic iron sand, gold, titanium, spinelle, quartz, &c. it is sometimes even penetrated by magnetic iron. In the same earths are found fragments of greenstone, and rolled masses of basalt, containing olivine and augite. It occurs also in Quito and Santa Fé.—More recently, Platina has been found in some of the gold mines of Brazil, and, according to Dr. Wollaston, is purer than that from Peru; it is mixed with grains of native palladium nearly pure.—Vauquelin has also discovered small quantities of Platina in some of the gray copper ores from Guadalcanal in Estremadura; it does not contain any of the four new metals already mentioned.—Platina has also been found in the eastern part of St. Domingo, in the sands of the river Jaki, at the foot of the mountains of Sibao.

New Metals in Platina. We have already remarked, that four metals, previously unknown, had been discovered in Native Platina.

1. IRIDIUM. *TENNANT.* This metal resembles Platina in color and infusibility; but it is not malleable. No simple acid dissolves

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* Gediegen Platin. WERNER. Platine natif ferrifère. HAUY. Platine natif. BRONGNIART. BROCHANT. Platina. KIRWAN. Its name is said to be a diminutive of the Spanish word *Plata*, which signifies silver. Platina was first made known in Europe by Don Ulloa about 1748.

it; and even the nitro-muriatic has but a very feeble action. It, however, becomes oxidated by fusion with potash or soda; and this oxide is soluble in the sulphuric, muriatic, or nitric acid. The first two acids give green solutions, which become blue by dilution with water; but the nitric solution, when concentrated, is red. All these solutions give, by the addition of an alkali, a precipitate of the same color as the solution. Its name was suggested by the variety of colors, it exhibits, while dissolving in muriatic acid.

2. OSMIUM. *TENNANT.* Of this substance in a metallic state little is known, except that it exists in the form of a dark gray or bluish powder. If the black powder, which remains after dissolving Platina in nitro-muriatic acid, be distilled with nitrate of potash, a volatile oxide of Osmium sublimes, and, when cool, is condensed into a solid, colorless mass. This oxide is very soluble in water; and, if an infusion of galls be added to this colorless solution, it produces a purple color, which soon changes to a deep and lively blue. The pungent *odor* of its volatile oxide suggested the name of the metal.

3. RHODIUM. *WOLLASTON.* This substance has not yet been sufficiently investigated. It is not malleable, and has a grayish white color. It is infusible, and insoluble in acids. But, when alloyed with copper, lead, or platina, it becomes soluble in nitro-muriatic acid. With arsenic it is fusible; and, by continuing the heat, the arsenic is driven off. Its spec. grav. appears to be above 11.—Its name is taken from the rose color, which it communicates to dilute solutions of salts, which contain it.

4. PALLADIUM. *WOLLASTON.* This metal is better known, than any one of the three preceding. Its color is grayish white, and scarcely distinguishable from that of Platina. It is malleable, very ductile, and, in thin plates, flexible, but without much elasticity. Its hardness differs but little from that of wrought iron; and its spec. grav. is somewhat above 11. It is not oxidated by the action of air and caloric; but in a high heat is fusible. It forms ductile alloys with gold and silver, and very much debases their color. (*CLOUD.*) In nitro-muriatic acid it rapidly dissolves, yielding a deep red solution, from which is obtained a yellowish white precipitate by prussiate of mercury, which does not throw down platina. The muriate of Palladium and potash crystallizes in four-sided prisms, which, being viewed at right angles to the axis, appear green, but, in the direction of the axis, are red. (*BRONGNIART.*)

GENUS III. *SILVER.*

Pure Silver is very nearly white. In lustre it is superior to gold, but in malleability is somewhat inferior. It is very ductile, and the tenacity of its wire is inferior only to that of iron, copper, and platina. It is a little harder than gold, more elastic, and more sonorous by percussion. But it is softer than copper, and easily cut by a knife. Its spec. grav. is 10.47.

Silver melts at about 23° W. It is not oxidated by exposure to the air, but acquires a tarnish, which arises from the action of sulphuretted hidrogen. It is not oxidated even by the action of caloric, unless at a high temperature long continued, or by the heat, produced by oxigen gas. Nitric acid is its proper solvent, from which it is precipitated by muriatic acid in the state of a white, insoluble substance, which, by exposure to the sun's rays, speedily assumes a violet or blackish tinge. Or it may be precipitated in a metallic state by a plate of polished copper.

(Uses and Remarks.) Silver, it is well known, is employed for coin, vessels of use, works of ornament, and for plating copper, &c. In these cases, however, it is usually alloyed with a little copper, which increases its hardness and renders it more sonorous, without debasing its color. The standard silver of the British coins contains 18 pwts. of copper in 1 lb. Troy of silver; and in the U. States 1664 grains of silver contain 179 grs. of copper.

Silver is soluble in the nitro-sulphuric acid, prepared by dissolving one pound of nitre in eight or ten pounds of strong sulphuric acid. This compound acid, which dissolves about one fifth of its weight of silver, does not act upon copper, lead, or iron; and hence may be economically employed for recovering silver from old, plated goods. The plated copper is added in small pieces to the acid, which should be frequently stirred, and kept at a temperature of between 100° and 200° Fahr. Muriate of soda precipitates the silver in the state of a muriate, which may be reduced by fusion with carbonate of soda.

The oxide of silver communicates an olive color to glass or enamel; and the nitrate of silver constitutes the basis of indelible ink.

Silver is usually extracted from its gangue or its ores by amalgamation with mercury, or by roasting and cupellation with lead. But it must be remembered, that all ores, which contain sufficient quantities of silver to be worth extraction, are not, strictly speaking, ores of Silver. (See geological remarks on the ores of silver.)

SPECIES 1. NATIVE SILVER.* *KIRWAN. JAMESON.*

Its general characters are those of pure Silver, though it is usually a little less white, less soft, and less malleable. Its surface is frequently tarnished with shades of gray, yellowish brown, grayish black, &c.

Native Silver is sometimes crystallized, and appears in cubes, octaedrons sometimes cuneiform, cubo-octaedrons, &c. The crystals are usually small, often aggregated, and sometimes so arranged, as to produce certain imitative forms. Sometimes it is branched or dendritic, presenting numerous crystals, attached to each other; when the branches all lie in the same plane, the form becomes reticulated, or resembles the leaf of a fern.—It also occurs cylindrical, dentiform, filiform, or capillary; and sometimes its filaments are curved, twisted, entangled, or even collected into little tufts, like those of thread or hair. In fine, it sometimes appears in leaves, plates, or spangles, or in amorphous masses, which in some cases are very large. It but rarely occurs in grains.

(Chemical characters.) Its relations to acids are nearly the same as those of pure silver. Sometimes, however, it will not dissolve in nitric acid, unless it has been previously melted. Native Silver is seldom, if ever, perfectly pure, being alloyed with small quantities of gold, copper, arsenic, iron, &c. The quantity of alloy is seldom less than 4 or 5 per cent.

Its malleability and other obvious characters are sufficient to distinguish it from antimonial silver, native antimony, &c.

Var. 1. AURIFEROUS NATIVE SILVER.† *KIRWAN. JAMESON.* This variety is rare, and sometimes contains a considerable proportion of gold. A specimen from Norway yielded 28 per cent. of gold. (*KIRWAN.*) Its color is yellowish white, or nearly brass yellow; and its spec. grav. is greater, than that of pure Silver.

It has been found chiefly at Kongsberg, in Norway.

(Geological situation and Localities.) Native Silver is connected with various other minerals, being disseminated in their masses, inserted in their fissures, or attached, often under some imitative form, to their surfaces. It accompanies nearly all the other ores of Silver in veins, which traverse primitive or transition rocks. It has but rarely been observed in secondary rocks.—Its gangue may be quartz, carbonate or fluate of lime, sulphate of barytes, &c. It is often associated with the sulphurets of iron, zinc, and lead, pyritous

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* Gediegen Silber. WERNER. Argent natif. HAÜY. BRONGNIART. BROCHANT.

† Guldisches gediegen Silber. WERNER.

copper, and sometimes with native bismuth and arsenic, and the ores of cobalt and nickel.

Native Silver is found in the mines of Mexico and Peru;—in Norway, at Kongsberg, where its gangue is the carbonate and fluate of lime, &c.—in Saxony, at Freyberg, in sulphate of barytes and brown spar;—in France, at Allemont, in a ferruginous clay, &c.

In the *United States;* Native Silver, ramous or branched, has been found in *New Jersey.*—In *New York*, near Sing Sing, in a very small vein. (GIBBS.)—In *Connecticut*, at Trumbull, with native bismuth; this silver contains a little arsenic, and does not dissolve in nitric acid, till it has been fused. (SILLIMAN.)—In *New Hampshire*, at West Mountain, opposite the mouth of West river; this is in capillary filaments, and, like the preceding, contains a little arsenic. (SILLIMAN.)

In a few instances very large masses of Native Silver have been found. Thus the mine of Kongsberg has furnished one, weighing nearly 300 lbs. A still larger mass is said to have been found at Schneeberg in Saxony; and it is added, that Albert, Duke of Saxony, in 1748, descended the mine, and used this immense block of Native Silver, as his dining table.

SPECIES 2. ANTIMONIAL SILVER.* *JAMESON.*

Its true color is nearly silver white, sometimes inclining to tin white. Its surface, however, has often a tinge of yellow, or reddish yellow, or is invested with a blackish coat; but its streak is metallic and shining.

Its structure and fracture are foliated, and its lustre metallic and shining, sometimes very highly. It yields to the knife, possesses little or no malleability, and may be broken without difficulty. Its spec. grav. varies from 9.44 to 10.0.

This ore is sometimes in grains, and sometimes in nodules or masses, composed of granular distinct concretions. Frequently, however, it appears in hexaedral or cylindrical prisms, whose sides are, in general, deeply and longitudinally striated. A cube, four-sided prism, and some other forms are also mentioned.

(*Chemical characters.*) Antimonial Silver, according to Klaproth, contains from 76 to 84 parts of silver, and from 16 to 24 parts of antimony. It melts before the blowpipe; the antimony is oxidated, and rises in a white smoke, yielding its peculiar odor; a globule of silver is also obtained, more easily however, if borax be added. In

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* Spiesglaz Silber. WERNER. Argent antimonial. HAUY. BRONGNIART. BROCHANT. Antimoniated native silver. KIRWAN.

nitric acid it becomes covered with a white oxide of antimony, and is reduced to a kind of pap. (*Brongniart.*)

(*Distinctive characters.*) Its foliated structure and want of malleability distinguish it from native silver.—The same structure also distinguishes it from arsenical iron and arsenical cobalt, the former of which is also harder and yields an odor of garlic, when struck with steel, and the latter communicates to borax a blue tinge.

(*Geological sit. and Localities.*) This species occurs in metallic veins, but is somewhat rare. Near Guadalcanal, in Spain, it occurs in carbonate of lime and sulphate of barytes. It is associated with sulphuret of lead, native silver, and sometimes with gray copper, &c. It is found also at Wittichen, &c. in Suabia;—and in the Hartz, &c.

Species 3. Arsenical Silver.* *Jameson.*

Its color differs little from that of the preceding species, except in sometimes inclining to lead gray. It has often a steel gray, or blackish tarnish, but its streak has a metallic lustre.—Its structure it less distinctly foliated, than that of antimonial silver; and its fracture, which is usually foliated, is sometimes even or conchoidal; its lustre is metallic and more or less shining. It is broken without difficulty, and easily yields to the knife. Its spec. grav. is very considerable.

It is sometimes reniform, globular, or botryoidal, and sometimes in irregular masses, composed of granular concretions.—It is said to occur also in hexaedral prisms and pyramids.

(*Chemical characters.*) When exposed to the blowpipe, it exhales a strong odor of garlic, in consequence of the volatilization of the arsenic; and a globule of silver, contaminated with iron, remains. A specimen from Andreasberg yielded Klaproth silver 12.75, arsenic 35.0, iron 44.25, antimony 4.0;=96.

Its softness distinguishes it from arsenical iron; but its claims to the rank of a distinct species are somewhat questionable. It has, indeed, been referred by some mineralogists to the preceding species.

(*Localities.*) It is found at Andreasberg in the Hartz, in carbonate of lime, accompanied by native arsenic, the sulphurets of lead and zinc, and red silver ore; it is sometimes in little spheres, aggregated into botryoidal masses. It occurs also in Suabia; but is a rare mineral.

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* Arsenik' Silber. Werner. Argent arsenical. Brongniart. Brochant. Argent antimonial ferro—arsénifère. Hauy. Arsenicated native silver. Kirwan.

Species 4. SULPHURET OF SILVER.*

The color of this ore is almost always a dark lead gray. By exposure to the air its surface becomes darker, or acquires a tarnish; but its streak is shining.

It is considerably malleable, and not easily broken. It yields with much ease to the knife, which leaves a shining, metallic surface, and the slices detached are flexible. Its spec. gravity lies between 6.90 and 7.21.

This mineral is sometimes crystallized in cubes, octaedrons, cubo-octaedrons, and dodecaedrons with rhombic faces; and some of these forms are subject to truncations on their edges or angles. The crystals are usually small and grouped.—It, however, more frequently occurs in amorphous masses, or leaves, plates, or membranes, or is dendritic, filiform, capillary, reticulated, &c. Its masses are never very large.

Its fracture is usually fine grained uneven, sometimes a little conchoidal, or nearly even; its lustre is more or less shining and metallic.

(Chemical characters.) Before the blowpipe, the sulphur is driven off, and a globule of silver remains. If slowly heated, the sulphur is dissipated, and the silver appears in filaments variously twisted, or dendritic, like native silver. Hence the opinion, that native silver, when filamentous, may have arisen from a similar decomposition. It is composed of silver 85, sulphur 15. *(KLAPROTH.)* It is a very rich ore.

(Geological situation.) This ore is found in metallic veins, where it is associated with other ores of silver, as native silver, sulphuretted antimonial silver, &c. also with the sulphurets of lead and zinc, arsenical and sparry iron. Indeed it is found in almost all silver mines, but never by itself constitutes whole veins.—Its more common gangues are quartz, carbonate of lime, and sulphate of barytes. It is often attached to the surface of its accompanying minerals.

(Localities.) These are numerous; but we mention only the mines of Freyberg, &c. in Saxony, and the numerous veins of silver in Mexico and Peru.

It is said to have been found in *Connecticut.*

Species 5. SULPHURETTED ANTIMONIAL SILVER.† *MURRAY.*

Red silver ore.

The powder of this mineral is always very nearly crimson red,

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* Argent sulfuré. HAUY. BRONGNIART. Glaserz. WERNER. Silver-Glance. JAMESON. L'Argent vitreux. BROCHANT. Sulphurated silver ore. KIRWAN.

† Argent antimonié sulfuré. HAUY. Roth gültigerz. WERNER. Red silver ore. KIRWAN. JAMESON. Argent rouge. BRONGNIART. BROCHANT.

whatever may be the external color of the mass; and hence the name of Red silver ore.* Its streak also is red, with some lustre.

Its external color is sometimes a pure red, sometimes dark cochineal or blood red, which is often strongly tinged with lead gray, or even passes into it, and sometimes it is reddish or grayish black with a metallic lustre. But most of its darker colors are merely superficial, and arise from an alteration in the mineral. Its external lustre is usually considerable.

This ore is brittle, and easily scraped by a knife. Its fracture is uneven, or imperfectly conchoidal with small cavities, sometimes nearly even, or almost foliated in the crystallized varieties; and its lustre, which varies from splendent to glimmering, is either metallic or adamantine.—It is usually translucent, often at the edges only; and sometimes it is opaque, though even in this case the centre of the mass is almost always translucent.—It is a conductor of electricity; and its spec. grav. lies between 5.44 and 5.68.

Red silver ore is sometimes in grains or small masses; sometimes it forms membranes or invests the exterior of other minerals, or is dendritic, capillary, &c. and very frequently it is crystallized.

This species presents no less, than fourteen secondary forms, all of which are hexaedral prisms, or double six-sided pyramids, frequently modified by truncations and acumination. The primitive form is an obtuse rhomb, whose plane angles are 104° 28′ and 75° 32′. This approaches the primitive form of carbonate of lime, and the secondary forms of both minerals resemble each other.

It is sometimes in regular six-sided prisms.—Sometimes this prism is terminated at each extremity (Pl. IV. fig. 35.) by three faces, standing on alternate lateral edges, but on different edges at each summit; the edges of the summits, and even all the edges of this crystal are subject to truncation.—Another secondary form is a dodecaedron or double six-sided pyramid (Pl. IV. fig. 36.), in which the alternate and least obtuse edges of each pyramid are truncated by hexaedral faces. The single pyramids, sometimes observed, belong to this variety.—It also occurs in crystals, composed of two incomplete, hexaedral pyramids (Pl. IV. fig. 37.), applied base to base, and truncated near their summits.—The faces of these crystals have usually a strong lustre, but are often striated, and a little convex; the edges and solid angles are commonly rounded or blunted.

(*Chemical characters.*) Before the blowpipe it decrepitates,

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* Werner has divided Red silver ore into two subspecies, *dunkles* and *lichtes roth gültigerz*, or dark and light red silver ore; and, according to Jameson, the streak of the former is cochineal or brick red, while that of the latter is aurora red.

melts, and exhales a whitish vapor, with an unpleasant odor, arising from antimony or arsenic, and often distinctly resembling that of garlic; it frequently burns with a bluish flame. By continuing the heat a globule of silver is obtained. When gradually heated, the silver appears in filaments or dendrites. According to the analysis of Vauquelin, it contains silver 56.67, antimony 16.13, sulphur 15.07, oxigen 12.13. This chemist supposes the two metals to exist in the state of an oxide, united with sulphur. Proust, on the contrary, believes both to be in a metallic state, and considers this ore a compound of the sulphurets of silver and antimony.—Further, according to the chemist last mentioned, the silver in this mineral is sometimes united to antimony only, sometimes to arsenic only, and sometimes to both metals. One specimen, which he analyzed, yielded sulphuret of silver 74.35, sulphuret of arsenic 25.0, sand and oxide of iron 0.65. If this analysis be correct, a new species must be added to the ores of silver.—The iron, which this mineral sometimes contains, without doubt, communicates a dark shade to its color.

(Distinctive characters.) There are several minerals, which this more or less resembles, viz. the sulphurets of arsenic, mercury, and silver, specular iron, red oxide of copper, and gray copper. But the red sulphuret of arsenic yields an orange yellow powder, and has a less specific gravity.—Sulphuret of mercury has a greater specific gravity, and is entirely volatilized before the blowpipe.—Sulphuret of silver is malleable.—Specular iron is harder, sensibly affects the needle, and its powder is less distinctly red.—The red oxide of copper has a less specific gravity, effervesces in nitric acid, and communicates to ammonia a blue color.—Gray copper is harder, and its powder is blackish.

(Geological sit. and Localities.) This mineral is found in metallic veins, associated with other ores, and occurs in almost all silver mines. It is sometimes disseminated, but never presents large masses. It is associated with other ores of silver, the sulphurets of lead, zinc, arsenic, &c. native arsenic, sparry iron, arsenical cobalt, gray copper, pyritous copper, arsenical iron, and nickel, &c.—Its more common gangues are the carbonate and fluate of lime, sulphate of barytes, quartz, and hornstone.

Among its numerous localities may be mentioned the Hartz, the mines of Freyberg in Saxony, of Guadalcanal in Spain, of Schemnitz, &c. in Hungary, those of Mexico, &c.

SUBSPECIES 1. BRITTLE SULPHURETTED ANTIMONIAL SILVER.*

Its color is dark lead gray, or a shining grayish black; indeed, when not tarnished, its external lustre is strong and metallic. It is very *brittle;* and, when cut with a knife, its particles fly off with considerable noise. It retains its lustre and color in its streak, but its powder is black.—Sometimes, however, in the same group of crystals, some give a red, and others a black, powder; thus connecting this subspecies with the common varieties.

Its fracture is uneven or conchoidal, and more or less shining with a metallic lustre. Its spec. grav. is 7.20.

It occurs amorphous, or in membranes, or crystallized in hexaedral prisms, which are sometimes terminated by six-sided pyramids. —Sometimes its crystals are tabular, and intersect each other, forming cells.

(Chemical characters.) It melts by the blowpipe, but not so easily, as the common variety; its volatile ingredients are dissipated, and a globule of silver, imperfectly malleable, remains. It contains, according to Klaproth, silver 66.50, antimony 10.0, sulphur 12.0, iron 5, copper and arsenic 0.5, earthy substances 1.0;=95.

(Geological sit. and Localities.) Like the common or red varieties of this species, with which it is usually associated, it always occurs in metallic veins. Its gangues and accompanying minerals are of course similar to those of the common variety.

It has been found chiefly in Hungary and Saxony.

SPECIES 6. SILVER BLACK.* *JAMESON.*

Its color is black, with a shade of blue or gray; but its streak is shining and metallic. It is sometimes more or less solid, but is easily broken, and presents a dull, earthy fracture, and sometimes it is friable, or even loose. It occurs in crusts or in masses, which are frequently cellular or corroded. It often slightly soils the fingers.

(Chemical characters.) Before the blowpipe it easily melts, and globules of silver may be obtained. It has not been analyzed, but the silver is evidently in variable proportions. It is most probably an alteration of the sulphuret of silver or of sulphuretted antimonial silver, both of which it usually accompanies. It may also proceed from the decomposition of muriate of silver.

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* Argent antimonié sulfuré noir. HAUY. Sprödglaserz. WERNER. Brittle Silver-Glance. JAMESON. Argent rouge aigre. BRONGNIART. Antimoniated silver ore. KIRWAN.

* Silber schwarze. WERNER. Argent noir. BRONGNIART. BROCHANT. Sooty silver ore. KIRWAN. Var. of argent ant. sulf. noir. HAUY.

(Geological sit. and Localities.) It is sometimes connected with quartz and hornstone, or invests other ores of silver or sulphuret of lead with thin crusts. Sometimes also it forms the interior of geodes of muriate of silver.

It is common in the mines of Mexico and Peru. It occurs also in the silver mines of Hungary, at Allemont in France, Freyberg in Saxony, &c.

Species 7. Carbonate of Silver.*

This rare mineral is grayish black, and its streak has considerable lustre. It has occurred only in amorphous masses, which are easily broken, and whose fracture is uneven or earthy, and glistening with a metallic lustre.

It effervesces in acids for a short time, and is easily reduced by the blowpipe. It contains silver 72.5, carbonic acid 12.0, carbonate of antimony with a little oxide of copper 15.5. *(Selb.)*—It is, perhaps, an alteration of antimonial silver.

(Locality.) It is found in the mine of Winceslas, in the Furstenberg, Suabia. Its gangue is sulphate of barytes, and it is associated with other ores of silver, among which is antimonial silver.

Species 8. Muriate of Silver.†

This mineral has usually the softness of wax. Hence it may be cut with great ease by a knife, which leaves a glossy surface; indeed in most cases it may be impressed by the finger nail. Its usual color is gray, often pearly, or with a tinge of yellow or green, sometimes nearly white, and sometimes even leek green. By exposure to light its color gradually darkens, and becomes violet blue or brownish. Its surface has sometimes a metallic aspect in consequence of decomposition.—It is more or less translucent, in some cases at the edges only. In thin pieces it is often a little flexible, or even malleable. Its spec. grav. extends from 4.74 to 4.80.

It is sometimes crystallized in cubes or parallelopipeds; but more frequently occurs in thick membranes or crusts, sometimes composed of minute crystals, or in small masses reniform, globular, or amorphous. Its fracture is uneven or imperfectly conchoidal, and, when recently made, has somewhat of a resinous lustre.

(Chemical characters.) Muriate of Silver is very fusible, and melts even with the flame of a candle. Before the blowpipe it diffuses the unpleasant odor of muriatic acid, and leaves on the charcoal

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* Argent carbonaté. Hauy. Brochant. Luftsaures Silber. Widenman.

† Argent muriaté. Hauy. Brongniart. Hornerz. Werner. Corneous silver ore. Kirwan. Jameson. L'Argent corné ou muriaté. Brochant.

a globule of silver nearly pure. When moist, it is a little volatile. (*Proust.*) If this ore be rubbed by a piece of zinc or iron, which has been moistened by the breath, a thin film of metallic silver immediately appears on the surface of the mineral. It contains silver 67.75, muriatic acid 21.0, oxide of iron 6.0, alumine 1.75, sulphuric acid 0.25 ;=96.75. (*Klaproth.*)

It has so little of a metallic aspect, that it would very often pass unobserved, were it not associated with more obvious ores of silver.

Subspecies 1. ARGILLACEOUS MURIATE OF SILVER.*

Its color is whitish, greenish white or pale green, and sometimes bluish gray or brownish at the surface. Its fracture is earthy and dull; it is almost friable.

Before the blowpipe it does not melt; but contracts and agglutinates, while minute globules of silver flow out. It contains silver 24.64, muriatic acid 8.28, clay 67.08, and a little copper. (*Klaproth.*)—It has been found at Andreasberg, in the Hartz, connected with quartz and calcareous spar.

(*Geological sit. and Localities.*) Muriate of Silver is somewhat rare. It is disseminated in other minerals, or invests them with a crust more or less thick. Sometimes it forms geodes, either empty or containing Silver black. It occurs in metallic veins, and almost always in the upper parts of the vein. Hence it is undoubtedly the most recent of the ores of Silver; sometimes indeed it is connected with fossil remains.

Quartz, sulphate of barytes, and carbonate of lime are usually its gangues; and it is accompanied by brown oxide of iron, native silver, and silver black, sulphuret and carbonate of lead, oxide and carbonate of copper, &c.

Thus at Schlangenberg, in Siberia, it occurs with native silver, oxide and carbonate of copper, carbonate of lead, native gold, &c.—At Allemont, in France, with several ores of silver, oxide of cobalt, &c.—In Peru, it sometimes envelopes masses of native silver, and is accompanied by gray copper, &c. It is considerably abundant in some of the Peruvian and Mexican silver mines.

(*Geological remarks on ores of Silver.*) The ores of Silver belong chiefly to primitive rocks; and occur in metallic veins, which traverse granite, gneiss, micaceous and argillaceous slates, greenstone, syenite, hornblende, and porphyry. They have also been observed in veins, which traverse gray-wacke, compact limestone, secondary slates, &c. but seldom or never in the more recent secondary rocks.

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* Argent muriaté terreux. Brongniart. Brochant. Erdiges hornerz and buttermilcherz of the Germans.

According to Brongniart, those ores of silver, which occur in secondary rocks, are usually the sulphuret of silver, and Red silver. It appears, however, that Silver is often mixed with those ores of other metals, which are supposed to belong more particularly to secondary mountains; such as the sulphurets of lead, zinc, antimony, and mercury.

Silver and its ores, in addition to the more common gangues, already mentioned, are sometimes connected with jasper, serpentine, talc, asbestus, &c. Indeed Silver is sometimes intimately mixed with that variety of asbestus, called mountain cork, in the proportion of 15 per cent. and this compound, which is reddish brown, has been regarded as a distinct ore of Silver.

We have already remarked, that all ores, from which Silver is extracted with advantage, are not, strictly speaking, ores of Silver. This is often the case with the sulphurets of lead, zinc, iron, &c. gray copper, arsenical iron, &c. In fact, a large proportion of the Silver of commerce is extracted from argentiferous sulphuret of lead. These ores, however, though sometimes arranged as ores of Silver, we refer to what appears to be their proper genera.[*]

(Silver mines.) Of these, the following are some of the more important; the silver being extracted from ores of Silver, or from other ores, which contain this metal, or from both.

Spain furnished the ancients with much Silver; but the most important mine, at present, is that of Guadalcanal, in Estremadura. It contains much Red silver in a gangue of carbonate of lime.

The mine of Allemont, in the department of Isère, France, is situated more than 3000 yards above the level of the sea in a micaceous rock, containing hornblende. This rock is traversed in all directions by veins, containing Native silver, Sulphuret of silver, Red silver, &c. These ores are accompanied by the oxide and arseniate of cobalt, nickel, native antimony, &c. and their gangue is usually ferruginous clay, or carbonate of lime. The richest part of the veins is near their surface.

In Germany, are numerous Silver mines in Saxony, Bohemia, Suabia, &c. In those of Freyberg, Saxony, the veins usually traverse gneiss, and contain Sulphuret of silver, Red silver, &c. native

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[*] Thus Wismuthisches silber (l'argent bismuthifère) is referred to *argento-bismuthal sulphuret of lead*;—Weissgültigerz (white silver ore of Jameson, or light and dark gray silver ore of Kirwan) to *argento-antimonial sulphuret of lead*;—Graugültigerz of Klaproth (gray silver ore), Schwartzgültigerz of Werner (black silver ore), and Argent gris, all to *gray copper*; also Gænsekoethiges silber (l'argent merde-d'oie) to *argentiferous arseniate of cobalt.*

arsenic, sulphuret of lead, gray copper, &c. the last two ores are argentiferous.

The Silver mines of the Hartz, and of Sahlberg, in Westmania, contain much argentiferous sulphuret of lead.

The mines of Schemnitz, &c. in Hungary—of Schlangenberg, Kolivan, &c. in Siberia, have furnished much Silver, and some of them are still very productive.

The mine of Kongsberg, in Norway, has formerly been more productive than at present. Its richest veins traverse nearly vertical beds of hornblende slate, contained in mica slate. These veins embrace different ores of Silver, but chiefly Native silver and Sulphuret of silver, accompanied by several ores of cobalt, and by the carbonate and fluate of lime, &c.

But the mines of Mexico, Peru, &c. in America furnish at least ten times as much Silver as all the mines of the old continent.

The mountain of Potosi, in Peru, is traversed by numerous veins, containing Native silver, Sulphuret of silver, Muriate of silver, and the Brittle sulphuretted antimonial silver. The gangue of the Peruvian silver is often a very brittle quartz. These veins have been found less rich, as they have been more deeply explored. But richer veins are now known north of Potosi. According to Humboldt, veins of silver in Peru often traverse compact limestone.

The mines of Mexico or New Spain are vastly more productive, than those of Peru. The great value, however, of these mines depends not on the richness, but the abundance of the ore. For, according to Humboldt, 1600 ounces of the ore does not, at a medium, yield more than 3 or 4 ounces of pure silver. The same quantity of ore in some of the Silver mines of Saxony affords from 10 to 15 ounces. The mine of Valenciana, in the district of Guanaxuoto, presents a vein more than 60 yards in width, and at least 600 yards in depth, traversing a mountain of argillaceous slate. This vein is composed of Native silver, Sulphuret of silver, Red silver, a little gold, the sulphurets of lead, &c. quartz, hornstone, &c.

(*Remarks.*) According to Humboldt, the annual product of the American Silver mines is equal in value to 32½ millions of dollars; of which New Spain furnishes about 22 millions, Peru about 5⅝ millions, Buenos Ayres about 4½ millions, and Chili the remainder. More than three fourths of this Silver is extracted from the ore by amalgamation with mercury.

GENUS IV. *MERCURY.*

This metal usually remains fluid, even when exposed to the greatest cold of the atmosphere in temperate regions. It becomes solid at about 40° below the zero on Fahr. and, in this state, is malleable, flexible, and capable of crystallizing in octaedrons. Its boiling point is about 660°. (*Dalton.*) When pure and fluid, it is still opaque, and nearly silver white with a strong lustre. Its spec. grav. is 13.56; that of solid Mercury is 15.61. (*Biddle.*)

It may be oxidated by exposure to caloric in contact with air, or even by long agitation in contact with air only; and its oxides are reducible by caloric. It combines with many of the metals, producing amalgams, which are either soft, or solid and brittle, according to the proportions employed.

The existence of Mercury, even in small quantities, in any of its ores, may be ascertained by mingling the ore with iron filings, and heating this mixture to redness under any cold body, as a plate of polished copper; the Mercury is volatilized, and condensed in minute globules on the plate.

(*Uses.*) The uses of this metal are numerous and important in Natural Philosophy, Chemistry, the Arts, and Medicine. Immense quantities are employed in extracting native silver and gold from their gangues by the process of amalgamation. (See remarks at the close of Sulphuret of mercury.)

Species 1. Native Mercury.* *Kirwan. Jameson.*

No one can mistake this metal in its native state. In color, lustre, fluidity, &c. it does not sensibly differ from the pure metal already described. It occurs in small globules, disseminated in other minerals. These globules are but feebly united to their gangue, and may be liberated by striking or heating the substance, which embraces them.

Native Mercury is generally pure, and may be entirely volatilized by the blowpipe; but it sometimes contains a little silver, which diminishes its fluidity.

(*Geological sit. and Localities.*) It is found in almost all those mines, which yield the Sulphuret of mercury, in which it is often disseminated, or appears at its surface. It is also interspersed through those minerals, which accompany the Sulphuret, such as argillaceous slate, sandstone, compact limestone, clay, &c. Indeed it sometimes flows through fissures in these minerals, and collects in

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* Gediegen Quecksilber. Werner. Mercure natif. Hauy. Brongniart. Brochant.

their cavities. It is, however, never abundant; and its localities are those of the Sulphuret of mercury.

In the *U. States*; it has been found in *Kentucky*, in small globules in a mass, which also appears to contain some native amalgam. (*Hayden.*)

Species 2. Argental Mercury.*

This native amalgam is more or less solid and brittle, according to the proportion of silver, which it contains. Some varieties, however, are but imperfectly solid; or may perhaps be viewed as a solid amalgam, mingled with native mercury.

Its color varies from tin to silver white. When rubbed on copper or gold, it leaves a metallic white trace. Its fracture is imperfectly conchoidal or uneven, and more or less shining with a metallic lustre. Its spec. grav. is above 10.

It occurs in plates or membranes, or in small globular or amorphous masses, and is also susceptible of crystallizing. Its crystals are regular octaedrons with truncated edges, or dodecaedrons with rhombic faces. This dodecaedron has sometimes its edges and four of its solid angles truncated (Pl. IV, fig. 38.), thus giving a solid with twenty eight faces; indeed, according to Cordier, the truncations are sometimes so numerous, that the crystal presents 122 faces.

(*Chemical characters.*) Before the blowpipe the mercury evaporates, leaving a globule of silver. When crystallized, it contains mercury 72.5, silver 27.5. (*Cordier.*) In other cases the proportions are variable.

Its want of ductility, and its action on a plate of copper sufficiently distinguish it from native silver.

(*Geological situation.*) This ore occurs in mines of the Sulphuret of mercury on the surface of other minerals, or disseminated in them. According to De Born, it is most frequently found in those veins of mercury, which are intersected by veins of silver, or in which the ores of the two metals are intermingled. Its gangue is sometimes lithomarge, or a ferruginous clay variously colored. It is a rare mineral.

Species 3. Sulphuret of Mercury.†

Cinnabar.

This species occurs much more abundantly, than any of the other ores of mercury, and is hence peculiarly interesting and important.

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* Mercure argental. Haüy. Brongniart. Natürliches amalgam. Werner. Natural amalgam. Jameson. L'Amalgame natif. Brochant.

† Mercure sulfuré. Haüy. Brongniart.

Its color always presents some shade of red, which sometimes passes to brown by foreign mixture; sometimes also the surface becomes dark metallic gray by a chemical change. But its powder and streak are scarlet or cochineal red. It is easily scraped by a knife, unless intermixed with harder bodies; and its spec. grav. varies from 7 to 10. When rubbed on white paper, it usually leaves a red trace.

Sulphuret of mercury is found amorphous, or under some imitative form, or crystallized. The primitive form, which it sometimes presents, is a regular hexaedral prism. This prism is liable to great alterations by additional faces; and hence the crystals of this species are sometimes described as obtuse rhombs, cubes, octaedrons, &c. Sometimes they are tabular. The crystal (Pl. IV, fig. 39.), when carefully examined, is found to be a short hexaedral prism, terminated at each extremity by six faces, or rather by three *pairs* of faces, which correspond to alternate lateral planes; the faces at one extremity also alternate with those at the other, and the lateral faces are sometimes rounded.—The crystals are usually small with a high lustre, and often much grouped. Their integrant particles are triangular prisms.

(*Chemical characters.*) When pure, it is entirely volatilized by the blowpipe, with a bluish flame, and a smoke having a feeble odor of sulphur. It is essentially composed of sulphur and mercury only. (See analyses under the varieties.)

(*Distinctive characters.*) From other red ores, as red silver, red oxide of copper, chromate of lead, and red sulphuret of arsenic, it is distinguished by being entirely volatile before the blowpipe, or by not yielding a metallic globule, nor the well known odor of garlic.

Var. 1. COMMON SULPHURET OF MERCURY.* (Common Cinnabar.) Its color is usually cochineal red, sometimes carmine or brownish red, or nearly lead gray, but its streak is a shining scarlet red. It is generally opaque, or translucent at the edges only; the crystals, however, are sometimes semi-transparent.

It is easily broken, and its fracture is granular or uneven, and sometimes even or conchoidal; its lustre is variable, either shining or only glimmering, and often slightly metallic.—When crystallized, its structure is foliated, and its spec. grav. about 10.21, which, in impure specimens, falls to 6.90 or lower.

This variety not only presents the crystalline forms already mentioned, but is found also in laminated, granular, or compact masses, or is reniform, dendritic, in membranes, &c.—in fine, it is some-

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* Mercure sulfuré compact, granulaire, &c. HAÜY. BRONGNIART. Dunkel rother Zinnober. WERNER. Dark red Cinnabar. JAMESON. Le Cinnabre commun. BROCHANT. Var. of Native Cinnabar. KIRWAN.

times in a loose state, and has then been called *flowers of Cinnabar*, or native vermillion.

It appears to be composed of mercury 85, sulphur 15. *(Klaproth.)*—Most of the Mercury of commerce is extracted from this variety.

2. FIBROUS SULPHURET OF MERCURY.* (Fibrous Cinnabar.) Its color is scarlet red, often lively, and sometimes with a tinge of yellow. Its structure is more or less fibrous, and its lustre, though feeble, is often silky; its cross fracture is earthy and dull. It is opaque, very easily broken, and soils the fingers a little, especially when wet.—It occurs amorphous, and sometimes invests other minerals, or is disseminated.

This variety is rare; and has hitherto been found chiefly at Wolfstein, &c. in the Palatinate, and accompanies the common variety.

Subspecies 1. BITUMINOUS SULPHURET OF MERCURY.†

Its color is reddish brown, or dark cochineal red with a mixture of lead gray, and is sometimes nearly iron black. Its streak, however, is a dark red, and has some lustre. It is opaque, yields to the knife, and is easily broken, especially when slaty.

It is sometimes in compact masses, whose fracture is, in general, nearly or quite even, with a moderate lustre.—Sometimes also its structure is slaty; the layers are usually a little curved, and possess considerable lustre, but their cross fracture is even or nearly dull. In all cases the lustre is somewhat metallic.

(Chemical characters.) When exposed to the action of heat, it yields a bituminous odor, and the mercury evaporates. It is a Sulphuret of mercury, mixed with an indurated bituminous clay. A specimen from Idria yielded Klaproth mercury 81.8, sulphur 13.75, carbon 2.3, silex 0.65, alumine 0.55, oxide of iron 0.20, of copper 0.02;=99.27. Sometimes it does not yield more than 20 per cent. of mercury.

This subspecies constitutes a large proportion of the mercurial ore in the mines of Idria, where it is accompanied by the common variety, &c.

(Geological situation of Sulphuret of Mercury.) We have already remarked, that this is the only species of the ores of mercury, which exists in any considerable quantity. The other three species, whenever they occur, are almost always connected with this.

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* Mercure sulfuré fibreux. Hauy. Brongniart. Hockrother Zinnober. Werner. Bright red Cinnabar. Jameson. Le Cinnabre fibreux. Brochant.

† Mercure sulfuré bituminifère. Hauy. Mercure sulfuré hepatique. Brongniart. Quecksilber Lebererz. Werner. Mercurial Liver-ore. Jameson. Hepatic mercurial ore. Kirwan. Le Mercure hepatique. Broch.

Sulphuret of mercury is rarely found in primitive rocks, and then almost always in small quantities. It has thus been observed in argillaceous and chlorite slates, with quartz, sparry iron, &c. There is, however, in the republic of Venice a mine of this Sulphuret, disseminated in granite, in sufficient quantity to be explored. (SPALLANZANI.)

But in secondary rocks this ore occurs in considerable quantities, and is connected with bituminous shale, sandstone, compact limestone, ferruginous clay, &c. Mercury is of course one of the more recent metals.

Sulphuret of mercury occurs in beds, or large irregular masses, and sometimes in veins; the general structure of the mass is sometimes cavernous. It is associated with the sulphurets of lead and zinc, oxide of iron, gray copper, quartz, calcareous spar, &c.

(*Localities.*) The mines, which furnish this ore, are by no means common; and many countries, as Sweden, Great Britain, Russia, &c. scarcely contain this mineral. Spain, Germany, and Peru possess the most important mines.

In Spain, at *Almaden*, near Cordova, these mines are in a mountain of argillaceous slate or shale. The Cinnabar, mixed with quartz, is found in beds or veins of sandstone or breccia, which traverse the mountain, and contain fragments of limestone and shale. These mines have been worked more than 2000 years.

In Germany, at *Idria*, in Carniola, the mines are situated partly in gray compact limestone, and partly in shale, penetrated with the Sulphuret of mercury. The ore is chiefly the Bituminous sulphuret of mercury; and is accompanied by the sulphuret of iron, which contains both the Sulphuret of mercury, and native mercury. These mines also contain a kind of lignite, or coal, which embraces more or less of this Sulphuret.

Numerous mines of Mercury are explored in the Lower Palatinate and in the duchy of Deux Ponts, as at Wolfstein, Potsberg, Landsberg, &c. The mountains are here composed of sandstone, argillaceous slate, ferruginous clay, &c. and the Sulphuret of mercury, accompanied by argental and native mercury, occurs in scattered masses, or irregular veins; its gangues are lithomarge, clay, hematite and ochreous oxide of iron.—Near Munster-Appel, the slate embraces fossil fish, spotted with Sulphuret of mercury.

In America, this ore occurs at Guancavelica, in Peru, in a vein more than 50 yards wide, traversing sandstone and limestone. Other mines of this ore are found in New Spain and New Grenada.

(*Remarks.*) Mercury is obtained chiefly by the distillation of its Sulphuret; iron filings or lime being added to detain the sulphur.

According to Humboldt, the quantity of Mercury, annually employed in the American mines in the extraction of silver from its ores by amalgamation, is about 25,000 quintals. Of this, the greater part has recently been furnished by the mines of Almaden and Idria. In 1802, the mines of Almaden yielded more than 20,000 quintals. The mercury mines of Guancavelica in Peru, which formerly produced 10,000 quintals annually, do not at present yield 4000.

Species 4. Muriate of Mercury.*

The color of this native mercurial salt is usually gray, sometimes pearl gray, or nearly white, sometimes shaded with yellow or green, and even passes into greenish yellow. It is usually translucent, at least at the edges. It is brittle, and may be easily scraped by a knife.

Muriate of mercury most frequently occurs in crusts, which are often reniform or tuberose, and line the cavities of its gangue. Within these cavities it also appears in shining crystals, so minute and grouped, that it is difficult to determine their form. Sometimes, however, they are prisms, having four hexagonal sides, and terminated by four rhombic faces, placed on the lateral edges.

(Chemical characters.) Before the blowpipe it is entirely volatilized without decomposition. A specimen yielded Klaproth mercury 76.0, muriatic acid 16.4, sulphuric acid 7.6. In some specimens the sulphuric is said to exceed the muriatic acid in quantity. According to Fourcroy, the Muriate of mercury is in the state of corrosive sublimate. It is soluble in water, and yields, on the addition of lime-water, an orange colored precipitate.

It does not, like muriate of silver, ever possess the softness of wax, nor leave a metallic globule, when heated.

(Localities.) This ore is rare. In the mercury mines of Deux Ponts, it occurs in the cavities of a ferruginous clay or sandstone, or of argillaceous oxide of iron, accompanied by other ores of mercury, gray copper, &c.—At Idria, it occurs in cavities of indurated clay with crystallized cinnabar, &c. and sometimes in shale.

GENUS V. *COPPER.*

This mineral is less malleable, than gold, silver, or platina. Its tenacity, or the strength of its wire, is greater than that of any metal, excepting iron. In hardness it is exceeded by iron and platina; but it is harder and more elastic than silver, and is the most sono-

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* Mercure muriaté. Haüy. Brongniart. Brochant. Quecksilber Hornerz. Werner. Mercurial Horn-ore. Jameson. Mercury mineralized by the vitriolic and marine acids. Kirwan.

tous of the metals. Its color is a pale red, tinged with yellow. Its taste is styptic, and nauseous. Its spec. gravity varies according to the operations, it has undergone; a mean of four experiments on Swedish and British copper by Hatchett gives 8.77.

Copper melts at about 27° W. It becomes oxidated by air, but not by water, when air is excluded. Its oxides are soluble in ammonia, to which they communicate a fine azure blue color. Even the pure metal becomes oxidated, and is dissolved by ammonia in open vessels, producing the same blue color. Borax is colored green by the oxide of Copper. The two last mentioned characters are very useful tests of the presence of Copper, or rather of its oxide. When dissolved in acids, it may be precipitated in a metallic state by a plate of polished iron.

(Uses.) The uses of Copper, either when pure, or when alloyed, are numerous, and in general well known. Thus, when alloyed with zinc, it forms *brass*, *pinchbeck*, &c. Copper and tin, in different proportions, are the principal ingredients in *bronze*, *bell-metal*, *speculum-metal*, &c. The oxides of Copper are employed to give a green color to the enamel on porcelain, and its salts enter into the composition of several pigments, as *verditer*, *Brunswick green*, &c. But it ought to be remembered, that the oxides and salts of Copper are violent poisons; and, of course, that vessels, constructed of Copper, should never be employed for culinary purposes. Even when the Copper is alloyed with zinc, thus forming brass, or when coated with tin, the danger is very far from being removed, and *fatal* accidents have sometimes resulted from the use of vessels, composed of brass or tinned Copper.

Species 1. Native Copper.* *Kirwan. Jameson.*

Native Copper presents nearly all the characters of pure Copper, already described. Although its true color is, in fact, the same, its surface is often tarnished with shades of brown, black, yellow, &c. but its streak is splendent and metallic. Its fracture is hackly, and has a metallic lustre. Its spec. grav. varies from 7.60 to 8.58.

Native Copper is often crystallized. Its forms are a cube, which may be truncated on the angles, or edges, or on both; an octaedron; a short six-sided prism with pyramidal terminations, &c. The crystals are usually small and much grouped.—It also presents certain imitative forms, being dendritic, branched, reticulated, filiform, or in tufts like moss, or in dentiform, reniform, or botryoidal concretions.

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* Gediegen Kupfer. Werner. Cuivre natif. Hauy. Brongniart. Brochant.

In fine, it sometimes occurs in laminæ or plates, and in grains, or amorphous masses.

Its malleability distinguishes it from arsenical nickel, and other ores, which it may resemble in color.

(Geological situation.) Native Copper is found chiefly in primitive rocks, through which it is sometimes disseminated, or more frequently it enters into the composition of metallic veins, which traverse these rocks. It is thus connected with granite, gneiss, micaceous and argillaceous slates, granular limestone, chlorite, serpentine, porphyry, &c. It also occurs in transition and secondary rocks. It accompanies other ores of copper, as the red oxide, the carbonate and sulphuret of copper, pyritous and gray copper, also the red and brown oxides of iron, oxide of tin, &c.—Its usual gangues are quartz, the fluate and carbonate of lime, and sulphate of barytes. At Oberstein, it occurs in prehnite; and in the Faroe islands, it accompanies zeolite.

Native Copper is not rare, nor is it found in sufficient quantity to be explored by itself. It sometimes occurs in loose, insulated masses of considerable size.

(Localities.) Some of its more important localities are the mines of Tourinski on the eastern side of the Uralian mountains, and of Schlangenberg in Siberia; of Fahlun in Sweden; of Cornwall and Anglesea in England, &c.

In the *United States.* In *Virginia*, it occurs in Orange Co. *(Conrad.)*—In *Maryland*, on the Blue Ridge, Washington Co. *(Hayden.)*—In *Pennsylvania*, in Hamilton Ban, Adams Co. *(Conrad.)*—In *New Jersey*, at Woodbridge, in grains and plates disseminated in a blackish friable rock. (Med. Repos.)—Also in Schuyler's mines.—In *Connecticut*, at Bristol, with the red oxide of Copper, in a small vein. *(Gibbs.)*—also near Newhaven in secondary rocks; on the Hamden hills, a mass of Native Copper, weighing about 90 lbs. was found, many years since, adhering in part to the surface of the rock, on which it rested, and even penetrating its fissures. *(Silliman.)*

Species 2. Sulphuret of Copper.*

Its true color is dark lead gray or iron black; but it is sometimes reddish from an intermixture of the red oxide of copper. Its surface is often tarnished, but its streak is metallic and shining, and its fine powder is blackish.

It easily breaks, and, when cut with a knife, it separates into

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* Cuivre sulfuré. Haüy. Brongniart. Kupfer-glas. Werner. Copper-glance. Jameson. Le Cuivre vitreux. Brochant. Vitreous Copper ore. Kirwan.

grains, and not into slices, like the sulphuret of silver. Its spec. grav. varies from 4.12 to 5.45. Its fracture is usually more or less conchoidal, or fine grained uneven, with a glistening metallic lustre, sometimes very feeble.—Some varieties present a foliated* structure.

Sulphuret of copper most frequently exists in compact, amorphous masses; and but rarely occurs in regular crystals. Its forms are a short, regular six-sided prism, sometimes truncated on its terminal edges, or otherwise modified, and a double six-sided pyramid, whose summits are sometimes truncated, &c. Its secondary forms, of which Haüy mentions five, are derived from the hexaedral prism.

(Chemical characters.) It is very easily fusible, often by the flame of a candle only. When melted on charcoal by the blowpipe, it yields an odor of sulphur, and is reduced into a grayish metallic globule, contaminated with iron, and usually magnetic. It tinges borax green, and ammonia blue. A specimen from Siberia yielded Klaproth copper 78.5, sulphur 18.5, iron 2.25;=99.25. In another from England Chenevix found copper 84, sulphur 12, iron 4.—It is of course a rich and valuable ore of copper.

(Distinctive characters.) This mineral somewhat resembles gray copper; but the latter usually decrepitates, when suddenly heated, is harder, and, when cut with a knife, the particles fly off.—It is easily distinguished from sulphuret of silver.

This ore is susceptible of an alteration similar to that, by which pyritous copper appears to be converted into variegated pyritous copper.

Var. 1. PSEUDOMORPHOUS SULPHURET OF COPPER.† This remarkable variety occurs in small, oval, flattened masses, with blackish projecting scales, and resembles the little cones of the pine tree, or ears of corn much compressed. Indeed these masses are by many supposed to arise from the penetration of these vegetable substances by Sulphuret of copper. Some of them, however, appear to be an aggregation of minute crystals.—They are found at Frankenberg, in Hessia, in veins, which traverse primitive rocks; and are sometimes covered with a film of native silver.

(Geological sit. and Localities.) Sulphuret of copper occurs most frequently in primitive rocks, associated with malachite, the red oxide, and other ores of copper, oxide of iron, quartz, calcareous spar, &c. With the red oxide of copper it sometimes forms large veins.

Siberia, Sweden, Hungary, and England contain some of its most important mines. The best crystals come from Cornwall.

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* Foliated Copper-glance. JAMESON.

† Cuivre sulfuré pseudomorphique. HAUY. Cuivre spiciforme. BRONGNIART. Also Hessian Corn-ears.

In the *U. States*, this Sulphuret, accompanied with the oxide and carbonate of copper, has been found in a red sandstone formation in New Jersey. (*Gibbs.*) It has also been observed in small quantities near Baltimore and Newhaven.

Appendix.

BLACK COPPER.* It is nearly brownish black, and occurs in dull, friable masses. Before the blowpipe it melts with the odor of sulphur, and tinges borax green.

It is associated with other ores of copper, more particularly the Sulphuret of copper, gray and pyritous copper, and is, without doubt, merely an alteration of some of these ores. Sometimes it invests their surface.

Species 3. Pyritous Copper.†

When this mineral is recently broken, its color is brass yellow, sometimes inclining to gold yellow, and sometimes strongly tinged with gray, depending probably on the relative proportions of copper and iron. Its surface is very often tarnished, sometimes with shades of brown, black, &c. and frequently the tarnish is very richly and beautifully *irised*, or pavonine, &c.

This ore is brittle, easily yields to a knife, seldom gives sparks with steel, and then with difficulty. Its fracture is commonly uneven, sometimes more or less conchoidal, or nearly even; its lustre is metallic and somewhat shining, but variable. Some varieties present an imperfectly foliated structure. Its spec. grav. usually lies between 4.08 and 4.34.

Pyritous copper occurs in amorphous masses of various sizes; also in plates, or dendrites, and sometimes in stalactites, or in reniform, tuberose, and botryoidal concretions. The surface of the concretions is often a bronze yellow, strongly tinged with a metallic gray, and presents numerous little cavities.—Pyritous copper also occurs in small crystals, which are seldom well defined. It sometimes presents its primitive form, a regular tetraedron, which may be truncated on its edges, or angles; and, in the latter case, the crystal may resemble a six-sided table.—Another form is a dodecaedron (Pl. IV, fig. 40.), formed by raising a low three-sided pyramid on each face of the tetraedron. It occurs also in octaedrons, which sometimes constitute hemitrope crystals.

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* Kupfer schwärze. Werner. Copper Black. Jameson. Black Copper ore. Kirwan. Le Cuivre noir. Brochant.

† Cuivre pyriteux. Hauy. Brongniart. Kupferkies. Werner. Copper Pyrites. Jameson. La Pyrite cuivreuse. Brochant. Yellow copper ore, Kirwan.

(Chemical characters.) Before the blowpipe it decrepitates, yields the odor of sulphur, and melts into a black globule, which, with some difficulty, may generally be made to assume the metallic lustre of copper. It tinges borax green. Pyritous copper is not composed of copper and sulphur only; it always contains iron, but in proportions extremely variable. Gueniveau obtained metallic copper 30.5, iron 33.0, sulphur 35.0;=98.5. The results of Sage are copper 40, iron 40, sulphur 20. Proust considers this ore a compound of the sulphurets of copper and iron; and the iron is, in fact, sometimes so abundant, that it is difficult to draw a limit between this species and the sulphuret of iron. There does not, however, appear to be sufficient sulphur to produce the two sulphurets; for, if all the sulphur were combined with the iron, it would not, in general, be more than sufficient to produce that compound, which constitutes the common sulphuret of iron.

It sometimes contains a little gold or silver. Moist air has less effect on this ore, than on the sulphuret of iron; sometimes, however, decomposition takes place, and sulphate of copper is produced.

(Distinctive characters.) This mineral much resembles sulphuret of iron or iron pyrites; but the latter is harder and almost always gives sparks with steel; its prevailing color is bronze yellow, in which the yellow is much mixed with gray, whereas the prevailing color of Pyritous copper is brass yellow. Sulphuret of iron seldom, if ever, presents those beautiful tarnishes, which so often appear on this species. In fine, sulphuret of iron never crystallizes in tetraedrons.—From native gold Pyritous copper is distinguished by its want of malleability.

(Geological situation.) This is a very common and abundant ore of copper. It occurs in veins, which are often very wide, and in beds, which are sometimes very thick. It is found chiefly in primitive and transition rocks, but sometimes in those, which are secondary. It is associated with other ores of copper, sparry and magnetic iron, oxide of tin, sulphurets of lead and iron, quartz, &c.

(Localities.) Its most important foreign localities will be mentioned at the close of this genus.

In the *United States*. In *Pennsylvania*, it is found in Montgomery Co. at the Perkiomen lead mine; *(*WISTER.*)*—also near Chester in Delaware Co. with sulphuret of molybdena. *(*CONRAD.*)*—In *New Jersey*, at Schuyler's copper mines.—In *Connecticut*, in the greenstone mountains, which extend northerly from Newhaven, through Cheshire, Simsbury, &c. with native copper and the red oxide of copper. At Cheshire, is found a singular compound of Pyritous copper, green carbonate of copper, quartz, carbonate of lime, sulphate of barytes, and sandstone, all blended in the same mass, but perfectly distinct. Numerous pits and galleries have been excavated in these hills to obtain copper, but with little success. The shaft and galleries of an ancient copper mine at Simsbury is at present a State prison. (SILLIMAN.)—In *Massachusetts*, in the lead mine in Southampton, Hampshire Co. the copper is either disseminated, or exists in a vein;—in Middlesex Co. at Woburn; also at Brighton, in quartz accompanying amygdaloid. (GODON.)—In *Maine*, at Brunswick, with sulphuret of molybdena in granite.

(*Remarks.*) A large proportion of the Copper, employed in commerce, is extracted from Pyritous copper, which, however, yields only from 2 to 20 and sometimes 36 per cent. The softer varieties are richest in copper. Its sulphur is sometimes collected by sublimation.

SUBSPECIES 1. VARIEGATED PYRITOUS COPPER.*

This ore is characterized chiefly by its lively and *variegated* colors. When recently broken, its color is reddish brown with a shade of yellow; but it quickly tarnishes and presents various and intermingled shades of blue, violet, purple, red, brown, reddish yellow, and green. Its streak and powder are usually reddish.

It is less hard, than the common Pyritous copper, and is sometimes so brittle, that it yields to the finger nail. Its fracture is conchoidal with small cavities, or uneven, with a shining metallic lustre, which diminishes with the tarnishing. Its spec. grav. is usually between 4.95 and 5.46. It occurs amorphous, or in plates; indeed its masses sometimes separate into plates.

(*Chemical characters.*) It effervesces with nitric acid; and melts before the blowpipe, on charcoal, yielding a metallic globule. A specimen from Silesia yielded Klaproth copper 58, iron 18, sulphur 19, oxigen 5. If this analysis be correct, it differs from Pyritous copper chiefly by containing oxigen; and is perhaps an alteration of the common Pyritous copper. Indeed Haüy remarks, that it is not rare to find specimens, in which the gradual alteration is perceptible.

Its greater spec. grav. may often assist to distinguish it from the tarnished specimens of Pyritous copper.

(*Geolog. sit.*) It occurs in metallic veins, or more often in beds, and most frequently in primitive rocks. It is associated with other ores of copper, more particularly Pyritous copper and sulphuret of copper.

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* Cuivre pyriteux panaché. BRONGNIART. Buntkupfererz. WERNER. Variegated Copper ore. JAMESON. Cuivre pyriteux hepatique. HAÜY. Purple Copper ore. KIRWAN. La Mine de Cuivre panachée. BROCHANT.

It is less abundant than Pyritous copper; but is smelted, and sometimes yields more than 50 per cent.

Species 4. Gray Copper.*

The color of this ore is steel gray of different shades, sometimes inclining to lead gray, and sometimes to iron black, and is liable to tarnish. Its powder is blackish, sometimes with a shade of red.

It is easily broken, and its fracture is usually uneven, but sometimes a little conchoidal or nearly even; its lustre is metallic and somewhat shining. Its spec. grav. commonly lies between 4.44 and 4.86. Its hardness is about the same as that of pyritous copper.

It is found both amorphous, and in regular crystals. The primitive form, under which it sometimes occurs, is a regular tetraedron, of which Haüy has described no less than twelve modifications, but in no instance is the nucleus or primitive form entirely concealed. Sometimes its solid angles are truncated;—and sometimes each solid angle is replaced by three faces, or even by four, or six faces.—Sometimes the edges of this tetraedron are truncated or bevelled;—and sometimes two of the preceding modifications are combined in the same crystal.—Another secondary form is a dodecaedron (Pl. IV, fig. 40.), produced by raising a low, three-sided pyramid on each face of the primitive.—Another form (Pl. IV, fig. 41.) is the tetraedron, truncated on its edges, while each solid angle is terminated by four faces.—The crystals are usually small, and often grouped.—When not tarnished, their external lustre is strong.

(*Chemical characters.*) Before the blowpipe it melts into a grayish, metallic globule, brittle, and not easily reduced. It usually decrepitates, and yields a whitish smoke.—The true composition of Gray copper is still enveloped in some uncertainty, although many researches have been made by Klaproth and others. Chemical facts, however, seem to support the opinion of Count Bournon, that this ore is essentially composed of copper, iron, and sulphur. Several specimens, both amorphous and crystallized, yielded Chenevix these three ingredients only. In a tetraedral crystal from Cornwall he found copper 52, iron 31, sulphur 14. (*Murray.*) This ore, however, usually contains other metals in variable proportions, more particularly *arsenic* and *antimony*. But it appears from the analyses of Klaproth, that some specimens contain a considerable proportion of arsenic with little or no antimony, while others contain much antimony with little or no arsenic. We hence adopt the distinction of

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* Cuivre gris. Haüy. Brongniart. Fahlerz. Werner. Gray Copper ore. Kirwan. Jameson. Le Cuivre gris. Brochant.

Brongniart, and divide this species into two subspecies, depending on the presence of *arsenic* or *antimony* in considerable quantities.

Another reason for believing, that all the metals found in this ore, excepting copper and iron, are not essential to the species, is, that their presence or absence does not materially affect the crystalline form or other external characters. This species is consequently composed of the same ingredients as pyritous copper, but in different proportions.

(Distinctive characters.) Its total want of action on the magnetic needle sufficiently distinguishes it from the magnetic and the specular oxides of iron.—It is less hard than arsenical iron, has usually a darker color, and does not, like that ore, yield the odor of arsenic, when struck.

SUBSPECIES 1. ARSENICAL GRAY COPPER.*

Its color is steel gray, usually rather light. In fact, its external characters are those of the species already given.

A minute fragment, exposed to t[illegible] flame of a lamp, diffuses a vapor, but does not suffer complete fusion. *(HAUY.)* Three specimens from near Freyberg yielded Klaproth copper 41.0 to 48.0, iron 22.5 to 27.5, sulphur 10.0, arsenic 14.0 to 24.1, silver 0.4 to 0.9, with a trifling loss in each experiment; one specimen contained 1.5 of antimony.

SUBSPECIES 2. ANTIMONIAL GRAY COPPER.†

Its color is steel gray, but usually darker than that of the preceding subspecies, and sometimes passes into iron black. It is also harder than the preceding; and its fracture, which is imperfectly conchoidal with small cavities, or uneven, has usually considerable lustre. According to Bournon, a reddish brown streak indicates the presence of both antimony and silver.

When a minute fragment is presented to the flame of a lamp, a vapor appears, and the fragment, at length, melts into a metallic globule. *(HAUY.)* Several specimens from different parts of Germany and Hungary yielded Klaproth copper 25.5 to 40.25, iron 3.25 to 13.50, sulphur 11.5 to 28.0, antimony 19.5 to 34.09, silver 0 to 14.77; there was a small loss in each experiment, and some of the specimens contained a little zinc, or mercury, or arsenic.

(Geological sit. of the species.) Gray copper exists extensively,

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* Cuivre gris arsenifère. HAUY. Cuivre gris arsénié. BRONGNIART.

† Cuivre gris antimonifère. HAUY. Cuivre gris antimonié. BRONGNIART. Graugültigerz and Schwarzgültigerz. WERNER. La Mine noire—et grise-riche. BROCHANT.

and in considerable abundance. It occurs in primitive rocks, where it appears in veins traversing gneiss, mica slate, argillaceous slate, &c. These veins are often very large, and contain various ores and other minerals. Pyritous copper, sulphuret of copper, black copper, sparry iron, red silver, &c. are among its accompanying ores. Its gangues are quartz, the carbonate and fluate of lime, and sulphate of barytes.

It is found also in transition and even secondary rocks, where it is most frequently in beds. *(Jameson.)*

(Localities.) These are numerous, among which are the mines of Saxony, Hungary, Sweden, Cornwall, &c. At Guadalcanal, in Spain, it contains a few parts of platina, sometimes amounting to 10 per cent. *(Vauquelin.)*

In the *United States.* In *Maryland,* Gray Copper has been observed at Pipe Creek, 18 m. from Baltimore; *(Hayden.)*—also at Liberty, in Frederick Co. with sulphate of barytes. *(Seybert.)*—In *Connecticut,* near Hartford and Washington, in the red sandstone formation. *(Maclure)*

Appendix.

WHITE COPPER.* This ore, which is said to contain 40 per cent. of copper, the residue being iron, sulphur, and arsenic, we subjoin, as an appendix to gray copper, till its composition shall be more accurately known.—Its color on a recent fracture is nearly silver white, sometimes with a feeble tinge of bluish gray or yellow, but it soon tarnishes with shades of gray, yellowish gray, or brown. It occurs in compact, amorphous masses, whose fracture is uneven or somewhat conchoidal, with a metallic lustre. Its spec. grav. is considerable, but, according to Lametherie, is sometimes as low as 4.5.

Before the blowpipe it melts, and exhales white fumes with the odor of arsenic.

(Localities.) This ore is rare. It occurs in Cornwall, Saxony, &c. in primitive rocks; and is accompanied with pyritous copper, sulphuret of copper, &c.

In the *United States.* In *Connecticut,* at Fairfield, 22 m. W. from Newhaven, is found an ore of copper in compact masses, whose recent fracture is a metallic white, which soon tarnishes to a dirty white, inclining to brown, and in time acquires a green coat. Its spec. grav. is remarkable, being between 8 and 9. It melts by the blowpipe with abundant fumes of arsenic, and yields with nitric acid a green solution. *(Silliman.)*

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* Weisskupfererz. Werner. White copper ore. Kirwan. Jameson.

Species 5. Red Oxide of Copper.*

Its ordinary color is a deep cochineal red, which, more particularly in amorphous masses, has often a tinge of lead gray. Its crystals have often a more lively red, which is sometimes a pure carmine. Its streak and powder are nearly brick red. In some impure varieties the red is contaminated by shades of brown or yellow.—It is very easily broken, or scraped with a knife, and does not scratch fluate of lime.

This Oxide is sometimes crystallized in regular octaedrons, or double four-sided pyramids, any two contiguous sides of which, on the same pyramid, are inclined at about 109° 28′. This octaedron, which is the primitive form, is sometimes cuneiform, and sometimes truncated on its angles, or edges, or on both.—It also occurs in cubes, whose edges or angles may be truncated.—The crystals are usually small, with smooth shining surfaces, often grouped, and sometimes capillary.

This ore occurs also in compact masses, and is sometimes friable; sometimes also it is in lamellæ, or thin plates. Its spec. grav. according to Widenmann, is scarcely 4, but that of a specimen from Cornwall was found by Phillips to be 5.60.

(Chemical characters.) It is not very easily fusible by itself, but, on charcoal, the purer varieties are easily reduced to a metallic state by the blowpipe, without odor. It dissolves in muriatic acid without effervescence; but in nitric acid effervescence takes place, and a green solution is obtained. A specimen from Cornwall, analyzed by Chenevix, yielded copper 88.5, oxigen 11.5. In another from Siberia, Klaproth found copper 91, oxigen 9.

(Distinctive characters.) This mineral is well distinguished from other ores of a similar color by its effervescence, while dissolving in nitric acid, and by the green color, which this solution assumes. Further, red sulphuret of mercury is volatile before the blowpipe, and does not dissolve in nitric acid, while red silver dissolves in this acid without effervescence. *(Vauquelin.)*

This Oxide presents a number of varieties.

Var. 1. FOLIATED RED OXIDE OF COPPER.† This variety occurs both massive and in regular crystals, and sometimes in lamellæ or scales. When in crystals, its color is often a pure and lively red. Its fracture is foliated or undulated, and sometimes nearly uneven, somewhat shining, and slightly metallic. When massive, it is nearly

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* Cuivre oxidulé. Haüy. Brongniart.

† Blättriches Rothkupfererz. Werner. Foliated Red copper ore. Jameson. Le Cuivre oxidé rouge lamelleux. Brochant.

or quite opaque, but the crystals are usually more or less transparent.

2. CAPILLARY RED OXIDE OF COPPER.* Its color is, in general, nearly carmine red, sometimes very pure and lively. It occurs in translucent capillary crystals, with a shining, silken lustre. The crystals are sometimes aggregated into little flakes.

3. COMPACT RED OXIDE OF COPPER.† Its color is cochineal red, often dark, or with a slight tinge of bluish gray. It occurs in opaque, compact masses, whose fracture is even or a little conchoidal with a feeble lustre. Sometimes it merely invests other minerals.

(Geolog. sit. and Localities.) The Red Oxide of Copper, though never in very large masses, is by no means an uncommon ore. Most frequently, however, it occurs in metallic veins, which traverse primitive rocks, and almost always accompanies native copper, which it very frequently invests. It is very often associated with malachite and brown iron ochre, and sometimes with pyritous copper, &c.—Though a rich ore, it does not occur in sufficient quantity to be explored by itself.

In Cornwall, fine octaedral crystals of this Oxide are attached to amorphous masses of the same substance; they are sometimes half an inch in one dimension, and sometimes mere points. It is there sometimes accompanied by the green oxide of uranium. *(PHILLIPS.)*—Siberia also furnishes this Oxide in fine groups of octaedral crystals. In the mine of Nikolaew are found insulated octaedrons, which are coated with malachite, and proceed from the interior of a red jasper, in a state of decomposition. *(BRONGNIART.)*—Some of the finest specimens of the Capillary variety are found near Cologne.

In the *United States.* In *Virginia*, on the property of the late Lord Fairfax, it occurs crystallized. *(HAYDEN.)*—In *Pennsylvania*, near Lancaster, with malachite.—In *New Jersey*, with carbonate of copper, &c. in the red sandstone formation. Several mines have here been opened, but have in general been abandoned. *(GIBBS.)*—In *Connecticut*, with native copper, &c. in the greenstone mountains, extending northerly from Newhaven. *(SILLIMAN.)*

A variety of this Oxide is sometimes found accompanying crystals of arseniate of copper. If a fragment be exposed to the blowpipe, it simply melts with effervescence, exhaling neither odor nor smoke; but, when supported on charcoal, it exhales the odor of arsenic, which probably proceeds from the decomposition of arsenic acid.

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* Haarförmiges Rothkupfererz. WERNER. Capillary Red copper ore. JAMESON. Fibrous Red copper ore. KIRWAN.

† Dichtes Rothkupfererz. WERNER. Compact Red copper ore. JAMESON.

SUBSPECIES 1. FERRUGINOUS RED OXIDE OF COPPER.*

Its color is hyacinth or brick red, usually dull, or mingled with shades of brown, yellow, or gray, thus passing to brownish red, &c. It is sometimes friable with an earthy fracture; and sometimes indurated and considerably hard, with an even or somewhat conchoidal fracture. It has little or no lustre.

Before the blowpipe it becomes black, but is infusible by itself. It renders borax a dirty green. It is a mixture of the Red Oxide of Copper and brown oxide of iron, in variable proportions.

This ore is found in those mines, which embrace the Red Oxide of Copper; and of course has the same accompanying minerals.—It is sometimes sufficiently abundant to be explored, and yields from 10 to 50 per cent. of copper.

SPECIES 6. AZURE CARBONATE OF COPPER.†

The characteristic color of this species is *azure* blue, often extremely beautiful and shining; but sometimes it inclines more or less to Prussian or indigo blue, and sometimes it is a pale or smalt blue. This mineral preserves its color in oil, and leaves a blue trace when rubbed on paper. The color of its streak is a light blue.

Even when not friable, it is easily broken, and readily yields to a knife. It is seldom quite opaque, and its crystals are sometimes nearly or quite transparent. Its spec. grav. varies from 3.23 to 3.60.

It very frequently occurs in small, shining crystals, of which the primitive form is an octaedron with scalene triangles. It has four or five secondary forms. Among these is an oblique, four-sided, rhomboidal prism, which, by truncations on the lateral edges, is sometimes converted into an eight-sided prism, terminated by diedral summits. —Also an oblique four-sided prism, truncated on two opposite lateral edges (Pl. V, fig. 1.), and terminated at each extremity by four faces. Some of its forms seem to be tabular.

This Carbonate of copper is sometimes in grains, or amorphous masses, or in little plates; and often in reniform or botryoidal concretions, striated from the centre to the circumference, and usually presenting a rough or drusy surface.

Its fracture, sometimes imperfectly foliated, usually presents broad, diverging fibres, with a vitreous lustre, more or less shining.

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* Cuivre oxidulé ferrifère. BRONGNIART. Cuivre oxidulé terreux. HAUY. Ziegelerz. WERNER. Tile-ore. JAMESON. Brick red copper ore. KIRWAN.

† Cuivre carbonaté bleu. HAUY. Cuivre azuré. BRONGNIART. Kupfer Lazur. WERNER. Copper Azure. JAMESON. L'Azur de cuivre. BROCHANT. Striated mountain blue. KIRWAN.

(Chemical characters.) This ore dissolves with effervescence in nitric acid. It is difficultly fusible by itself; but with borax, to which it communicates a fine green, it yields a globule of copper. It is composed, according to Pelletier, of copper 66 to 70, carbonic acid 18 to 20, oxigen 8 to 10, water 2. Klaproth found copper 56, carb. acid 24, oxigen 14, water 6.

It is very remarkable, that oxide of copper, combined with ammonia, has the same color and crystalline forms, which this species exhibits.

This Carbonate resembles the azure phosphate of iron; but the latter becomes darker or brownish in oil, and by the blowpipe is converted into a scoria, obedient to the magnet.

Var. 1. EARTHY AZURE CARBONATE OF COPPER.* Its color is pale, or nearly smalt blue. It occurs in thin coats, or small friable masses, composed of dull earthy particles. It appears to be rendered impure by earthy substances.

(Geological sit. and Localities.) This species occurs only in small quantities, either disseminated in ores [illegible] other minerals, or investing their surfaces. It exists in both primitive and secondary mountains, accompanying other ores of copper, more particularly the green carbonate of copper, pyritous copper, and gray copper; and is very often connected with the brown oxides of iron. It is also associated with the carbonate and phosphate of lead, sulphuret of iron, &c. &c. Its crystals are sometimes found ornamenting the cavities of its accompanying minerals.

Fine specimens are found in Siberia and Moldavia.

In the *United States.* It is found in *Pennsylvania,* at the Perkiomen lead mine. *(CONRAD.)*

(Remarks.) This mineral is sometimes employed as a paint, of which there is said to be a manufactory in the Tyrol.—Quartzy or calcareous substances, penetrated by this salt of copper, have been called *Armenian stone.*

SPECIES 7. GREEN CARBONATE OF COPPER.†

This interesting salt of copper has always a green color; most frequently it is emerald, grass, or apple green, but varies to leek or verdigris green; and in some impure varieties it becomes olive or pistachio green. Its streak and powder are also green, but paler. Its hardness is moderate; it may easily be scratched by a knife, and is sometimes friable. Its spec. grav. lies between 3.57 and 3.99.

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* Cuivre carbonaté bleu terreux. HAUY. Erdige Kupfer Lazur. WERNER. Earthy Copper Azure. JAMESON. Earthy mountain blue. KIRWAN.

† Cuivre carbonaté vert. HAUY. Cuivre Malachite. BRONGNIART.

It is sometimes in fibres or fibrous masses, which are often delicate and silky; sometimes in concretions, whose texture is more or less compact; and sometimes amorphous.

(*Chemical characters.*) This mineral dissolves with more or less of effervescence in nitric acid, and gives a green solution. To ammonia it *slowly* communicates a blue color. Before the blowpipe it blackens and frequently decrepitates; but is infusible by itself. It melts with borax, which assumes a green or yellowish green color. To the flame of burning bodies it gives a green tinge. It contains, according to Klaproth, copper 58.0, carbonic acid 18.0, oxigen 12.5, water 11.5; and, according to Proust, black oxide of copper 71.0, carb. acid 27, carbonate of lime 1.0, sand 1.0.

The green and blue Carbonates of copper undoubtedly constitute two distinct species, depending either on the degree of oxidation in the metal, or on the quantity of water present.

(*Distinctive characters.*) Its effervescence in nitric acid may serve to distinguish it from the green oxide of uranium, the green phosphate of lead, and the green arseniate of copper.—It often much resembles the muriate of copper; but this latter salt dissolves in nitric acid without effervescence, and *immediately* produces a blue color in ammonia.

This species presents a number of varieties, most of which pass into each other.

Var. 1. FIBROUS MALACHITE.* *KIRWAN. JAMESON.* The structure of this very beautiful variety is distinctly fibrous; and the fibres, which are usually delicate and capillary, are collected into small masses, or more frequently into little bundles or tufts, in which they diverge more or less, and are sometimes stellular. Its predominant color is a lively emerald green, glistening with the lustre of silk; but sometimes passes to grass or leek green. When the fibres are short, these tufts have the soft and shining aspect of green velvet.

These fibres are, in fact, translucent crystals, whose forms are indeterminable; and the masses, produced by their aggregation, when broken, commonly exhibit a glistening lustre more or less silky.

This variety most frequently appears on the surface of other ores, more particularly the sulphuret of copper, gray copper, red oxide of copper, pyritous copper, brown and argillaceous oxides of iron, and is often associated with the azure carbonate of copper.

(*Localities.*) Though in small quantities, it is not an uncommon ore. Some of the finest specimens come from the Uralian mountains in Siberia.

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* Fasriger Malachit. WERNER. Cuivre carb. vert aciculaire. HAUY. Cuivre Malachite soyeux. BRONGNIART. La Malachite fibreuse. BROCHANT.

In the *United States*. This variety has been observed in *Pennsylvania*, at the Perkiomen lead mine;—in the copper mines of *New Jersey*;—and at Cheshire, &c. in *Connecticut*, in small but good specimens.

2. COMPACT MALACHITE.* *KIRWAN. JAMESON.* Its color is frequently emerald green, but passes to verdigris, apple, or grass green; indeed the shade of green often varies in the same specimen. It has little or no external lustre; and is opaque, or translucent, but chiefly at the edges.

This variety is sometimes amorphous, in plates, tuberose, or stalactical, but more frequently in globular, reniform, or botryoidal concretions. These concretions are composed of parallel, curved, or undulated layers, often striated in the direction of their thickness, and differ so much in their shades of green, that the mass has a striped aspect. They usually contain numerous cavities in their interior.—The surface of the concretions, and of the layers, which compose them, is often greenish white, or invested with a thin crust of earthy malachite, or exhibits black dendrites.

Its fracture sometimes presents extremely minute, diverging fibres, and sometimes appears even or a little conchoidal, or passes into uneven. Though sometimes nearly dull, it often has a moderate and silken lustre.

Both this and the preceding variety are said to occur in distinct, prismatic crystals.

Compact Malachite is found in the cavities of metallic veins. It is often associated with the fibrous variety, and other ores of copper. —Some of the best specimens come from the Uralian mountains.

In the *United States*, in *Maryland*, it is found on the Blue Ridge.

(*Uses.*) Compact Malachite is often in masses considerably large, and, when sufficiently compact, is sometimes sawed into tables. These tables, when highly polished, are rendered very beautiful by their different shades of green, arranged in parallel zones, and by their soft and silken lustre. A rare table of Malachite, about 33 inches by 18, exists at St. Petersburg. This variety is sometimes employed as a pigment.

3. EARTHY MALACHITE.† This variety has, in general, an earthy appearance. Its color, which is usually verdigris green, sometimes passes to other shades of green, or becomes pale. It is usually opaque,

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* Dichter Malachit. WERNER. Cuivre carb. vert concrétionné. HAUY. Cuivre Malachite concrétionné. BRONG. La Malachite compacte. BROCHANT.

† Cuivre carb. vert terreux. HAUY. Cuivre Malachite chrysocolle. BRONGNIART. Kupfer grün. WERNER. Copper green. JAMESON. Mountain green. KIRWAN. Le vert de cuivre. BROCHANT.

sometimes translucent at the edges.—It is sometimes indurated, and sometimes friable, or in a state of powder. Its fracture is earthy and dull, and sometimes uneven or conchoidal with a little lustre.

It most frequently occurs as a crust or coat on other minerals, but sometimes in small reniform masses, &c.

It effervesces but slightly in nitric acid. In a specimen from Siberia Klaproth found copper 40, oxigen 10, carbonic acid 7, water 17, silex 26.

It accompanies malachite and other ores of copper, but is not common.

Subspecies 1. FERRUGINOUS GREEN CARBONATE OF COPPER.*

Its color is olive or pistachio green, and sometimes leek or blackish green, and becomes paler in the streak. It is nearly or quite opaque, and very easily broken. It is sometimes in tender, friable masses, with an earthy dull fracture; and sometimes it is more solid with a conchoidal fracture, and a glistening lustre, either vitreous or resinous.

It appears to be a compound of carbonate of copper and oxide of iron. Indeed it sometimes becomes magnetic after exposure to heat.

It accompanies other ores of copper; but is rare. It has been found at Saalfield in Thuringia, &c. In Cornwall, it is associated with the arseniate of copper.

(Geolog. sit. of the species.) The Green Carbonate of copper, of which the fibrous and compact Malachite are the most common varieties, occurs in all classes of rocks from the oldest to the newest, and accompanies most of the other ores of copper. It is often connected with the brown oxide of iron, and sometimes with the ores of other metals.

The azure and green Carbonates of copper are sometimes intimately mixed in the same specimen. Indeed certain crystals, originally blue, have in some instances become green, in consequence of some chemical change. *(Haüy.)*

(Remarks.) The *Turkois* or Turquoise, a substance originally brought from Turkey, has a blue, greenish blue, or pale green color, and has generally been supposed to be the teeth or bones of animals, impregnated with the oxide of *copper*. It appears, however, from more recent experiments, that these osseous substances derive their color from phosphate of iron, and contain no copper. (See phosphate of iron.)—The name Turkois has probably been applied to substances

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* Cuivre carb. vert ferrugineux. HAÜY. Cuivre Malachite erugineux. BRONGNIART. Eisenschüssiges Kupfer grün. WERNER. Iron-shot Copper green. JAMESON. Iron-shot mountain green. KIRWAN.

of a different nature; for a specimen, analyzed by Dr. John, yielded alumine 73.0, oxide of copper 4.5, oxide of iron 4.0, water 18.0; =99.5.

Species 8. Dioptase.[*] *Brochant.*

This rare mineral has a fine emerald green color, and is, in general, more or less translucent. It scarcely scratches glass; and its spec. grav. is about 3.30.

It has been found only in six-sided prisms, terminated by three-sided pyramids, whose faces stand on alternate, but different, lateral edges at the two extremities. Its natural joints are obvious,[†] and its primitive form is an obtuse rhomb. Its structure is foliated, the laminæ separating in three different directions. Its lustre is shining and vitreous.

Before the blowpipe it is infusible, but becomes chesnut brown, and tinges the flame yellowish green. With borax it yields a globule of copper. A specimen, analyzed by Vauquelin, yielded oxide of copper 28.57, carbonate of lime 42.85, silex 28.57; =99.99.

Its inferior hardness, and the negative electricity, which it acquires by friction, when insulated, distinguish it from the emerald.

It is brought from Siberia, associated with malachite.

Species 9. Muriate of Copper.[‡]

The color of this mineral varies from emerald to leek green, and sometimes approaches olive green. Its streak is a paler green.—It is sometimes in minute, shining crystals, which are either four or six-sided prisms, bevelled at their extremities, or cuneiform octaèdrons, with the edges of the summits sometimes truncated. It occurs also in acicular fibres, much resembling those of malachite; sometimes also in masses or concretions with a radiated structure, or nearly compact; and sometimes in minute grains.—It is easily broken, and its fracture is shining. Its crystals are somewhat transparent, but the other varieties are opaque. Its spec. grav. lies between 3.52 and 3.75.

(Chemical characters.) When projected on ignited charcoal, it communicates to the flame a peculiar and very beautiful color, *both green and blue.* Its powder, thrown into ammonia, almost instantly communicates a lively blue color. In nitric acid it dissolves without

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[*] Cuivre Dioptase. Hauy. Brongniart. Kupfer Schmaragd. Werner, Copper Emerald. Jameson.

[†] Hence its name from the Greek Δια, and Οπτομαι, to see.

[‡] Cuivre muriaté. Hauy. Brongniart. Brochant. Salz Kupfer. Werner. Copper Sand. Jameson.

effervescence, forming a green solution. On charcoal it gives by the blowpipe a globule of copper. A specimen from Chili yielded Proust oxide of copper 76.5, muriatic acid 10.6, water 12.7; = 99.8. The sandy variety from Peru afforded Klaproth oxide of copper 73, muriatic acid 10, water 17.

(Distinctive characters.) Its solubility in nitric acid without effervescence, the color it gives to flame, and the rapidity, with which it renders ammonia blue, will distinguish it from the green carbonate of copper.—From arseniate of copper it differs by not exhaling an arsenical odor before the blowpipe.

Var. 1. SANDY MURIATE OF COPPER.* This variety was first known. It occurs in minute grains, like sand. This green sand, however, appears to be composed, in part at least, of crystals, either entire or in fragments, and is usually mixed with a little quartz.

(Localities.) Muriate of copper has been found chiefly in Chili and Peru.—At Remolinas in Chili, it is mixed with a little oxide of iron, and accompanied by malachite, quartz, &c.—The sandy variety from Peru is said to be found in the sand of a small river in the province of Lipes.

This species is probably more common than has generally been supposed, having been frequently confounded with malachite.

SPECIES 10. SULPHATE OF COPPER.†

Blue vitriol.

This very beautiful salt of copper is but seldom found native. It has a deep and rich sky blue color, a styptic and disagreeable taste, and is very soluble in water. When rubbed on polished iron a little moistened, it leaves a reddish trace of copper.

Its artificial crystals are prismatic, having four, six, eight, or ten sides. Haüy mentions eleven varieties of form, of which the primitive and one secondary form are represented in Pl. V, fig. 2 and 3.

By the analysis of Proust, Sulphate of copper contains oxide of copper 32, sulphuric acid 33, water 36.

Its solubility and taste distinguish it from the azure carbonate of copper.

It is found in the waters of those mines, which contain the sulphuret of copper, from the decomposition of which it undoubtedly proceeds. From solution in these waters it is deposited on other minerals in the form of a powder or crust, or in concretions, or sometimes in crystals.

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* Cuivre muriaté pulverulent. HAUY. BRONGNIART. Green sand of Peru. KIRWAN.

† Cuivre sulfaté. HAUY. BRONGNIART.

(Uses and Remarks.) Its principal use is in dying. It is also employed to communicate a brown color to fowling pieces, &c.

The sulphate of copper, employed in commerce, is obtained either from the natural waters just mentioned, or by roasting poor ores of pyritous copper, exposing the residue to air and moisture, and by subsequent lixiviation and crystallization.

SPECIES 11. PHOSPHATE OF COPPER.* *JAMESON.*

The color of its fracture varies between emerald and verdigris green, a little spotted with black; but its streak is a paler green. Its external surface is blackish green.—It is opaque, easily broken, and its fracture presents very delicate and diverging fibres, glistening with the lustre of silk.

It occurs in crystals, which appear to be rhombs slightly obtuse with convex faces. These crystals have a splendent surface, and are united in reniform and botryoidal groups. Sometimes they are so small, that they resemble a mere mould. It exists also in small masses nearly compact.

(Chemical characters.) On charcoal it melts before the blowpipe into a brown scoria, which soon falls into a number of fragments. *(KLAPROTH.)* It is fusible even by the flame of a lamp; and yields a dull metallic gray globule. In nitric acid it dissolves without effervescence, forming a pale green solution. It contains oxide of copper 68.13, phosphoric acid 30.95;=99.08. *(KLAPROTH.)*

Its chemical characters will serve to distinguish it both from green carbonate and muriate of copper.

Very few localities of this rare mineral have been mentioned. Among these is Firneberg, near Cologne, where it occurs in a gangue of opaque, white, cavernous quartz, associated with arseniate of copper and carbonate of lead.

SPECIES 12. ARSENIATE OF COPPER.† *BOURNON.*

This mineral, although rare and but recently examined, has already presented a great diversity of external characters, and even of composition, in regard to the proportions of its ingredients. It is hence almost impossible to give those general, definite, external characters, which may enable one to recognise all the varieties with certainty. Chemistry, however, very readily offers its assistance to decide the fact, which other characters may leave doubtful.—It is, indeed, uncertain, whether all the substances, which at present are comprised in

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* Cuivre phosphaté. HAUY. BROCHANT. BRONGNIART. Phosphor Kupfer. WERNER.

† Cuivre arseniaté. HAUY. BROCHANT. BRONGNIART.

this species, and which are composed chiefly of oxide of copper and arsenic acid, do in fact belong to the same species. A permanent difference in the degree of oxidation of the copper, or the presence or absence of water may yet show, that this species ought to be divided into two or more distinct species.

Its predominant colors are green and blue of different shades, either pale or deep, and sometimes intermixed; sometimes also the green is more or less contaminated with shades of brown or yellow, or even passes into gray, or pale greenish white.

Its hardness is variable, but never enables it to scratch glass. It usually occurs in crystals or fibres; and these fibres are often collected into small masses, whose structure is radiated, and whose surface has the lustre of silk. The primitive form of the crystals is supposed by Haüy to be an octaedron.

(Chemical characters.) In nitric acid it dissolves without effervescence, yielding a greenish solution. To ammonia its powder rapidly communicates a fine blue. Before the blowpipe it decrepitates, and on charcoal melts, diffusing a very sensible odor of arsenic, while those parts of the globule in contact with the charcoal are reduced to a metallic state. With borax it is more easily fused and reduced.

(Distinctive characters.) To distinguish this from some other green ores, it may be remembered, that green carbonate of copper effervesces with nitric acid;—that the green oxide of uranium yields a yellowish solution in the same acid; and that the green muriate of copper does not exhale an arsenical odor before the blowpipe.

The following are the most important varieties hitherto observed.

Var. 1. OBTUSE OCTAEDRAL ARSENIATE OF COPPER.* Its usual color is sky blue, more or less deep, sometimes passing to verdigris or other shades of green, which, however, are often only superficial. It occurs in small, shining crystals, whose form is an obtuse octaedron, composed of two four-sided pyramids with rectangular bases. According to Bournon, two opposite faces of the same pyramid unite at the summit under an angle of 130°, and the other two under an angle of 115°. This octaedron, which is sometimes cuneiform, is divisible parallel to its sides, and is hence supposed to be the primitive form.—These crystals are translucent, and their external lustre is vitreous. They are very brittle, and have a spec. gravity of 2.88. They scratch the carbonate, but not the fluate, of lime.

It contains oxide of copper 49, arsenic acid 14, water 35;=98. *(CHENEVIX.)*

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† Cuivre arseniaté octaèdre obtus. BROCHANT. Cuivre arseniaté obtus. BRONGNIART. Linsenerz. WERNER. Lenticular ore. JAMESON.

2. ACUTE OCTAEDRAL ARSENIATE OF COPPER.[*] Its color is a deep bottle or brownish green, and is sometimes blackish on the surface; but its streak has constantly a shade of green. Its crystals, which are small and often aggregated, are acute octaedrons, of which two opposite faces in each pyramid unite at the summit under an angle of 84°, and the other two under an angle of 68°. These octaedrons are often cuneiform, and sometimes so elongated, that they assume the aspect of a prism, slightly modified. They are semitransparent, or only translucent.—This is the hardest variety, and scratches fluate of lime. Its spec. grav. is 4.28.

It contains oxide of copper 60,0, arsenic acid 39.7 ;=99.7. (*CHENEVIX.*)

3. FOLIATED ARSENIATE OF COPPER.[†] Its color is a fine emerald green, sometimes passing to verdigris green. It occurs chiefly in hexagonal plates or tables, bounded by six narrow trapezoidal faces, three of which, taken alternately, are inclined toward one of the broader faces, and the remaining three toward the other.

These plates are often applied to each other, forming small masses divisible like those of mica; their lustre on the broader faces is splendent, and a little pearly. They are translucid or even transparent, according to the thickness.

This variety is soft, slightly scratching the sulphate, but not the carbonate, of lime. Its spec. grav. is 2.54.

It is composed of oxide of copper 58, arsenic acid 21, water 21. (*CHENEVIX.*)

4. PRISMATIC ARSENIATE OF COPPER.[‡] Its color is verdigris or bluish green, which, by the action of the air, often becomes blackish green; but the streak discovers the true color. It occurs in small, triangular prisms, whose sides are feebly and transversely striated; one of the lateral edges is sometimes truncated. These crystals are often transparent.—This variety scarcely scratches carbonate of lime; and its spec. grav. is 4.28.

It contains oxide of copper 54, arsenic acid 30, water 16. (*CHENEVIX.*)

Other regular forms of the Arseniate of copper, as a four and six-sided prism, an acute rhomboid, &c. are mentioned by mineralogists.

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[*] Cuivre arseniaté octaèdre aigu. HAUY. BROCHANT. Cuivre arseniaté aigu. BRONGNIART. Var. of Olivenerz ? WERNER.

[†] Cuivre arseniaté lamelliforme. HAUY. BROCHANT. BRONGNIART. Kupfer glimmer. WERNER. Copper Mica. JAMESON.

[‡] Cuivre arseniaté prismatique triangulaire. HAUY. Cuivre arsen. trièdre. BRONG. Var. of Olivenerz ? WERNER.

5. FIBROUS ARSENIATE OF COPPER.* Its colors are grass green, and olive green, more or less mingled with yellow or brown; sometimes also it is bluish, or a pale greenish or satin white.

It sometimes appears in delicate, capillary crystals or fibres, loosely united, and sometimes projecting in groups from the surface of reniform masses of the same substance.

At other times it occurs in more compact, reniform masses, whose structure, like that of malachite, presents delicate, diverging fibres, glistening with a silken lustre. The colors are often arranged in parallel or even concentric zones.—It is opaque, or slightly translucent; and its spec. grav. is about 4.28.

The capillary crystals yielded Chenevix oxide of copper 51, arsenic acid 29, water 18;=98. In the reniform masses he found oxide of copper 50, arsenic acid 29, water 21.—The reniform masses are liable to decomposition, during which the fibres separate and become yellowish, or eventually whitish gray.

This variety sometimes resembles the fibrous oxide of tin.

SUBSPECIES 1. FERRUGINOUS ARSENIATE OF COPPER.†

The color of this mineral is pale blue, or light brownish yellow with sometimes a shade of green. It occurs in reniform masses, whose surface presents groups of small, shining crystals. Their form is a very oblique four-sided prism, terminated at each extremity by four triangular faces, placed obliquely on the sides of the prism, whose lateral edges are sometimes truncated. Its spec. gravity is 3.40.

It contains oxide of copper 22.5, oxide of iron 27.5, arsenic acid 33.5, water 12.0;=95.5. (*CHENEVIX.*)

(*Geological sit. and Localities.*) The several varieties of Arseniate of copper were discovered about 30 years since, and have been found chiefly in the mines of Cornwall. Their gangue is quartz; and they are associated with several other ores of copper, brown oxide of iron, &c. This Arseniate has also been found in a few places in Germany.‡

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* Cuivre arseniaté fibreux. BROCHANT. Cuivre arsen. aciculaire—et mamelonné fibreux. HAUY. Fasriges Olivenerz. WERNER. Fibrous Oliven ore. JAMESON.

† Cuivre arseniaté ferrifére. HAUY. BROCHANT. BRONG.

‡ Other ores of copper are sometimes described; but they appear to be merely mixtures of some of the preceding species with other minerals. Thus *copper slate* is a bituminous marlite, impregnated with pyritous copper, &c.—*Bituminous copper* is nearly allied to the preceding.—*Bell metal* ore is a mixture of ores of copper and tin.

(Geological remarks on ores of Copper.) The most important and abundant ores of Copper are found chiefly in primitive rocks, such as gneiss, mica slate, &c. but rarely in the oldest formations of granite. They however occur in transition and even secondary rocks. Native and pyritous copper, gray copper, the red oxide and sulphuret of copper are among the oldest ores of this metal; while the azure and green carbonates extend from the oldest to the newest rocks.

Ores of Copper, seldom in beds, are usually found in veins, of which they sometimes constitute but a small part, being mingled with earthy, saline, or metallic substances. Veins of copper *intersect* most of the other metallic veins, which occur in the same rocks; and of course must be more recent, than the *intersected* veins.

(Copper mines.) In France, are the copper mines of Baigorry in the Pyrennees, and of St. Bell and Chessy, near Lyon.—In Great Britain, are numerous and productive veins of copper. The metalliferous mountains of Cornwall are composed of granite and gray-wacke, and the copper ores, which they furnish, are chiefly pyritous and native copper and the red oxide of copper. All the ores of Cornwall are in veins; and the number of mines now worked is at least 100, of which about 45 yield copper, 28 tin, and 18 copper and tin.—The copper mines of Anglesea are very productive, and consist chiefly of pyritous copper, which yields from 16 to 40 per cent. The ore is melted at Swansey, &c. and the annual produce is said to be 4000 tons. (Nicholson's Chem. Dict.)—In Delicarlia, Sweden, is the ancient copper mine of Fahlun. Although the ore is not rich, these mines have been very productive.—In Germany at Riegeldorff, a bituminous marlite, impregnated with pyritous copper, &c. and bearing impressions of fish, is explored as an ore of copper.—The Uralian mountains in Siberia furnish some remarkable mines of copper. Those of Goumechew and Tourinski are situated in primitive mountains, composed of argillaceous slate, porphyry, &c. The ore is composed chiefly of native copper, sulphuret of copper, and malachite; and the vein, which contains it, traverses beds of white granular limestone. Its gangue is clay variously colored.—Copper mines are also explored at Herngrund, &c. in Hungary—in Japan, &c. in the East Indies—and in Coquimbo, &c. in South America.

GENUS VI. *IRON.*

No one, who examines the universal and abundant diffusion of Iron, the most important of the metals, can disregard so strong an indication of the benevolence of the Creator. This metal is united with other minerals in proportions so extremely variable, that it is sometimes difficult to say, whether a given mineral shall, or shall not, be called an *ore* of iron.

Pure Iron has a bluish gray color. It is the hardest of the metals, and is more or less malleable at all temperatures. Its ductility is extremely great, and permits it to be drawn into a finer and stronger wire than that of any other metal. Its texture is fibrous or granular, and its spec. grav. is about 7.70. It is always attracted by the magnet, but does not, when perfectly pure, long retain magnetic properties. It is susceptible of a high polish.

Iron is oxidated both by air and moisture; and is soluble in all the acids. At about 158° W. it melts. In oxigen gas it burns with great brilliancy. That, which is commonly called *rust* of iron, is one of its oxides, sometimes combined with a little carbonic acid.

Whenever iron occurs in its metallic state, it is easily recognised by being obedient to the magnet. When in the state of an oxide, if the oxigen do not exceed about 30 per cent. or, when combined with sulphur, if the sulphur do not exceed about 40 per cent. it is still more or less affected by the magnet. Carbon and phosphorus also, as well as sulphur, when combined with iron, enable it to retain the magnetic fluid. But the presence of arsenic, manganese, and antimony may counteract the magnetism of iron.—Prussic acid has a strong affinity for iron, and detects it in any of its combinations, yielding a blue prussiate of iron.

A fragment, supposed to be an ore of iron, may be examined by gradually roasting it in a platina spoon, and then exposing it, mixed with some fatty substance, on charcoal to the greatest heat of the blowpipe; if the globule, thus obtained, embraces iron even in small quantity, it will be magnetic. But, as both cobalt and nickel are also magnetic, this globule may be dissolved in muriatic acid, and, if it contain iron, the prussiate of potash and iron will produce a blue precipitate.

(*Uses.*) We shall say nothing of the numerous and well known uses of Iron in its different states. It may be well to remark, that *crude* or *cast* or *pig* iron usually contains both oxigen and carbon, and sometimes also phosphorus, manganese, silex, &c.—that when deprived of most of these foreign ingredients, it constitutes *forged* or *bar* iron—and that steel is pure iron, combined with from about $\frac{1}{15}$ to $\frac{1}{140}$ of its weight of carbon.

SPECIES 1. NATIVE IRON.* *KIRWAN. JAMESON.*

Native iron differs somewhat in its characters from forged iron. Its color is whiter, being a light steel gray. It is usually more malleable, than forged iron, and not so easily oxidated by exposure to the weather. But, although its surface may be covered with a brownish crust, its streak has a metallic lustre.

Native iron has in a very few instances been observed under a ramose or stalactical form, or even in octaedral crystals. Thus, according to Schreiber, Native iron exists in the mountain of Oulle, near Grenoble, in a vein of fibrous brown oxide of iron, traversing gneiss. The iron is ramose or stalactical, and occurs at the depth of 12 feet, mixed with quartz, &c.—According to Karsten, Native iron is found at Kamsdorf in Saxony, disseminated in brown oxide of iron, and mingled with sparry iron and sulphate of barytes. Klaproth found in it iron 92.5, lead 6.0, copper 1.50.†

But most of the Native iron, hitherto observed, has appeared on the surface of the earth in loose insulated masses, often very large, and at a great distance from mines of iron. These masses, though sometimes nearly or quite compact, more frequently contain numerous minute cells, by which their spec. grav. is reduced, sometimes to 6.4. It is certain that many of these masses, and very probably all of them, are slightly alloyed with *nickel;* some of them also contain small quantities of carbon, and a few seem to be in the state of steel. It is without doubt the nickel, which renders this Native iron whiter, more malleable and tenacious, and less easily oxidated, than forged iron.—Very probably the Native iron, just described as containing nickel, and possessing other peculiar properties, ought to constitute a distinct subspecies; and may perhaps be called *meteoric native iron.*

The following are some of the more striking examples.

1. A mass, found by Pallas in Siberia, near the mountains of Kemir, and not far from the river Jenisei. This mass, weighing about 1600 lbs. is very malleable and white. Its interior contains numerous cells, filled with a yellowish, transparent, vitreous substance, capable of scratching glass, and somewhat resembling olivine in composition. It was found at the surface, near the top of a mountain, which embraces a vein of magnetic oxide of iron; but there was no appearance of scoriæ in the vicinity. This mass, now preserved in the

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* Gediegen eisen. WERNER. Fer natif. HAUY. BRONGNIART. BROCHANT.

† Some mineralogists still doubt the existence of Native iron in metallic veins, as in the examples just mentioned.

Academy of Sciences at St. Petersburg, is composed of metallic iron 98.5, nickel 1.5. (*Klaproth.*)

2. Another mass, weighing 30,000 lbs. was found near St. Jago del Estero, in the province of Tucuman, in South America. It was partly buried in argillaceous earth in the midst of an extensive plain, which contains neither strata nor masses of any other minerals.—It is compact near the surface, and cellular in the interior; but its cells do not contain any vitreous substance, like those of the Siberian iron. Its surface is indented. (*Rubin De Celis.*) It contains a little nickel, and a trace of carburet of iron. (*Proust.*)

3. A mass near the river Senegal in Africa. It contains nickel.

4. A mass, now in the Imperial cabinet at Vienna. It was brought from Heraschina, near Agram, in Croatia, where it fell from the atmosphere in 1751; it appeared in the air, like a globe of fire. This mass contains iron 96.5, nickel 3.5. (*Klaproth.*)

5. Another mass was found at Aken, near Magdeburg, which is said to possess the qualities of good steel; and, of course, must contain carbon. Its weight is estimated at about 16,000 lbs.

6. For our knowledge of this example of Native iron we are indebted to Col. Gibbs, for whose personal exertions and general patronage, mineralogy is already under numerous obligations.

This mass he observed at Bithbourg, in the department des Forets, in France.—It is perfectly compact, and in some parts gives fire with steel, while in others it is softer. Its weight is estimated at 2500 lbs.—It contains nickel.

7. Another mass has recently been found near Red River in Louisiana. The form is irregular, its length being 3 feet 4 in. and its greatest breadth 2 feet 4 inches; its weight exceeds 3000 lbs. Its surface, covered with a blackish crust, is deeply indented, and its spec. grav. is 7.40. It is very malleable and compact; but is unequally hard, some parts being easily cut by a chisel, while others have nearly the hardness of steel. It contains nickel, and probably a little carbon; and is less easily oxidated, than purified iron.—This mass is rendered extremely interesting by the octaedral crystals, which have been discovered in its interior by Col. Gibbs. These crystals may be easily cut by a knife, and exhibit striæ, like those of magnetic iron. The largest is more than half an inch in length.

The two last mentioned examples differ from those of Siberia and S. America by their compact texture, unless it should appear, that they contain cavities in their interior.

8. Similar masses have been found in Mexico and Peru;—that of Durazzo is said to weigh 40,000 lbs.

9. Native iron, in small masses, and alloyed with nickel, exists

in aerolites, or in those stony substances, which are known to have fallen from the atmosphere.

It seems almost certain, that these masses of Native iron must have proceeded from volcanoes, or fallen from the atmosphere. There appears, however, to be a strong resemblance in many of their physical characters, as well as in their composition; and the fact, that the Native iron from Croatia, &c. actually fell from the atmosphere, seems to indicate an atmospheric origin for the whole.—This opinion is confirmed by an examination of those aerolites, which have fallen from the atmosphere at different times, and in different places. They all contain metallic iron, and this iron embraces nickel. Indeed these aerolites sometimes contain a hard substance, not much unlike that in the cavities of the Siberian iron.

Species 2. Arsenical Iron.*

Its true color is between tin and silver white, but it is often tarnished with shades of yellow, &c. It gives fire with steel more or less freely, and the sparks are attended by a little train of white smoke, having the odor of garlic; indeed the same odor is produced by friction against a hard body.—It is not, in general, very easily broken, and its fracture is almost always uneven; its lustre is metallic and somewhat shining. Its spec. grav. varies from 5.60 to 6.52.

Arsenical iron is often in crystals; and the primitive form, under which it sometimes appears, is a four-sided prism with rhombic bases, whose obtuse angles are 111° 18′. This prism is sometimes terminated by diedral summits (Pl. V, fig. 4.), whose faces stand on the acute lateral edges; these faces, which meet under an angle of 154° 56′, are usually striated parallel to the edge of the termination or bevelment.—Sometimes the prism is very short, and the two summits nearly or quite meet.—Sometimes also the crystals are acicular.

Arsenical iron also occurs in amorphous masses, either compact, or composed of prismatic distinct concretions, which sometimes terminate in crystals.

(*Chemical characters.*) Before the blowpipe, the oxide of arsenic is volatilized in the form of a white smoke, exhaling the odor of garlic, and a brownish oxide of iron remains. It contains, according to Lampadius, iron 58.9, arsenic 42.1;=101.

(*Distinctive characters.*) This mineral resembles arsenical co-

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* Fer arsenical. Haüy. Brongniart. Arsenik Kies. Werner. Arsenical Pyrites. Jameson. Arsenical Pyrites or Marcasite. Kirwan. La Pyrite arsenicale. Brochant.

balt; but the latter does not give sparks with steel, it tinges borax blue, and, when immersed in nitric acid, begins to effervesce much quicker than arsenical iron.—The compact texture of arsenical iron will serve to distinguish it from gray cobalt and antimonial silver, both of which have a foliated structure.—Its color, and its odor, when struck, distinguish it from sulphuret of iron. It is, however, hardly possible to define limits between arsenical iron and arsenical sulphuret of iron.

(*Geological situation and Localities.*) This species belongs to primitive mountains, where it occurs in metallic veins or beds in gneiss, micaceous, argillaceous, or chlorite slate, &c. and is sometimes disseminated in other minerals. Its gangues are quartz, carbonate and fluate of lime, &c. It is often associated with the oxide of tin, the sulphurets of lead and iron, pyritous copper, magnetic iron, &c.

This ore is found in Bohemia, Saxony, Cornwall, &c.

In the *U. States*, it occurs near Boston, sometimes prismatic, in argillite, &c. (GODON.)

It is seldom explored as an ore of iron; but is employed to furnish the white oxide of arsenic, and also to prepare the sulphuret of arsenic.

SUBSPECIES 1. ARGENTIFEROUS ARSENICAL IRON.*

It is whiter than the common arsenical iron, being more decidedly silver white; but it is usually tarnished with a shade of yellow. It has, in general, less lustre and a finer grain than pure arsenical iron. It is sometimes in acicular crystals, but seldom in masses of any considerable size.

A specimen from the Hartz yielded Klaproth iron 44.25, arsenic 35.0, silver 12.75, antimony 4.0;=96.

It is a rare ore, and usually accompanies common arsenical iron. —At Freyberg and Braunsdorf in Saxony, it is explored as an ore of silver.

Arsenical iron sometimes contains a little cobalt or gold.

SPECIES 3. SULPHURET OF IRON.†

Pyrites. Iron Pyrites.

Its color is usually bronze yellow, sometimes passing to pale brass yellow, or steel gray, or even into brown. It has nearly or quite

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* Fer arsenical argentifère. HAUY. BRONGNIART. Weisserz. WERNER. Argentiferous arsenical pyrites. KIRWAN. JAMESON.

† Fer sulfuré. HAUY. BRONGNIART. Schwefel kies. WERNER. Iron pyrites. JAMESON. Martial pyrites. KIRWAN. La pyrite sulfureuse. BROCHANT.

the hardness of quartz, and almost always gives fire with steel, exhaling the odor of sulphur. Its texture is sometimes compact, and sometimes fibrous; its fracture is commonly uneven, sometimes more or less conchoidal. Its powder, obtained by a file, is usually blackish. Its spec. grav. extends from 4.10 to 4.83. It sometimes feebly moves the magnetic needle. (*HAUY.*)

Sulphuret of iron occurs in small amorphous masses, or presents some imitative form, and is very frequently crystallized. The primitive form of its crystals is probably a cube, of which M. Haüy has described no less than 16 modifications.

1. A cube;—this is often truncated on all its angles, and sometimes so deeply, that the truncating faces touch or even intersect each other.—It is often elongated into a parallelopipedon. These cubic crystals are sometimes extremely beautiful.

2. A striated cube (Pl. V, fig. 5.);—the striæ on any one face are perpendicular to those on the adjacent faces. Very frequently the centre of the faces is a little prominent.

3. A cube, truncated on all its edges. (Pl. V, fig. 6.)

4. A cube, in which each solid angle is terminated by a three-sided pyramid, the vertex of which is sometimes truncated.—In fine, this cube is so modified by additional faces, that one variety of form, when complete, presents 134 faces, the greatest number hitherto observed on any crystal.

5. A dodecaedron with pentagonal faces, equal and similar. Six of its edges, or six of its angles are sometimes truncated.

6. An icosaedron (Pl. V, fig. 7.), presenting eight equilateral, and twelve isosceles, triangles. Six of its edges are sometimes truncated.

7. A solid, bounded by 24 faces, each of which is a trapezium.

8. A solid, bounded by 30 faces (Pl. V, fig. 8.), of which six are rhombs, parallel to the faces of the cubic nucleus, and the remaining 24 are trapeziums.

9. An icosaedron, of which each face bears a low triangular pyramid. (Pl. V, fig. 9.)

10. An octaedron, sometimes cuneiform, and sometimes with edges and angles variously modified. (See Pl. V, fig. 10.)

These crystals, sometimes large, are often small; they are frequently very perfect, with surfaces highly splendent.

(*Chemical characters.*) Before the blowpipe it exhales a strong odor of sulphur, and yields a brownish globule, obedient to the magnet; and, by continuing the heat, it is converted into a blackish scoria. It is composed of iron* and sulphur, for the proportions of

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* Some mineralogists have supposed the iron in this mineral to exist in the

which see the several varieties. Certain specimens from Peru are said to contain carbon.

Some varieties of the Sulphuret of iron are decomposed and yield the sulphate of iron much more readily than others; and this difference is, by Mr. Hatchett, attributed to a small quantity of oxigen originally combined with the sulphur.

Sulphuret of iron sometimes contains small quantities of gold, silver, copper, arsenic, or titanium; and may thus be distinguished as *auriferous* sulphuret of iron, &c. When such Pyrites decompose, the gold, being incapable of oxidation, is left naked.

(*Distinctive characters.*) It sometimes resembles pyritous copper; but the latter has a more lively yellow, and very often exhibits irised colors, which but seldom appear on sulphuret of iron; pyritous copper is less hard, and rarely and with difficulty gives fire with steel; in fine, the scoria, obtained by the blowpipe from pyritous copper, renders ammonia blue.—When sulphuret of iron is free from arsenic, it may be distinguished from arsenical iron by its color, and its sulphurous odor before the blowpipe.

Var. 1. COMMON SULPHURET OF IRON OR PYRITES.* Its color is bronze yellow, sometimes approaching pale brass yellow, or steel gray; it is sometimes tarnished with shades of red, brown, &c. Its fracture is usually uneven, with a metallic lustre somewhat shining; sometimes it is conchoidal with a very high lustre.

Its crystals have the forms already described; and it is frequently amorphous.

Sometimes it appears in membranes or *dendritic* branches, which are often embraced between layers of slaty minerals.

Sometimes also it occurs in *plates*, with indented edges, and so arranged as to resemble the crest of a *cock's comb;* these plates often appear to consist of flattened octaedrons partly inserted into each other. Sometimes the edges of the plates are rounded.

Sulphuret of iron also presents *concretions*, whose forms may be globular, cylindrical, reniform, &c. Their surface is sometimes rough or scaly.

Three crystals, analyzed by Hatchett, yielded iron 47.30 to 47.85, sulphur 52.15 to 52.70.

(CAPILLARY PYRITES.) This occurs in very delicate needles, which sometimes cross each other in various directions.

CELLULAR PYRITES.† JAMESON. This subvariety presents little

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state of an oxide; but there seems to be better reasons for believing it to be in a metallic state.

* Gemeiner schwefel kies. WERNER. Common iron pyrites. JAMESON.

† Zellkies. WERNER.

cells, which are often considerably regular, and lined with minute crystals. Its color inclines strongly to steel gray.

2. RADIATED SULPHURET OF IRON.* Its color is usually a pale bronze yellow, more or less inclining to steel gray, and sometimes passing even to tin white on the fresh fracture. It is liable to tarnish, and may then become brass yellow, &c. or exhibit variegated colors.

Its crystals are usually octaedrons, sometimes elongated, and sometimes with truncated angles.† But more frequently its form is globular, botryoidal, reniform, tuberose, cylindrical, conical, &c. Its surface is often rough, and sometimes distinctly presents the solid angles of octaedral crystals.

It is easily broken, and its fracture is fibrous and glistening. When its form is spherical, the fibres diverge from the centre, and, when nearly cylindrical, from the axis. It sometimes presents curved lamellar concretions, traversing those, which are granular.

A mean of two analyses by Hatchett gives iron 46.03, sulphur 53.97.

This variety is rarer, and more liable to decomposition than the common Pyrites, and capillary crystals of sulphate of iron sometimes appear on its surface.—It sometimes occurs in veins of lead and silver; and sometimes in chalk, clay, and marl.

In the *U. States*, in *Maine*, at Harpswell, it occurs in globular and botryoidal masses.

3. HEPATIC SULPHURET OF IRON.‡ This embraces those varieties of Sulphuret of iron, which are susceptible of a peculiar decomposition, by which the sulphur is more or less disengaged. During this process, the Pyrites is converted, either entirely or in part, into a compact oxide of iron of a *liver*§ brown color; but still retains its original forms. Its hardness and spec. gravity are somewhat diminished, and its lustre disappears. This decomposition commences at the surface, and gradually extends to the centre. In fact, portions of Pyrites, not decomposed, have been observed near the centre of masses of a reddish oxide of iron.

The decomposition, of which we here speak, is of a very different

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* Strahl kies. WERNER. Radiated pyrites. JAMESON. Fer sulfuré radié. HAUY. BRONGNIART.

† According to Haüy, the primitive form of these crystals is a rhomb with angles of 106° 36′ and 73° 24′. Of course, in a crystallographical arrangement of minerals, this variety would form a distinct species.

‡ Leber kies. WERNER. Hepatic pyrites. JAMESON. Fer sulfuré epigene. HAUY,

§ Hence the term *Hepatic*, from the Latin, *Hepar*, liver.

nature from that, by which the Sulphuret of iron is converted into sulphate of iron (copperas.) Indeed the cause and manner of this decomposition have not yet been well explained.

This variety presents nearly all the forms of the common Sulphuret of iron. Sometimes also the radiated variety undergoes a similar alteration.

(*Geological remarks.*) Few minerals are more universally diffused, than Sulphuret of iron, especially the common variety, which extends from primitive rocks to alluvial earths. Indeed there are but few earthy or saline simple minerals, occurring in considerable masses, in which it is not sometimes more or less interspersed. But though usually disseminated in other minerals, or mingled with other ores, it sometimes constitutes almost the only ore in veins of quartz, carbonate of lime, &c.

There is scarcely a metallic vein or bed, which does not contain Pyrites. In coal also it is not uncommon.—In volcanic productions, however, it is rare; and, according to Brongniart, has seldom been observed in the sulphate or phosphate of lime, or in anthracite.

Sulphuret of iron sometimes invests the crystals of other substances;—and sometimes it is pseudomorphous, constituting the substance of the cornu ammonis, belemnite, &c.—In other cases it penetrates fossil wood.—Flints and other hard stones, immersed for some time in certain stagnant waters, become invested with a thin coat of Pyrites.

Although Pyrites has been found in all the Meteoric stones, which have been examined, we are indebted to Col. Gibbs for the discovery of two cubic crystals of Pyrites in the Meteoric stone, which fell at Weston (Con.) in 1807. One of these crystals is about $\frac{3}{4}$ of an inch in diameter. (Bruce's Min. Jour. v. i.)

It is unnecessary to enumerate localities of a mineral so very common.

(*Uses and Remarks.*) This substance, though never employed to furnish iron, is still a valuable ore. Its sulphur is sometimes extracted by sublimation. But it is chiefly valued for the sulphate of iron (copperas), which it affords by decomposition;—a change, which some varieties undergo much more readily than others. In this process, the sulphur receives oxigen from the air, or from moisture, and is converted into sulphuric acid. This acid combines with the oxide of iron, thus forming sulphate of iron, which is extracted by lixiviation, evaporation, and crystallization. Sometimes this decomposition is spontaneous, or effected by merely exposing the Pyrites to air and moisture; but some varieties must be previously roasted.—The sulphate of iron often appears on the surface of the Pyrites, or the mineral, which contains it, in yellowish or white silky efflorescences, sometimes mixed with sulphate of alumine.

Whenever large masses of Pyrites undergo decomposition, a great degree of heat is produced; and to this heat may be attributed the spontaneous combustion of certain coal mines, and the elevated temperature of warm springs. In fine, this decomposition often takes place in cabinets.

In the *United States*, manufactories of the sulphate of iron, or copperas, are established in *Tennessee*;—in *Maryland*, about 20 miles from Baltimore, where the Pyrites is extremely abundant, and readily efflorescent;—in *New Jersey*;—in *Vermont*, at Thetford;—and in *Maine*, at Winthrop.

Pyrites was formerly employed for the same purpose as flint; and hence probably the origin of the name.

SUBSPECIES 1. MAGNETIC SULPHURET OF IRON.*

Magnetic Pyrites.

The most remarkable character of this subspecies is that of moving the magnetic needle, and of constituting a permanent magnet.—Its color is bronze yellow, more or less mingled with copper red, and sometimes it is pinchbeck brown, or even gray; its surface has often a dull brown or variegated tarnish.

It is always amorphous; its masses are easily broken, and have an uneven or imperfectly conchoidal fracture; its lustre is metallic, but variable. Its spec. grav. is 4.51.

Before the blowpipe it exhales the odor of sulphur, and melts into a blackish globule, obedient to the magnet. It contains iron 63.50, sulphur 36.50. (*HATCHETT.*)

Haüy considers this subspecies a common Sulphuret of iron, mixed with a little metallic iron.—Magnets, made with this Sulphuret, are said to be more durable, than others.

(*Geological situation and Localities.*) This ore has hitherto been found, perhaps exclusively, in primitive rocks, such as mica slate, gneiss, granite, greenstone, limestone, &c. It is disseminated, or exists in beds. It is generally associated with the common pyrites, and other metallic sulphurets, magnetic oxide of iron, garnets, hornblende, &c. In Bohemia, its beds sometimes lie between gneiss and greenstone, and sometimes between gneiss and limestone.

In the *United States*. In *New York*, it occurs in the Highlands;—it is also frequent in the iron mines on the west side of Lake

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* Fer sulfuré magnetique. BRONGNIART. Fer sulfuré ferrifère. HAÜY. Magnet Kies. WERNER. Magnetic Pyrites. KIRWAN. JAMESON. La Pyrite magnetique. BROCHANT.

Champlain. *(Gibbs.)*—In *Connecticut*, at Brookfield, in granite; it is abundant, highly magnetic, decomposes rapidly in the air, and furnishes excellent copperas. *(Silliman.)*—In *Massachusetts*, near Boston.—In *Maine*, at Brunswick, in granular limestone, with common pyrites in cubes, green talc, &c.

Subspecies 2. ARSENICAL SULPHURET OF IRON.

This is a Sulphuret of iron, containing variable proportions of arsenic, which may be discovered by its odor, when the mineral is struck or heated. It is often difficult to distinguish it from pure Sulphuret of iron, on one side, and from arsenical iron, on the other, between which extremes there seem to be numerous intermediate shades. In general, with an increase of arsenic, the yellow tinge of the sulphuret of iron diminishes and passes to gray.

In the *U. States*, this mineral is found in *New York*, in the Highlands.—In *Connecticut*, at Derby, Middletown, Chatham, &c. at the last place it is associated with arsenical cobalt. *(Silliman.)*

Species 4. Magnetic Oxide of Iron.*

Its color is iron black, usually darker than forged iron, but sometimes passes to bluish or steel gray. Its powder is always nearly or quite black. Its surface is liable to tarnish.

Although its hardness is very considerable, it is in general very easily broken, and some varieties are friable. It sometimes gives fire with steel.

This ore always acts more or less on the magnetic needle, and sometimes attracts filings of iron. Its spec. gravity varies from 4.20 to 4.93.

The primitive form of its crystals is a regular octaedron, under which it frequently appears. This octaedron, when broken, often presents laminæ parallel to its faces, and its surface is sometimes striated parallel to the sides of the faces. Sometimes also it is cuneiform and lengthened; and sometimes truncated on all its edges.—Another form is a dodecaedron with rhombic faces, often striated in the direction of the longer diagonals of the faces.—These crystals are often very regular, and sometimes large.

Sometimes this ore occurs in masses, whose structure and fracture are more or less distinctly foliated; and in a few instances it has been observed with a fibrous structure. It also presents itself in lamellæ or plates, and sometimes in the state of sand.

But it most frequently occurs in compact or granular masses, of

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* Fer oxidulé. Hauy. Brongniart. Magneteisenstein. Werner. Magnetic iron stone. Kirwan. Jameson. Le Fer magnetique. Brochant.

which the granular concretions are sometimes separable by the finger. Its fracture is usually uneven, or more or less conchoidal with small cavities, and sometimes nearly even, or splintery; its lustre is metallic, but variable from splendent to glimmering.

It is insoluble in nitric acid. Before the blowpipe it becomes brown, but does not melt. It is an oxide of iron, containing probably from 10 to 20 per cent. of oxigen.

Its strong action on the magnetic needle, and the black color of its powder will serve to distinguish it from the specular oxide of iron.

Var. 1. NATIVE MAGNET.* (Loadstone.) The magnetism of iron, or its power of moving the magnetic needle, is not destroyed by the addition of a small quantity of oxigen, and may, perhaps, continue sensible even with 30 per cent. Possibly, however, the presence of a small quantity of some combustible may be essential to the permanent magnetism of the oxides of iron.

Some of these low oxides of iron attract iron filings, and possess also a sensible polarity, by which, if the two extremities of a small fragment be alternately presented to the same pole of a magnetic needle, one extremity will attract and the other repel the needle. This polarity is sometimes imperceptible, unless a very feeble needle be employed; for, when a fragment, whose polarity is very weak, is presented to a strong needle, its poles are instantly inverted, and of course it constantly attracts the needle. Hence by employing very weak needles M. Haüy has been able to observe polarity in many specimens of the brown oxide of iron. Perhaps all magnetic oxides really possess polarity, though it is often extremely feeble.

It appears then, that those oxides of iron, which possess a very sensible magnetism, belong to the species, called Magnetic oxide of iron; and that those varieties, which attract iron filings and exhibit polarity in the strongest degree, constitute the variety, which is called *Native magnet.*

This variety acts very sensibly on strong needles, and easily raises filings of iron. Though sometimes crystallized, it is usually in amorphous masses, whose fracture is granular, or somewhat foliated. Its color, in consequence of foreign intermixture, is sometimes brownish red or even gray.

The magnet is generally situated in the earth nearly in the direction of the meridian, that is, with its north pole toward the north; but sometimes this position is inverted.

Delicarlia in Sweden, Norway, Siberia, &c. furnish some of the strongest magnets.

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* Fer oxidulé aimantaire. BRONGNIART.

In the *United States*, this variety has been observed in *New Jersey*, at Schooley's mountain;—and in *Maine*, at Topsham, where its polarity is sometimes very strong. Sometimes the polarity of the entire crystal is feeble, while that of its fragments is very considerable.

2. IRON SAND.* *JAMESON.* This variety occurs in small octaedral or dodecaedral crystals, or in fragments of crystals, or in grains, constituting a sand. This sand has but little lustre, is strongly attracted by the magnet, and may thus be separated from other sandy particles, with which it is usually mixed.

This sand is not always a pure oxide, but sometimes embraces considerable quantities of the oxide of titanium. A specimen yielded Klaproth oxide of iron 85.5, of titanium 14.0, of manganese 0.5. Sometimes the oxide of titanium forms more than 20 per cent.

Iron sand is found on the bottom of vallies, on the banks of rivers, or on the margin of the sea; and appears to have been separated by the action of water from those minerals, which once enveloped it, such as wacke, basalt, chlorite slate, &c.

It is sometimes sufficiently pure and abundant to be smelted.

In the *U. States*, it is found in *Virginia*.—In *Maryland*.—In *Connecticut*, at Westhaven, on the beach, which forms the margin of the sea shore. This sand is highly magnetic, uncommonly pure, and has very obviously proceeded from the disintegration of the chlorite slate, contiguous to the beach, and abounding with minute octaedral crystals of magnetic iron. These crystals, liberated from the slate and broken by the action of the waves, constitute the magnetic sand of the beach. (*SILLIMAN.*)

(*Geological remarks on the species.*) Magnetic oxide of iron is most frequently found in primitive mountains, where it exists in granite, gneiss, mica slate, greenstone, and rocks abounding with hornblende.—It has been observed also in transition and even secondary rocks.

It is sometimes disseminated—sometimes in beds or veins, which are frequently very large—and sometimes it constitutes the greater part of whole mountains, as that of Taberg in Sweden.

It is associated with the sulphuret of iron both common and magnetic, arsenical iron, sulphuret of copper, oxide of titanium, &c. also with garnets, carbonate of lime, hornblende, epidote, coccolite, augite, &c.

(*Localities.*) Of foreign localities Sweden is the most important; and the ore is there very abundant.

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* Eisen sand. WERNER. Magnetic sand. KIRWAN. Le Fer magnetique sablonneux. BROCHANT.

In the *United States.* In *North Carolina*, it occurs in the western part of the State.—In *Maryland*, near Baltimore, &c.—In *Pennsylvania*, in Chester Co. and on Edge Hill in Buck's Co. (*Wister.*) —In *New Jersey*, in the primitive mountains, which extend from N. E. to S. W. through the northern parts of the State, to the vicinity of the Delaware river; (*Gibbs.*)—in Sussex Co. its gangue is sometimes the red oxide of zinc. (*Bruce.*)—In *New York*, it occurs in immense quantities on the west side of Lake Champlain, in granitic mountains; the ore is in beds from one to twenty feet in thickness and generally unmixed with foreign substances—also in the Highlands; in fact, large beds of this ore extend with little interruption from Canada to the neighborhood of New York. (*Gibbs.*)—In *New Hampshire*, at Franconia, Grafton Co. 8 m. east from Connecticut river; the bed, from 5 to 8 ft. thick, is contained in gneiss; the ore is is compact, or fine grained, and bluish gray, and is accompanied by garnet, epidote, and hornblende. (*Gibbs.*)—In *Maine*, at Topsham, Lincoln Co. disseminated in granite; it is generally in octaedral crystals, varying in size from that of a pin's head to 2 inches diameter;—also at Paris and Buckfield in Oxford Co.

(*Remarks.*) Magnetic oxide of iron sometimes yields from 80 to 90 per cent. of metallic iron; but from some of its ores not more than 60 per cent. is obtained. It furnishes the best of bar iron, and the Swedish, so much esteemed, is obtained from this ore. Its bar iron, however, is sometimes *red short.*

Species 5. SPECULAR OXIDE OF IRON.*

Its usual color is steel gray, light or dark, sometimes passing into iron black, and sometimes with a tinge of red. Its surface is often beautifully tarnished with azure blue, or is pavonine, irised, or like tempered steel. But however dark its external color, its streak and powder are a dark cherry red, or blackish red; and its powder, rubbed on paper, leaves a brownish red trace. Its surface has a metallic lustre, which is often highly splendent.

It has a very feeble action on the magnetic needle, and does not raise iron filings, even in those cases, in which it possesses a sensible polarity; its powder is slightly affected by the magnet.

It is sufficiently hard to scratch glass, and breaks with difficulty in some varieties, while in others it is very brittle. Its spec. grav. usually lies between 4.67 and 5.21. Its fracture is uneven or conchoidal with small cavities, and sometimes foliated; its lustre is

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* Eisen glanz. WERNER. Iron glance. JAMESON. Specular iron ore. KIRWAN. Le Fer speculaire. BROCHANT. Fer oligiste. HAUY. BRONGNIART.

metallic, sometimes splendent, but more frequently somewhat shining.

Specular iron is frequently in crystals, whose primitive form, which it sometimes presents, is a rhomb slightly acute; its angles being nearly 93° and 87°. Of this nucleus, which is most easily obtained from certain massive varieties, Haüy has described not less than 15 modifications. Some of its secondary forms differ extremely from each other, as well as from the primitive. The following are some of the more common.

1. Sometimes two solid angles of the primitive, diagonally opposite, are replaced by three triangular faces.

2. A solid, contained under 24 faces (Pl. V, fig. 11.), of which six are pentagons, six are isosceles triangles, and twelve are scalene triangles. Or it resembles a cube, of which two solid angles, diagonally opposite, are terminated by three triangular faces, and all the other angles by two triangular faces.—This form is common in those beautiful crystals, which proceed from the isle of Elba, where they occur in groups, and often present a very lively and irised play of colors.

3. Another form (Pl. V, fig. 12.) consists of two hexaedral pyramids, applied base to base, with their summits deeply truncated; any two opposite sides are inclined at the common base at nearly 121°. The summits are often truncated so near to the common base, that the crystal becomes a thin *hexagonal table*, bevelled on the edges.—This form prevails at Framont in France.

4. Sometimes the solid angles (Pl. V, fig. 13.) about the common base of the preceding form are truncated by rhombic faces.—Sometimes also the alternate lateral edges are truncated.

5. Sometimes the summits of the primitive rhomb are deeply truncated. The crystals, which belong to this variety, often have the aspect of an octaedron much compressed, or of a thin segment of an octaedron, and thus become six-sided tables or plates, surrounded by trapezoidal faces. Sometimes also the solid angles of the bevelment are truncated.—These plates or tables are most frequently found in volcanic productions; they are highly polished, brittle, and have a conchoidal fracture.

In most cases the crystals of Specular iron, unless tarnished, exhibit a very strong, metallic, external lustre, sometimes equal to that of highly polished steel.

Sometimes the edges and angles are so rounded, that the crystal assumes a lenticular form.—Sometimes it is in plates, whose surface is often marked by striæ, intersecting each other.

Specular iron also occurs in granular or compact masses, which are often very large.

(Chemical characters.) It does not dissolve in nitric acid. Before the blowpipe it is infusible, but becomes reddish. It is an oxide of iron, containing, according to Kirwan, from 24 to 30 per cent. of oxigen. It sometimes contains silex and alumine, even when crystallized.

(Distinctive characters.) Its reddish powder and feeble action on the magnetic needle distinguish it from the magnetic oxide of iron. —Gray copper and sulphuret of lead yield a black powder, and are not in any degree magnetic.

(Geological sit. and Localities.) Specular iron usually occurs in primitive mountains, and sometimes also in transition rocks. It is sometimes disseminated in other minerals; but more frequently constitutes large veins or beds, or irregular masses, and sometimes whole mountains, as in the island of Elba. Its finest crystals are found in cavities in the interior of the massive or compact varieties.

It is accompanied by magnetic iron, red oxide of iron, quartz, &c.

Its most important localities are the isle of Elba, where it is extremely abundant;—Framont in France; Norberg, &c. in Sweden; Bergen, &c. in Norway.

In the *U. States*, it has been observed in *Maryland*, near Baltimore, in gneiss; also lamellar in chlorite. (HARDEN.)—In *Massachusetts*, at Brighton and the Blue Hills in thin laminæ in quartz. (GODON.)

Specular iron frequently occurs in the fissures and other cavities of lava, often near the crater of volcanoes; and, in many cases, has evidently been sublimed by volcanic fire. It exists in highly polished and very brittle plates, or tabular crystals, bevelled on their edges.—In Auvergne, it occurs in small scales, disseminated in a porous lava. —In Stromboli, in the fissures of lava; the largest plates are 4 inches by 3½, while others cannot be observed without a glass; they all possess polarity, although they are not affected by the magnet, unless previously reduced to fine particles. (SPALLANZANI.)

(Remarks.) When abundant, Specular iron is a valuable and profitable ore. It furnishes good iron, both cast and malleable; but the latter is said to be harder, than that obtained from magnetic iron.

It generally yields from 65 to 75 per cent.

Subspecies 1. MICACEOUS OXIDE OF IRON.[*]

Its color is iron black or steel gray; but its streak and powder are a dark cherry red. In some specimens, however, the tinge of red is visible only under a particular incidence of light. Very thin laminæ are translucent, and sometimes appear deep blood red.

Its fracture is foliated, with a shining metallic lustre; the laminæ are often curved. Its spec. grav. sometimes 5.07, is stated by Bournon at 3.96.—It is less hard, than common specular iron, is easily broken, and reduced into small shining scales; indeed the friction of the finger often detaches minute particles, which are unctuous to the touch.

It occurs in masses, composed of thin shining laminæ or scales, applied to each other, and sometimes diverging from a centre. Sometimes also it is in distinct tabular crystals.[†]

(*Geological sit. and Localities.*) It occurs in primitive mountains, sometimes on the surface of rocks, or on other ores of iron, or is disseminated; sometimes also in veins, or in beds or masses of considerable size.—It is often found in connexion with the common specular iron, and is sometimes associated with the red oxide of iron, &c. It is sometimes closely allied to the scaly red oxide of iron.

In the *U. States*, it is found in *Virginia.*—In *Maryland*, near Baltimore, in primitive rocks. (*Harden.*)—In *Pennsylvania*, in Upper Dublin, Montgomery Co. in hexagonal tables. (*Conrad.*)—In *Connecticut*, at New Stratford.

(*Remarks.*) It is but rarely in sufficient quantity to be explored by itself. It is said to yield about 70 per cent. of iron.

Species 6. Red Oxide of Iron.[‡]

In this species the iron appears to be more highly oxidated, than in either of the two preceding. It is nearly or quite destitute of magnetism, and very seldom exhibits a lustre really metallic. It has, in fact, more of an earthy, than a metallic aspect. Though never crystallized, it often presents some imitative form. Its texture is usual-

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[*] Micaceous iron ore. Kirwan. Eisen glimmer. Werner. Iron mica. Jameson. Le Fer micacé. Brochant. Fer oligiste ecailleux. Hauy. Brongniart.

[†] Bournon considers this a distinct species, in which the iron is more highly oxidated, than in common specular iron. He says the primitive form of its crystals is a cube, that its hardness and spec. grav. are less, and its powder redder, than in the common variety, and that it is not magnetic.

[‡] Fer oxidé rouge. Brongniart. Roth eisenstein. Werner. Red iron stone. Jameson. La Mine de fer rouge. Brochant. Var. of Fer oligiste Hauy.

ly fibrous or compact; but it sometimes occurs in a loose or slightly indurated state.

Its external color is red, usually more or less mixed with a shade of brown or gray; but its streak and powder are always red, most frequently blood red, sometimes with a slight tinge of brown or yellow. Its powder is fine, and very hard, but not rough.

Before the blowpipe, on charcoal, it grows darker, becomes magnetic, and even acquires polarity; but does not melt. It has not been satisfactorily analyzed; but appears to be nearly a pure oxide of iron, sometimes contaminated with silex, alumine, lime, or oxide of manganese.

Var. 1. SCALY RED OXIDE OF IRON.* Its color usually varies between cherry red and brownish red, and sometimes inclines to steel gray. Its surface is sometimes irised. Its lustre is glossy, and, in some instances, nearly metallic.—It is unctuous to the touch, soils the fingers strongly, and leaves on them numerous, little spangles, which closely adhere.

It occurs in crusts or masses, more or less friable, and composed of minute scales.—It has also been observed in little translucid plates, of a lively red, united in globular masses, in cavities of the red hematite. (*HAUY.*)

This variety appears to differ but little from micaceous oxide of iron, into which it passes. A specimen, analyzed by Henry, yielded iron 66.0, oxigen 28.5, silex 4.25, alumine 1.25.

(*Geological sit. and Localities.*) Though usually in primitive mountains, it has been observed in secondary rocks, and even upon coal. Rarely in masses, it usually appears in crusts on other minerals, as specular and sparry iron, &c. and is even intermixed with the micaceous oxide. It is often associated with the other varieties of the red oxide of iron, quartz, &c.—At Sahl, in Henneberg, it occurs in sufficient quantity to be smelted, and yields good iron. (*JAMESON.*)

In the *U. States*, it is found in *Pennsylvania*, at the Perkiomen lead mine. (*CONRAD.*)

2. RED HEMATITE.† *JAMESON. KIRWAN.* Its color is usually brownish red, often with a tinge of steel gray; it sometimes inclines

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* Fer oxidé rouge luisant. BRONGNIART. Rother eisenrahm. WERNER. Red iron froth. JAMESON. Fer oligiste luisant. HAUY.

† Fer oxidé rouge hématite. BRONGNIART. Rother glaskopf. WERNER. L'Hématite rouge. BROCHANT. Fer oligiste concretionné. HAUY.

The term Hematite is derived from the Greek, Αιμα, blood, in allusion to the red color of this mineral.

to blood red, or even steel gray, especially at the surface. Its streak and powder, however, always appear nearly blood red.

Its structure is always very distinctly fibrous; and the fibres, though sometimes nearly parallel, almost always diverge from one point in each concretion toward the circumference; sometimes they even radiate from a centre. Its lustre is either glistening and slightly metallic, or, when the fibres are very delicate, it resembles that of silk.

It is solid, and has sometimes almost the hardness of quartz. By friction against a hard body, it often acquires a lustre nearly metallic. Its fragments sometimes resemble splinters of wood.

It is seldom amorphous, but almost always in concretions, which are usually reniform, sometimes globular, botryoidal, stalactical, or cylindrical. The cylinders are sometimes aggregated. In fact, its larger masses are usually composed of smaller concretions, which are sometimes lamellar.—Its spec. grav. extends from 4.74 to 5.00.

(Geological sit. and Localities.) It occurs chiefly in primitive mountains, but sometimes in secondary rocks. It is found in veins, of which it sometimes constitutes the greater part; also in beds or masses, which are sometimes extremely large. It is usually accompanied by the compact variety of this species.

Though not very common, it is yet found in large quantities in certain countries, as Saxony, Bohemia, Lancashire in England, &c.

(Remarks.) It is difficult to melt; but yields from about 60 to 75 per cent. of iron of excellent quality, whether cast or forged. When reduced to powder, it is sometimes employed for polishing other metals.

3. COMPACT RED OXIDE OF IRON.* The color of this variety, like that of the preceding, is most commonly brownish red, often with a mixture of steel gray. Its streak and powder are blood red.—Its texture is compact, and its fracture even or conchoidal, sometimes uneven; it is dull, or has only a feeble lustre.—It is usually a little less hard, than the red hematite, breaks without difficulty, and sometimes soils the finger.

It occurs in amorphous masses, and sometimes under imitative forms, as globular, reniform, &c.—Sometimes also it presents false crystals, whose forms are pyramidal or cubic, derived from quartz, sulphuret of iron, &c. It seems probable, that the sulphuret of iron is sometimes converted by decomposition into this compact red oxide;

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* Fer oxidé rouge compacte. BRONGNIART. Dichter roth eisenstein WERNER. Compact red ironstone. JAMESON. KIRWAN. La Mine de fer rouge compacte. BROCHANT. Fer oligiste terreux. HAUY.

for in some of these cubic crystals a portion of sulphuret of iron is found at the centre.—Its spec. grav. lies between 3.42 and 3.86.

A cubic crystal from Thuringia yielded Bucholz iron 70.5, oxigen 29.5. A specimen, analyzed by Lampadius, yielded oxide of iron 65.4, silex 20.7, alumine 9.3, oxide of manganese 2.7;=98.1.

Its *Geological situation* and *Localities* are similar to those of the red hematite, already mentioned. It is often associated with quartz and hornstone.—In the Fichtelberg, near Bareuth, its beds separate into columns, like basalt.

In the *U. States*, it is found in *New York*, at Canton, St. Lawrence Co. (*Hall.*)

It passes into the preceding and following varieties of this species, and into some varieties of the argillaceous oxide of iron.

It commonly yields good iron; its forged iron is somewhat soft.

4. OCHREY RED OXIDE OF IRON.* (Red ochre.) Its color is blood red, sometimes lively, and sometimes it is brownish red. It is usually friable, and always easily reduced to powder. Its fracture and general aspect are dull and earthy. It strongly soils the fingers, but is not unctuous, like the scaly variety. Its spec. grav. is a little below 3.00. Seldom in large masses, it usually appears on the surface of other ores of iron, or is disseminated.

It never effervesces with acids, unless from accidental mixture; and is often a very pure oxide. By mixture, however, with argillaceous earths, it gradually passes into reddle, bole, &c.

It almost always accompanies the two preceding varieties, and is often found with specular and sparry iron. In its purest state, it seldom occurs in large quantities.

In the *United States*, this ochre, more or less pure, occurs in numerous instances, and sometimes very abundantly.

(*Uses and Remarks.*) It melts easily, and furnishes a soft and very good malleable iron.—When purified by agitation in water, it constitutes an important paint for many purposes. It may be made to assume various tints of red, by changing its state of oxidation by the action of a mild heat.—To this variety belongs the pigment, called *Indian red*, brought from the isle of Ormus, in the Persian gulph.

Haüy has arranged this species under specular iron, (Fer oligiste). Indeed the crystals of the latter are sometimes found adhering to the sides of cavities in the former; and some specimens of the red oxide divide into rhombs, slightly acute, resembling the primitive form of specular iron.

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* Fer oxidé rouge ocreux. BRONGNIART. Ochricher roth eisenstein. WERNER. Red ochre. KIRWAN. JAMESON. Fer oligiste terreux. HAUY.

The Red oxide of iron is rare in Norway, Sweden, Russia, and Hungary. (*JAMESON.*)

SPECIES 7. BROWN OXIDE OF IRON.*

Hidrate of Iron.

This, like the preceding species, is destitute of a lustre strictly metallic; and its general aspect is stony or earthy. Its prevailing color is brown, usually deep, sometimes blackish brown, and sometimes with a strong tinge of yellow. Its powder, however, is always brownish yellow, or yellowish brown. This powder is less fine, and less hard, than that of the red oxide of iron.

It is frequently amorphous, sometimes in an earthy state, and often presents certain imitative forms; indeed, according to Haüy, it is sometimes crystallized in cubes. The texture of its masses is compact or fibrous.

Its spec. grav. varies from 3.40 to 3.90. With a weak and delicate needle some specimens discover magnetic polarity; but, in general, it is scarcely sensible.

(*Chemical characters.*) Most of its varieties become reddish or reddish black by calcination. It is infusible by the blowpipe; but, on charcoal, it acquires more or less of polarity.—According to Daubuisson, it is essentially composed of oxide of iron 85, water 15, being in fact a *Hidrate of iron.*—It is, however, never pure, but contains more or less of the oxide of manganese, silex, and alumine. —He also includes under the same name the *nodular*, *granular*, and *bog ore* varieties of the following species. (See analyses under the several varieties.)

The color of its powder sufficiently distinguishes it from the preceding species.

Var. 1. SCALY BROWN OXIDE OF IRON.† Its color is brown, sometimes inclining to steel gray. It is nearly or quite friable, and, though sometimes in small masses, usually occurs in crusts. It presents small scaly particles with a glistening lustre, somewhat metallic. It is unctuous to the touch, and soils the fingers.

It is usually found in cavities of the hematitic variety.

2. HEMATITIC BROWN OXIDE OF IRON.‡ (Brown hematite.) Its

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* Fer oxidé brun. BRONGNIART. Brauner eisenstein. WERNER. Brown ironstone. JAMESON. La Mine de fer brune. BROCHANT. Fer oxidé rubigineux HAÜY.

† Brown scaly iron ore. KIRWAN. Brauner eisenrahm. WERNER. Brown iron froth. JAMESON.

‡ Brauner glaskopf. WERNER. Brown hematite. KIRWAN. JAMESON. Fer oxidé brun fibreux. BRONGNIART. Fer oxidé hématite. HAÜY.

true color is often nearly clove brown; but it varies from blackish or bluish brown to yellowish brown or brownish yellow. Its surface is often tarnished; hence it is sometimes irised, or velvet black; indeed some specimens seem to be covered with a beautiful, shining, black varnish. But its streak and powder are always very nearly brownish yellow. Its external lustre is considerable, sometimes splendent.

Its structure is always fibrous; and the fibres, either straight or curved, are sometimes extremely delicate and close. Though sometimes parallel, they usually diverge, or even radiate from a centre. Its lustre is variable, but commonly glistening, and either silky or resinous.

This variety, seldom amorphous, presents a great number of imitative forms. Thus it occurs reniform, stalactical, cylindrical, coralloidal, tuberose, botryoidal, &c. The cylinders are sometimes aggregated in rows. Its masses sometimes present lamellar concretions.

It is less hard, and more easily broken, than the red hematite.

According to Daubuisson, it contains, on a mean of two analyses, oxide of iron 80.5, water 14.5, oxide of manganese 2.0, silex 2.0; =99.

(*Geological situation.*) This ore occurs in primitive, transition, and secondary rocks. It exists in veins, beds, or masses, and accompanies the compact variety, in the cavities of which it is often found. It often accompanies sparry iron.

(*Localities.*) In the *United States.* In *Virginia*, on the Shenandoah.—In *Maryland*, fine specimens are found 17 m. from Baltimore. (*Hayden.*)—In *Pennsylvania*, stalactical in a cavern in Messersburgh.—Also at Jenkintown in Montgomery Co. stalactical and mammillary, very beautiful; (*Conrad.*)—also near Lancaster.—In *New Jersey*, in the northern parts of Burlington Co. mammillary, and ploughed up in the fields. (*Woodbridge.*)—In *New York.*—In *Connecticut*, at Kent and Salisbury. The ore from Salisbury is sometimes in very beautiful stalactites; it supplies the Salisbury and Ancram furnaces, and yields the best bar iron in the northern States. (*Gibbs.*)—In *Rhode Island*, at Scituate.—In *Vermont*, at Monkton.—In *New Hampshire*, at Chesterfield, on West River mountain;—also at Pembroke.

(*Remarks.*) It is a very fusible ore, and commonly yields from 40 to 60 per cent. of iron. Its cast iron is ordinarily inferior to that obtained from the red oxide of iron. Its forged iron is hard, very malleable, and furnishes excellent steel. Indeed the Brown hematite may be converted into steel at about the same expense, as into bar iron. In this way much of the German steel is manufactured.

3. COMPACT BROWN OXIDE OF IRON.* Its color is, in general, nearly clove brown, either light or dark, sometimes passing to blackish brown, and sometimes the brown is mixed with yellow or even steel gray. Its surface is sometimes reddish; but its streak and powder are yellowish brown, sometimes passing to ochre yellow.

Its texture is compact, and never fibrous, like the preceding variety. According to Brongniart, its structure is sometimes slaty.—Its fracture is commonly even, sometimes a little conchoidal, and also passes to uneven or earthy. It is dull, or has only a glimmering lustre.

Though usually in amorphous masses, it sometimes occurs under various imitative forms, as reniform, globular, botryoidal, cylindrical, cellular, dendritic, stalactical, &c.

It is usually less hard, than the brown hematite, and its spec. gravity is seldom higher than 3.60.

A mean of two analyses by Daubuisson gives oxide of iron 76.5, water 12.0, oxide of manganese 2.0, silex 6.0, alumine 1.5;=98. The proportion of manganese is in some specimens considerably greater; indeed this ore sometimes passes by insensible shades into the oxide of manganese.

Its *Geological characters* and *Localities* are, in general, the same as those of the preceding variety, with which it is usually connected. It is, however, much more abundant, and is found in veins, beds, and masses, which are often very large. It sometimes forms the substance of certain fossils, such as madreporites, &c.

Both the compact and hematitic varieties are very often accompanied by the ochrey brown oxide of iron.

In the *United States*; in *Maryland*, on the Blue Ridge, at Mount Alto, Hughe's mine, it occurs in stalagmites, or very beautifully dendritic, resembling, in large masses, a grove of trees. (*HAYDEN.*)

This variety is much explored; but it yields a little less iron than the preceding.

4. OCHREY BROWN OXIDE OF IRON.† (Yellow ochre.) Its color is yellowish brown of different shades, sometimes inclining to ochre yellow, and sometimes to brown. It occurs in dull, earthy masses, which are nearly or quite friable, and strongly soil the fingers.

It contains oxide of iron 83, water 12, silex 5. (*DAUBUISSON.*)—Though it sometimes reddens when slightly heated, it never assumes a lively red, like yellow earth, from which it is hereby distinguished.

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* Fer oxidé brun compacte. BRONGNIART. Dichter braun eisenstein. WERNER. Compact brown ironstone. KIRWAN. JAMESON.

† Fer oxidé brun ocreux. BRONGNIART. Ochricher braun eisenstein. WERNER. Ochrey brown ironstone. JAMESON.

It usually accompanies the two preceding varieties, and is often found with sparry iron.

The preceding species, which is abundant in Germany, France, &c. is, according to Werner, rare in Norway, Sweden, and Russia.

Appendix.

We subjoin a notice of two varieties of oxide of iron but little known.

The one was found in the department of the Lower Rhine, adhering to the brown oxide of iron. It is black and vitreous, and affords a yellow powder. It slightly scratches glass, and its spec. grav. is 3.2.

Before the flame of a lamp it becomes magnetic, but does not melt. It contains oxide of iron 80.25, water 15.0, silex 3.75; =99. (*VAUQUELIN.*)

The other variety has been found near Freyberg, &c. Its aspect is that of a brown resin, and it is easily broken.

It melts by the flame of a lamp, and becomes magnetic. It contains oxide of iron 67, water 25, dry sulph. acid 8. (*KLAPROTH.*)

SPECIES 8. ARGILLACEOUS OXIDE OF IRON.

In this species, the oxide of iron is united, either by mixture or combination, with several other substances, but principally with clay, which is composed of silex and alumine. Its varieties are so numerous, that it is impracticable to give any general characters, which will be useful.

Var. 1. COLUMNAR ARGILLACEOUS OXIDE OF IRON.* This variety occurs in masses, composed of little prisms or columns, either straight or curved, often long and slender, and aggregated almost always parallel to each other; sometimes, however, they diverge. They separate easily; and are sometimes articulated, like basalt.

It is very brittle, and presents a dull, fine grained, earthy fracture. It adheres to the lip.

Its color varies from cherry red to a deep brownish red, sometimes with a tinge of yellow. Its streak and powder are also red.

It occurs in secondary rocks, particularly in stratified argillaceous beds. It is frequently in the vicinity of earths, exposed to subterraneous fires, to the action of which its structure has been attributed. But it also occurs in situations, where such fires do not appear to have existed, as in the island of Arran, &c.

It is a rare variety, but is sometimes explored.

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* Stänglicher thoneisenstein. WERNER. Columnar clay ironstone: JAMESON. Fer oligiste bacillaire—conjoint. HAUY.

In the *United States*, it is found in *New York*, near Plandome.—In *Massachusetts*, on Gayhead, in Martha's vineyard.

2. GRANULAR ARGILLACEOUS OXIDE OF IRON.* This variety occurs in small masses or grains, nearly or quite spherical, and often equal in size to a pea, or still larger. These globules are composed of thin, concentric layers, which decrease in density, as they approach the centre. The exterior layers are compact, and present an even, glistening fracture with a resinous lustre, whereas the centre of the grain is almost always friable, and has a dull, earthy fracture. They are easily broken, and may be cut by a knife. Their spec. grav. is 3.40.

Their true color is yellowish brown, light or dark, and sometimes even blackish brown; their streak also is usually yellowish brown; but the color of the surface is often altered by the earth, which unites them.

It is composed, according to a mean of two analyses by Daubuisson, of oxide of iron 71.5, water 14.5, oxide of manganese 0.5, silex 7.5, alumine 3.5;=97.5. Another analysis by Mollinghof gives oxide of iron 60, water 15, alumine 13, silex 12.—According to these analyses, this variety evidently belongs to the brown oxide of iron.

These grains, sometimes solitary, are generally united by a ferruginous cement, either argillaceous or calcareous, which adheres to their surface.

(Geological sit. and Localities.) This variety is found in secondary rocks; and exists in beds, or in masses, deposited in fissures or hollows. Hence it is often found in calcareous rocks, which are so frequently traversed by fissures, or contain cavities. It is sometimes embraced in beds of clay, lying over compact limestone; and sometimes its beds are immediately under the soil.—It has been remarked, that the grains of the same locality are nearly of equal size.

Sometimes it contains fossil shells, penetrated by the oxide of iron.

This ore is abundant in some countries, particularly in France, Switzerland, and some parts of Germany.

In the *U. States*. In the southern part of *New Jersey*, it is disseminated in a ferruginous clay. *(*WOODBRIDGE.*)*—In *Connecticut*, it occurs at Salisbury.

(Remarks.) This ore is easily explored and worked, and sometimes yields from 30 to 40 per cent. But it is obvious, that the result must depend much on the quantity of cement. The iron, which

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* Bohnerz. WERNER. Pea ore. JAMESON. Pisiform or granular iron stone. KIRWAN. Fer oxidé rubigineux globuliforme. HAUY. Fer oxidé brun granuleux. BRONGNIART. Hidrate of iron, according to DAUBUISSON.

it yields, is sometimes very brittle, in consequence probably of containing the phosphate or phosphuret of iron; the phosphorus being derived from the animals, whose remains appear in this ore.

3. LENTICULAR ARGILLACEOUS OXIDE OF IRON.* This variety differs but little from the preceding. Its masses are composed of very minute distinct concretions, sometimes round or granular, but more frequently lenticular or flattened. It is easily broken; and its fracture has a moderate lustre, somewhat metallic.—Its colors are brownish red, yellowish or blackish brown, and sometimes steel gray. The color of its streak varies but little from that of the mass.

A specimen from Radnitz yielded Lampadius oxide of iron 64.0, water 5.0, alumine 23.0, silex 7.5 ;=99.5. Some varieties are less rich in oxide of iron.

It occurs in masses or beds in secondary rocks; sometimes between strata of sandstone and shell limestone. According to Werner, it sometimes exists in transition mountains.—Fossil shells are not uncommon in this ore.

It ordinarily melts with ease, affording from 30 to even 60 per cent. of iron.

4. NODULAR ARGILLACEOUS OXIDE OF IRON.† This remarkable variety occurs in masses, varying from the size of a walnut to that of a man's head. Their form is spherical, oval, or nearly reniform, or sometimes like a parallelopiped with rounded edges and angles. They have a rough surface, and are essentially composed of concentric layers.

These nodules often embrace at the centre a kernel or nucleus, sometimes moveable, and always differing from the exterior in color, density, and fracture. In this case, the color near the exterior is ordinarily brown or dark yellowish brown; but within it becomes paler or more yellow, and at the centre is sometimes ochre yellow.—The texture of the exterior is compact and solid; but the density gradually diminishes to the centre, which has an earthy texture. Sometimes there is a cavity at the centre, either empty, or partly filled with a friable, yellow earth, which is moveable.—The fracture toward the surface is even or nearly conchoidal and glistening; but near the centre it is dull, and earthy.

Its spec. grav. is about 2.57; and its hardest parts are sometimes difficultly scraped by a knife.

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* Linsenförmiger thoneisenstein. WERNER. Lenticular clay ironstone. JAMESON. Fer oxidé brun granuleux. BRONGNIART.

† Nodular iron ore. KIRWAN. Eisenniere. WERNER. Reniform iron ore. JAMESON. Fer oxidé géodique. HAUY. Fer oxidé brun Ætite. BRONGNIART. Hidrate of iron, according to DAUBUISSON.

According to a mean of two analyses by Daubuisson, it is composed of oxide of iron 77.0, water 13.5, oxide of manganese 1.0, silex 6.0, alumine 0.5 ;=98. It of course belongs to the brown oxide of iron.

(*Geological sit. and Localities.*) This ore is disseminated in beds of ferruginous clay in secondary earths, and sometimes in alluvial deposites of clay, loam, or sand. In France, it has been found in banks of sand, which cover beds of yellow earth, or even in the interior of these beds. (SAGE.)

In the *United States*. In *Maryland*, it forms extensive beds 3 m. S. and W. from Baltimore. The nodules are composed of concentric layers, between which very beautiful, dark brown, lenticular crystals of sparry iron are sometimes found. These crystals are very minute, occur in druses, and give to the surface the rich aspect of velvet. (GILMOR and SILLIMAN.)—In *Massachusetts*, near Plymouth.

(*Remarks.*) This ore is frequently worked, and yields very good iron.—The ancients gave to these nodules the name of *eagle stone*, from an opinion that this bird transported them to its nest to facilitate the laying of its eggs.—Nothing very satisfactory can be said on the manner, in which these nodules have been formed.

5. COMMON ARGILLACEOUS OXIDE OF IRON.* Its more common colors are yellowish, bluish, or reddish gray, brown, yellowish or reddish brown, and sometimes brick red. By exposure to the air its paler colors often become darker.

It has usually an earthy aspect, but is sometimes considerably compact, or has a slaty structure. Its fracture is dull, earthy or uneven, and sometimes even, or a little conchoidal.—It is, in general, easily cut by a knife, or broken, but is sometimes considerably hard. It usually adheres somewhat to the tongue, and, when moistened, often yields an argillaceous odor. Its spec. grav. varies from 2.93 to 3.47.

Before the blowpipe it blackens, but does not melt. In a specimen from Bohemia, Lampadius found oxide of iron 39, water 9, alumine 40, magnesia 6, silex 5, sulphur 1.

It sometimes resembles compact limestone or indurated clay, but has a greater specif. gravity.

(*Geological sit. and Localities.*) This ore occurs in beds, or in insulated masses, or in nodules considerably large in secondary

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* Gemeiner thoneisenstein. WERNER. Common clay ironstone. JAMESON. Common argillaceous iron ore. KIRWAN. Fer terreux argileux commun. BRONGNIART.

rocks, such as shale, bituminous shale, &c. Hence it is often in the vicinity of coal mines. It sometimes presents vegetable impressions.

This variety is abundant in England and Scotland, and is frequently found in the vicinity of coal mines.

In the *U. States*, it occurs in a number of places, at some of which it is worked.

This variety yields from 30 to 40 per cent. of iron. It sometimes appears to pass into the compact brown oxide of iron.

A subvariety of this ore has the general aspect of jasper; and has hence been called *jaspery clay ironstone.* Its color is brownish red; and it usually breaks into rhomboidal or cubical fragments.—A large bed exists between Vienna and Hungary.

Another subvariety (Fer oxidé cloisonné of Haüy) occurs in flattened spheroidal masses, of a moderate size, divided by prisms into little polygonal compartments or cells, sometimes filled, and sometimes empty.—Other spheroidal masses of this ore are composed of concentric layers, alternately brown and compact, yellow and friable.

6. BOG ORE.* This ore presents considerably diversity of texture, fracture, and color in the same bed, or even in the same specimen. It sometimes resembles the ochreous and compact brown oxides of iron, and might, in some instances, be mistaken for a scoria.

Its prevailing colors are yellowish brown, light or dark, brownish yellow, brown, blackish or reddish brown.

It occurs in amorphous, rounded, or tuberose masses, which are seldom or never compact and homogeneous, being almost always corroded or cellular. It appears also in crusts or grains.

Sometimes it is nearly or quite friable, soils the fingers, and has a dull, earthy or uneven fracture.—Sometimes it is more compact and solid, but still easily broken, and its fracture becomes nearly even, or flatly conchoidal with a resinous lustre more or less shining.—Sometimes indeed the same specimen presents a number of compact, undulated zones with a shining fracture, while the intermediate portions are friable and ochreous. Its spec. grav. is variable, sometimes 2.94.

According to Daubuisson, it is composed of oxide of iron 61, water 19, oxide of manganese 7, silex 6, alumine 2, phosphoric acid 2.5; =97.5. Sometimes also chromic acid, magnesia, or lime is present. The phosphoric acid is derived from vegetables.

(Geological remarks.) Bog ore is found, often abundantly, in low places in alluvial deposites, or in marshy or swampy gounds, or

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* Rasen eisenstein. WERNER. Bog iron-ore. JAMESON. Lowland iron ore. KIRWAN. Fer terreux limoneux. BRONGNIART. Hidrate of iron, according to DAUBUISSON.

even under water, as on the bottom of ponds. When in meadows or other low grounds, it often lies immediately under the soil, but sometimes alternates with beds of clay or sandstone.—The interior of its cells is sometimes lined with a blue phosphate of iron. It often embraces the remains of vegetables, or shells.

This ore is of recent, and even daily formation, being deposited from stagnant water, containing the oxide of iron.—Roots of trees and even shells are sometimes converted into this ore.

Bog ore is sometimes distinguished into three varieties, according to its geological situation. Thus, according to Werner, the first or *lowest* deposite is earthy, friable, and yellowish, and is called *morassy* ore.—As the water gradually evaporates, the deposites become browner, more indurated, and constitute *swampy* ore.—When the waters are nearly or quite evaporated, and soil appears, the swampy ore becomes harder, darker colored, and is called *meadow* ore.

Bog ore is said to be less frequent in the south, than in the north of Europe, where it is abundant in the vicinity of the Baltic, &c.

In the *United States*, this ore is very common, either in alluvial earths, or at the bottom of ponds and lakes. In the southwestern parts of *New Jersey*, its several varieties are abundant. The same place may often be explored a *second* time in 20 years, or even less, in consequence of the renewal of this ore by deposition from water. Roots of trees and shells are here sometimes converted into bog ore. In the furnace, it is often mixed with other kinds of ore, brought down the Delaware from Easton. (*Conrad* and *Woodbridge.*)—In *Vermont*, at the north end of Lake Champlain. This ore is worked at the furnaces in Vergennes, where the brown hematite from Monkton, and the magnetic iron from the west side of the lake are also used. (*Gibbs.*)—In *Massachusetts*, Plymouth Co. in Carver and Middleborough, it is abundant at the bottom of ponds, from which it is dragged. (*Gibbs.*)

(*Remarks.*) This ore generally yields about 30 or 35 per cent. of cast iron, which is rendered somewhat brittle by containing phosphate of iron; hence also its bar iron is often more or less *cold short*. It is advantageously melted with the brown oxide and other ores of iron. The hardest varieties of bog ore are the least fusible.

Oxide of iron, deposited in loose earth or sand, often exerts a very strong cementing power. Hence roots of trees, which penetrate banks of sand, have sometimes a kind of tube or case formed around them. Hence also particles of sand are sometimes firmly united into masses.

Species 9. Carbonate of Iron.*

Sparry Iron.

Its colors vary from a grayish white or pale yellowish gray to pale yellow or yellowish brown, and thence pass to brown, reddish brown, or even blackish brown. When recently obtained from the mine, it is usually grayish or yellowish gray; but, by exposure to the air, assumes the darker colors just mentioned. This change is produced by the combination of oxigen with the iron, or more frequently with the manganese, which this ore so often contains.—The lighter colored varieties are translucent, at least at the edges, and the crystals sometimes transparent; but the darker colors are often opaque.

Its structure and fracture are almost always foliated; and the foliæ, either straight or curved, have a pearly lustre, sometimes shining, and sometimes very feeble. It is harder than calcareous spar; and its spec. grav. lies between 3.64 and 3.90. It is easily frangible, falling into rhomboidal fragments.

Carbonate of iron is susceptible of mechanical division in three directions, parallel to the sides of an obtuse rhomb, which is its primitive form, and is perfectly similar to that of carbonate of lime. Its secondary forms also are similar to those of the calcareous carbonate.

It sometimes presents the primitive rhomb, either entire, or truncated on its summits—and sometimes a more obtuse rhomb.—But one of its most common forms is *lenticular*, originating from the last mentioned rhomb, whose obtuse edges are rounded; these crystals often adhere by their acute edges to other minerals, and are sometimes extremely minute, occurring in druses.

The very small rhombs are sometimes so closely aggregated, that the texture of the mass appears scaly;—and sometimes they resemble thin plates with their edges bent back, like those of a hat.

Sparry Iron occurs also in laminated and lamellar masses. Sometimes the laminæ are very large; and sometimes so small, that the mass resembles certain varieties of granular limestone. Some specimens resemble brown blende.

It has also been observed with a fibrous structure;—and sometimes it is nearly compact, and its fracture a little splintery.

(Chemical characters.) Before the blowpipe it blackens, and acquires the power of moving the magnetic needle, but does not melt. In nitric acid it becomes brown, and slowly dissolves with a moderate effervescence.—This ore appears to be essentially composed of

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* Fer oxidé carbonaté. Haüy. Spath eisenstein. Werner. Sparry ironstone. Jameson. Sparry iron ore. Kirwan. Fer spathique. Brongniart. Brochant.

iron slightly oxidated and carbonic acid; but it usually contains variable quantities of the oxide of manganese, lime, and magnesia. Those varieties, which contain a large quantity of magnesia, are so refractory in the fire, that the iron can scarcely be reduced; they however become more fusible by long exposure to the atmosphere.

A specimen, analyzed by Bayen, yielded oxide of iron 66, carbonic acid 34. From a crystal, Bucholz obtained iron slightly oxidated 59.5, carb. acid 36.0, water 2.0, lime 2.5. In the laminated variety Descotils found iron slightly oxidated 49.0, carb. acid 37.5, oxide of manganese 1.5, magnesia 12.5, lime 0.3 ;=100.8. Another specimen yielded Klaproth oxide of iron 58.0, carb. acid 35.0, oxide of manganese 4.25, magnesia 0.75, lime 0.5 ;=98.5.

Not only are its colors darkened, but its specific gravity, and hardness are diminished, and its structure rendered less lamellar by long exposure to the atmosphere.

This ore seems to pass by insensible shades into brown spar, a subspecies of carbonate of lime. Hence Bergman obtained oxide of iron 22, carb. acid 17, oxide of manganese 28, lime 26, water 6 ;=99. Its greater spec. grav. and its power of becoming magnetic by exposure to heat will, however, generally serve to distinguish it from brown spar.

(*Geological situation.*) This ore is frequently disseminated in metallic veins, and sometimes itself forms very large veins in primitive rocks, as in gneiss, &c. It occurs also in beds in secondary rocks. —It is sometimes associated with the brown oxide of iron, the sulphurets of lead and iron, pyritous and gray copper, calcareous spar, brown spar, quartz, &c.

(*Localities.*) This ore occurs in small quantities in Great Britain and Sweden, but is abundant in some parts of Germany and France.

In the *United States.* In *Maryland,* near Baltimore, in lenticular crystals attached to gneiss; (*Hayden.*)—also in very beautiful, minute, lenticular crystals of a dark brown color, in druses, between layers of nodular argillaceous oxide of iron, near the same city.—In *Connecticut,* at Washington, Litchfield Co. It is said to be refractory in the fire, and of course it probably contains a large proportion of magnesia. (*Gibbs.*)

(*Remarks.*) Sparry iron is a very valuable ore, more especially as it is readily converted into excellent steel; and is hence sometimes called *steel ore.*

M. Haüy mentions a rhombic crystal, in part composed of white carbonate of lime, producing a lively effervescence in acids, and in part of sparry iron, capable of becoming magnetic by heat;—also a specimen of sparry iron in a state of decomposition, and containing in its interior laminæ of carbonate of lime.

Different opinions have been expressed in regard to the origin and nature of this ore, but our limits will not permit an examination of these opinions.

SPECIES 10. SULPHATE OF IRON.*

Copperas.

This salt may be recognised by its peculiar, astringent taste. It very rarely occurs in crystals of a determinate form, or in masses of any considerable size. It usually appears in efflorescences, or in tuberose or stalactical concretions, or in crusts, composed of fibres or capillary crystals, or in a state of powder. Its colors are commonly some variety of white, gray, green, or yellow, as greenish or yellowish white, &c.

When artificially crystallized, its color is a lively green. Its primitive form is an acute rhomb, which is liable to truncation on its angles and edges. (Pl. V, fig. 14.)

(*Chemical characters.*) Its solution in water gives a blue precipitate with the prussiate of potash and iron, by which it is distinguished from alum. It is decomposed, and its iron precipitated by astringent vegetables. Hence the addition of tincture of galls gives a *black* precipitate of gallate of iron, the basis of ink. Hence also a drop of its solution placed on oak bark, immediately produces a black spot. When pure, it is composed of oxide of iron 23, sulph. acid 39, water 38. (*BERGMAN.*)

Sulphate of iron is usually found with sulphuret of iron, by the decomposition of which it is produced. (See sulphuret of iron.) It often effloresces on argillaceous or micaceous slate, which contains the sulphuret of iron or pyrites. Its crystals sometimes appear in the caverns or galleries of mines.

(*Localities.*) This native Sulphate usually occurs in very small quantities, but is not uncommon. In the *U. States*, it occurs in considerable quantities in *Tennessee*, Warren Co.—In *Maine*, near East Andover, &c. its efflorescences are sufficiently abundant to be worth collection.

(*Uses.*) Its uses in the arts are important, particularly in dying black cloths, and making ink. In medicine it is employed as a tonic. —The Copperas of commerce sometimes contains sulphate of copper, and sometimes alum. (See uses of sulphuret of iron.)

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* Fer sulfaté. HAUY. BRONGNIART. Eisen vitriol. WERNER Iron vitriol. JAMESON.

Species 11. Phosphate of Iron.*

Its color is almost always an indigo blue, either deep or pale. Though sometimes in regular crystals, or small laminated masses, it is more frequently amorphous with an earthy texture, and is very often friable.

It is soluble in diluted nitric acid, but does not communicate its blue color to the solution. To ammonia it does not impart its color, and thus differs from the ores of copper.

Var. 1. FOLIATED PHOSPHATE OF IRON.† This variety has occurred principally in small, shining, brittle plates, slightly adhering to each other, or in minute prismatic crystals, confusedly grouped. These plates, separately examined, are translucid, and slightly greenish, but in the mass they appear deep blue, sometimes, however, in consequence of an earthy phosphate of iron interposed between them.

More recently this variety has been observed in eight-sided prisms with diedral summits, and in lenticular crystals.

It scratches sulphate of lime; and its spec. gravity is 2.60. Its powder is a pale blue.

Before the blowpipe it becomes yellowish, and melts into a globule, which has a metallic lustre. A specimen from the isle of France yielded Fourcroy and Laugier iron 41.25, phosphoric acid 19.25, water 31.25, alumine 5.0, silex 1.25 ;=98.

(Localities.) This variety has been found in the isle of France, Brazil; and in the department of Allier, France.

In the *U. States.* In *New Jersey*, it appears to exist in druses of green, lenticular crystals in bog iron ore, and is usually accompanied by the earthy variety. These crystals, which possess the softness and transparency of selenite, become *blue* by exposure to the air, or a moderate heat. *(Woodbridge.)*

2. EARTHY PHOSPHATE OF IRON.‡ The *original* color of this variety is generally grayish, yellowish, or greenish white, or with a very slight tinge of blue; but, by exposure to the air, it absorbs oxigen, and becomes indigo blue of different shades, sometimes pale.— It is sometimes in small masses, considerably compact and solid, but more frequently it is friable, or even loose, and soils the fingers. It is often a mere coat.

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* Fer phosphaté. Haüy. Brongniart.

† Fer phosphaté cristallisé. Haüy. Fer phosphaté laminaire. Brongniart.

‡ Fer phosphaté terreux. Haüy. Fer phosphaté azuré. Brongniart. Blaue eisenerde. Werner. Blue iron earth. Jameson. Le fer terreux bleu. Brochant. Blue martial earth. Kirwan.

Before the blowpipe it becomes reddish brown, and then melts into a magnetic, blackish globule. In oil it usually acquires a shade of brown. A specimen yielded Klaproth iron slightly oxidated 47.5, phosphoric acid 32.0, water 20.0 ;=99.5. But the proportion of acid appears to be extremely variable in different specimens.

(*Geological sit. and Localities.*) This variety of Phosphate of iron is found in alluvial deposites, where it exists in little nests, or in nodules of various sizes, or in thin crusts, or disseminated in a state of powder. It is thus found in bog iron ore; also in beds of clay, which contain, or at least once contained, *organic bodies*; indeed it frequently appears in cavities formerly occupied by these bodies, and sometimes invests fragments of *bones* or vegetables, contained in the clay.

The preceding remarks render it satisfactorily evident, that the phosphoric acid of this mineral has proceeded from organized bodies; and hence the variable proportions, in which it exists.

At the Straits of Taman, between the Black Sea and the sea of Azoph, Phosphate of iron is associated with fossil remains of animals, which have furnished the acid. (Prof. *Clark.*)

In the *United States.* In *New Jersey*, it occurs at Allenstown, Monmouth Co. and various other parts of the State. It generally accompanies bog ore, or certain argillaceous deposites. It is sometimes in masses, weighing 30 lbs. or more, with a texture more or less compact and solid. When first obtained, it is yellowish white; but, by exposure to the air, it assumes a fine blue color. In some instances it apppears to contain very little acid. (*Cutbush* and *Conrad.*)—In *Massachusetts*, near Plymouth.—In *Maine*, at York, in a ferruginous clay.

It is sometimes employed with advantage, as a pigment.

3. GREEN IRON EARTH.* *Jameson.* No analysis of this substance has been published. Haüy has arranged it as an oxide of iron. Others consider it a phosphate of iron.

Its color is green more or less tinged with yellow. It is sometimes indurated with a dull earthy fracture, yielding a gray streak; but it is usually more or less friable, and stains the fingers.

Before the blowpipe it becomes reddish or brown, but does not melt. According to Kirwan, it is not easily soluble in acids.

It is rare; and has been found chiefly at Schneeberg and Braunsdorf in Saxony, in veins with quartz, pyrites, &c. It is sometimes merely a crust.

Appendix.

Turkois or Turquoise. This substance, already mentioned un-

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* Grüne eisenerde. Werner. Fer oxidé terreux. Haüy.

der azure carbonate of copper, has been generally supposed to be fossil bones, colored by the oxide of copper. More recent experiments, however, show that the coloring matter, at least in many cases, is Phosphate of iron. A specimen, analyzed by Bouillon-la-Grange, yielded phosphate of lime 80.0, carbonate of lime 8.0, phosphate of magnesia 2.0, phosphate of iron 2.0, alumine 1.5, water 6.0; =99.5.

Species 12. ARSENIATE OF IRON.*

This rare mineral has an olive green color, more or less deep, sometimes with a strong tinge of yellow or brown, which by decomposition passes to reddish brown. Its streak and powder are a pale yellow. It is translucent, and sufficiently hard to scratch carbonate of lime.

It crystallizes in small, shining, well defined cubes, the angles of which are sometimes truncated; the cube is also its primitive form. It is sometimes in stalactites, covered with groups of crystals. Its fracture is a little conchoidal, or imperfectly foliated, with a glistening lustre somewhat metallic. Its spec. grav. is about 3.00.

Arseniate of iron melts even in the flame of a candle. When heated on charcoal before the blowpipe, it melts with ebullition, and exhales a strong odor of arsenic. It contains oxide of iron 48, arsenic acid 18, water 32, carbonate of lime 2. (*VAUQUELIN.*) Chenevix found 9 parts oxide of copper, which, however, he considered accidental.

This ore has been found only in Cornwall, in veins composed of ferruginous quartz, sulphuret of copper, arsenical iron, &c. The crystals are attached to the sides of cavities in these veins.

Species 13. CHROMATE OF IRON.†

The color of this mineral is a dark or blackish brown, or nearly black, and sometimes inclines to steel gray. Its powder is gray. It is usually opaque; is sufficiently hard to scratch glass; and its spec. grav. is about 4.00.

It is sometimes in regular crystals, sometimes in grains, and sometimes in amorphous masses of various sizes.

(*Chemical characters.*) Before the blowpipe it is infusible by itself; but with borax yields a beautiful and lively green glass.—This property is very characteristic, and will distinguish it from magnetic iron, or any of the dark colored oxides of iron or uranium, and from dark brown blende.

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* Fer arséniaté. HAUY. BROCHANT. BRONGNIART. Würfelerz. WERNER. Cube ore. JAMESON.

† Fer chromaté. HAUY. BROCHANT. BRONGNIART.

An amorphous specimen from France yielded Vauquelin oxide of iron 34.7, chromic acid 43.0, alumine 20.3, silex 2. In another from Siberia, Laugier found oxide of iron 34, oxide of chrome 53, alumine 11, silex 1.—It does not appear to be yet determined, whether the chrome is uniformly in the state of an acid, or of an oxide. The American Chromate has not been analyzed.

Var. 1. CRYSTALLIZED CHROMATE OF IRON. It occurs in regular octaedrons, or double four-sided pyramids, which are divisible in directions parallel to all the faces;—an octaedron is of course the primitive form.—In some crystals the common base appears to be a rhomb, and in others a rectangular parallelogram.—Sometimes one pyramid is depressed, and sometimes both.

These crystals vary from a size extremely minute, till their faces become nearly one eighth of an inch in length. Their color is nearly black, sometimes with an inclination to steel gray; their faces are smooth and polished, and, when presented to a bright light, often exhibit the colors of tempered steel. They are usually opaque; but, when placed on white paper in the rays of the sun, they sometimes transmit a deep blood red light. Their fracture is conchoidal; their lustre vitreous; and they sensibly move the magnetic needle. (HAYDEN.)

This and the following variety have hitherto been found and recognised in the *United States* only;—and for our knowledge of them we are indebted to Messrs. Hayden and Gilmor of Baltimore.

2. GRANULAR CHROMATE OF IRON. It occurs in irregular grains, varying in size from that of a mustard seed to that of a grain of pepper.

3. AMORPHOUS CHROMATE OF IRON. This is found in masses more or less compact, which sometimes resemble dark brown blende.

Its fracture is usually uneven or conchoidal, and sometimes imperfectly foliated; its lustre is metallic, but feeble, excepting on the faces of the foliæ, where it is somewhat shining.

(*Geological sit. and Localities.*) The amorphous variety was first observed by Pontier, near Gassin, depart. of Var, in France; its masses are disseminated in serpentine.—A variety from the Uralian mountains presents a texture more foliated, and has a greater lustre, than that from France; its surface exhibits greenish spots of the oxide of chrome.

In the *United States.* In *Maryland*, at the Bare Hills, near Baltimore, all its varieties occur, and some of them abundantly, in veins, or in masses, in serpentine.—The crystals are found in channels, worn by water in the sides of the hill, and the serpentine is here traversed by veins of indurated talc. Many of the crystals are injured by attrition. They are mixed with sand and the granular variety.—The granular variety occurs either loose, as already mentioned, or is disseminated in an indurated steatite or serpentine.—The amorphous variety is associated with talc, steatite, &c. in serpentine. (*Hayden.*)—In *Pennsylvania*, at Chesnut Hill, 10 m. W. from Philadelphia. (*Wister.*)—In *New Jersey*, at Hoboken, in octaedral crystals in serpentine and other magnesian rocks.—In *Connecticut*, near Newhaven, on the Milford Hills, disseminated in the marble, which also contains serpentine.

(*Uses.*) This mineral is employed to furnish the chromic acid, which, when united with the oxide of lead, forms chromate of lead, a very beautiful yellow pigment, of which there is a manufactory at Philadelphia. It is sold under the name of *chromic yellow*, and is employed for painting furniture, carriages, &c.

(*Geological remarks on iron.*) There is no class of minerals from primitive to alluvial, which does not contain iron; but the different species of ores do not occur indifferently in all classes of rocks. Thus the magnetic and specular oxides of iron, and arsenical iron are found chiefly in primitive mountains, while the argillaceous oxides belong to secondary or alluvial deposites. The red and brown oxides of iron and sparry iron are found in both primitive and secondary rocks.

(*Iron mines.*) Mines of iron occur in all countries; but, it is said, more abundantly in northern than southern latitudes.

In Spain, the most important mines are in Biscay, Catalonia, &c. and yield sparry iron, and the red and brown oxides.

Of France the principal iron ores are sparry iron, brown oxide of iron, specular iron, and the argillaceous oxides.

Great Britain affords the red, and brown, and the argillaceous oxides in abundance.

In Germany, the mines of Eisenerz in Stiria, and Huttenberg in Carinthia are celebrated for the abundance and quality of the iron, they produce. The ores are sparry iron, the brown oxide, &c.

In the island of Elba, near the coast of Tuscany, is one of the most ancient and celebrated mines of iron. The ore, which is the specular oxide, is very abundant, and yields about 65 per cent.

The iron of Sweden is much esteemed. It is obtained chiefly from the magnetic oxide, which is there found abundantly in primitive mountains.

Russia is rich in iron, large quantities of which she obtains from the Uralian mountains in Siberia.

In the *United States*, ores of iron are abundant. Those hitherto worked are chiefly the magnetic oxide, brown hematite, and the argillaceous oxide, particularly the bog ore. According to Dr. Beck, there were in 1810 no less than 530 furnaces, forges, and bloomeries in the U. States, 60 of which were in the State of New York. The iron, manufactured at Ancram, New York, is said to be superior for many purposes to the Russian and Swedish iron.*

GENUS VII. *LEAD.*

The color of pure Lead is bluish gray with considerable lustre, but it soon tarnishes by exposure to the air. By friction this metal exhales a peculiar and somewhat disagreeable odor; and, when rubbed on paper or the fingers, it leaves a dark bluish trace. Its spec. grav. is 11.35.

Lead is fusible at about 612°; and may be crystallized in octaedrons.—When received into the stomach, it operates as a violent poison.

(*Uses.*) The uses of metallic lead are well known, and considerably numerous. It ought not, however, to be employed in the construction of vessels for containing water, or of pipes for the conveyance of water, designed for the use of families; for it appears, that Lead, immersed in water, is gradually oxidated at the common surface of the air and water, and this oxide may eventually be conveyed into the stomach. We must also repeat, that the use of earthen ware, glazed with the oxide of lead, is extremely dangerous. Wine, cider, apple sauce, or any substance containing an acid, or in which an acid may be produced by fermentation, ought never to be preserved in such vessels.

Its oxides and some of its salts are employed in painting—and also in medicine, as external applications. Its oxides, in small quantities, enter into the composition of certain kinds of glass without communicating any color; but in larger quantities they render glass or enamel yellowish.

Although its ores are considerably numerous, only one species occurs in sufficient quantity to be explored by itself.

Species 1. Native Lead.

Several instances of the occurrence of Native lead have been mentioned, though in but few of them does the fact appear to be well established. In the island of Madeira, it is found in small masses, in lava, and has undoubtedly been reduced to its present state by volcanic fire.

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* See Dr. Beck's Address before the Soc. for the promotion of Useful Arts; Albany; 1813.

Species 2. Sulphuret of Lead.*

Galena.

The common color of this ore is that shining bluish gray, usually called lead gray; sometimes it becomes very dark, and sometimes it is nearly steel gray. Its streak has a metallic lustre, but its fine powder is nearly black. It is easily broken, and may be cut by a knife. Its spec. grav. is about 7.58.

Its structure is commonly foliated, sometimes granular or compact, and sometimes striated or fibrous. It occurs in regular crystals; but is more frequently massive. Its crystals and laminated masses divide with great ease by percussion into little cubes, thus discovering the primitive form, of which M. Haüy has described 8 modifications.

The primitive cube is liable to truncation on its edges and angles, and is sometimes elongated.—Another of its secondary forms is a regular octaedron, sometimes cuneiform, and often truncated on its edges, or solid angles, or on both. In addition to truncations upon the angles, each edge is sometimes bevelled, and even the edges of these bevelments truncated.—Other forms are mentioned, some of which seem to arise merely from a greater or less extent of certain faces.

(Chemical characters.) Before the blowpipe it usually decrepitates, and, on charcoal, is decomposed and melted, yielding a globule of metallic lead. It is essentially composed of lead and sulphur. A specimen, analyzed by Westrumb, yielded lead 83.0, sulphur 16.41, silver 0.08;=99.49. From another, Dr. Thompson obtained lead 85.13, sulphur 13.02, silver 0.5;=98.65. In a specimen from St. Genevieve, Dr. Meade has found lead 72, sulphur 24, silex and oxide of iron 4, with a trace of silver. A mean of 4 analyses by Vauquelin gives lead 67.5, sulphur 17.0, lime and silex 15.5.

It very often contains a little silver, sometimes in the proportion of $\frac{1}{20}$ or even $\frac{1}{10}$, and is hence frequently worked as an ore of silver. It may also contain variable proportions of antimony, bismuth, and sometimes of iron, which increases its hardness. It is sometimes contaminated by silex and lime; indeed some varieties do not yield more than 50 or 60 per cent. of lead.—The opinion that those varieties of Galena, which contain the most silver, usually have the highest lustre, does not appear to be correct.

(Distinctive characters.) Its greater spec. gravity and some other obvious characters distinguish it from graphite and sulphuret of

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[*] Plomb sulfuré. Haüy. Brongniart. Blei glanz. Werner. Lead-glance. Jameson. La galene. Brochant.

molybdena.—Its streak, unlike that of the sulphuret of zinc, is metallic and shining.

Var. 1. COMMON SULPHURET OF LEAD OR GALENA.* Its color is lead gray, but has sometimes a tinge of black, or is beautifully irised. It presents the crystalline forms already described, but usually occurs in laminated masses; sometimes also in plates, or is reticulated, corroded, reniform, &c.—Its fracture is foliated, presenting laminæ of various sizes, which sometimes resemble *scales*, lying in all directions. Its lustre is metallic, frequently splendent, but sometimes moderate. When broken, it falls into cubical fragments. Its spec. grav. is sometimes a little above or below that already stated.

GRANULAR SULPHURET OF LEAD. This subvariety presents itself in masses, composed of granular concretions more or less minute, sometimes resembling the grain of steel. It forms a passage from the common to the compact variety.

2. COMPACT SULPHURET OF LEAD OR GALENA.† Its color is usually a little lighter than that of the common variety, and sometimes passes to steel gray. Its grain is very fine; its texture close and compact; and its fracture even, or a little conchoidal with a moderate but metallic lustre.—It occurs in masses, or nodules, and is sometimes specular, being then called *slickenside*.

It often contains a considerable proportion of silver.

3. FIBROUS SULPHURET OF LEAD.‡ Its fracture presents diverging striæ, which are sometimes large and broad. This structure is supposed to arise from the presence of sulphuret of antimony.

SUBSPECIES 1. ANTIMONIAL SULPHURET OF LEAD.§

Its color is dark lead gray. It scratches the carbonate of lime, but not the fluate. Its spec. grav. is only 5.57. It occurs both amorphous, and crystallized in low, rectangular four-sided prisms, or elongated cubes. Its fracture is coarse grained uneven with a moderate lustre.—Sometimes, however, it is striated or fibrous; and

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* Plomb sulfuré laminaire. HAUY. BRONGNIART. Gemeiner Bleiglanz. WERNER. Common Lead-glance. JAMESON. La Galene commune. BROCHANT. Common Galena. KIRWAN. It is often called Potter's Lead ore.

† Plomb sulfuré compacte. HAUY. BRONGNIART. Bleischweif. WERNER. Compact Lead-glance. JAMESON. La Galene compacte. BROCHANT. Compact Galena. KIRWAN.

‡ Plomb sulfuré strié. BRONGNIART. Var. of common Lead-glance. JAMESON. Plomb sulfuré antimonifère. HAUY.

§ Triple sulphuret of lead, antimony, and copper. BOURNON. Bournonite. JAMESON.

probably many specimens of the fibrous variety, already mentioned, belong to this subspecies.

Before the blowpipe it is fusible, with the escape of white fumes, into a dark gray globule, whose interior is composed of metallic copper. A specimen, analyzed by Hatchett, yielded lead 42.62, antimony 24.23, sulphur 17.0, copper 12.8, iron 1.2;=97.85.

It has been found chiefly in Cornwall and Clausthall.

Subspecies 2. ARGENTO-ANTIMONIAL SULPHURET OF LEAD.[*]

Its color varies from a light lead gray to nearly iron black. Its fracture is usually even, with a moderate lustre. Some specimens exhibit delicate fibres, indicating the presence of sulphuret of antimony.—A specimen of the dark colored variety from near Freyberg yielded Klaproth lead 41.0, antimony 21.5, silver 9.25, sulphur 22.0, iron 1.75, alumine and silex 1.75;=97.25.

Near Freyberg, it occurs in veins with the common sulphuret of lead, red silver, and sulphuret of antimony.

Subspecies 3. ARGENTO-BISMUTHAL SULPHURET OF LEAD.[†]

This subspecies has a light lead gray color, an uneven fracture, and a glistening metallic lustre.

When exposed on charcoal to the action of the blowpipe, small globules of bismuth flow from it, and communicate to borax an amber yellow with reddish spots. (*Klaproth* in Brochant.)—A specimen, analyzed by Klaproth, yielded lead 33.0, bismuth 27.0, silver 15.0, sulphur 16.3, iron 4.3, copper 0.9;=96.50.

It has been found chiefly in Schwarzwald.

(*Geological remarks on Sulphuret of Lead.*) This species occurs in primitive and transition mountains, but is more frequently found in secondary rocks, especially in compact limestone. Its beds sometimes alternate with shell limestone. It has also been found in beds of coal, and its veins sometimes contain bitumen.

Sulphuret of lead constitutes beds and veins, both of which are sometimes very extensive. Its more common gangues are quartz, sulphate of barytes, and the carbonate and fluate of lime.

It is almost always accompanied by the sulphuret of zinc, and frequently by other ores of zinc and lead, by pyritous copper, sulphuret of iron, and sometimes by red silver, &c. &c.—Jameson remarks, that the sulphuret of lead, which occurs in veins, contains more silver, than that, which exists in beds;—and that, when the compact

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[*] Plomb sulfuré antimonifère et argentifère. Haüy. Weissgültigerz. Werner. White silver ore. Jameson.

[†] Wismuthisches silber. Werner. L'Argent bismuthifère.

and common varieties are found in the same vein, the former always forms the sides of the vein.

(Localities.) Sulphuret of lead is found more or less in every country. It is, however, said to be rare in the Uralian mountains, and in Peru, two countries abounding with other ores. We shall mention but few foreign localities.

In France, at Huelgoet and Poullaouen, this ore is found in large veins in primitive rocks;—and at La Croix, in the Vosges, it is disseminated in a vein of granite.—At Tarnowitz, in Silesia, it occurs in grains, nodules, or veins, contained in a bed of brown ferruginous marl, which is undulated, the concave parts being richer in ore, than those, which are convex. This marl rests on horizontal beds of compact limestone, containing shells and asphaltum, and is also covered by a bed of compact limestone, containing calamine and brown oxide of iron; above this are beds of marl, clay, and sand.—In Derbyshire, are important mines of Sulphuret of lead, contained in a compact, shelly limestone. The veins are irregular in direction and width, but seldom or never penetrate the rock, which covers them. In some instances, the side of the vein has little or no adhesion to the wall of the vein or the mass of the mountain, but the contiguous surfaces are smooth, and often have the high polish of a mirror; they have hence received from the workmen the name of *slickenside.* Whenever the mass, which presents this smooth surface, is broken through, a violent explosion takes place, detaching large fragments of the vein. (For a more particular account of the structure of this part of Derbyshire, see the article Toadstone.)

In the *United States.* In Upper *Louisiana,* near St. Genevieve, on the western bank of theMissisippi. This ore, of which an analysis has already been given, belongs to the common variety, has a laminated structure, and a lustre unusually brilliant. Its gangues appear to be carbonate of lime and sulphate of barytes.—About 10 mines have been opened in this district. The ore, which is here very abundant, is sometimes found in detached masses, of from 1 to 50 or even 500 lbs. in alluvial deposites of gravel or clay, immediately under the soil; and sometimes in veins or beds in limestone. The annual produce of the Mine à Burton is about 245 tons of ore, yielding 66$\frac{2}{3}$ per cent. At Mine à la Mott the ore is said to contain 50 ounces of silver in the ton.*—In *Virginia,* Wythe Co. on the Great Kanhaway, in transition rocks. *(Maclure.)* The average produce of the ore is said to be about 60 per cent.—In *Maryland,* near Baltimore.—

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* See Report to the President of the United States by Amos Stoddard, Civil Commandant of Upper Louisiana.

In *Pennsylvania*, on Perkiomen Creek, 24 m. from Philadelphia; the Sulphuret is here accompanied by the carbonate, phosphate, and molybdate of lead, yellow blende, several ores of copper, and the scaly red oxide of iron;—also on Conestoga Creek, 9 miles from Lancaster, in limestone, and accompanied by the carbonate of lead, calamine, &c. (*CONRAD.*)—also in Bald Eagle valley, in limestone.—In *New York*, Columbia Co. at Ancram, where the ore is very rich.—Also at Claverack, a vein has recently been discovered—and in the Shawangunk mountains, Ulster Co. several veins have been observed; (*GIBBS.*)—this ore is found also at Armenia, and, it is said, at Herkimer.—In *Connecticut*, near Middletown, where a mine was formerly opened;—also at Trumbull, with native bismuth, and is said to be rich in silver. (*SILLIMAN.*)—In *Vermont*, at Thetford and Sunderland. (*HALL.*)—In *Massachusetts*, Hampshire Co. at Southampton, about 8 m. S. W. from Northampton. This vein of Galena traverses granite or other primitive rocks, and is inclined at about 12° or 15° to the horizon; it is 6 or 8 feet in diameter, and extends at least 20 miles, from Montgomery to Hatfield. The fracture of this ore sometimes presents broad laminæ; and sometimes the foliæ are so small, that its structure appears granular. The bulk of the vein is quartz, in which the ore is disseminated in masses, which are sometimes less than an inch, and sometimes more than a foot, in diameter. This quartz, sometimes very beautifully crystallized, frequently presents a radiated structure, resulting from its great tendency to crystallize; it is sometimes intermixed with sulphate of barytes, and fluate of lime. This ore affords from 50 to 60 per cent. of lead, and contains only 12½ oz. of silver to the ton. (*SILLIMAN.*)* The same vein also contains the sulphate, molybdate, muriate, and phosphate of lead, pyritous copper, and blende.—In *Maine*, at Topsham, in small quantities.

SPECIES 3. OXIDE OF LEAD.†

The occurrence of lead in the state of a pure Oxide is very rare. The existence, however, of a native *red oxide* of lead appears to be well established.—Its color is a lively scarlet red. It occurs in a loose state, or in masses, composed of flakes with a crystalline texture.—When gently heated, it becomes darker, and, by a stronger heat, on charcoal is reduced.

It is found in the lead mines of Breylau in Westphalia, disseminated in calamine with galena and carbonate of lead.

We subjoin a notice of another ore of lead, which is more com-

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* See Bruce's Min. Jour. v. i.; and North American Review No. 3, v. i.

† Plomb oxidé rouge. HAUY. Native minium.

mon than the preceding, and which appears to be an impure oxide of lead, at least in many cases.

Var. 1. EARTHY OXIDE OF LEAD.* Its color exhibits various shades of gray and yellow, either intermixed with each other, or tinged with green, and is sometimes brownish red; but most of its colors appear to be produced by the presence of ferruginous earths.

It occurs in dull masses, either friable, earthy, and rough to the touch, or somewhat indurated and compact, with an uneven fracture. Its spec. grav. is usually between 4.16 and 5.54.

On charcoal it is easily reduced by the blowpipe. In nitric acid, especially when warm, it often produces a feeble effervescence, arising from the escape of part of its oxigen. But, if this oxide be not mingled with any carbonate, whatever effervescence it produces in muriatic acid, is attended with the odor of oxymuriatic acid gas.—If mixed with the carbonate of lead or of lime, it effervesces in the stronger acids; and it then becomes almost impossible to distinguish it from some varieties of amorphous carbonate of lead.

This oxide occurs in small quantities, and is disseminated in the sulphuret and other ores of lead, or in the gangue, which contains them.—The friable variety sometimes forms a mere crust, or appears in cavities.

SPECIES 4. CARBONATE OF LEAD.†

The color of this very beautiful metallic salt is generally white, either pure, or tinged with gray, yellow, or brown, and sometimes it is silver white. It is sometimes limpid and transparent, and sometimes only translucent. Its crystals exhibit double refraction in a high degree. Its spec. grav. usually lies between 6.07 and 7.23.

It is very brittle, and easily scratched by a knife. Its fracture is usually conchoidal with small cavities, sometimes also uneven or splintery; its lustre, which may be splendent or only glimmering, is most frequently adamantine or resinous.

It is usually crystallized; and the primitive form is a rectangular octaedron, of which Haüy has described 12 modifications.—It also occurs in plates or spangles, like mica—and sometimes in small compact, reniform, or amorphous masses.

(Chemical characters.) It is soluble, with effervescence, in nitric acid, especially when diluted; and is rapidly blackened by the action of gas from solutions of alkaline sulphurets. Before the blow-

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* Plomb oxidé terreux. BRONGNIART. Bleierde. WERNER. Lead earth. JAMESON.

† Plomb carbonaté. HAUY. BRONGNIART. Weiss bleierz. WERNER. White lead ore. KIRWAN. JAMESON. Le Plomb blanc. BROCHANT.

pipe it decrepitates, and on charcoal is easily reduced to a globule of lead. A specimen from the Lead Hills, Scotland, yielded Klaproth lead 77, oxigen 5, carbonic acid 16, water 2. In another from Zellerfield, Westrumb found oxide of lead 81.2, carb. acid 16.0, lime 0.9, oxide of iron 0.8 ;=98.9.

(Distinctive characters.) Its high spec. gravity, its change of color by the action of alkaline sulphurets, and its easy reduction to metallic lead sufficiently distinguish it from the carbonate of lime and sulphate of barytes, the last of which it sometimes much resembles.

Var. 1. CRYSTALLIZED CARBONATE OF LEAD. Some of its more common forms are the following.—A cuneiform octaedron, which in fact resembles a very oblique four-sided prism, bevelled at its extremities by planes, which stand on the lateral edges.—A six-sided prism, subject to several modifications; sometimes its terminal edges are truncated—sometimes it is terminated by six-sided pyramids, like quartz—and sometimes by only four faces (Pl. V, fig. 15.), two of which stand on opposite lateral faces and meet in an edge under an angle of 141° 02′, while the other two faces stand on two opposite lateral edges.—A double six-sided pyramid.—Sometimes its prisms are tabular.—The crystals are usually small with highly polished faces, whose lustre is often waxy; sometimes the exterior is a metallic gray, in consequence of partial reduction.

2. ACICULAR CARBONATE OF LEAD.* This occurs in delicate needles, sometimes insulated, and sometimes united in fascicular groups. Their lustre is often very strong and silky; and their surface is sometimes coated with malachite in a state of powder.—Few minerals present finer specimens, than this variety, which comes from the mines of the Hartz, &c.

3. COLUMNAR CARBONATE OF LEAD.† Its masses are composed of minute prisms or columns, often channelled, variously aggregated, and intersecting each other. It much resembles columnar sulphate of barytes, with which it is sometimes associated.

4. COMPACT CARBONATE OF LEAD.‡ This variety occurs in amorphous masses, or reniform concretions. Sometimes its texture is compact, and its fracture glistening, often with a resinous aspect. Sometimes it is nearly or quite opaque, and almost friable. Its color has often a strong tinge of yellow.

Its effervescence in nitric acid is much stronger, than that of the earthy oxide of lead.

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* Plomb carbonaté aciculaire. HAUY. BRONGNIART.

† Plomb carbonaté bacillaire. HAUY. BRONGNIART.

‡ Plomb carbonaté massif. BRONGNIART.

(*Geological sit. and Localities.*) Carbonate of lead, though never in sufficient quantities to be explored by itself, is not uncommon in those mines, which contain the sulphuret of lead. It is, of course, associated with the various substances, found in those mines, and is sometimes intermixed with the azure and green carbonates of copper. Sometimes it appears in silver white spangles on the surface of other minerals.—It is found in the Hartz, at the Lead Hills in Scotland, &c. &c. Fine crystals come from Daouria in Siberia.

In the *United States*. In *Pennsylvania*, at the Perkiomen Lead mine, it is associated with other salts of lead; and is also found on Conestoga Creek, near Lancaster. (CONRAD.)

Subspecies 1. BLACK CARBONATE OF LEAD.[*]

Its color is grayish black or black with considerable lustre, especially in certain parts. It is nearly or quite opaque, and its streak is grayish, sometimes with a tinge of blue.—It is easily scratched by a knife, or broken; and its fracture is uneven or imperfectly conchoidal, with a moderate lustre slightly metallic. It often soils the fingers.—It is amorphous, or occurs in six-sided prisms. Its spec. grav. is about 5.75.

Before the blowpipe it decrepitates, and is easily reduced on charcoal. According to Lampadius, it contains lead 75.0, oxigen 3.5, carbonic acid 18.0, water 2.0, carbon 1.5. Its color appears to have undergone some alteration, similar to that, produced by the action of alkaline sulphurets on the white carbonate of lead.

It is found on the surface, or in the cavities, of other ores of lead. It is usually associated with the common carbonate and sulphuret of lead, the latter of which it often incrusts, being at the same time covered by the former.

We subjoin a notice of the *Blue Lead ore* of Jameson. (Blau bleierz of Werner.) Its color is darker than lead gray, and approaches indigo blue or bluish black. Its streak has a metallic lustre. It occurs most commonly in opaque six-sided prisms, with rough, dull surfaces, sometimes curved. It is easily broken, and its fracture is usually even, sometimes uneven, with a feeble metallic lustre. Its spec. grav. is about 5.46.

Before the blowpipe it yields a feeble bluish flame, a sulphurous odor, and is reduced to metallic lead.

This is undoubtedly an alteration of some of the other ores of lead. Both the carbonate and phosphate of lead occur in six-sided prisms. But, if the Blue lead ore be an alteration of the phosphate,

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[*] Schwarz bleierz WERNER. Black lead ore. KIRWAN. JAMESON. Plomb noir. BRONGNIART.

the change must have rendered it *reducible* by the blowpipe.—At Zschoppau in Saxony, it is associated with the carbonate and phosphate of lead, &c.

Species 5. Carbonated Muriate of Lead.*

Its color is light green, greenish yellow, or a pale yellow, and sometimes it is whitish or colorless. It is translucent, and sometimes more or less transparent. It is brittle, and may be scratched by carbonate of lead. Its spec. grav. is 6.06.

It is usually crystallized in cubes, whose edges and angles are liable to truncation; sometimes the cube is elongated, and sometimes the truncations on the terminal edges are so deep, that pyramidal terminations appear. It occurs also in compressed six-sided prisms. (*Brochant.*)

Its structure, in two directions perpendicular to each other, is foliated; its cross fracture conchoidal; and its lustre strong and vitreous.—It is sometimes amorphous.

(*Chemical characters.*) When its powder is thrown into nitric acid, a small portion only of it is dissolved. On charcoal before the blowpipe it melts, and, by continuing the heat, the muriatic acid is disengaged in vapor, and globules of metallic lead appear. It is composed, according to Klaproth and Chenevix, of oxide of lead 85.5, muriatic acid 8.5, carbonic acid 6.

Its crystalline form, inferior hardness, and chemical characters will serve to distinguish it from carbonate of lead.

(*Localities.*) It accompanies the sulphuret of lead, and was first observed in Derbyshire.—In the *United States.* In *Massachusetts*, at the lead mine in Southampton, it occurs on galena, in groups of very light green, and nearly transparent crystals. They have a cubic form, and are terminated by tetraedral pyramids. (*Meade.*)

Species 6. Sulphate of Lead.†

This mineral usually occurs in small, shining crystals. Its color is white or gray, sometimes tinged with yellow or reddish yellow. It is sometimes limpid and transparent, and sometimes only translucent. It is easily scraped by a knife, or reduced into fragments. Its fracture, sometimes splintery, has usually a splendent lustre, either vitreous or adamantine. Its spec. grav. lies between 6.2 and 6.3.

The primitive form of its crystals, under which it sometimes appears, is an octaedron. The common base of the two pyramids is

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* Plomb muriaté. Brochant. Brong. Corneous lead ore. Jameson.

† Plomb sulfaté. Hauy. Brongniart. Blei vitriol. Werner. Lead vitriol. Jameson. Le Vitriol de plomb natif. Brochant.

rectangular, two of its opposite edges presenting angles of 109° 18′, and the other two, angles of 78° 28′. Haüy has described 7 modifications.—This octaedron is often cuneiform, its summits being formed by a line in the direction of the obtuse edges of the common base. —Sometimes the obtuse edges of the common base are truncated, in addition to which the solid angles about this base are sometimes bevelled, and even the edges of these bevelments truncated. (Pl. V, fig. 16.)—Sometimes its crystals have a tabular aspect.

(Chemical characters.) It is insoluble in nitric acid. On charcoal it is easily reduced by the blowpipe; indeed the surface of a fragment may be reduced to a metallic state by the flame of a candle. It contains oxide of lead 70.5, sulphuric acid 25.75, water 2.25;= 98.5. *(Klaproth.)*

Its chemical properties sufficiently distinguish it from the carbonate of lead, which it often much resembles in its external characters.—It is much more easily reduced, than the molybdate of lead.

(Localities.) This substance, which is still rare, accompanies the sulphuret of lead, by the decomposition of which it may have been produced.—In the island of Anglesea, it occurs in the cavities of a cellular and friable reddish brown oxide of iron.

In the *U. States.* In *Massachusetts*, at the Southampton lead mine, it occurs in plates or tables on cubes of sulphuret of lead, and not unfrequently in cavities of quartz, which is the gangue of the sulphuret. It is white, with a strong vitreous lustre, in some parts translucent, in others transparent. Its spec. grav. is 6.2. *(Meade.)* The molybdate, and some other salts of lead occur in the same vein.

Species 7. Phosphate of Lead.*

Few metallic salts present so many colors, as the Phosphate of lead. Its most common color is some shade of green, sometimes a pure grass green, sometimes pistachio or olive green, and sometimes it passes to greenish or sulphur yellow, or even to greenish white; some varieties are gray, often tinged with yellow or brown, and others are brown, or reddish brown, &c. Its powder, however, is usually gray, sometimes with a slight tinge of yellow. It is commonly translucent, and sometimes opaque.

It is sometimes amorphous, or in crusts, or reniform concretions, but is most frequently crystallized. Its crystals are regular six-sided prisms, sometimes truncated on the lateral or terminal edges. This prism may also be terminated by six-sided pyramids, whose

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* Plomb phosphaté. Haüy. Brongniart. Braun and Grün bleierz. Werner. Brown and Green lead ore. Jameson. La Mine de plomb brune et verte. Brochant.

faces correspond to the lateral planes, forming with them an angle of 130° 53′.—These prisms are usually short, with shining surfaces, and often with a waxy lustre; the brown varieties, however, have less lustre, their surface being often rough and blackish. Sometimes the lateral faces of the prisms converge toward their extremities.—The crystals are sometimes acicular.

Its fracture is uneven or splintery, glistening with a resinous lustre. It is easily broken; but is sufficiently hard to scratch carbonate of lead. Its spec. grav. lies between 6.27 and 6.94.

(Chemical characters.) Phosphate of lead does not effervesce in nitric acid, although soluble therein. Before the blowpipe it melts into a grayish globule, which, on cooling slowly, presents a polyedral form, whose faces, when examined by a microscope, often exhibit concentric striæ; but it is not reducible even on charcoal without the addition of soda or some other flux. The brown variety, when melted, is said to form acicular crystals, while cooling. A specimen of the green Phosphate yielded Klaproth oxide of lead 77.10, phosphoric acid 19.0, muriatic acid 1.54, oxide of iron 0.10;=97.74. From a brown crystal, he obtained oxide of lead 78.58, phos. acid 19.73, muriatic acid 1.65;=99.96. It usually contains a little muriatic acid.

(Distinctive characters.) The peculiar globule, which it yields before the blowpipe, is very often a good distinctive character. Its want of effervescence in nitric acid will distinguish it from the carbonate of lead and the green carbonate of copper.

ACICULAR PHOSPHATE OF LEAD.* It occurs in acicular crystals, usually short and diverging in little groups. Sometimes they resemble the surface of velvet, or a kind of moss, and invest other minerals.

(Localities.) Phosphate of lead, like the carbonate of lead, with which it is often associated, is found in mines, which contain the sulphuret of lead, more especially in primitive mountains; and of course it has the same gangues and accompanying minerals, as the sulphuret.

In the *U. States.* In *Pennsylvania*, in the Perkiomen lead mine, it occurs with other salts of lead. *(*WISTER.*)*—In *Massachusetts*, it is said to exist in the Southampton lead mine.

SUBSPECIES 1. ARSENIATED PHOSPHATE OF LEAD.†

Its color is yellow, or yellowish green, more or less deep. It is sometimes crystallized in the forms belonging to the species, and

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* Plomb phosphaté aciculaire. HAÜY. Plomb phosphaté brioïde. BRONGNIART.

† Plomb phosphaté arsenifère. HAÜY.

sometimes occurs in reniform, or tuberose concretions with a fibrous structure.

Before the blowpipe it exhales the odor of arsenic, and yields a globule, like the pure phosphate. It contains oxide of lead 76.0, phosp. acid 18.0, arsenic acid 7.0, muriatic acid 1.75, water 0.5 ;= 98.25. (*Klaproth.*)

It has been found at Roziers in France—in Saxony, &c. and often invests quartz.*

Species 8. Arseniate of Lead.†

Although this species is rare, it has presented considerable diversity of external characters. Its colors are pale yellow, greenish or brownish yellow, yellowish green or even grass green, and sometimes yellowish white. It is tender and easily broken. Its spec. grav. usually lies between 5.06 and 6.41.

It sometimes occurs in six-sided prisms, or in small pyramidal crystals; but more frequently its crystals are acicular; they are often translucent, and when transparent, their angles scratch glass.—Sometimes it is in hexagonal or rounded plates, grouped in the form of a rose.—Sometimes it is in delicate filaments with a silken lustre, slightly flexible, and reducible to powder by mere pressure.—Sometimes it is in semitransparent grains with a resinous aspect, collected into botryoidal groups.—Sometimes it is in opaque reniform concretions with a glistening conchoidal fracture, somewhat resinous.—In fine, it is sometimes in an earthy state.

(*Chemical characters.*) Before the blowpipe, on charcoal, it is reduced to a metallic state, and exhales the odor of arsenic, which may also be perceived, when its powder is thrown on hot coals. In nitric acid it does not effervesce. A specimen from Saxony yielded Rose oxide of lead 77.5, arsenic acid 19.02, muriatic acid 1.53, oxide of iron 0.25 ;=98.30. Another from Cornwall yielded Gregor oxide of lead 69.76, arsenic acid 26.40, muriatic acid 1.58, with a little oxide of iron, silex, and alumine.—It is still uncertain, whether the arsenic, in some specimens referred to this species, is not in the state of arsenious rather than arsenic acid.

A comparison of its chemical characters with those of the other salts of lead will, in general, serve to distinguish it from any of them, it may resemble.

(*Localities.*) It occurs in veins of sulphuret of lead. Near Saint-Prix in France, it is in acicular crystals, or silken filaments in

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* The Bluish phosphate of lead, mentioned in the Tabular View, is described under the Black carbonate of lead.

† Plomb arséniaté. Haüy. Brongniart. Reniform lead ore. Jameson.

a gangue of quartz, &c.—In Andalusia, in botryoidal clusters in a gangue of feldspar and quartz.—In Cornwall, it occurs in six-sided prisms, &c. in a gangue of quartz, in a vein containing native copper, gray copper, &c. Its color is sometimes yellow with a shade of brown, and its powder resembles resin. The crystals are sometimes transparent, and their spec. grav. is 6.41. (GREGOR.)

Brongniart has mentioned a mineral, composed of oxide of lead 22, oxide of arsenic 38, oxide of iron 39. Its texture is compact, and its fracture smooth, like that of jasper.* Its color is yellowish brown, and that of its powder ochre yellow. It is fusible, and, when melted on charcoal, exhales the odor of arsenic, and becomes obedient to the magnet. It converts the muriatic into the oximuriatic acid.—Its locality is unknown.

SPECIES 9. CHROMATE OF LEAD.†

Its color is a very beautiful hyacinth or aurora red; but its streak and powder are nearly orange yellow. It is translucent, and sometimes almost transparent. It is easily broken, and may be scraped even by the finger nail. Its fracture is generally uneven, and its lustre somewhat shining. Its spec. grav. extends from 5.75 to 6.04.

Though sometimes massive, or in thin plates, it is usually in crystals, whose general form is a rectangular four-sided prism, more or less modified. Sometimes this prism is terminated at each extremity by four faces, making with the lateral planes, on which they stand, an angle of 143° 18′.—Sometimes all the lateral edges are truncated, or only two of them;—and sometimes the prism is terminated by three-sided summits.—Sometimes both extremities are obliquely bevelled, and, when the prism is short, it has a rhomboidal aspect.—The form of these crystals is frequently incomplete and difficult to determine, although their faces are often well defined and possess considerable lustre. The sides are often longitudinally striated.

(*Chemical characters.*) It does not effervesce in nitric acid, but gives to muriatic acid a green tinge in the course of a few hours. (*HAUY.*) It is fusible by the blowpipe;—it tinges borax green, and is in part reduced. It contains oxide of lead 64, chromic acid 36. (*THENARD.*)

(*Distinctive characters.*) There are several *red* ores, which this Chromate may more or less resemble. But the red sulphuret of arsenic yields the odor of garlic, when heated—the red sulphuret of mercury has a red powder, and may be volatilized by the blowpipe—

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* Plomb oxidé jaspoïde.

† Plomb chromaté. HAUY. BRONGNIART. Roth Bleierz. WERNER. Red Lead ore. JAMESON. Le Plomb rouge. BROCHANT.

and the red sulphuretted antimonial silver has also a red powder and yields a globule of silver. In fine, no one of the preceding three tinges borax green.—It is easily distinguished from the red oxide of copper.

(Geological situation and Localities.) This ore has been found chiefly in Siberia, near Catharinenberg, in the gold mine of Berezof. It is there disseminated in a metallic vein, traversing gneiss and mica slate; its gangue is quartz, and it is associated with the sulphuret of lead, the hepatic sulphuret of iron, containing gold, and with a greenish mineral, supposed to be a compound of the oxides of lead and chrome.—A little north of this mine, it occurs in the fissures of sandstone, or even in beds of clay, which alternate with this sandstone; here also it is accompanied by a similar sulphuret of iron, containing gold.—A brown Chromate of lead has been brought from Zimapan, in Mexico, by Humboldt.

(Uses.) This ore is sometimes employed as a paint, particularly in Russia. It mixes well with oil, and yields a fine color, which is durable in the air. The native Chromate is scarce. But an artificial chromate of lead is manufactured at Philadelphia, the chromic acid being obtained from the Baltimore chromate of iron. (See chromate of iron.)

Appendix.

SUB-CHROMATE OF LEAD.[*] This substance accompanies the Siberian chromate of lead, and occurs in acicular crystals, or in a powder, attached to crystals of the Chromate or to their gangue. Its color is green or greenish yellow, which it preserves, when exposed to the action of fire. It tinges borax green, and communicates to nitric acid a red color, shaded with orange.—It appears to be a compound of the oxides of lead and of chrome; and is supposed by some to have been a red chromate of lead, which, by some means, has lost a part of its oxigen, the chromic acid being hereby converted into an oxide.—It may, however, be a distinct species.

Species 10. MOLYBDATE OF LEAD.[†]

Its color is ordinarily wax yellow, but varies to lemon or greenish yellow, orange yellow, or yellowish brown. It is usually more or less translucent, at least at the edges, but is sometimes opaque. It is brittle, easily yielding to the knife; and its spec. grav. is about 5.48. Its fracture is uneven or imperfectly conchoidal, and has usually a glistening, waxy lustre.

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[*] Plomb chromé. BRONGNIART.

[†] Plomb molybdaté. HAUY. BRONGNIART. Gelbes Bleierz. WERNER. Yellow Lead ore. JAMESON. Le Plomb jaune. BROCHANT.

It most commonly occurs in crystals, whose general form is tabular or octaedral. The primitive form, which it sometimes presents, is an octaedron with isosceles triangular faces; and it has not less than 9 secondary forms. The primitive octaedron is sometimes truncated on its summits, or on the solid angles about the common base, or on all its solid angles, or on its lateral edges, or several of these modifications may combine (Pl. V, fig. 17.)—Sometimes it occurs in rectangular four-sided tables, or parallelopipeds, which in some instances become cubes. The parallelopiped may be truncated on its terminal edges. The table may be bevelled on its edges or narrow faces, or be converted by truncation into an eight-sided table (Pl. V, fig. 18.), which may suffer still further modification.—Sometimes the table has 12 sides.

The tables are frequently grouped, and often intersect each other. Their surface, though often shining, is sometimes dull.

This ore also occurs in lamellæ or plates; and sometimes it is amorphous with a compact texture.

(Chemical characters.) Before the blowpipe it decrepitates, and melts into a gray or dark colored mass, which, by urging the heat, discovers globules of lead. It is soluble in hot nitric acid without effervescence, unless carbonate of lime be accidentally present. According to Klaproth, it contains oxide of lead 64.42, molybdic acid 34.25 ;=98.67.

(Distinctive characters.) From carbonate of lead it may be distinguished by its want of effervescence in nitric acid, by its more difficult reduction before the blowpipe, and usually by its color.—Sulphate of lead, it will be recollected, is very easily reduced—and phosphate of lead is not reducible by the blowpipe, but yields a polyedral globule.

(Geological sit. and Localities.) At Bleyberg in Carinthia, and at Zimapan in Mexico, it occurs on compact limestone, and at the former place is accompanied by other ores of lead. It is sometimes associated with sulphuret of molybdena.

In the *United States.* In *Pennsylvania,* at the Perkiomen lead mine, where it is finely crystallized in small, quadrangular tables with bevelled edges; it is associated with other salts of lead in the same vein. *(CONRAD.)*—In *Massachusetts,* at the Southampton lead mine, in small tabular crystals of a dark wax yellow, attached by their edges to cavities of crystallized quartz, and frequently intersecting each other. The sulphate and other salts of lead occur in the same mine. *(MEADE.)*

GENUS VIII. *TIN.*

The color of pure tin is less white than that of silver, being slightly tinged with gray. It has more lustre and malleability, and is harder, and more tenacious than lead. It is very flexible, and, when a small bar or plate of this metal is bent, a peculiar crackling sound is heard. Its spec. grav. is 7.29.

It melts at about 442° Fahr. By exposure to the air it loses its lustre, but, at common temperatures, is scarcely, if in any degree, oxidated by air and moisture. When melted, however, it readily attracts oxigen from the air.

(Uses.) These are numerous and important. With mercury it forms the compound, applied to the back of mirrors or looking glasses. With copper it constitutes *bronze*, *bell metal*, *gun metal*, &c. It enters into the composition of pewter and soft solder.—It is employed in the preparation of *tin-plate*, which consists of iron, whose surface is *tinned* to prevent oxidation. It is also applied to the surface of copper vessels, designed for the preparation of food, to prevent the injurious effects, arising from the copper; but it does by no means render the use of such vessels safe.

The oxides of Tin are difficultly fusible, and enter into the composition of enamels and glasses, to which they communicate an opaque white.—Muriate of tin is employed in dying.

This genus embraces only two species; for there is not sufficient evidence, that native tin has ever been observed.

Species 1. Oxide of Tin.*

This ore has but little of a metallic aspect. Its colors vary from blackish brown and brownish black to brown, yellowish or reddish brown, or nearly red, and even to yellowish gray, greenish or grayish white. Its streak and powder are gray, or grayish white. It is sometimes opaque, and sometimes semitransparent, according as its color is dark or light. Its spec. grav. lies between 6.30 and 6.98. Few oxides have so high a spec. grav. when compared with that of the pure metal.

It is sufficiently hard to strike fire with steel, but is easily broken. Its fracture is uneven or a little conchoidal, and rarely more or less foliated; its lustre is shining in various degrees, and nearly vitreous.

This Oxide is found amorphous, or in grains, and very often in crystals, whose primitive form appears to be an octaedon, or double four-sided pyramid with square bases. Its secondary forms are about

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* Etain oxidé. Hauy. Brongniart. Zinnstein. Werner. Tinstone. Jameson. Kirwan. La Pierre d'étain. Brochant.

eleven in number; but the crystals are often so much grouped, that it is difficult to perceive their form.

Its general form is a rectangular four-sided prism, whose edges are liable to truncation or bevelment.

This prism is sometimes terminated by four-sided pyramids, whose faces make with the lateral planes, on which they stand, an angle of 135°; it is sometimes truncated on the lateral edges. (Pl. V, fig. 19.) When the prism is short, this crystal may be viewed as an octaedron, truncated on the common base, and is sometimes so described.—The same four-sided prism may be terminated by pyramids, whose faces stand on the lateral edges.—Sometimes this prism is terminated, at each extremity, by an eight-sided pyramid, whose vertex is formed by only four planes (Pl. V, fig. 20.), which stand on the most obtuse edges of the pyramid, and correspond to those faces, which terminate the first mentioned variety.—The most common form, however, is a hemitrope or twin crystal, composed of two halves of crystals incorporated together, and presenting on one side a re-entering angle more or less large. These hemitropes are most frequently composed of crystals, belonging to the variety of form first described. (Pl. V, fig. 21.)—The surface of the crystal has often a strong lustre.

(*Chemical characters.*) Before the blowpipe it decrepitates, but even on charcoal is with difficulty reduced. A specimen from Cornwall yielded Klaproth tin 77.50, oxigen 21.5, silex 0.75, iron 0.25.

(*Distinctive characters.*) Its hardness, which enables it to give sparks with steel, may serve to distinguish it from the sulphuret of zinc and ferruginous tungsten, both of which have a lamellar structure.—The powder of calcareous tungsten in nitric acid becomes yellow, which is not the case with that of the oxide of tin.

(*Geological situation.*) The Oxide of tin appears to belong exclusively to primitive rocks, although it is frequently found in the state of grains or sand in alluvial deposites, which have arisen from the disintegration of primitive rocks. It is found even in the oldest formations, as granite, gneiss, mica slate, &c. in which it is disseminated, or exists in irregular masses, or beds, or more frequently in veins, which traverse these rocks. It is accompanied by arsenical iron, the oxide and other ores of copper, the ores of tungsten, sulphuret of molybdena, &c. also by quartz, topaz, the fluate and phosphate of lime, hornblende, mica, &c. It is seldom or never connected with carbonate of lime or sulphate of barytes.—Its grains adhere to other substances, or appear in the form of sand.

Tin is evidently one of the oldest metals. It is disseminated in the oldest rocks; and its veins are always *intersected* by those of other metals, when they occur together.

(Localities.) Tin is a very rare metal; and in many extensive countries has not yet been found. The most ancient and celebrated mines of tin appear to be those of Cornwall, in England. The Oxide of Tin is there disseminated in granite, or exists in veins, traversing granite and other primitive rocks, or is found in alluvial earths. When in veins, it is often associated with red oxide of copper, &c.—Some of the tin mines of Cornwall extend under the sea; and that of Huel-Cock is so near the bottom of the sea, that the noise of the waves and the rolling of the pebbles may be distinctly heard. *(Brongniart.)*

Tin is also found in Gallicia in Spain, in veins traversing granite. —Also in Bohemia and Saxony—and in Malacca, Banca, and Siam in India.

(Remarks.) This Oxide is the only ore of Tin, which occurs in sufficient quantity to be explored.—It is remarked by Jameson, that the greater part of the English and Indian tin and much of the Spanish is obtained from alluvial deposites.

Subspecies 1. FIBROUS OXIDE OF TIN.*

Its color is hair brown, light or dark, or nearly chesnut brown, which passes into reddish brown or yellowish gray. It is opaque; easily broken; and its spec. grav. is between 6.45 and 6.73.

It occurs in small masses more or less globular, reniform, or tuberose. Its structure is fibrous; and its masses, when broken, present delicate, diverging fibres with a feeble resinous lustre. Its fibres are sometimes intersected by undulated, parallel, lamellar concretions or zones.

Before the blowpipe it becomes brownish red, but is neither fusible nor reducible. A specimen from Cornwall yielded Vauquelin oxide of tin 91, oxide of iron 9. Another from Mexico yielded Descotils oxide of tin 95, oxide of iron 5.

Some specimens are nearly black at the surface and much resemble brown hematite; but the ore of Tin has a much higher specific gravity.

This fibrous Oxide is found at Cornwall in alluvial earths.—Also in Mexico.

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* Etain oxidé concretionné. Haüy. Brongniart. Kornishches Zinnerz. Werner. Wood Tin. Jameson. Kirwan.

Species 2. Pyritous Tin.*

Its color is steel gray, more or less mixed with yellow. Its streak has a metallic lustre, but its powder is blackish. It is always amorphous. It is easily broken, and may be scraped by a knife. Its fracture is usually uneven or granular with a metallic lustre. Its spec. grav. is between 4.35 and 4.78.

Before the blowpipe it yields the odor of sulphur, and melts into a black scoria, but is not reduced. It gives to borax a yellowish tinge, and its powder effervesces in nitric acid. It contains tin 34, copper 36, sulphur 25, iron 2;=97. It is very probably a mixture of sulphuret of tin and pyritous copper.

It has been found only in Cornwall in a vein, where it is associated with pyritous copper and blende.

GENUS IX. *ZINC.*

Pure Zinc is white, slightly tinged with blue, and has considerable lustre. Its structure is foliated, but its fracture presents broad striæ. Its hardness is such, that it is not easily cut by a knife; and its spec. grav. is about 7.00. By uniform pressure between laminating rollers it may be extended into plates; but, at a temperature between 212° and 300° Fahr. its malleability is so much increased, that it may be hammered into thin plates, or even drawn into wire. At a higher temperature, however, it again becomes brittle under the hammer.

By exposure to the air, it loses its lustre, but is very little oxidated. It melts at about 680°; and, in that state, easily combines with the oxigen of the air.—At a higher temperature, it burns with a greenish blue flame, which, by increasing the heat, assumes a brilliant white color, and a white oxide of Zinc is sublimed in the form of very light flocculi.

(*Uses and Remarks.*) Zinc, united with copper, forms *brass*, one of the most useful metallic alloys. It has other less important uses, as in fireworks. Its oxide and salts are sometimes employed in medicine. Its white oxide may be used as a pigment with oil, and is in some respects preferable to white lead.

The ores of Zinc are few; and in some of them the existence of a metal would never be suspected from their external aspect.—The presence of this metal may be determined by roasting the ore, and then fusing it by the blowpipe on charcoal with filings of pure copper. If Zinc be present, the copper will be converted into brass.

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* Etain pyriteux. Brongniart. Zinnkies. Werner. Tin pyrites. Kirwan. Jameson. Etain sulfuré. Hauy. La Pyrite d'etain. Brochant.

Species 1. Sulphuret of Zinc.*

Blende.

This ore exhibits a great diversity of external aspect. Its colors may be reduced to three principal varieties, *yellow*, *brown*, and *black*, all of which exhibit different shades, or are more or less tinged with other colors. Its powder is gray, often with a tinge of yellow, or even of brown in the darker varieties. It is sometimes transparent, more frequently translucent, and sometimes opaque.

Its spec. grav. usually lies between 3.96 and 4.16. It scratches sulphate of barytes, but not glass, and does not give fire with steel.

Its structure, and its fracture are almost always more or less distinctly foliated. The laminæ separate in six different directions, parallel to the sides of a rhomboidal dodecaedron. The surface of the fracture has most commonly a strong lustre, often splendent, but sometimes feeble; in some cases it is resinous, in others vitreous or adamantine, and sometimes it is metallic.—Its masses present granular distinct concretions of various sizes.

It is sometimes in crystals, sometimes in plates or reniform concretions, and often massive. Its crystals are often so grouped, that it is difficult to determine their form, and their surface has frequently a very high lustre.

It rarely presents the primitive form of its crystals, which is a dodecaedron with rhombic faces; or it may be viewed as a six-sided prism, terminated at each extremity by three faces, which stand on alternate lateral edges. It has 7 or 8 secondary forms.

Sometimes six solid angles of the primitive form are truncated.—Sometimes it presents a tetraedron, which is liable to truncations on its angles—and sometimes a regular octaedron, which may be truncated on its edges, or solid angles, or on both.—One of its forms (Pl. V, fig. 23.) is complex in its structure; it has 24 faces, of which 12 are trapeziums, and the remaining 12 are isosceles triangles, joined two and two at their bases; sometimes also four of its solid angles are truncated.—Sometimes the crystals are acicular.

(Chemical characters.) Before the blowpipe it usually decrepitates, and, though generally infusible even with borax, it sometimes melts into a scoria. Its powder in sulphuric acid yields the odor of sulphuretted hidrogen gas. The yellow variety afforded Bergman zinc 64, sulphur 20, water 6, iron 5, fluoric acid 4, silex 1. From the brown variety Dr. Thompson obtained zinc 58.8, sulphur 23.5, iron 8.4, silex 7.0;=97.7. A lead colored specimen, from Perkio-

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* Zinc sulfuré. Hauy. Brongniart. Blende. Werner. Kirwan. Jameson. La Blende. Brochant.

men Creek* in Pennsylvania, whose spec. grav. was 5.31, yielded Woodhouse zinc 72, sulphur 22, iron 3, silex 3. Some chemists suppose the zinc in this ore to exist in the state of an oxide, while others believe it to be in a metallic state. Bergman has suggested, that the union of metallic zinc with sulphur may be facilitated by the iron, which is usually present.—Blende sometimes contains small quantities of gold, silver, &c.

(*Distinctive characters.*) The streak of Sulphuret of zinc is always dull, while that of the sulphuret of lead is shining and metallic; their powders also exhibit different colors.—Its foliated structure and inferior hardness separate it from the oxide of tin.—It is also less hard, than chromate of iron, and does not tinge borax green.—It is much lighter than the black oxide of uranium.

Var. 1. YELLOW SULPHURET OF ZINC, or BLENDE.* Its more common colors are wax or wine yellow, and sulphur yellow; sometimes also it is hyacinth or brownish red, or even green with a tinge of yellow. It is translucent, and sometimes transparent, like resin.

Its crystals, both externally and internally, exhibit a strong lustre, which is often a little adamantine. When rubbed or scraped by a hard body, even under water, it is usually phosphorescent in the dark, and exhales the odor of sulphuretted hidrogen gas. Some specimens must be rubbed with a steel point, while in others the point of a quill is sufficient to produce phosphorescence.—It occurs both massive and crystallized.

It is one of the rarest varieties of Blende.—Good specimens are found in the Pyrennees, and in Bohemia.

2. BROWN SULPHURET OF ZINC, or BLENDE.† This is the most common variety of Blende. Its color is brown, more or less tinged with red or yellow, and is sometimes blackish brown. It is seldom quite transparent, most frequently translucent, at least at the edges, and is sometimes opaque.

It occurs both massive and crystallized; and its fracture has a lustre nearly resinous, often strongly shining, but sometimes only glimmering.

3. BLACK SULPHURET OF ZINC, or BLENDE.‡ Its colors are black, grayish or brownish black, and sometimes they have a shade of deep

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* Zinc Sulfuré jaune. BRONGNIART. Gelbe Blende. WERNER. Yellow Blende. KIRWAN. JAMESON. La Blende jaune. BROCHANT.

† Zinc sulfuré brun. BRONGNIART. Braune Blende. WERNER. Brown Blende. KIRWAN. JAMESON. La Blende brune. BROCHANT.

‡ Zinc sulfuré noir. BRONGNIART. Schwarze Blende. WERNER. Black Blende. KIRWAN. JAMESON. La Blende noire. BROCHANT.

red. It is often irised, and usually opaque, but sometimes transmits a red light at its edges.

It occurs both massive and crystallized; and its fracture is often less distinctly foliated, than that of the preceding varieties. Its lustre is strong and usually metallic.—It sometimes resembles a dark sulphuret of lead.

4. FIBROUS SULPHURET OF ZINC.* Its color is iron black, passing to gray or reddish brown, and in some parts is yellowish. It is opaque, or a little translucent at the edges. Its streak is reddish brown; and its spec. grav. about 3.63.

It is usually in reniform or tuberose masses. Its structure is fibrous; and its fracture, which is dull, or has only a feeble lustre, presents very delicate, diverging fibres or striæ. Its cross fracture is conchoidal.—By friction it yields the odor of sulphuretted hidrogen.

Before the blowpipe it decrepitates, burns with a blue flame, and yields the odor of sulphur.

It is a rare variety. At Geroldseck in Brisgaw, it occurs in clay, in a vein of sulphuret of lead.

(Geological situation.) Sulphuret of Zinc, which seldom forms an entire vein by itself, is very common in other metallic veins in primitive and transition rocks; it occurs also in secondary rocks, especially compact limestone. It is almost constantly associated with the sulphuret of lead, frequently with the sulphuret of iron, pyritous copper, and sometimes with sulphuret of silver, brown hematite, sparry and magnetic iron, &c.—Its gangues are usually quartz, carbonate and fluate of lime, and sulphate of barytes. Jameson remarks, that the yellow variety belongs to the oldest formation of Blende.

(Localities.) It is unnecessary to enumerate foreign localities. Rammelsberg, near Goslar, furnishes large quantities of Zinc, either in a metallic state, or in that of an impure oxide, obtained while roasting ores, which contain Blende.

In the *United States.* In *Maryland*, near Baltimore, the yellow variety occurs with galena in gneiss. *(HAYDEN.)*—In *Pennsylvania*, at the Perkiomen lead mine, are found the yellow, brown, and black varieties. At Webb's mine, 24 miles from Northumberland, the yellow Blende is imbedded in calcareous spar. *(CONRAD.)*—In *New Jersey*, at Hamburg, Blende is associated with magnetic iron—and at Sparta, the yellow variety is accompanied by graphite.—In *Massachusetts*, at the Southampton lead mine, it occurs both massive and finely crystallized; it is sometimes yellow.

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* Zinc sulfuré strié. HAUY. Zinc sulfuré compacte. BRONGNIART. Fasrige braune blende. WERNER. Fibrous brown blende. JAMESON.

(*Uses.*) This ore cannot be so easily explored, nor economically reduced, as calamine. It has, however, in a number of places, when previously roasted or calcined, been used in the preparation of brass, and may probably be employed in the manufacture of this useful alloy with more advantage, than has generally been supposed.—It is sometimes converted into sulphate of Zinc or white vitriol.—The miners often call it Black Jack.

SPECIES 2. RED OXIDE OF ZINC. *BRUCE.*

For our knowledge of this *new* species among the ores of Zinc we are indebted to Prof. Bruce of New York.

Its color is red, either light or dark, approaching blood red, ruby or aurora red. Its powder is brownish yellow, approaching orange. It is generally translucent at the edges.

Its spec. grav. is 6.22. Its structure and fracture in one direction are foliated; its cross fracture is slightly conchoidal. Its fresh fracture is shining; but, by long exposure to the atmosphere, becomes dull, and is eventually covered with a pearl white crust. It is brittle, and easily pulverized, or scratched by steel.

(*Chemical characters.*) It is soluble in the nitric, sulphuric, or muriatic acid, yielding a colorless solution. It is infusible by the blowpipe; but with borax melts into a transparent, yellow bead. Before the compound blowpipe it sublimes with a brilliant white light.—Its powder, mixed with potash, melts into an emerald green mass, which communicates to water the same color; but, on the addition of a few drops of nitric, sulphuric, or muriatic acid, the green solution immediately becomes rose red.—It is composed of zinc 76, oxigen 16, oxides of manganese and iron 8. (*BRUCE.*)

(*Distinctive characters.*) It differs from red sulphuretted antimonial silver and from the chromate of lead by its infusibility before the blowpipe;—from the red oxide of copper by its greater spec. gravity and by its colorless solution in nitric acid;—from the red oxide of titanium by its solubility in acids;—and it is not, like the red sulphuret of arsenic, volatilized before the blowpipe with the odor of garlic.

(*Geological sit. and Localities.*) It is sometimes imbedded in calcareous spar, and sometimes it forms the gangue of magnetic iron, which is either in crystals, or more frequently in irregular grains.—It is found in *New Jersey*, Sussex Co. in the Franklin, Stirling, and Rutgers iron mines, and near Sparta. At Franklin it also assumes a micaceous form, and is imbedded in a whitish oxide of Zinc.

(*Remarks.*) This ore is well adapted for the manufacture of the best kind of brass, and may be employed without any previous preparation. It is reduced without difficulty to a metallic state; and may be made to furnish the sulphate of Zinc. It is remarked by Prof. Bruce, that this ore, "from its abundance, and the many uses, to which it may be applied, promises to be a valuable acquisition to the manufacturing interest of the U. States."

Species 3. Siliceous Oxide of Zinc.*

Calamine.

This oxide has the aspect of an earthy or a stony mineral, rather than that of an ore. Its ordinary colors are yellowish gray, grayish white, or white, sometimes with a tinge of green or blue; also pale yellow, reddish or yellowish brown. It may be scraped by a knife, and is sometimes friable. Its spec. grav. usually lies between 3.43 and 4.10. When crystallized, or nearly in a state of purity, it easily becomes electric by heat, and preserves its electricity some hours.

It is sometimes crystallized with a foliated or radiated structure; but more commonly its texture is compact, or earthy; it frequently presents various imitative forms.

(*Chemical characters.*) In nitric acid it does not effervesce, but is converted into a jelly. It is infusible by the blowpipe; but it usually whitens, and, if previously solid and translucent, it becomes opaque and friable. It is composed of oxide of zinc, united with silex in variable proportions. Pelletier found oxide of zinc 38, silex 50, water 12. A specimen, analyzed by Tennant, yielded oxide of Zinc 68.3, silex 25.0, water 4.4;=97.7. Another by Klaproth gave oxide of Zinc 66, silex 33;=99. When not crystallized, it is sometimes contaminated by iron, clay, or carbonate of lime; and hence may sometimes effervesce with acids.

(*Distinctive characters.*) Its infusibility by the blowpipe sufficiently distinguishes it from the zeolite, which it sometimes resembles in its structure, as well as in becoming electric by heat, and forming a jelly with acids; but the last two properties serve to distinguish it from other minerals, which it may also resemble.

Var. 1. FOLIATED SILICEOUS OXIDE OF ZINC.† It is sometimes in lamellæ or in small crystals with a foliated structure, and a vitreous lustre, considerably shining. Their most common forms are a compressed six-sided prism (Pl. V, fig. 22.), terminated by diedral summits; a rectangular four-sided table, with its edges sometimes bevel-

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[*] Zinc oxidé. Haüy. Zinc calamine. Brongniart. Var. of Galmei. Werner. Var. of Calamine. Jameson.

[†] Zinc calamine lamelleux. Brong. Blættriger galmei. Werner. La Calamine lamelleuse. Brochant. Striated calamine. Kirwan.

led, and its angles truncated;—and an octaedron. They are sometimes nearly transparent and limpid, and sometimes whitish, &c.

These crystals, seldom insulated, appear in druses, or are collected into globular, or botryoidal groups.

The amorphous or reniform masses of this Oxide, with a radiated or striatéd texture, may also be referred to this variety; for they are in fact the result of crystallization. Such masses are usually more or less translucent.

Its crystals are usually found in cavities of the compact or striated masses.

2. COMMON SILICEOUS OXIDE OF ZINC.* Though sometimes amorphous, it is more frequently in nodular, reniform, botryoidal, or stalactical concretions, and is sometimes cellular, corroded, in crusts, &c. Its fracture is earthy, uneven, or splintery, and nearly or quite dull.—It is opaque, and its colors are sometimes variegated.

Some specimens are sufficiently compact to receive a polish, and even to give fire with steel, while others are more or less friable, and even soil the fingers.

Its colors, which are often white, grayish or yellowish white, are sometimes rendered darker by the oxide of iron. Indeed this variety is often contaminated by clay or carbonate of lime.

(Geological situation.) This ore of Zinc is found in secondary rocks, where it exists in metallic veins, or in crusts on other minerals, or in undulated, cellular masses, or in extensive beds, which are most frequently interposed between those of compact limestone. Its accompanying minerals are the brown and argillaceous oxides of iron, blende, &c. Its concretions are often disseminated in mines of the sulphuret of lead.

(Localities.) This ore exists in extensive beds in the Duchy of Juliers.—It is found also in several counties in England, in Scotland, &c. Fine crystals come from Friburg, in Brisgaw. Patrin mentions an uncommon variety, found in a lead mine in Daouria. It is in very small translucent globular masses, united in clusters; its color is nearly honey yellow, and its surface is chatoyant.

In the *U. States*, Calamine has been found in *Pennsylvania*, at the Perkiomen lead mine, and also on Conestoga Creek, 9 miles from Lancaster; but the writer knows not, whether it is the siliceous oxide, or the carbonate of zinc.

(Uses.) Most of the Zinc of commerce is obtained from this and the following species, both of which are called *Calamine;* and are

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* Zinc calamine commune. BRONGNIART. Gemeiner galmei. WERNER. La Calamine commune. BROCHANT. Compact calamine. KIRWAN.

also the two ores of Zinc, which are chiefly employed in the preparation of *brass*. In this process, the oxide or the carbonate of Zinc, previously calcined, is mixed with charcoal and granulated copper, and then exposed to a suitable heat. The color and other properties of the brass depend much on the proportions of the copper and zinc, the latter of which may vary from 15 to 25 per cent.—The pure oxide of zinc is employed in medicine, as an antispasmodic.

Species 4. CARBONATE OF ZINC.*

This species can scarcely be distinguished from the preceding by its external characters, and has long been confounded with it under the common name of *Calamine*.

Its color is gray or white, often with shades of yellow or brown, and sometimes brownish yellow, &c. Its spec. gravity extends from 3.58 to 4.38. It is not rendered electric by heat; nor is it capable of scratching glass.

It is sometimes in opaque, dull, compact masses, and sometimes in concretions, reniform, &c. with an uneven or imperfectly conchoidal fracture.—It sometimes presents distinct lamellar concretions.—It also crystallizes in rhombs, either acute or obtuse, which are sometimes nearly cubes, and have six edges truncated.

(*Chemical characters.*) It dissolves with effervescence in cold sulphuric acid, or in warm nitric acid; but it does not, like the siliceous oxide of Zinc, form a jelly with the latter acid. It is not melted by the blowpipe.—If paper, which has been immersed in a solution of this salt in nitric acid, be dried, and then held at the distance of a few inches from glowing coals, it spontaneously kindles.—The crystallized variety from Derbyshire yielded Tennant oxide of zinc 65.2, carbonic acid 34.8. In a concretion from Carinthia he found oxide of zinc 71.4, carb. acid 13.5, water 15.1.

(*Geological situation.*) This ore, like the oxide of zinc, occurs in secondary rocks; and most frequently in carbonate of lime. Near Limburg, in Germany, its crystals exist in a compact oxide of zinc. —In England, it is found in Somersetshire, Derbyshire, &c. indeed most of the Calamines of England and Scotland are said to belong to the Carbonate of zinc.

Species 5. SULPHATE OF ZINC.†

White vitriol.

This salt is rarely found native. It occurs in capillary effores-

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* Zinc carbonaté. HAUY. BRONG. Var. of Galmei of *Werner*, and of the Calamine of *Jameson*.

† Zinc sulfaté. HAUY. BRONGNIART. Vitriol of Zinc. KIRWAN.

cences, or in crusts, or in tuberose concretions, and sometimes in minute crystals. It is generally translucent, and its color is white or gray, often shaded with yellow or red.

It has a sharp, styptic taste, and is soluble in water. If unmixed with the sulphate of iron, its solution does not yield a black precipitate on the addition of tincture of galls. A specimen from Rammelsberg yielded Klaproth oxide of Zinc 27.5, sulphuric acid 22.0, water 50.0, oxide of manganese 0.5.

The native Sulphate of zinc is found in mines, which contain the sulphuret of zinc, from the decomposition and oxidation of which it proceeds.—In Cornwall, it has been observed in minute shining crystals, yellowish at the surface.

(Remarks.) In preparing the *white vitriol* of commerce, the Sulphuret of zinc is roasted, and then exposed to the action of moisture and air. The sulphur is thus converted into sulphuric acid, which, combining with the oxide of zinc, produces the Sulphate. The salt is then extracted by lixiviation, and rapidly crystallized; hence its granular appearance, like white sugar.—It often contains iron, and sometimes a little lead.

This salt is employed in medicine, and operates almost instantly as an emetic, although perfectly safe; and may hence be used, when poison has been swallowed. When the white vitriol of commerce is employed, it should be purified by dissolving it in water, and adding the filings of zinc, which, by frequent agitation, precipitate the foreign metals.

GENUS X. *NICKEL.*

The color of pure Nickel is intermediate between that of silver and platina. When polished, it has a high lustre. Its hardness is but little inferior to that of iron; and, when thoroughly hammered, its spec. grav. is 8.93. *(Tourte.)* It is ductile, and may be hammered into very thin plates. In common with iron, it is magnetic, capable of acquiring polarity, and may be formed into permanent magnetic needles.

It is not oxidated by exposure to air or moisture. It is less easily fusible, than iron; and its solution in nitric acid is nearly grass green.

Species 1. Native Nickel.*

Its color is bronze yellow, sometimes inclining to steel gray. It occurs in slightly flexible needles or filaments, which often diverge in groups. It is not magnetic.

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* Nickel natif. Haüy. Var. of Haarkies of *Werner*, and of capillary pyrites of *Jameson*.

It contains a little cobalt and arsenic, the latter of which undoubtedly destroys its magnetism.—It has been found in Bohemia and the Hartz, with gray copper, quartz, &c.

Metallic nickel is also found in all meteoric stones, and is in alloy with iron.

Species 2. Arsenical Nickel.*

Its color is copper red, or a pale reddish yellow. It is opaque; and its spec. grav. varies from 6.60 to 7.56. It is sufficiently hard to give sparks with steel, and at the same time yields the odor of arsenic.

It is brittle; and its fracture is uneven, or imperfectly conchoidal, sometimes granular, glistening or even shining with a metallic lustre.—It usually occurs in amorphous masses, which are sometimes large. Some specimens resemble a slag.

(*Chemical characters.*) When heated by the blowpipe, it exhales the odor of arsenic, and is with difficulty converted into a scoria. In nitric acid it forms a green solution, in which a greenish deposite shortly appears. It is essentially composed of nickel and arsenic, but usually contains, as unessential ingredients, iron, sulphur, cobalt, &c. A specimen, examined by Sage, yielded nickel 75, arsenic 22, sulphur 2;=99.' This ore, by long exposure to the atmosphere, exhibits greenish spots, arising from oxidation.

(*Distinctive characters.*) It strongly resembles native copper; but the latter is malleable.—From the tarnished varieties of pyritous copper it may be distinguished by its greenish deposite in nitric acid, and its odor of arsenic before the blowpipe.

(*Geological situation.*) This ore is found most frequently in primitive rocks, where it either constitutes the principal part of the vein, or is disseminated among ores of cobalt, silver, and copper. Its connexion with certain ores of cobalt is very constant, and it is usually accompanied by the oxide of nickel.—Its gangues are quartz, sulphate of barytes, carbonate of lime, &c.

It is the only ore of nickel, which occurs in any considerable quantity.—It is found in Bohemia, Saxony, Cornwall, France, &c.

In the *U. States.* In *Maryland*, it is found in the copper mines in Frederick Co. (*Hayden.*)—In *Connecticut*, at Chatham, it accompanies cobalt. (*Gibbs.*)

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* Nickel arsenical. Hauy. Brong. Kupfernickel. Werner. Brochant. Copper-nickel. Jameson.

SPECIES 3. OXIDE OF NICKEL.*

Its color is apple green; and, even when greenish white, its true color appears by immersion in an acid. It is seldom even in small masses, but almost always occurs in the form of a powder, forming a coat or efflorescence on other minerals.

Its solution in nitric acid is green. It is reducible by the blowpipe to metallic nickel with the assistance of borax, which it colors yellowish red.

It somewhat resembles the green carbonate of copper, and, when ammonia is added to its solution in nitric acid, a pale blue precipitate is produced; but, unless copper be present, this blue changes in a few hours to violet, and, on the addition of an acid, the violet gives place to apple green.

It usually occurs as a crust or efflorescence on arsenical nickel, or on the ores of cobalt, or is disseminated in certain earths.—It will be recollected, that this oxide colors the chrysoprase, and exists in the green earth, which envelopes that mineral.—This oxide, in many cases, undoubtedly proceeds from the oxidation of arsenical nickel.

GENUS XI. *COBALT.*

This metal, when pure, is grayish white, with a moderate lustre; but, by long exposure, it acquires a violet or reddish tinge. Its texture is compact and fine-grained. It is hard, brittle, and easily reduced to powder. Its spec. grav. is 7.8. (*Murray.*) It is attracted by the magnet.—By exposure to air or moisture it is scarcely oxidated; and it does not melt at a less heat than 130° W.

(*Uses and Remarks.*) As *metallic* Cobalt has not been applied to any use in the arts, it is seldom reduced to that state, except for chemical experiments. But when extracted from its ores, Cobalt exists in the state of an impure oxide, which is usually grayish. This impure oxide is called *zaffre;* but, when fused with about 3 parts siliceous sand, and an alkaline flux, it is converted into a *blue* glass, called *smalt.* It is this zaffre or smalt, which is employed in the arts, to give a fine deep blue to glass, enamel, porcelain, &c. It is from this oxide, that linen derives its bluish tinge.

The presence of Cobalt in any of its ores may be discovered by fusing them with borax or some other alkaline salt, to which they communicate a blue color. Or the ore, supposed to contain Cobalt, may be dissolved in nitromuriatic acid, and letters written with this solution somewhat diluted;—if it be an ore of cobalt, the letters,

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* Nickel oxidé. HAUY. BRONG. Nickel ocker. WERNER. Nickel ochre. KIRWAN. JAMESON. L'Ocre de nickel. BROCHANT.

though invisible when cold, will become green, when moderately heated.

Species 1. Arsenical Cobalt.*

When recently broken, its color is a shining tin white, or almost silver white, sometimes passing to light steel gray; but, by exposure to the air, it tarnishes, and assumes a grayish, reddish, or violet tinge.—Its texture is granular, or nearly compact; its fracture is usually uneven, sometimes a little conchoidal; and its lustre is metallic and somewhat shining.—It is not easily scratched by steel, but is broken without difficulty. Its spec. grav. is 7.72, and sometimes lower.

It exists amorphous, or in concretions reniform, &c. and sometimes in crystals. Thus it occurs in cubes, which may be truncated on the angles and edges (Pl. V, fig. 24.), and also in octaedrons.—The surface of the crystals is smooth, and somewhat shining.

(Chemical characters.) When exposed to the flame of a candle, it yields a white smoke and a very sensible odor of garlic. With the blowpipe, the smoke is more abundant, and the odor more striking. It often melts with ease, and always colors borax blue. When immersed in nitric acid, it almost *instantly* produces a considerable effervescence.—It has not been accurately analyzed; but, in addition to cobalt and arsenic, it is said, that iron, silver, nickel, &c. are sometimes present.

(Distinctive characters.) Its granular or nearly compact texture, and the odor of garlic, which it exhales by exposure to the flame of a *candle only*, distinguish it from gray cobalt, the following species, which has a foliated structure, and does not, when barely exposed to a candle, exhale the odor of arsenic.—Its *sudden* effervescence in nitric acid, and the blue color, it gives to borax, may prevent it from being confounded with arsenical iron.

Var. 1. DULL ARSENICAL COBALT.† Its color is commonly a light steel gray, but its surface is usually tarnished, either grayish black, or like tempered steel. It is never crystallized. Its fracture, though sometimes uneven, is in general nearly or quite even, and is either dull or has only a feeble lustre. Its spec. grav. is sometimes as low as 5.30. *(Kirwan.)*

Before the blowpipe it yields an arsenical odor, but is said to be difficultly fusible. It probably contains more iron than the common variety.‡

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* Cobalt arsenical. Hauy. Brong. Weisser Speiskobolt. Werner. White Cobalt ore. Jameson. Bright white Cobalt. Kirwan.

† Dull gray cobalt ore. Kirwan. Grau[illegible] Speiskobolt. Werner. Gray Cobalt ore. Jameson. Cobal[illegible]nical g[illegible]-noiratre. Hauy.

‡ What has been called *reti[illegible]ted* cobalt appears to be native silver, mix-

(Geological sit. and Localities.) This ore occurs in veins, which more frequently traverse primitive, than secondary rocks. It is associated with ores of nickel, arsenic, silver, bismuth, and copper. It is disseminated in quartz, carbonate of lime, hornblende, &c.

It is found in Spain, France, Germany, Sweden, &c.

In the *United States*. In *Connecticut*, at Chatham near Middletown, an ore of Cobalt, containing both arsenic and sulphur, is disseminated in a rock, which appears to be composed principally of hornblende and actynolite. This mine was explored about 40 years since, and the ore exported to England. *(Silliman.)*

(Remarks.) This and the following species are the only ores of Cobalt, which occur in sufficient abundance to be explored for the purpose of commerce. No mine of Cobalt is at present explored out of Europe; and all the smalt or oxide of cobalt, employed in India, proceeds from the mines and manufactories of Germany. *(Brongniart.)* Some of the principal mines of Cobalt are at Schneeberg &c. in Saxony; Joachimsthal, &c. in Bohemia; Tunaberg, &c. in Sweden.

Species 2. GRAY COBALT.*

When recently broken, its color is a shining metallic white with a shade of gray, or nearly tin white; but it gradually tarnishes with shades of gray, red, &c.

Its structure is more or less distinctly foliated, and its crystals exhibit distinct natural joints, parallel to the sides of a cube. It is not very easily broken, is sufficiently hard and compact to give fire with steel, and, at the same time, exhales the odor of arsenic. Its spec. grav. varies from 6.33 to 6.45. Its fracture, especially in amorphous specimens, is sometimes imperfectly foliated, or even striated. Its lustre is metallic, and more or less shining.

Though sometimes crystallized, it is usually amorphous, and seldom presents any imitative form. Its crystals, like those of the sulphuret of iron, have a cube for their primitive form; and their secondary forms, six in number, are perfectly similar to those of that sulphuret.—Thus it occurs in cubes, whose edges are sometimes truncated;—in dodecaedrons with pentagonal faces;—in regular octaedrons, which are sometimes cuneiform with the terminating edges truncated (Pl. V, fig. 25.);—and in icosaedrons.—Their forms are

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ed with arsenical cobalt in a state of decomposition, or with the arseniate of cobalt. Its surface is dull ash gray.

* Cobalt gris. Haüy. Brongniart. Glanz kobolt. Werner. Cobalt Glance. Jameson. Le Cobalt eclatant. Brochant. Bright white Cobalt. Kirwan.

often very perfect, and their size sometimes considerable. Their surface has usually a splendent, metallic lustre; that of the cube is often striated.

(Chemical characters.) Before the blowpipe it exhales a whitish smoke, and a strong odor of arsenic, the latter of which is scarcely perceptible, when a fragment is exposed to the flame of a candle only. To borax it imparts a fine blue. A specimen from Tunaberg in Sweden yielded Klaproth cobalt 44.0, arsenic 55.5, sulphur 0.5. In another, Tassaert found cobalt 37.0, arsenic 49.0, iron 5.66, sulphur 6.5.

It appears from the foregoing analyses, that this, like the preceding species, is an arsenical cobalt; and it is still doubtful whether they constitute two distinct species. They scarcely differ, except in their structure, and the degree of heat, at which they begin to exhale an arsenical odor. Future and more numerous analyses must remove the present uncertainty.

The *distinctive characters* between arsenical and gray cobalt have already been mentioned.—The structure and chemical characters will serve to distinguish gray cobalt from ores of other metals.

(Geological sit. and Localities.) Gray Cobalt occurs chiefly in primitive and transition rocks, and often in beds. It is accompanied by other ores of cobalt, and by those of nickel, arsenic, silver, &c. —It is found in Germany, and other parts of Europe. The finest crystals come from Tunaberg in Sweden, where this ore exists in mica slate.

(Uses.) This species and arsenical cobalt are explored to furnish zaffre or smalt, which is employed to give a blue color to porcelain. (See remarks under arsenical cobalt.)

SPECIES 3. SULPHURET OF COBALT.

This ore is whitish, or bright steel gray. Its texture is compact, and its fracture uneven, presenting metallic grains. It occurs massive, or botryoidal with a shining surface.

Before the blowpipe it exhales the odor of sulphur, and melts into a brittle, shining globule, whose fracture is a much lighter gray, than its exterior. It gives to borax a deep blue. It is composed of cobalt 43.2, sulphur 38.5, copper 14.4, iron 3.53, earths 0.33; =99.96. *(HISINGER.)*

It is found near Riddarhyttan in Sweden.

SPECIES 4. OXIDE OF COBALT.*

Its colors vary from a dull bluish or brownish black to brown or

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* Cobalt oxidé. HAUY. BRONGNIART.

yellowish brown, and thence to a dirty straw yellow or yellowish gray. Though sometimes friable, it is usually more or less indurated, but is easily broken. Its fracture is, in general, dull and earthy, but in some varieties it becomes uneven or a little conchoidal. It has a shining streak; and, when rubbed by a hard, smooth body, it acquires a strong resinous lustre, which constitutes a character somewhat peculiar. Its spec. grav. is sometimes 2.42.

(*Chemical characters.*) Before the blowpipe it gives to borax a blue more or less deep, and sometimes exhales an arsenical odor. It is an oxide of cobalt sometimes considerably pure, but is more frequently mixed with oxide of iron or with arsenic. The black is supposed to be the purest variety.

Its chemical characters sufficiently distinguish it from black silver and the black oxide of manganese.

Var. 1. BLACK OXIDE OF COBALT.* Its color is bluish black, which, when the mass is friable, often becomes brownish or grayish black. It is sometimes more or less indurated and compact, and sometimes friable and earthy, or even loose. It occurs amorphous, or in reniform or botryoidal masses, or in crusts, or is cellular and resembles a scoria. Its fracture is, in general, dull and earthy, but sometimes uneven or nearly conchoidal with a little lustre.

It is sometimes disseminated in quartz, or sulphate of barytes.

2. BROWN OXIDE OF COBALT.† Its color is liver brown, or yellowish brown, sometimes grayish brown. It is always amorphous, with a dull earthy fracture. It is often impure, being mixed with an ochreous oxide of iron.

3. YELLOW OXIDE OF COBALT.‡ Its color is a dull straw yellow, passing to yellowish gray. It occurs amorphous, and is sometimes corroded, or traversed by cracks. It is sometimes friable.—By friction it acquires a resinous lustre, and to borax communicates a blue color. —It is a rare variety.

(*Geological sit. and Localities.*) The Oxide of cobalt seldom exists in any considerable quantity; but it occurs in both primitive and secondary rocks. It often contains the arseniate of cobalt, disseminated in rose colored spots. It is also associated with the oxides of iron and nickel, with certain ores of copper and silver, and sometimes incrusts them.

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* Schwarzer Erdkobolt. WERNER. Black Cobalt ochre. KIRWAN. JAMESON. Cobalt oxidé mamelonné-terreux-vitreux. HAUY. BRONGNIART.

† Cobalt oxidé brun. BRONG. Brauner Erdkobolt. WERNER. Brown Cobalt ochre. KIRWAN. JAM. Le Cobalt terreux brun. BROCH.

‡ Cobalt oxidé jaune. BRONG. Gelber Erdkobolt. WERNER. Yellow Cobalt ochre. KIRWAN. JAM. Le Cobalt terreux jaune. BROCH.

It is found at Schneeberg, &c. in Saxony; Saalfield in Thuringia, &c. At Riegelsdorf in Hessia, it occurs in scattered masses in veins, composed of quartz, sulphate of barytes, and carbonate of lime, which traverse compact limestone, sulphate of lime, and a black slate, which is sometimes bituminous, and contains copper and impressions of fish.

The Oxide of cobalt, when sufficiently pure and abundant, is extremely valuable in the preparation of smalt.

Species 5. Sulphate of Cobalt.*

This salt has a pale rose red color, is translucent, and soluble in water.—It has been found in stalactites in the galleries of a copper mine at Hergrundt, in Hungary.

Species 6. Arseniate of Cobalt.†

The color of this ore is somewhat peculiar, being ordinarily a peach-blossom or violet red, though sometimes passing to other shades of red, or even to other colors in consequence of decomposition. Its powder retains very nearly the color of the mass.—It occurs in minute or acicular crystals, or in crusts, or in small masses sometimes reniform, &c.

(Chemical characters.) Before the blowpipe it is neither melted nor volatilized; but its acid is in part disengaged, exhaling the odor of arsenic, and a dark gray or blackish oxide remains. To borax it communicates a fine blue.—In many cases, it appears to result from the decomposition of arsenical cobalt; indeed this latter mineral, when exposed to air and moisture, often exhibits a reddish efflorescence.

Var. 1. ACICULAR ARSENIATE OF COBALT.‡ Its peculiar peach-blossom red sometimes passes into crimson red; and, from decomposition, may become brown or grayish. It is usually translucent, sometimes at the edges only. It has, in general, a strong external lustre, and its color is scarcely changed in the streak.—It is brittle, easily scraped by a knife, and has a low spec. gravity.

It occurs in minute prisms or acicular crystals, usually short, and sometimes compressed. When distinct, they often appear to be double six-sided pyramids, or four or six-sided prisms.—These crystals are usually aggregated, and sometimes form small masses, whose

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* Cobalt sulfaté. Brongniart.

† Cobalt arséniaté Hauy. Brong. Rother Erdkobolt. Werner. Red Cobalt ochre. Jameson. Le Cobalt terreux rouge. Brochant. Red Cobalt ore. Kirwan.

‡ Cobalt arséniaté aciculaire. Hauy. Brong. Koboltblüthe. Werner. Cobalt-bloom. Jameson. Fleurs de cobalt. Brochant.

fracture presents broad, diverging, or even radiated fibres; their lustre is more or less shining and pearly. Sometimes the fibres constitute mere crusts.

2. EARTHY ARSENIATE OF COBALT.* This variety also is peach-blossom red, which sometimes inclines to crimson red, and sometimes to rose red or reddish white. It is either friable, or somewhat indurated with an earthy, dull fracture. It occurs in crusts, which are sometimes reniform or botryoidal. As it often accompanies other ores of cobalt, it frequently serves to point them out.

(Geological situation.) This is one of the more common ores of Cobalt; but has never occurred in sufficient quantities to be explored.

It is found in most mines of Cobalt; it exists also in mines of copper and silver, and is sometimes disseminated in the gangues of these ores.

SUBSPECIES 1. ARGENTIFEROUS ARSENIATE OF COBALT.†

It occurs in friable masses, which, however, are not easily reduced to a fine powder. Its colors are composed of green and yellow variously intermingled, or are greenish and reddish black.—It appears to be a mixture of the arseniate of cobalt with the oxides of cobalt and nickel and with an earthy gangue, containing silver. Sometimes it invests the sulphuret of silver; and sometimes capillary native silver appears on its surface.

A specimen from Allemont yielded Schreiber cobalt 43.0, arsenic 20.75, silver 12.75, water and sulphuric acid 15.25, the remainder being iron and mercury.

It is explored as an ore of silver at Mt. Chalances, near Allemont; at Schemnitz in Hungary, &c.

GENUS XII. *MANGANESE.*

Manganese, which is with great difficulty obtained in a metallic state, has a grayish white color with some lustre. Its texture is granular; and its hardness is nearly the same as that of iron. Its spec. grav. is about 6.85. It has little or no malleability.—It absorbs oxigen by exposure to the air;—and its melting point is estimated at about 160° W.

(Uses and Remarks.) In its metallic state manganese is not applied to any use. Its native oxide is employed to furnish oxigen gas, and, with the assistance of muriate of soda, to prepare oxymuri-

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[*] Cobalt arséniaté pulverulent. HAUY. BRONG. Koboltbeschlag. WERNER. Cobalt crust. JAM. Le Cobalt terreux rouge pulverulent. BROCH.

[†] Cobalt arséniaté terreux argentifère. HAUY. Cobalt Merdoie. BRONG. Gænsekœthiges silber of the Germans.

atic acid for bleaching.—When added in small quantities to glass, it removes the greenish or yellowish tinge, which arises from iron or other impurities; but, in larger quantities, it communicates to glass or enamel a violet or purple color.—It also enters into the composition of certain brown colors, employed in the painting of porcelain, and is sometimes used to give a black color to the glazing of certain kinds of pottery.

The ores of Manganese present much diversity in their external characters. But all minerals containing any considerable quantity of this metal, when melted with borax and a little nitre, yield a violet glass. Saline and earthy substances, which contain the oxide of manganese, become brown by exposure to heat, although previously white, gray, &c. indeed some undergo this change even by the action of the air.

Species 1. Oxide of Manganese.

This is the only ore of Manganese, which occurs in any considerable quantity. Its external characters are so various, that very little benefit can result from general expressions of these characters.

It is infusible by the blowpipe, but is converted into a brownish oxide. To borax it communicates a violet color, which varies a little, according to the degree of oxidation; thus it sometimes inclines to red, and sometimes is violet blue. Heated with sulphuric acid, it yields oxigen gas; and with muriatic acid, it exhales the odor of oxymuriatic acid.—The manganese in this species is highly oxidated; and, although sometimes it is nearly a pure oxide, several foreign substances are often present.

Var. 1. RADIATED OXIDE OF MANGANESE.* Its general aspect is metallic, and very often with a strong lustre. Its color is a dark steel gray, sometimes inclining to iron black, and sometimes to silver white. Its streak and powder are dull, and nearly black. It is tender, easily scraped by a knife, and, when rubbed on paper, usually leaves a black trace.

Its structure is generally fibrous or radiated; sometimes also it is foliated,† but the surface of the foliæ is marked with striæ. Its spec. grav. extends from 4.75 to 4.14 or even lower.

This variety is sometimes massive, and sometimes in crystals more or less distinct. The primitive form, which it sometimes presents, is a four-sided prism with rhombic bases of about 100° and 80°.

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* Strahliges grau Braunsteinerz. WERNER. Radiated gray Manganese ore. JAMESON. Manganèse oxidé métalloïde. HAUY.

† Blättriges grau Braunsteinerz. WERN. Foliated gray Manganese ore. JAM.

This prism is often truncated on its lateral edges, and terminated by diedral or tetraedral summits (Pl. V, fig. 26.). Sometimes the prism is short.—These crystals are very frequently acicular;—their lustre is often very high; and, when traversing small cavities in their gangue, they sometimes appear extremely beautiful.—Sometimes it is filiform or capillary, and resembles metallic threads or hairs, scattered on the surface of other minerals.

The acicular crystals are usually aggregated into masses, whose fracture is fibrous or striated, and more or less shining with a metallic lustre. The fibres, either broad or narrow, are sometimes parallel, but more frequently diverge in fascicular groups, or in stars, or are interlaced, crossing each other in all directions. Sometimes also the fracture is foliated.

A specimen from Ilefield in the Hartz yielded Klaproth oxide of manganese 99.25, water 0.25;=99.50. In another from Piedmont, Cordier found manganese 44.0, oxigen 42.0, oxide of iron 3.0, silex 5.0, carbon 1.5;=95.5. The quantity of oxigen appears to vary from 26 to 45 per cent. It sometimes contains a little iron, silex, or carbonate of lime.

Its infusibility sufficiently distinguishes it from the sulphuret of antimony.

ARGENTINE OXIDE OF MANGANESE.* Its color is yellowish gray or yellowish white, with a lustre like that of silver. It occurs in delicate filaments, sometimes united in tufts; or in small masses, composed of grains or scales; or in thin layers on the surface of sparry iron or the brown hematite, or in cavities of the latter ore, &c. It is easily crumbled between the fingers.

The Radiated oxide of manganese is found chiefly in primitive rocks. Fine specimens come from France, and from the Hartz; at the latter place it occurs in large crystals, in a gangue of sulphate of barytes.

2. COMPACT OXIDE OF MANGANESE.† Its colors are dark steel gray, iron or bluish black; brownish black, brown or violet brown. It sometimes scratches glass, but is, in general, easily broken, or scraped by a knife. It soils the fingers more than the preceding variety.

Its texture is compact; and its fracture even, or a little conchoidal, and sometimes uneven. It is dull, or has a moderate metallic lustre, which is principally confined to certain points. Though its

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* Manganèse oxidé argentin. HAÜY.

† Dichter grau—and schwarz—Braunsteinerz. WERNER. Compact gray—and black—Manganese ore. JAMESON. Manganèse oxidé compacte, &c. HAÜY. Manganèse terne compacte. BRONGNIART.

texture is compact, its masses sometimes embrace small cavities; and its spec. grav. is sometimes as low as 3.70.—It occurs amorphous, and is sometimes reniform, tuberose, stalactical, botryoidal, dendritic, &c.

This variety is often impure. According to the analyses of Cordier, Vauquelin, and others, it may contain from 84 to 67 parts of oxide of manganese. Sometimes 18 or 20 per cent. of iron is present; the other ingredients are chiefly silex, carbonate of lime, magnesia, and barytes, the last of which sometimes amounts to nearly 15 per cent. and increases the hardness of the ore.

It often resembles the brown hematitic oxide of iron; but its compact texture, and more especially its black powder, and the violet glass, which it produces with borax, sufficiently distinguish it.

3. EARTHY OXIDE OF MANGANESE.* Its color varies from a very dark steel gray or iron black to bluish or brownish black, and even to brown, and reddish brown. Its texture and fracture are earthy. It is easily reduced to powder, being usually more or less friable, and sometimes it occurs loose. It is dull, or sometimes contains minute scaly particles, which give it a glimmering lustre. It strongly soils the fingers.—Its spec. gravity is so low, being sometimes between 2 and 3, that it appears too light to contain any metallic substance.—It occurs amorphous, or in crusta, dendritic, or tuberose, or is composed of small globular masses, loosely connected.

It sometimes contains a large quantity of iron. In a specimen from Devonshire, Mr. Wedgewood found oxide of manganese 43, oxide of iron 43. In another from the Hartz, Klaproth found oxide of manganese 68.0, water 17.5, silex 8.0, oxide of iron 6.5, carbon 1, barytes 1;=102.

In the Cevennes, this variety occurs in granite; it is extremely light and friable, and divides into irregular prisms.

The Earthy manganese of Devonshire is often called *Black Wad.* It is generally blackish or reddish brown, very light, and strongly soils the fingers. When dry, and moderately heated with one fourth its weight of linseed oil, it inflames.

(*Geological situation.*) The Oxide of manganese, though sometimes in secondary rocks, is most frequently found in primitive or transition mountains. It occurs in nodules or irregular masses, in veins, and in beds. The radiated variety is more particularly confined to primitive rocks; but the three varieties are often connected

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* Manganèse oxidé pulverulent. Haüy. Erdiches grau Braunsteinerz. Wern. Earthy gray Manganese ore. Jam. Ochre of Manganèse. Kirwan. Manganèse terne terreux. Brong.

with each other. It frequently accompanies the brown oxide of iron; —and in secondary rocks is most common in compact limestone.

But, though mines of this ore may be somewhat uncommon, there is scarcely any metal, iron excepted, more *extensively* diffused, than manganese in the state of an Oxide. It enters into the composition of many minerals, and often performs the part of a coloring matter. Limestones, which contain this Oxide, become brown by exposure to the action of heat; and the lime, which they furnish, possesses the valuable property of forming a hard mortar under water.

This Oxide often appears in thin crusts, or in black dendrites on compact limestone and various other minerals, stony, saline, and metallic. It exists even in the vegetable kingdom, and hence appears in the ashes of certain vegetables.

The Oxide of manganese is often associated with sulphate of barytes, and frequently contains the base of this salt. It exists in variable proportions in the garnet, schorl, epidote, augite, &c. &c.—also in several ores of iron, especially the brown oxide and sparry iron.

(*Localities.*) This Oxide is found in France, England, Germany, and various other parts of Europe.

In the *United States.* In *Louisiana*, in the district of St. Genevieve.—In *Virginia*, in Shenandoah Co. on the North Mountain; (*Barton*)—also in Albermarle Co.—In *Maryland*, near Baltimore, in small quantities.—In *Pennsylvania*, in Luzerne Co. near Wilkesbarre, both crystallized and amorphous; (*Wister.*)—also near Lancaster—and in Northumberland Co.—also on the east branch of the Susquehannah, near where it enters the State.—In *New York*, near Ancram.—In *Vermont*, at Monkton, it occurs both crystallized and earthy, in connexion with the brown hematite. (*Gibbs.*)—In *Connecticut*, at Lebanon in small quantities.

Subspecies 1. FERRUGINOUS OXIDE OF MANGANESE.*

This mineral is by some arranged among the ores of iron, and is indeed said to be sometimes smelted as such. Hence we have distinguished it by the epithet *ferruginous*, although other varieties of the Oxide of manganese are known to contain large quantities of the oxide of iron.—It has not been analyzed; but, like the preceding varieties of the Oxide of manganese, it yields with borax a violet glass, and its external characters resemble those of this Oxide.

Its color is nearly bluish black, or dark steel gray. It occurs amorphous, reniform, botryoidal, tuberose, &c. Its structure sometimes exhibits very delicate diverging fibres; but more frequently its frac-

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* Schwarz Eisenstein. WERNER. Black Ironstone. JAMESON. La Mine de fer noire. BROCHANT.

ture is conchoidal or uneven. Its lustre is feeble, and scarcely metallic; but its streak is shining. It is considerably hard, but does not strike fire with steel. Its spec. grav. is 4.07.

It melts easily, gives a violet blue glass with borax, and yields good iron, but acts strongly on the sides of the furnace. *(Jameson.)*

It occurs both in primitive and secondary rocks, and is usually associated with sparry iron, and the brown oxide of iron.

Species 2. Sulphuret of Manganese.*

Its color is blackish gray, or brownish black; and, when recently broken, it has a metallic lustre. Its streak is somewhat shining, but its powder is a dull greenish yellow. *(Brongniart.)*—It sometimes presents a texture more or less foliated, but more frequently it has an uneven or granular fracture. It is easily scratched by a knife, which thus detaches a great number of small grains. Its spec. grav. is 3.95. —The foliated variety is sometimes divisible into rhombic prisms.

(Chemical characters.) Before the blowpipe it is infusible. When diluted sulphuric acid is poured on this mineral in a state of powder, sulphuretted hidrogen gas is rapidly disengaged. A specimen from Nagyag yielded Vauquelin manganese slightly oxidated 85, sulphur 15. Klaproth found a little carbonic acid, which probably proceeded from the gangue.

The Sulphuret of manganese is found in the gold mines of Nagyag in Transylvania; its gangue is carbonate of manganese and quartz.—It has also been discovered in Mexico.

Species 3. Carbonate of Manganese.†

The general aspect of this ore is stony. Its colors are white, reddish white or rose red, pale yellow, and sometimes yellowish brown, or brown;—the shade of brown probably proceeds from exposure to the air. It is slightly translucent, especially at the edges. It is often sufficiently hard to scratch glass, but is easily broken. Its spec. grav. is about 3.23.

It occurs in masses, either amorphous, tuberose, or reniform, &c. and is sometimes earthy and loose. Its fracture is uneven, or splintery, sometimes even, or a little conchoidal, and sometimes more or less foliated. It is dull, but often presents glimmering points.—It is said to occur in rhombs, like those of carbonate of lime.

(Chemical characters.) When exposed to heat, all its colors

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* Manganèse sulfuré. Haüy. Brongniart.

† Manganèse oxidé carbonaté. Haüy. Manganèse lithoïde. Brong. Roth Braunsteinerz. Werner. Red Manganese ore. Jameson. Le Manganèse rouge. Broch.

are brown. It is not melted by the blowpipe, but it gives to borax a violet color, which has often a strong shade of red. A specimen from Transylvania yielded Lampadius manganese slightly oxidated 48.0, carbonic acid 49.0, oxide of iron 2.1, silex 0.9. In a brown specimen from Bohemia, Descotils found oxide of manganese 53.0, carbonic acid and water 35.6, oxide of iron 8.0, lime 2.4, silex and arsenical iron 4.

But, in a rose colored specimen from Transylvania, Ruprecht found oxide of manganese 35.17, silex 55.06, iron 7.14, alumine 1.56, water 0.78; =99.71.—If this analysis is correct, and it is confirmed by Lampadius, it is obvious, that two ores, similar in external characters, but very different in composition, are yet included in this species. Like calamine, it embraces a carbonate and a siliceous oxide.

(Localities.) The white and red varieties have been found chiefly in the mines of Kapnic and Nagyag in Transylvania. They occur in veins and constitute a part of the gangue of native auriferous tellurium; they are accompanied by gray copper, the sulphurets of lead, antimony, &c.—The brown variety is found in Bohemia, and much resembles sparry iron.

Species 4. Phosphate of Manganese.*

In the purer varieties its color is brown, reddish brown or brownish red; but it sometimes passes to blackish brown or black. Its powder also is brown, or reddish brown. It is nearly or quite opaque. It slightly scratches glass, but is easily broken and reduced to powder.

It occurs in masses, whose fracture is imperfectly conchoidal, or uneven, and sometimes foliated; it is either dull, or glistening with a resinous lustre. Mechanical division indicates a rectangular prism with square bases for the primitive form. Its spec grav. is 3.95.

(Chemical characters.) Before the blowpipe it melts into a black enamel;—and is soluble in nitric acid without effervescence. When brownish red, it appears to be nearly a pure phosphate; but a specimen, analyzed by Vauquelin, yielded oxide of manganese 42, phosphoric acid 27, oxide of iron 31. The quantity of iron is extremely variable.

This ore has been found chiefly at Limoges in France, in a vein of quartz, containing the beryl, and traversing granite.—It is said also to occur in *Pennsylvania.*

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* Manganèse phosphaté. Brong. Manganèse phosphaté ferrifère. Haüy. Eisen Pecherz. Werner. Pitchy iron ore. Jam. Fer phosphaté. Broc

GENUS XIII. *ARSENIC.*

Metallic Arsenic is remarkably brittle, and indeed almost friable, being easily broken by a slight blow, and reducible in a mortar to a fine powder.. Its hardness is moderate; and its spec. grav. is about 8.30 Its texture is more or less foliated, and sometimes striated. The color of its fresh fracture is bluish gray, with considerable lustre.

But, when exposed to the air, it soon absorbs oxigen, loses its lustre, and eventually becomes black; indeed it sometimes falls to powder. Its volatility is so great, that, even before it melts, it sublimes, in the state of an oxide, forming a white vapor or smoke, which exhales a strong and peculiar odor, much resembling that of *garlic*. By increasing the heat, it burns with a bluish flame.

(*Uses and Remarks.*) Arsenic in its metallic state enters into the composition of certain alloys. Its oxide is employed in the manufacture of glass, in dying, and the preparation of certain pigments. It is sometimes used in medicine; but, when in the state of an oxide, it forms the most violent of mineral poisons.

The existence of the oxide of arsenic in solution may, in general, be satisfactorily ascertained, by *successively* adding small quantities of a solution of carbonate of potash and of sulphate of copper to the *suspected* fluid, both solutions being warm. If arsenic be present, the fluid assumes a lively grass green color.

Arsenic is obtained in the state of oxide during the roasting of certain ores, particularly those of cobalt. In this process, the oxide is sublimed, and condensed in long flues, connected with the furnace. Much of it is thus obtained in Saxony and Bohemia.

Arsenic, in whatever state it exists, may be recognised by the peculiar odor of garlic, which it exhales, when exposed to a proper degree of heat. An odor somewhat similar is indeed exhaled by the oxide of antimony; but it is much less striking, and easily distinguished after a few experiments. Antimony is less volatile than arsenic, and melts before it is volatilized.

Species 1. Native Arsenic.* *Kirwan. Jameson.*

In most of its characters it resembles purified Arsenic. The color of its recent fracture is steel gray or nearly tin white; but it soon tarnishes, and eventually becomes grayish black with a diminished lustre. It is not very easily scratched by a knife, and its streak has a shining metallic lustre; but its powder is dull and black. It is very easily broken, but less so than purified arsenic. Its spec. grav. usu-

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* Gediegen Arsenik. Wern. Arsenic natif. Haüy. Broch. Brong.

ally lies between 5.67 and 5.76.—When struck or rubbed by a hard body, it exhales the odor of garlic.

It is never crystallized; but occurs in amorphous masses, or in concretions reniform, botryoidal, &c. or in plates, and is sometimes corroded. Its fracture is uneven, or even, or imperfectly foliated with curved layers, and sometimes it presents diverging fibres. Its lustre is metallic, but moderate.

(Chemical characters.) Its chemical characters are those of purified arsenic. When exposed to heat on charcoal, a coat of white oxide of arsenic remains on the coal. It is seldom perfectly pure. It sometimes contains a little silver or gold, and very often a little iron, which remains as a scoria, when the arsenic is volatilized.

Var. 1. CONCRETED NATIVE ARSENIC.[*] It usually occurs in reniform, tuberose, botryoidal, or stalactical concretions, which are composed of curved and concentric layers. Sometimes the concretion embraces a nucleus of sulphuretted antimonial silver.

2. SPECULAR NATIVE ARSENIC.[†] This very remarkable variety of Arsenic possesses a metallic brilliancy, and exists in thin layers, attached to the surface of other minerals.—Before the blowpipe it exhales white fumes with the odor of garlic; it leaves no metallic globule, nor does it, like arsenical cobalt, give a blue color to borax.

It has been found at Annaberg in Bohemia. It is always attached to the surface of those minerals, which are contiguous to the walls of the vein. It has been suggested, that its lustre may arise from friction.

3. AMORPHOUS NATIVE ARSENIC.[‡] It occurs in amorphous masses, whose texture may be fibrous, compact, or earthy. Its fracture often presents a great number of minute glistening scales. It is sometimes very friable.

(Geological sit. and Localities.) Native Arsenic belongs chiefly to primitive rocks. But, instead of forming veins by itself, it usually accompanies other ores, particularly those of silver, cobalt, nickel, &c. Thus it is associated with the sulphuret of silver, sulphuretted antimonial silver, arsenical and gray cobalt, arsenical nickel, gray copper, sparry iron, &c.

It is not a very rare mineral; and is found in several mines of Saxony, Bohemia, France, England, &c.

In the *United States*, it is said to occur at Gayhead, on Martha's Vineyard.

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[*] Arsenic natif concretionné. BRONG. Arsenic tuberculeux testacé. HAUY.

[†] Arsenic natif speculaire. BRONGNIART.

[‡] Arsenic natif amorphe. HAUY. BRONGNIART.

Species 2. SULPHURET OF ARSENIC.*

This ore, as its name indicates, is composed of Arsenic and Sulphur. Hence before the blowpipe it burns, is volatilized, and exhales the odor *both* of arsenic and sulphur. Its colors are *red* or *yellow*, depending probably on different proportions of the ingredients.—Two subspecies have been established on this distinction of color.

Subspecies 1. REALGAR.† *Kirwan.*

Red Sulphuret of Arsenic.

Its color is a lively red, often more or less tinged with yellow, being most frequently an aurora or a scarlet red, and sometimes nearly blood red. Both its streak and powder are orange yellow. It is sometimes opaque, often translucent, and its crystals are semitransparent.

It is so soft and tender, that it may be scratched by the finger nail. Its fracture is uneven or conchoidal, and more or less shining with a vitreous lustre. It acquires negative electricity by friction, even when not insulated;—and its specific grav. is about 3.27.

It occurs in regular crystals, in compact masses, in concretions, or in crusts, which are sometimes earthy.

The primitive form of its crystals appears to be an octaedron, bounded by scalene triangles, like that of sulphur. It has 6 or 7 secondary forms, all of which are prismatic.—One of its forms is an oblique four-sided prism, terminated by pyramids, whose faces stand on the lateral planes, and are parallel to the faces of the primitive octaedron.—This prism is subject to truncation and bevelment on its lateral edges, and sometimes becomes an eight-sided prism. (Pl. V, fig. 27.) Sometimes the solid angles are truncated.—These crystals are usually small; their surface is longitudinally striated, and has a strong lustre.

(Chemical characters.) It melts easily, burns with a bluish flame, and is volatilized by the blowpipe, exhaling white fumes of arsenic, and the odor of arsenic and sulphur. In nitric acid its color disappears. It is composed, according to Thenard, of arsenic 75, sulphur 25. Klaproth found arsenic 69, sulphur 31.

(Distinctive characters.) The color of its powder distinguishes it from sulphuret of mercury and red silver, both of which have a *red* powder, and the latter of which is reducible by the blowpipe to a glo-

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* Arsenic sulfuré. HAUY. BRONG. Rauschgelb. WERNER. Orpiment. JAMESON. Le Réalgar. BROCH.

† Arsenic sulfuré rouge. HAUY. Arsenic sulfuré Realgar. BRONG. Rothes Rauschgelb. WERNER. Red Orpiment. JAM. Le Réalgar rouge. BROCH.

bule of silver.—In color it resembles the chromate of lead; but the chromate is about twice as heavy, and tinges borax green.

(*Geological sit. and Localities.*) Realgar occurs more frequently in primitive, than in secondary rocks. It is disseminated in other minerals, or exists in metallic veins, and sometimes appears as a crust or efflorescence in those veins, which contain native arsenic. It is also associated with red silver, the sulphurets of lead and antimony, gray copper, &c.

It is found in the mines of Saxony, Bohemia, Hungary, &c. At St. Gothard, it is disseminated in dolomite;—and on the North West coast of America, it is mixed with orpiment.

Realgar is not unfrequently sublimed by volcanic fire, and is found in the fissures of lava, and near the craters of volcanoes. It thus occurs at the Solfaterra, near Naples;—at Etna, &c.—At Vesuvius, it is crystallized in the current of lava, which flowed in 1794.—At Guadaloupe, it is called *red sulphur*.

(*Uses.*) It is sometimes employed as a pigment. In China, it is formed into Pagods, and into vessels for medical purposes. In these vessels, some vegetable acid is permitted to remain for a certain time, and is then used as a remedy in disease.

SUBSPECIES 2. ORPIMENT.* *KIRWAN.*

Yellow Sulphuret of Arsenic.

Its color is usually a lemon yellow, which is often shining and very beautiful; indeed the surface of its laminæ sometimes reflects the gilded yellow of gold—sometimes also it is sulphur or orange yellow. Its streak and powder have the same color as the mass. It is opaque, or translucent, sometimes at the edges only.

Its structure is foliated, with laminæ large or small, and often curved. The laminæ usually separate with ease, like those of mica, and are translucent, or even transparent; they are flexible, but very soft and tender. Its fracture, which of course is foliated in one direction, has, when recently made, a strong lustre, sometimes waxy, and sometimes nearly metallic. When its foliæ are small, its masses are composed of granular distinct concretions.—By friction it acquires negative electricity without being insulated;—and its spec. grav. varies from 3.52 to 3.04.

It occurs in laminated or lamellar masses—in concretions—and sometimes in minute crystals, whose forms it is not easy to determine. They appear, however, to be octaedrons.

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* Arsenic sulfuré jaune. HAUY. Arsenic sulfuré Orpiment. BRONG. Gelbes Rauschgelb. WERNER. Yellow Orpiment. JAMESON. Le Realgar jaune. BROCHANT.

(Chemical characters.) It is principally volatilized before the blowpipe with a white smoke, and with the odor of both sulphur and arsenic; a small, earthy residue usually remains. It melts somewhat less easily than realgar, and, on cooling, assumes an orange tinge. According to Thenard, it is composed of arsenic 57, sulphur 43. The result of Klaproth's analysis is arsenic 52, sulphur 38.

Different opinions have existed in regard to the real difference between the *red* and *yellow* sulphurets of arsenic. But, according to the experiments of Proust and Thenard, the arsenic is, in both cases, in a metallic state, though combined with the sulphur in different proportions. Hence realgar, melted with sulphur, produces orpiment;—and orpiment, combined with an additional quantity of arsenic, is converted into realgar.

(Distinctive characters.) The foliated structure of Orpiment, and its arsenical odor, when exposed to heat, distinguish it from native sulphur.—Indeed the chemical characters of Orpiment sufficiently distinguish it from all other *yellow* minerals.

(Geological sit. and Localities.) Orpiment is more frequently found in secondary, than in primitive rocks.—It occurs in Hungary, Natolia, India, &c. In Transylvania, it is sometimes in globules, grouped like the oolite. On the North West coast of America, it is mixed with realgar.

(Uses.) Orpiment is employed, as a pigment, but is, in general, artificially prepared. It comes chiefly from the Levant.—The Sulphuret of arsenic, though poisonous, is much less active, than the oxide of that metal.

Species 3. Oxide of Arsenic.*

Its proper color is white, but it is often tinged with gray, yellow, &c. It is opaque, or, when crystallized, translucent. It has an acrid taste; and its spec. grav. is 3.70.

It is sometimes crystallized in quadrangular prisms or tables, or in octaedrons, or appears in groups of acicular crystals, either diverging or interlaced.—Sometimes also it is friable and earthy, forming an efflorescence or crust—and sometimes it is more indurated, its form being tuberose, botryoidal, &c. Its fracture is earthy and dull, or sometimes fibrous with a moderate lustre.

(Chemical characters.) This Oxide is very nearly pure. It is soluble in about 80 times its weight of water at 60°. Before the blowpipe it is entirely volatilized in a white smoke with a strong odor of arsenic. It is blackened by the action of combustibles.

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* Arsenic oxidé. Haüy. Brongniart. L'Arsenic oxidé natif. Brochant. Native calx of arsenic. Kirwan.

Its solubility in water distinguishes it from the arseniate of lime, and, in connexion with its other chemical characters, may serve to distinguish it from all other minerals, which it resembles.

(*Geological sit. and Localities.*) It is usually associated with native arsenic, or ores of cobalt. The earthy efflorescences are sometimes in metallic veins, and sometimes in the fissures of volcanic mountains, having been sublimed by the action of subterraneous fires.—It has been found at Andreasberg in the Hartz;—in Hessia;—in Hungary;—and at Joachimsthal in Bohemia, where it occurs in quadrangular prisms on sulphate of barytes.

(*Remarks.*) This white Oxide is the substance usually known in commerce by the name of Arsenic; but that is artificially obtained during the roasting of certain ores of cobalt, &c.—When we consider the solubility of this Oxide in water, and its fatal action on the stomach of animals, we must recognise the goodness of the Creator in rendering it a very rare mineral.

GENUS XIV. *BISMUTH.*

Pure Bismuth is yellowish white with a strong lustre; indeed a very slight tinge of red or violet is also perceptible, especially after exposure to the air, by which its lustre is tarnished. Its structure is foliated with broad laminæ, which are sometimes obviously parallel to the sides of an octaedron. Its hardness differs but little from that of silver. Its spec. grav. is 9.82.—It is neither ductile nor malleable, although, when cautiously hammered, it flattens a little before it breaks. It is easily crystallized in octaedrons, or prisms.

Bismuth melts at about 476° Fahr. and, of course, when in small fragments, may be fused by the flame of a candle. It is soluble in nitric acid, and the solution is decomposed by the addition of water, yielding a white précipitate of the sub-nitrate of bismuth. It is scarcely oxidated by air or water at common temperatures.

(*Uses.*) Bismuth in its metallic state is employed in the composition of pewter, soft solder, printers' types, &c. and is sometimes added to lead to increase its hardness.—Its oxide renders glass more fusible; and, if added in large quantities, it gives a yellowish tinge. The white oxide, or rather the sub-nitrate is employed in medicine with success, as an antispasmodic, &c.

SPECIES 1. NATIVE BISMUTH.* *KIRWAN. JAMESON.*

Native Bismuth has a foliated structure, and possesses, in fact, all the essential characters of the purified metal. Its color is nearly

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* Bismuth natif. HAÜY. BROCHANT. BRONGNIART, Gediegen Wismuth, WERNER.

silver white with a slight tinge of red; and its surface is sometimes irised. Its spec. grav. varies from 9.57 to 9,02.

It is sometimes crystallized in octaedrons, rhombs, or quadrangular tables, &c.—sometimes it is in plates or leaves, whose surface often exhibits plumous striæ;—sometimes it is branched, reticulated, or dendritic;—and sometimes it occurs in lamellar masses.

In some cases, this metal is so disseminated in its gangue, that it is invisible to the eye; but its great spec. grav. and a slight greenish efflorescence may often indicate its existence, and, if the specimen be exposed to heat, the Bismuth exudes, and appears in little globules, attached to the surface.

(Chemical characters.) Its chemical characters are those of pure bismuth. Before the blowpipe it yields a white metallic globule, which, by urging the heat, is volatilized in the state of a yellowish white oxide. Native bismuth is seldom perfectly pure, but usually contains a little arsenic, or cobalt, and sometimes sulphur. Hence it may exhale the odor of arsenic, when heated.

Its want of malleability distinguishes it from native silver.

(Geological situation.) Native bismuth has been found almost exclusively in primitive rocks, more particularly gneiss and mica slate. It seldom constitutes the principal mass of the vein, but is mingled with ores of cobalt, arsenic, silver, &c. Hence it is accompanied by arsenical and gray cobalt, arsenical nickel, native silver, and the sulphurets of lead, zinc, &c. Its gangues are quartz, jasper, carbonate of lime, and sulphate of barytes.—Its leaves, plates, and dendrites are either disseminated in the gangue, or attached to its surface.

(Localities.) Native bismuth, which is the only ore of this metal ever explored, is still a rare mineral. It has been found more frequently in Saxony and Bohemia, than in other parts of Europe. At Schneeberg, it occurs in large irised plates, and in dendrites; the latter are in a gangue of jasper, and add much to its beauty, when polished.

In the *United States*, in *Connecticut*, at Trumbull, Native bismuth is disseminated in a vein of quartz in brilliant plates or small lamellar masses, seldom more than an inch in diameter; its surface is sometimes reticulated. It is associated with native silver, and the sulphurets of iron and lead. *(Silliman.)*

Species 2. Sulphuret of Bismuth.*

This species is not easily recognised by its external characters.

Its color is a light lead gray, often tarnished with a tinge of yellow, and sometimes irised. It is brittle, very easily scraped by a knife, and sometimes soils a little. Its powder is black and glistening. (*Kirwan.*) Its spec. grav. lies between 6.46 to 6.10.

Its structure is sometimes foliated, like that of sulphuret of lead, and sometimes striated or fibrous, like that of sulphuret of antimony. Its fracture, which of course is either foliated or fibrous, has a metallic lustre more or less shining.

It occurs massive, or in acicular crystals. M. Haüy has observed natural joints, parallel to the sides of a rhombic prism.

(*Chemical characters.*) It is easily fusible even by the flame of a candle. Before the blowpipe it melts, yielding a blue flame and the odor of sulphur. It is with great difficulty reduced; but, by continuing the heat, much of it is volatilized. It does not effervesce in cold nitric acid.—It is composed of bismuth 60, sulphur 40. (*Sage.*) It sometimes contains a little cobalt, or some other metal.

(*Distinctive characters.*) From native bismuth this ore is distinguished by its want of effervescence in cold nitric acid;—and from sulphuret of lead it differs by the same character and by its greater fusibility.—It is less volatile before the blowpipe, than sulphuret of antimony, and does not, like that sulphuret, so rapidly and entirely disappear, when fused on charcoal. Its spec. grav. is also greater, than that of sulphuret of antimony.

(*Geological sit. and Localities.*) The Sulphuret of bismuth is a rare ore, and occurs in veins, where it is associated with native bismuth, sparry and arsenical iron, pyritous copper, &c. Its gangue is usually quartz.—It has been found at Schneeberg in Saxony—in Bohemia—in Sweden, &c.—In Hessia, it occurs in delicate, irised needles in a mine of sparry iron.

Appendix.

We subjoin to this species a notice of the *Nadelerz* of Werner, the *Needle ore* of Jameson, and the *Bismuth sulfuré plumbo-cuprifère* of Haüy.

Its color is nearly steel gray, which readily assumes a yellowish tarnish. It is amorphous, or in acicular hexaedral prisms, which are usually invested with a greenish crust.† Its fracture is uneven, some-

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* Bismuth sulfuré. Haüy. Brong. Wismuth glanz. Werner. Bismuth glance. Jameson.

† The greenish crust abovementioned is the *Chromocker* (Chrome ochre) of Werner. Its color varies from green to yellow. It also occurs in small indurated masses, with a dull uneven fracture. It has not been analyzed.

what shining, and metallic. It may be scraped by a knife, and its spec. grav. is 6.10.

It effervesces in nitric acid. It contains bismuth 43.2, sulphur 11.58, lead 24.32, copper 12.10, nickel 1.58, tellurium 1.32;=94.1. (*John.*)

It is found in a gold mine near Schlangenberg in Siberia. Its gangue is quartz, containing also native gold, sulphuret of lead, &c.

Species 3. Oxide of Bismuth.*

Its color varies from greenish yellow to straw yellow, and sometimes passes to yellowish gray or gray in consequence of impurities. It occurs in the form of a powder, or in small masses, either friable, or having the hardness of chalk, with an uneven or earthy fracture, nearly or quite dull. Its spec. grav. is about 4.37.

It is soluble in nitric acid;—and on charcoal is easily reduced to metallic bismuth, which forms its most important character. A specimen, analyzed by Lampadius, yielded oxide of bismuth 86.3, oxide of iron 5.2, carbonic acid 4.1, water 3.4;=99.

Its yellow color may serve to distinguish it from the oxide of nickel, and certain ores of copper.

This Oxide is rare, and occurs in veins, which contain native bismuth, on the surface of which it sometimes appears in the form of an efflorescence.

GENUS XV. *ANTIMONY.*

The color of pure antimony is white with a slight tinge both of gray and blue. Its lustre is shining and metallic, but is diminished by exposure to the air. Its structure is foliated, and the laminæ are often found to be parallel to the sides of an octaedron, and to those of a dodecaedron with rhombic faces. It is neither ductile, nor malleable. Its hardness is nearly the same as that of tin; but it is easily reduced to powder. Its spec. grav. is 6.71.

Antimony is not oxidated by air or water at common temperatures. It melts at about 810° Fahr. and, by increasing the heat, it is volatilized in the form of a whitish smoke, which is an oxide of Antimony. It is easily oxidated by nitric acid, and in part dissolved.

(*Uses.*) The uses of antimony are numerous and important. It enters into the composition of several metallic alloys, and often very considerably increases their hardness. United with lead, it forms the alloy, of which printers' types are composed; the proportion of

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* Bismuth oxidé. Hauy. Brong. Wismuth ocker. Werner. Bismuth ochre. Jameson.

Antimony may vary from 15 to 25 per cent. It is an important circumstance in casting types, that this alloy expands by cooling.—Its oxides are employed in the preparation of yellow colors for painting on porcelain and enamel.—In fine, this metal, in the state of an oxide or a salt, furnishes a considerable number of important medical preparations.

Species 1. Native Antimony.* *Kirwan. Jameson.*

The structure and indeed all the characters of this mineral are similar to those of purified antimony. The surface of its fresh fracture, which is nearly tin white, often becomes tarnished with shades of gray or yellow. It occurs in reniform or lamellar masses. Its spec. grav. is about 6.70.

Before the blowpipe it easily yields a metallic globule, and exhales a white smoke, which has a faint odor, resembling that of garlic. It is very nearly pure. A specimen from the Hartz yielded Klaproth antimony 98, silver 1, iron 0.25.

(*Distinctive characters.*) This ore may somewhat resemble the sulphuret of antimony, arsenical iron, and antimonial silver. But the first, when melted, exhales the odor of sulphur—the second has an uneven fracture and gives fire with steel—and the third yields a globule of silver before the blowpipe.—From native bismuth it differs in color, and in not being in any degree flattened under the hammer.

(*Geological sit. and Localities.*) Native antimony is a rare ore, and is found in veins with the sulphuret and other ores of antimony, &c. At Sahlberg in Sweden, its gangue is calcareous spar.—At Andreasberg in the Hartz, its gangues are quartz and calcareous spar, and it is associated with sulphuretted antimonial silver.—At Allemont, near Grenoble, it is often invested with a crust of oxide of antimony.

In the *U. States*, in *Connecticut*, at Harwinton, Native antimony in broad plates is associated with the sulphuret of antimony. (*Silliman.*)

Subspecies 1. ARSENICAL NATIVE ANTIMONY.†

It is sometimes in crusts, whose surface is slightly undulated. The foliæ, which it presents, are smaller and more shining, than those of pure antimony. Its fracture is conchoidal.

When struck with a hammer, or heated by the blowpipe, it ex-

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* Antimoine natif. Hauy. Brong. Brochant. Gediegen Spiesglas. Werner.

† Antimoine natif arsenifère. Hauy. Brongniart.

hales a white smoke, which has a strong odor of garlic.—The arsenic is sometimes in the proportion of 16 per cent.

It has been found at Allemont, near Grenoble.

Species 2. SULPHURET OF ANTIMONY.[*]

The more common aspect of this ore is that of shining, metallic needles, collected into masses. Its color is lead gray, approaching more or less to steel gray. It is liable to a tarnish, which may be azure blue, pavonine, irised, &c. It is opaque, easily scraped by a knife, and so brittle, that small fragments may often be broken by the pressure of the finger. Its spec. grav. varies from 4.13 to 4.51. Its powder is dull and black or grayish black, soils the fingers, and, when rubbed on paper, leaves a black trace.

It is sometimes compact; but more frequently its structure and form are the result of crystallization, more or less regular.

Its crystals are four-sided prisms, nearly rectangular, terminated by four-sided pyramids, whose faces correspond to the lateral planes. —Sometimes two opposite lateral edges of the prism are truncated. (Pl. V, fig. 28.)—Sometimes the edges of the prism are so rounded, that the crystal becomes cylindrical, and is marked with longitudinal striæ or channels.—Sometimes the prisms are acicular.—These crystals are divisible in one direction, parallel to the axis, and present highly polished faces.

These cylinders and needles are almost always aggregated into masses, more or less large, and are usually divergent.

(Chemical characters.) This ore melts very easily, even by the flame of a candle. Before the blowpipe it exhales the odor of sulphur, and is principally volatilized in a white smoke, leaving a small residue of white oxide of antimony. When charcoal is employed, much of the melted antimony is absorbed. It is composed of antimony 74, sulphur 26. (BERGMAN.) It sometimes contains a little silver, iron, arsenic, gold, or cobalt.

(Distinctive characters.) Its easy fusibility distinguishes it from the oxide of manganese;—and from native antimony it differs in spec. gravity, color, and by its sulphureous odor, when heated.—In fact, its great fusibility will also distinguish it from some other minerals, it may resemble.

Var. 1. RADIATED SULPHURET OF ANTIMONY.[†] This is by far

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[*] Antimoine sulfuré. HAUY. BRONG. Grau Spiesglaserz. WERNER. Gray Antimony ore. JAMESON. L'Antimoine gris. BROCHANT. Sulphurated Antimony. KIRWAN.

[†] Antimoine sulfuré cylindroïde—aciculaire. HAUY. Strahliges grau Spiesglaserz. WERN. Radiated gray antimony ore. JAMESON.

the most common variety. It is sometimes in distinct crystals, whose forms have already been mentioned. But it more frequently occurs in masses, composed of cylindrical or acicular prisms, seldom parallel, but usually more or less diverging, and sometimes stellular, or promiscuously intersecting each other. Its longitudinal fracture is fibrous. The fibres are often broad; and their faces, though sometimes only glistening, frequently present a high lustre and lively polish.—This variety passes into the following.

2. FOLIATED SULPHURET OF ANTIMONY.* This variety is less common than the preceding. It is usually in granular distinct concretions, whose fracture in one direction is foliated.

3. COMPACT SULPHURET OF ANTIMONY.† This is the rarest variety. Its fracture is granular or uneven with a moderate lustre. It is usually associated with the other varieties.

4. PLUMOUS SULPHURET OF ANTIMONY.‡ Its color is a dark steel gray, sometimes a little bluish or blackish, and liable to tarnish. It is very tender, and almost friable. It presents itself in capillary crystals, extremely delicate, promiscuously grouped or interlaced, and sometimes collected into small masses.

Before the blowpipe it exhales a white smoke, and a black scoria remains. It is said to contain a little arsenic, and sometimes small portions of silver or gold.

This variety is rare, and is often merely a coat on other minerals. It is found near Freyberg in Saxony, Felsobanya in Hungary, &c.

(*Geological situation of the species.*) Sulphuret of antimony is the only ore of this metal, which occurs in masses or veins of sufficient extent to be explored. It is found in primitive, transition, and also in secondary rocks. Its gangues are quartz, sulphate of barytes, carbonate of lime, &c. Some specimens of this ore are so penetrated by particles of quartz, that they give fire with steel.

This Sulphuret is accompanied by other ores of antimony, by the sulphurets of lead, zinc, and iron, gray copper, native arsenic, silver, and tellurium, &c.

(*Localities.*) This ore is found at Freyberg, &c. in Saxony.—Schemnitz, &c. in Hungary—also in France, Italy, Norway, Scotland, England, Spain, &c.—Near Freyberg, is found an argentiferous Sulphuret of antimony in short, striated prisms, with diedral summits.

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* Blättriges grau-spiesglaserz. WERN. Foliated gray antimony ore. JAM.

† Dichtes grau spiesglaserz. WERN. Compact gray antimony ore. JAM.

‡ Antimoine sulfuré capillaire. HAUY. BRONG. Feder erz. WERNER. Plumose gray antimony ore. JAMESON.

In the *United States*. In Louisiana, good specimens of Sulphuret of antimony have been recently found.—In *Virginia*, it exists near Richmond. (*Hayden.*)—In *Connecticut*, at Harwinton, accompanied by native antimony. (*Silliman.*)—It is said also to exist at East Hartford.—In *Massachusetts*, near South Hadley—and in *Maine*, on Saco river. (*Gibbs.*)

Appendix.

An ore of Antimony, *Schwarz spiesglaserz* (Black antimony) of Werner is found in Cornwall, &c. Its color is iron black, and it is always crystallized in rectangular, four-sided tables, with truncated edges or angles. Its fracture is shining, metallic, and conchoidal. —It has not been analyzed, but is probably a variety of this Sulphuret.

At Treusberg in Nassau, is found an ore, composed in part of broad, parallel plates, of a shining white, like antimony, and in part of a compact substance with a glimmering lustre. Its spec. grav. is 5.65.—On charcoal it easily melts, exhaling vapors of arsenic, and is converted into a white, brittle, refractory globule. It contains antimony 47.75, nickel 25.25, arsenic 11.75, sulphur 15.25.

Species 3. Oxide of Antimony.*

Its color is white, either pure, or tinged with yellow or gray, especially at the surface. It is translucent, easily scraped by a knife, tender, and sometimes friable. It has a foliated structure, and occurs in rectangular four-sided plates or tables, or in acicular crystals. Sometimes also it exists in an earthy state. The tables are often aggregated, and the acicular crystals usually occur in fascicular or stellular groups. Its fracture is shining with a lustre almost pearly.

(*Chemical characters.*) Before the blowpipe it decrepitates; sometimes also it melts with great ease even by the flame of a candle, and sometimes it is volatilized either entirely or in part without fusion. It is sometimes a pure oxide; but a specimen from Allemont yielded Vanquelin oxide of antimony 86, silex 8, iron 3. According to Lampadius, it is sometimes in the state of a muriate of antimony.

It is sufficiently distinguished from zeolite and stilbite by its chemical characters.

(*Geological situation and Localities.*) This Oxide occurs in veins, and usually accompanies the sulphuret and other ores of antimony. Near Allemont in France, it appears in groups of diverging

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* Antimoine oxidé. Hauy. Brongniart. Weiss Spiesglaserz. Wern. White Antimony ore. Jameson. Antimoine blanc. Brochant. Muriated antimony. Kirwan.

needles, and sometimes forms a crust on native antimony.—At Przibram in Bohemia, it occurs in shining tabular crystals on sulphuret of lead, and is a pure oxide, according to Klaproth.

Var. 1. EARTHY OXIDE OF ANTIMONY.* Its color is usually straw yellow, passing to yellowish gray. It is sometimes friable, and sometimes indurated with a dull, earthy fracture.—It is usually a mere crust on other ores of antimony.

Before the blowpipe it is in part volatilized, but does not melt.

At Tornavera in Gallicia, it invests large crystals of sulphuret of antimony, and has probably arisen from the decomposition of that ore. Indeed the same crystal is sometimes in part a sulphuret of antimony, and in part an oxide.

Species 4. Sulphuretted Oxide of Antimony.†

Its color is a deep or cherry red, sometimes with a tinge of brown, and sometimes passing to a dull brick red. Its surface is liable to tarnish. It is tender, and sometimes perfectly friable. It is opaque, and preserves its color both in its streak and powder. Its spec. grav. is about 4.0.

It is sometimes in capillary crystals with a glistening lustre almost metallic. These crystals are often collected into groups, in which they diverge from a common centre.

It occurs also in amorphous masses, of a dull brick red color, sometimes with a tinge of yellow.

(Chemical characters.) Before the blowpipe it melts, burns with a bluish flame, and is entirely volatilized. In nitric acid it becomes covered with a white powder. The acicular crystals from Braunsdorf yielded Klaproth antimony 67.5, oxigen 10.8, sulphur 19.7;=98.

This ore appears to be produced by a partial decomposition and alteration of the sulphuret of antimony. In the same group, while some crystals remain in the state of a metallic gray sulphuret, others are converted into the state of a red sulphuretted oxide of antimony. Indeed the alteration may sometimes be observed, while it exists at the surface only.

Its color, and more especially its chemical characters, when compared with those of the red oxide of copper, arseniate of cobalt, &c. sufficiently distinguish it from other minerals.

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* Antimoine oxidé terreux. Hauy. Spiesglas ocker. Werner. Antimony ochre. Jameson.

† Antimoine oxidé sulfuré. Hauy. Roth Spiesglaserz. Werner. Red Antimony ore. Jameson. L'Antimoine rouge. Brochant. Antimoine hydrosulfuré. Brong. Red antimonial ore. Kirwan.

(Geological sit. and Localities.) This ore accompanies the sulphuret and other ores of antimony. Sometimes it appears in fissures, and sometimes it invests the surface of the sulphuret with acicular crystals or an earthy crust.

It is found in Tuscany;—at Braunsdorf in Saxony;—Kapnic in Transylvania, &c. At the last place the amorphous variety is mixed with minute crystals of sulphur.

GENUS XVI. *TELLURIUM.**

This newly discovered metal, in many of its properties, resembles antimony, while in others it is totally distinct. Its color is a shining white, being nearly tin white with a shade of blue, and somewhat approaching the color of zinc. Its structure is foliated, and its specific gravity only 6.11. It is extremely brittle, easily reducible to powder, and on paper leaves a blackish trace. Its hardness is moderate.

It is more fusible that antimony, but less so than lead; and, when slowly cooled, its surface exhibits a radiated crystallization. When heated by the blowpipe, it burns with a bluish flame, greenish at the edges, and may be volatilized in the state of a white oxide with a pungent odor, which is by some thought to resemble that of a radish.

It is more tender, and less heavy than antimony; and its odor before the blowpipe is different. Its solutions in acids are precipitated by metallic antimony. With nitric acid it forms a limpid solution.

Species 1. Native Tellurium.†

Native Tellurium is never perfectly pure. It always contains a greater or less quantity of gold, and sometimes embraces iron, silver, lead, copper, and sulphur.

When only a small quantity of alloy is present, the physical and chemical characters of this ore differ but little from those of pure tellurium.—Its color is nearly tin white, sometimes with a slight tinge of yellow. Its structure is foliated, and its fracture shining and metallic.—It occurs massive, or in indistinct crystals, or in little plates often confusedly gropped. Its spec. gav. is 5.72; and its primitive form appears to be an octaedron.

(Chemical characters.) It melts with a moderate heat, exhaling a white smoke, and a disagreeable odor. A specimen, analyzed by Klaproth, yielded tellurium 92.55, iron 7.20, gold 0.25.

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* Silvan. Werner.

† Tellure natif auro-ferrifère. Haüy. Gediegen Silvan. Werner. Native Sylvan. Jameson. Le Silvane natif. Brochant. Tellure natif ferrifère. Brongniart.

The variety here described is found almost exclusively at Facebay, in Transylvania, where it exists in veins, traversing gray-wacke and compact limestone. Its gangue is quartz, &c. and it is associated with the sulphurets of lead, zinc, and iron.—It is said to exist in the mines of Berezof in Siberia.

Subspecies 1. AURO-ARGENTIFEROUS NATIVE TELLURIUM.*

Its color is tin white, or light steel gray, with a strong external lustre. It is sometimes massive, but usually in small prismatic crystals, which appear to be four or six-sided prisms. These prisms are often so arranged in rows, that they more or less resemble written characters; and hence the name of *graphic ore.*—Its structure is foliated; its longitudinal fracture has a high metallic lustre, and its cross fracture is uneven and glistening. Its spec grav. is 5.72.

It contains tellurium 60, gold 30, silver 10. (*Klaproth.*)

It has been found only at Offenbanya in Transylvania, where it is in veins, traversing syenite and granular limestone. It occurs on the surface of quartz and other minerals, and is associated with the sulphurets of zinc, and iron, gray copper, &c.

Subspecies 2. AURO-PLUMBIFEROUS NATIVE TELLURIUM.†

Its color is sometimes silver white with a strong shade of yellow, or nearly brass yellow, and sometimes gray, or a shining blackish gray, somewhat like iron. Its longitudinal fracture is foliated and shining with a metallic lustre; its cross fracture is uneven. Its spec. grav. varies from 8.91 to 10.67. Its laminæ are somewhat flexible, but not elastic.

It occurs in short hexaedral prisms or tables, or in four-sided prisms, or in little plates partly inserted in their gangue, and sometimes in masses either lamellar or nearly compact.

Like the other subspecies, when exposed to heat, it melts, and the tellurium is volatilized with its peculiar odor. The gold, which it contains, appears in minute globules. A yellowish white specimen yielded Klaproth tellurium 44.75, gold 26.75, lead 19.5, silver 8.5, sulphur 0.5.

This subspecies has been found only at Nagyag, in Transylvania. It occurs in veins with the sulphurets of lead, zinc, &c. gray copper,

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* Tellure natif auro-argentifère. Hauy. Schrifterz. Werner. Graphic ore. Jameson. Le Silvane graphique. Brochant. Tellure natif graphique, Brong.

† Tellure natif auro-plumbifère. Hauy. Weiss Silvanerz and Nagyagerz. Werner. Yellow—and black sylvan ore. Jameson. Tellure natif plumbifère. Brongniart.

&c. Its gangues are quartz, brown spar, and carbonate of manganese.

The preceding species is explored as an ore of gold, and sometimes also of silver. Hence the mines, whence it is taken, are called gold mines.

GENUS XVII. *CHROME.*

This metal, which was discovered by Vauquelin, derives its name from the Greek, Χρωμα, color, in consequence of the various and very beautiful colors, which its oxide and acid communicate to those minerals, into whose composition they enter, either as essential or accidental ingredients.

Chrome is grayish white, brittle, hard, and has a radiated texture. It is with difficulty reduced to its metallic state and melted. Neither the metal, nor its oxide is much acted upon by acids. In its highest degree of oxidation it constitutes Chromic acid, of a ruby red color. Its oxide communicates to glass a lively and durable green, which resists the action of the strongest fire.

(Uses and Remarks.) The oxide of Chrome, and some of the saline combinations, formed by the Chromic acid, are employed in the arts, and furnish very beautiful and durable pigments. The artificial chromate of lead has a very fine orange or reddish yellow color, and is ground with oil. This compound is prepared at Philadelphia, the chromic acid being obtained from the native chromate of iron, found near Baltimore. It is sold by the name of Chromic yellow.

The oxide of Chrome is employed at the manufactory of Sèvres, in France, to give a fine deep green to the enamel of porcelain. It is applied without a flux, and melted with the enamel.

Although Chrome exists in a number of minerals, there is no ore, of which it is yet known to constitute the base; and of course there is no species to be described under this genus. The substances, called *Needle ore,* and *Chrome ochre,* both of which have been considered as ores of Chrome, have already been mentioned. (See sulphuret of bismuth.)

In the state of an acid, Chrome is found united with the oxides of lead, and iron, forming the chromates of lead, and iron. If there really exists, as is supposed by some, a combination of the oxides of Chrome and iron, this compound must be arranged under this genus, as a ferruginous oxide of Chrome.—The Chromic acid is found also in the spinelle.

In the state of an oxide, Chrome forms the coloring matter of the emerald, actynolite, and some varieties of diallage and serpentine. A mineral, found with the Siberian chromate of lead, appears to be a compound of the oxides of chrome and lead.

GENUS XVIII. *MOLYBDENA.*

This metal is so nearly infusible in the greatest heat of a furnace, that it can hardly be said to have ever been reduced to a well fused mass. It has generally been obtained in metallic grains feebly agglutinated, and sometimes in small, shining metallic globules. This metal appears to be nearly silver white, brittle, and very hard; and to have a spec. grav. of about 8.6.

The action of sulphuric acid converts this metal into an indigo blue or greenish blue oxide; and this blue oxide is by nitric acid converted into a yellowish white powder, which is Molybdic acid.

The metallic molybdates display various colors, some of which are lively and permanent, and will probably become useful in the art of dying.—This genus contains but one species.

SPECIES 1. SULPHURET OF MOLYBDENA.*

Its color is lead gray with a shining metallic lustre. It is very soft, and may be scratched by the finger nail, which leaves a shining streak. Its structure and fracture are distinctly foliated; the laminæ separate with ease, are somewhat flexible, often curved, and have a strong metallic lustre.—It is smooth and unctuous to the touch, soils the finger, and, when rubbed on paper, leaves a trace resembling that of graphite or plumbago. It is opaque; and its spec. grav. extends from 4.04 to 4.73. It is a conductor of electricity; and, when rubbed on sealing wax, communicates to the wax positive electricity.

It occurs in regular crystals, or in plates, or in small lamellar masses. Its crystals are short six-sided prisms, or tables. The tables are either equilateral or elongated, and sometimes extremely thin;—in some instances the prism is terminated by six-sided pyramids. Their primitive form is probably a right prism with rhombic bases.

(*Chemical characters.*) It is infusible by the blowpipe, but is in part volatilized, exhaling white fumes and the odor of sulphur. By calcination at a high temperature it is converted into molybdic acid. It is also converted into molybdic acid by the action of nitric acid, repeatedly applied, and distilled to dryness. It is composed of

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* Molybdène sulfuré. HAUY. BRONGNIART. Wasserblei. WERNER. Molybdena. KIRWAN. JAMESON. Le Molybdène. BROCHANT.

Molybdena 60, sulphur 40. (*Klaproth.*) A little iron is sometimes present.

(*Distinctive characters.*) The Sulphuret of molybdena strongly resembles graphite or plumbago in its external characters, and was formerly confounded with it. But, if the two minerals be rubbed on white porcelain or any fine pottery, the trace of Molybdena has a greenish tinge, and contains numerous little scales, while the trace of graphite is dark gray, and composed chiefly of grains. The structure of Molybdena is always foliated, but the texture of Graphite is usually granular. By trituration Molybdena is reduced into minute plates or scales, whereas graphite is usually converted into a powder. And further, when the two minerals are gently rubbed on white paper, the trace of Molybdena is much more shining, than that of graphite. —It is easily distinguished from micaceous oxide of iron.

(*Geological situation.*) This ore belongs exclusively to primitive rocks, in the oldest of which, as granite and gneiss, it most frequently occurs. Sometimes it is disseminated through these rocks in crystals, minute plates, or in masses or nodules of a moderate size. Sometimes it occurs in metallic veins, which traverse these rocks, and is associated with the oxide of tin, ferruginous tungsten, native arsenic, magnetic iron, &c.

(*Localities.*) Near Mont Blanc, it is disseminated in granite.—At Zinnwald in Bohemia, it occurs in veins of tin.—In Norway, Sweden, &c. it is disseminated in granite.

In the *United States.* In *South Carolina.*—In *Virginia.*—In *Maryland*, near Baltimore, in granite. (*Hayden.*)—In *Pennsylvania*, Delaware Co. near Chester, it occurs both massive and in crystals. (*Wister.*)—In *New York.*—In *Connecticut*, at Brookfield, &c. In *Maine*, at Brunswick, on the banks of the Androscoggin, Sulphuret of molybdena is abundantly disseminated in granite and gneiss. It is sometimes finely crystallized in short hexaedral prisms, or rather in tables, or thin plates. The tables are sometimes equilateral, and sometimes elongated, being more than an inch in length; sometimes also they are very small. In some instances, hexaedral laminæ are superimposed on each other, with a decreasing extent, so as to form a solid somewhat pyramidal. Frequently also it occurs in small foliated masses, varying from one tenth of an inch to two inches or more in diameter. It is sometimes associated with a yellowish or greenish yellow substance in the form of a crust or efflorescence, which has the external characters of oxide of uranium.

GENUS XIX. *TUNGSTEN.*[*]

Little can be said with confidence concerning the characters of this metal in a pure state. Chemists have usually obtained it in detached globules, rather than in a well fused mass. It is said to be grayish white, brittle, and very hard. Its spec. gravity, according to Allen and Aiken, is 17.22; while Guyton found it to be only 8.34 in a well fused mass.

It is fusible in the most intense heat only. Both the metal and its oxide are nearly insoluble in acids; but the oxide, when digested in nitric acid, assumes a lemon yellow color.

Species 1. Calcareous Oxide of Tungsten.[†]

This ore has the general aspect of a stone; but its spec. gravity lies between 5.57 and 6.06. Its colors are gray or whitish, yellowish white or yellowish gray, sometimes with a tinge of brown. Its surface has often a resinous lustre, and is sometimes tarnished. It is more or less translucent, or even semi-transparent, when crystallized. It may be scratched by a knife, and is easily broken.

Its fracture is foliated, but often imperfectly, and in some directions is uneven or conchoidal; its lustre is shining and a little resinous. The laminæ separate in directions parallel to the sides both of a cube and octaedron.

It is sometimes amorphous, and frequently in crystals, whose general form is an octaedron, bounded by isosceles triangles. Or it may be called a double four-sided pyramid, of which any two contiguous sides, belonging to opposite pyramids, contain an angle, at the common base, of 113° 36′. This octaedron is sometimes cuneiform—or bevelled on its lateral solid angles, or on the common base. —The primitive form is also an octaedron, but more acute, than the one just mentioned.—Sometimes also it presents the primitive octaedron with its summits and oblique lateral edges truncated.

(Chemical characters.) It becomes opaque before the blowpipe, and decrepitates, but is infusible. By digestion in nitric acid, it is converted into a yellow powder, which is the oxide of Tungsten. A crystallized specimen from Schlackenwald yielded Klaproth yellow oxide of tungsten 77.75, lime 17.60, silex 3.0;=98.35. Another from Bitsberg yielded Scheele oxide of tungsten 65, lime 31, silex 4.

(Distinctive characters.) The preceding characters, and more especially the yellow color, which its powder assumes in nitric acid,

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[*] Scheel. Werner. Scheelin. Hauy. It was discovered by Scheele.

[†] Scheelin calcaire. Hauy. Brongniart. Schwerstein. Werner. Tungsten. Kirwan. Jameson. La Pierre pesante. Brochant.

will sufficiently distinguish it from the oxide of tin, carbonate of lead, and sulphate of barytes, all of which it may somewhat resemble.

(*Geological sit. and Localities.*) This ore occurs in primitive rocks only, and is associated with the oxide of tin, ferruginous tungsten, brown hematite, quartz, mica, &c.

It is found at Schlackenwald, &c. in Bohemia;—Bitsberg in Sweden;—Pengilly in Cornwall, &c.

Species 2. Ferruginous Oxide of Tungsten.*

Its color is nearly black, sometimes dark grayish or brownish black, with somewhat of a metallic aspect. It is opaque, and both its streak and powder are dark reddish brown or a deep violet. Its specif. gravity lies between 6.83 and 7.33. It does not give fire with steel, and may be easily scratched by a file.

Its structure and longitudinal fracture are foliated, and more or less shining with a lustre nearly metallic; its cross fracture is uneven with less lustre. When in laminated masses, its fracture, under certain points of view, has a fibrous aspect.

Its crystals are prismatic, or tabular. Their primitive form, which it sometimes presents, is a rectangular four-sided prism (Pl. V, fig. 29.)—This prism is sometimes truncated on its solid angles (Pl. V, fig. 30.), and in addition to this its lateral edges may also be truncated.—Sometimes the prism is oblique, and terminated by a bevelment, while the edges around the bevelment are truncated.—It occurs also in broad six-sided prisms, terminated by four-sided summits; two faces of each summit correspond to the broader faces of the prism, and meet in a line.—Sometimes it presents rectangular four-sided tables, whose edges and angles are modified by truncation or bevelment.—These crystals are sometimes large; but they are often badly defined.

This oxide of Tungsten occurs also in plates, or in foliated masses, whose laminæ easily separate by percussion. Its foliæ are sometimes small; and its masses often present curved, lamellar distinct concretions.

(*Chemical characters.*) Before the blowpipe it decrepitates, but is infusible. According to Vauquelin, it contains oxide of tungsten 67.0, oxide of iron 18.0, oxide of manganese 6.25, silex 1.5;=92.75.—D'Elhuyart found oxide of tungsten 64.0, of iron 13.5, of manganese 22.0;=99.5. The proportion of iron and of manganese is extremely variable, and sometimes reaches 30 per cent. When its powder is digested in muriatic acid, a yellow oxide of tungsten appears.

(*Distinctive characters.*) It somewhat resembles the magnetic

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* Scheelin ferruginé. Hauy. Brongniart. Wolfram. Werner. Jameson. Kirwan. Brochant.

and specular oxides of iron; but it is heavier, and is not affected by the magnet.—Its structure is more distinctly foliated, than that of the oxide of tin; it is also less hard, and the color of its powder is different.

(Geological situation and Localities.) This ore belongs chiefly to primitive rocks, and often accompanies the oxide of tin.—Thus it occurs in the tin mines of Bohemia, Saxony, and Cornwall.—In Siberia, it is associated with the beryl and topaz.—Near St. Leonard, in the department of Upper Vienne, it occurs in considerable quantities in a vein of quartz.—It is less rare, than the preceding species.—It sometimes appears in transition rocks.

GENUS XX. *TITANIUM.**

Titanium is with great difficulty obtained in a metallic state, and, of course, its properties have been but little examined. It is brittle; and has a dark copper red color with a strong metallic lustre, which tarnishes by the action of the air.—It is almost infusible.

Titanium has hitherto been found in the state of an oxide only, either pure, or combined with the oxides of other metals or with certain earths. It exhibits a considerable diversity of external character, but it has seldom much of a metallic aspect.

If the native oxide of Titanium be fused with four times its weight of potash, and if this fused mass be repeatedly digested in water, a whitish powder appears, which is oxide of titanium. This white oxide is soluble in nitric acid, from which it is precipitated brownish yellow by the prussiate of potash, and brownish red by tincture of galls. If the solution be concentrated, the latter precipitate somewhat resembles curdled blood.

If the native oxide be fused with six times its weight of carbonate of potash, and the melted mass digested in water, the white powder obtained will be a carbonate of titanium, which is soluble in nitric acid with effervescence.

This metal was discovered by Klaproth.

SPECIES 1. RED OXIDE OF TITANIUM.†

The ordinary color of this ore is red with a tinge of brown; but its color varies from blood red to brownish red, copper or yellowish red, and sometimes to grayish red, or even steel gray, especially at the surface. Its external lustre is usually considerable, and often more

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* Menak. WERNER. It was first found in Menachan, Cornwall.

† Titane oxidé. HAUY. Titane Ruthile. BRONGNIART. Rutil. WERNER. Rutile. JAMESON. Le Ruthile. BROCHANT. Titanite. KIRWAN. It has also been called *red schorl.*

or less metallic. It is opaque, or translucent, sometimes at the edges only, and some crystals are semi-transparent.—It scratches glass, and sometimes quartz; and, when not too brittle, gives sparks with steel. Its spec. grav. lies between 4.10 and 4.24.

Its structure and longitudinal fracture are foliated; its cross fracture is conchoidal or uneven; and it has usually a strong lustre, either adamantine or metallic.—Its laminæ separate in two directions, parallel to the axis, and at right angles to each other, and lead to its primitive form, which is a rectangular prism with square bases; the side of the base is to the height of the prism nearly as 10 to 11, and the prism is divisible in the directions of the diagonals of its bases.—It often breaks into cubical fragments.

It occurs also in masses, whose texture is fibrous or granular, or nearly compact, and, according to Lucas, it is sometimes in a pulverulent state.

This Oxide, though sometimes massive, &c. is usually in prismatic crystals, whose forms are very often imperfect. Sometimes it presents the primitive form already mentioned.—But its more common forms are an oblique four-sided prism, or an eight-sided prism, both of which are sometimes terminated by four-sided summits, whose faces correspond to the sides of the prism. These prisms are frequently *geniculated*, that is, two prisms are united, base to base, at an obtuse angle, and form a kind of *knee* (Pl. V, fig. 31 and 32.); sometimes even four prisms are thus united, forming three joints.—It occurs also in six-sided prisms, whose extremities are sometimes rounded (Pl. V, fig. 33.); this convexity seems to arise from a tendency to six-sided, pyramidal terminations.

These prisms are usually marked with longitudinal striæ. Sometimes they become cylindrical; and sometimes they are traversed by seams, perpendicular to the axis.—They are often acicular or even capillary, sometimes very long, and sometimes collected into fascicular groups, or are reticulated.

(Chemical characters.) This oxide is infusible by the blowpipe, unless a flux be employed. It is sometimes a pure oxide, according to Klaproth; and sometimes it contains a little iron, chrome, or silex.

(Distinctive characters.) It is sensibly harder than the silico-calcareous oxide of titanium, from which it also differs in crystalline form and structure, and usually in color.—Its structure is more distinctly foliated, than that of the oxide of tin, and it has a lower specific gravity.

RETICULATED RED OXIDE OF TITANIUM.* It is composed of acicu-

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* Titane Ruthile reticulé. BRONGNIART.

lar or capillary crystals, crossing each other, like the threads of a net. The interstices are sometimes triangular. This subvariety is sometimes applied to the surface of other minerals, and is sometimes rendered very beautiful by being embraced in transparent quartz.

(*Geological situation.*) This oxide appears to belong exclusively to primitive rocks, more particularly granite, gneiss, mica-slate, or limestone. It is attached to the surface of these rocks, or disseminated in the masses or veins of quartz, feldspar, &c. which these rocks contain.—Sometimes also it occurs in detached crystals in alluvial earths, proceeding from primitive rocks; and in this case its prisms usually have blunted edges, or are broken.

(*Localities.*) In Hungary, in the Carpathian mountains, it occurs in mica slate or gneiss, in a gangue of quartz, and is sometimes reticulated.—At St. Gothard, it is often reticulated, and appears on the surface of gneiss, feldspar, quartz, and mica, or is even mingled with crystals of mica.—In France, near St. Yrieix, it occurs in alluvial earths.

In the *United States*, this Oxide occurs in various places, and sometimes in considerable quantities. In *South Carolina*, Pendleton Co. it exists in alluvial earths. (HAUY.)—In *North Carolina*, in the interior of the State. (CLOUD.)—In *Virginia*, near Richmond, it is sometimes massive and granular—and sometimes compact, of a blood red color, and imbedded in milk white quartz; it is associated with the ferruginous oxide of titanium. (BRUCE.)—In *Maryland*, near Baltimore, it is light red, prismatic, and laminated, in a yellowish quartz. (BRUCE.)—In *Delaware.*—In *Pennsylvania*, Chester Co. at London Grove, its crystals are imbedded in granular limestone, and associated with the silico-calcareous oxide; (CONRAD.)—also in Delaware Co. its crystals have been found adhering to an insulated mass of smoky quartz, or even penetrating through the mass. (CLOUD.)—In *New-Jersey*, Bergen Co. near Schuyler's copper mines, in an insulated mass of bluish quartz; the crystals are hexaedral prisms with rounded summits, of a steel gray color, with a strong metallic lustre. (BRUCE.) —In *New York*, near Kingsbridge, on the island of New York, this oxide is disseminated in veins, which traverse primitive limestone, and which are composed of fetid quartz, feldspar, mica, and limestone. It occurs amorphous, or in small, quadrangular, prismatic, semi-transparent crystals, which are sometimes geniculated, and sometimes acicular; its color varies from dark blood red to a light red;—also on Hudson's river, it occurs both crystallized and amorphous, of a dark grayish red, with a strong metallic lustre, and translucent at the edges; its gangue is carbonate of lime. (BRUCE.)—In *Connecticut*, near New-Haven.—In *Massachusetts*, Hampshire Co. at Worthington, in prismatic, striated crystals, imbedded in a white quartz, which is said to occur in hornblende slate. (*Bruce.*)—In *Maine*, at Topsham. (See Bruce's Min. Jour. v. i.)

Species 2. Ferruginous Oxide of Titanium.*

Its color is black, often grayish or iron black, and sometimes brownish black; and it is perfectly opaque. It occurs in masses of moderate size, and in angular grains, which are frequently rounded or flattened, and possess very little external lustre.

Its fracture is, in most cases, imperfectly foliated in one direction, while in other directions it is more or less conchoidal or uneven; its lustre is glistening, and almost metallic. In some specimens the texture is compact.—It is easily broken, and its spec. grav. lies between 4.27 and 4.67. It often has a feeble action on the needle, and, when reduced to powder, it is usually moved by the magnet.

(*Chemical characters.*) With the exception of one variety, it is infusible by the blowpipe. It appears to be essentially composed of the oxides of titanium and iron; but the proportions are extremely various, and it sometimes embraces other substances. In fact, it appears to pass by imperceptible shades into magnetic iron sand, of which some well characterized varieties contain from 5 to 15 per cent. of the oxide of titanium.

It, however, differs from magnetic iron sand by never possessing a strong magnetic power, and by being sometimes entirely destitute of it.

Several varieties have received distinct names.

Var. 1. MENACHANITE.† *Kirw. Jameson.* Its color is grayish black, and remains unaltered in the streak. It is feebly attracted by the magnet; and may be easily scratched by steel. It occurs in small, rounded grains, which have a glimmering surface, and sometimes resemble gunpowder.

A specimen from Cornwall yielded Klaproth oxide of titanium 45.25, magnetic oxide of iron 51.0, silex 3.5, oxide of manganese 0.25. In another from Botany Bay, Chenevix found oxide of titanium 40, oxide of iron 49, silex 11.

It is less hard than magnetic iron sand.

(*Localities.*) This variety was first found in the valley of *Menachan*, in Scotland; and hence its name. It occurs in the bed of a rivulet in the form of sand, mingled with grains of quartz.—In Liguria, its grains are imbedded in mica slate. (Prof. *Viviani.*)—At Spessart, in Franconia, it occurs in small masses, with an uneven fracture, harder

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* Titane oxidé ferrifere. Hauy. Titane Menakanite. Brongniart.

† Menakan. Werner. Le Menakanite. Brochant.

than the Menachanite of Cornwall, and containing, according to Klaproth, oxide of titanium 22, oxide of iron 78.

2. NIGRINE.* *JAMESON.* It is found in grains or rolled pieces, and is harder than the preceding variety. Its color is *black* or brownish black; and hence its name. Its streak is yellowish brown. It is scarcely, if at all, affected by the magnet.

In a specimen from Transylvania, Klaproth found oxide of titanium 84, oxide of iron 14, oxide of manganese 2. But in another from the Uralian mountains, Lowitz found oxide of titanium 53, of iron 47.

(Localities.) At Ohlapian, in Transylvania, it occurs in alluvial earths, and is mixed with the red oxide of titanium, garnets, cyanite, &c. and with fragments of granite and gneiss.—Also in the island of Ceylon.

3. ISERINE.† *JAMESON.* This variety also occurs in grains or pebbles; and its color is iron or brownish black, both in the mass and in its streak. It is not easily scratched by a knife; and its fracture is conchoidal in all directions.—It is very feebly magnetic.

According to Jameson, it melts by the blowpipe into a blackish brown glass. A specimen from the river Don, analyzed by Thomson, yielded oxide of titanium 48, oxide of iron 44, oxide of uranium 4;=96. The uranium sometimes equals 10 per cent. and is sometimes absent.

(Localities.) This variety was first found at the base of the Riesengebirge in Bohemia, near the river *Iser*; and hence its name. It is there disseminated in sand, which appears to have originated from granite.

(Geological remarks.) It appears from the preceding details, that, although this Oxide has most frequently been found in alluvial earths, it probably belongs to primitive rocks, from the disintegration of which it has proceeded.

In the *United States*, it has been found in *Virginia*, near Richmond. It is sometimes compact, and sometimes granular, and is associated with the red oxide of titanium. *(BRUCE.)*

SPECIES 3. SILICO-CALCAREOUS OXIDE OF TITANIUM.‡

This ore, which has nothing of a metallic aspect, presents a considerable variety of colors, most of which, however, may be referred to brown or yellow. Thus it is sometimes a deep chesnut or clove brown, hair brown, yellowish or reddish brown, or even violet or

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* Nigrin. WERNER. † Iserin. WERNER.

‡ Titane siliceo-calcaire. HAUY. Gelb Menakan-erz and Braun Menakan-erz. WERNER. Rutilite. JAMESON. Titane Nigrine. BRONGNIART. Le Nigrine. BROCHANT. Calcareo-siliceous titanitic ore. KIRWAN.

blackish brown; sometimes it is yellow of different shades, as isabella or wax yellow, yellowish gray or yellowish white; and sometimes it has a tinge of green, or is grayish white or bluish gray.—It is opaque, or translucent, sometimes at the edges only, and sometimes the paler crystals are transparent.

Its longitudinal fracture is foliated, though sometimes imperfectly; its cross fracture is conchoidal or even; and its lustre is often glistening, and a little resinous.—It usually scratches glass; but, though easily broken, is with some difficulty reduced to a fine powder.

Its spec. grav. varies from 3.23 to 3.51. One variety is rendered electric by heat, and, as is usually the case, exhibits both electricities.

This Oxide sometimes occurs in small amorphous masses, or in irregular grains, and very often presents itself in crystals, whose primitive form appears to be an obtuse octaedron, composed of two four-sided pyramids with rhombic bases. Nine or ten secondary forms have been observed.

Its more common form is an oblique four-sided prism, whose extremities usually exhibit a greater or less number of faces, oblique to the axis; the obtuse angle of this prism is about 136°50′.—Sometimes this prism is bevelled at each extremity (Pl. V, fig. 34.) by planes, standing on the obtuse lateral edges of the prism, and meeting each other at an angle of 60°.—Sometimes the preceding form is also bevelled on the solid angles, formed by the acute lateral edges at the base (Pl. V, fig. 35.) and the bevelling faces are parallel to the sides of the primitive octaedron.—Sometimes two obtuse solid angles of the prism, one at each base and diagonally opposite, are obliquely bevelled (Pl. V, fig. 36.); so that the prism becomes terminated by triedral pyramids.—Sometimes the prism is truncated on the four solid angles, where the obtuse lateral edges meet the base (Pl. V, fig. 37.); in addition to which the solid angles, formed by the acute edges at the base, are also sometimes bevelled.—In fine, this prism sometimes becomes hexaedral;—and sometimes it appears without any truncation or bevelment (Pl. V, fig. 38.)

The crystals are sometimes large, and sometimes very small; and some of them are much compressed or flattened; the lustre of their surface is sometimes very strong.

In some instances two crystals are so applied to each other by their lateral faces, as to form a projecting edge on one side, and a small *channel** on the other. Sometimes four crystals are thus grouped.

The crystals, which are thus united, become electric by heat, and their two summits possess opposite electricities.

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* Titane siliceo-calcaire canaliculé. HAÜY.

(*Chemical characters.*) On charcoal before the blowpipe, it is partially and difficultly fusible into a dark brown enamel. In a specimen from Passau, Klaproth found oxide of titanium 33, silex 35, lime 33 ;=101. A brownish specimen from Arendal yielded Abilgaard oxide of titanium 58, silex 22, lime 20.

(*Distinctive characters.*) It differs from epidote and actynolite in its crystalline structure.—From the red oxide of titanium it may be distinguished by the form of its crystals, or its inferior hardness, or color.—It is less hard, and less heavy, than the oxide of tin.

(*Geological sit. and Localities.* This species belongs to primitive rocks, in which it is sometimes so disseminated, as to form almost a constituent part. At Passau, in Bavaria, it is disseminated in an aggregate of feldspar, hornblende, quartz, mica, and steatite.—In Norway, at Arendal, &c. it occurs in granite, and in those primitive aggregates, which contain beds of magnetic iron ; it is sometimes associated with augite, wernerite, epidote, hornblende, &c.—Near Nantz, in France, it occurs in granite with hornblende.—Near Andernach, it is in very small, yellowish crystals, disseminated in sand. —Near Dissentis, on Mt. St. Gothard, it occurs in channelled groups on granite, with chlorite and crystals of adularia. The titanium from this locality is electric by heat.

In the *United States.* In *Maryland*, at Petapsco Falls, 10 m. from Baltimore, its crystals are disseminated in granite ; and at the Bare Hills in feldspar. (*Gilmor.*)—In *Pennsylvania*, near the Falls of the Schuylkill, 5 m. from Philadelphia, in granite or gneiss, or in veins of quartz, which traverse these rocks ; (*Wister.*)—also at London Grove, in Chester Co. in granular limestone, which also contains crystals of the red oxide of titanium and of yellow tourmaline. (*Conrad.*)—In *New Jersey*, at Newton, in Sussex Co. in small, semi-transparent, yellowish, rhomboidal prisms, imbedded in lamellar carbonate of lime with graphite ;—also at Wantage, in the same County, in yellow, flat, rhomboidal prisms, terminated by triedral summits ; these crystals, sometimes transparent, are imbedded in an aggregate of hornblende and feldspar, which constitutes a vein, traversing a granitic mountain. (*Bruce.*)—In *New York*, at Kingsbridge, in small, rhomboidal prisms with diedral summits, of a light dove color, in primitive limestone ;—also on Staten Island, near Fort Richmond, in yellowish gray crystals, sometimes large, in a gangue of feldspar and dark green hornblende ;—also near Peekskill, in an aggregate of feldspar, quartz, and hornblende ;—also near Lake George, in clove brown crystals, in an aggregate of feldspar and hornblende with graphite ;—also at Ticonderoga, in large yellowish gray, rhomboidal prisms, with diedral summits, in feldspar with hornblende and graphite.

The specimens from Staten Island, discovered by Drs. Prince and Bloodgood,—from Peekskill, discovered by Dr. Langstaff,—and from Ticonderoga, discovered by Col. Gibbs, are said greatly to resemble those of the same oxide from Arendal in Norway. (*Bruce*. See Min. Jour. v. i.)

Species 4. Octaedral Oxide of Titanium.*

It is always crystallized in acute, elongated octaedrons, consisting of two pyramids, whose faces are isosceles triangles, and whose bases are squares. The sides of these pyramids are inclined at the common base at an angle of 137° 10′; and the plane angles at the summits are each 40° 8′. This is the primitive form, and is divisible in directions parallel to all the sides, and to the common base, thus indicating the form of the integrant particles.

Sometimes the summits of the octaedron are truncated—sometimes they are replaced by four triangular faces (Pl. V, fig. 39.), standing on the sides of the pyramid—and sometimes by eight triangular faces.—The crystals are small; their surface has a strong lustre, nearly metallic, and is marked with feeble transverse striæ.

Its colors are indigo or blackish blue, brown or blackish brown, and sometimes pass to dark reddish or yellowish brown. Those varieties, which appear dark brown in certain positions, exhibit a metallic gray, when favorably situated to reflect the light. It is opaque, or translucent, and sometimes nearly transparent.

This ore of titanium is easily broken; and its fracture is foliated with a strong lustre. It scratches glass; has a spec. grav. of 3.85; and is a conductor of electricity.

(*Chemical characters.*) Before the blowpipe it is infusible by itself. With borax it is fusible into a glass, whose color varies according to the degree of heat, and the quantity of borax employed. Thus, with an equal quantity of borax, the glass is often emerald green; but, with a greater quantity of borax, a hyacinth red or reddish brown glass is obtained, which passes to blue or white, or again returns to reddish brown, according to the degree of heat. By the analysis of Vauquelin, it is nearly a pure oxide of titanium, sometimes containing a little silex.

It is distinguished from minute crystals of the sulphuret of zinc by its greater hardness and crystalline form.

(*Locality.*) It has been found only at Vaujani, near Oisans, in

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* Titane Anatase. Brongniart. Anatase. Hauy. Brochant. Octaedrite. Werner. Octaedrite. Jameson.

Dauphiny. It is attached to granite, and accompanied by crystals of quartz and adularia; or occurs in veins, which are composed of feldspar, quartz, mica, chlorite, axinite, and micaceous oxide of iron, and traverse gneiss and mica slate.

GENUS XXI. *URANIUM.*

Metallic Uranium is obtained with great difficulty, and its properties have been but little examined. According to Klaproth, its color is a dark gray with a metallic lustre. It has a fine granular texture, and is not hard. Its spec. grav. is 8.1, or, according to Bucholz, 9.00,

This metal is very difficultly fusible. Its oxide is soluble in diluted nitric acid, affording a yellowish solution, from which prussiate of potash throws down a deep brownish red precipitate, while that with the pure alkalis is lemon yellow. With tincture of galls it yields a small quantity of a blackish precipitate; but, on the addition of an alkali, the precipitate is copious and chocolate brown.—To the enamel on porcelain this oxide imparts a deep orange color.

It was called *Uranium* by Klaproth, its discoverer, in allusion to the name, given by the German Astronomers to the planet Herschel, and derived from the Greek Ουρανος.

SPECIES 1. BLACK OXIDE OF URANIUM.*

The color of this rare ore is black, often brownish, bluish, or grayish black; and its powder has the same color, as the mass. It is perfectly opaque. Its spec grav. lies between 6.37 and 7.50.

It is usually in amorphous masses, whose fracture is imperfectly conchoidal or uneven, and somewhat shining with the lustre of pitch or resin. Sometimes, however, its structure is granular, or slaty in one direction; or its masses may be said to be composed of lamellar or granular concretions. It may without difficulty be scratched by a knife. It is a conductor of electricity.

(Chemical characters.) It is infusible by the blowpipe. It dissolves in nitric acid with a disengagement of nitrous gas, and yields a yellowish solution. A specimen from Joachimsthal yielded Klaproth uranium slightly oxidated 86.5, sulphuret of lead 6.0, magnetic iron 2.5, silex 5.0.

(Distinctive characters.) Its high spec. gravity, its fracture, and the black color of its powder distinguish it from blackish sulphuret of zinc.—It is heavier than chromate of iron, and does not, like that ore, communicate to borax a green color.—Its fracture and the

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* Urane oxidulé. HAUY. BRONG. Pechers. WERNER. Pitch ore. JAMESON. L'Urane noir. BROCHANT. Sulphurated Uranite. KIRWAN.

color of its powder distinguish it from the ferruginous oxide of tungsten.

(Geological sit. and Localities.) This Oxide of uranium is found in small masses, disseminated in metallic veins in primitive rocks, and accompanying the sulphurets of lead, copper, silver, pyritous copper, native arsenic, ores of cobalt, &c. sulphate of barytes, carbonate of lime, indurated clay, &c. It is also associated with the green oxide of uranium.

It has been found at Joachimsthal in Bohemia, Schneeberg, &c. in Saxony, and Kongsberg in Norway.

Species 2. Green Oxide of Uranium.*

The colors of this oxide vary from emerald or grass green to yellowish green, or even straw yellow. It is sometimes crystallized, and sometimes amorphous. Its spec. grav. lies between 3.12 and 3.24. It is brittle, easily scraped by a knife, and is sometimes friable.

In nitric acid it dissolves without effervescence, yielding, when pure, a lemon yellow solution, if the acid be saturated. It is infusible by the blowpipe. It appears to be an oxide of uranium nearly pure, but sometimes contains a little copper or iron.

Var. 1. CRYSTALLIZED GREEN OXIDE OF URANIUM.† Its ordinary colors are emerald or grass green or yellowish green, but it is sometimes greenish or sulphur yellow. It is more or less translucent, and has often a strong external lustre.

The primitive form of its crystals is a rectangular prism with square bases, and it sometimes presents this form. But it more frequently appears in small rectangular plates, or in tabular crystals, composed of thin laminæ, applied to each other by their broader faces.—Sometimes the narrow faces of these tables are bevelled.—Sometimes also the crystals are octaedrons, either entire, or with truncated summits.

In some cases the laminæ are so grouped as to resemble a fan or sheaf; in other cases they are irregular, and appear like mere scales or thin plates on the surface of other minerals.—These laminæ, when separated, have a shining and somewhat pearly lustre, and are easily broken.

(Distinctive characters.) It much resembles green mica; but the laminæ of mica are flexible and elastic, while those of uranium are brittle, and do not bend; and further, mica is not soluble in nitric

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* Urane oxidé. Hauy. Brongniart.

† Urane oxidé micacé. Brong. Uran Glimmer. Werner. Uran Mica. Jameson. L'Urane micacé. Brochant. Micaceous uranitic ore. Kirwan.

acid.—The solution of this Oxide in nitric acid does not yield a blue precipitate with ammonia, unless in small quantity from the accidental presence of copper, and may thus be distinguished from solutions of the green ores of copper.—It does not, like muriate of copper, communicate a greenish blue color to flame.

(Geological situation and Localities.) These crystals or plates are usually disseminated in the fissures, or attached to the surface, of other minerals, especially the compact brown oxide of iron, black oxide of uranium, quartz, hornstone, granite, mica slate, indurated clay, &c.

It is found in Cornwall; at Johanngeorgenstadt, &c. in Saxony; in France, Hungary, &c.—In the *United States*, it has probably been observed in *Maryland*, near Baltimore.

2. EARTHY GREEN OXIDE OF URANIUM.* Its color is greenish yellow, sometimes sulphur or straw yellow. The shade of green, which is not always very obvious, may often be brought to view by moistening the surface; and sometimes, from accidental impurities, the yellow is mixed with a shade of brown or red.

It is sometimes in the state of a powder, forming a mere crust; and sometimes in small masses, either friable, or somewhat indurated with an earthy or uneven fracture, nearly or quite dull.

(Localities.) It most frequently accompanies the other ores of uranium; and of course has the same localities.—In the *United States*, this variety is supposed to exist in *Maryland*, near Baltimore; —and in *Maine*, at Brunswick.

GENUS XXII. *COLUMBIUM.* HATCHETT.†

Columbium may be extracted in the state of a white oxide from its ores; and this oxide may be reduced by a strong heat into a globule moderately hard, with a metallic lustre at its surface, and a dull grayish black fracture. This metallic substance is by the action of acids again converted into a white oxide.

This Oxide has a spec. grav. of 6.50. Its color is not changed in a red heat, nor does it communicate any color to borax, when fused with it. It is nearly insoluble in the nitric, muriatic, and sulphuric acids. Its proper solvent is potash or crystallized carbonate of potash. When fused with eight times its weight of carbonate of potash, a mass is obtained, which is soluble in water. If any of the three preceding acids be added to this solution, the oxide of Columbium is precipitated, and is not redissolved by an excess of acid. But the

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* Urane oxidé terreux. HAUY. Uran ocker. WERNER. Uran ochre. JAM.

† Tantalum. EKEBERG.

same oxide, if not permitted to become dry, is entirely dissolved by the oxalic, citric, or tartaric acid. Tincture of galls produces an orange colored precipitate in solutions of this oxide, provided there be no excess of alkali, or of the oxalic, citric, or tartaric acid. Any excess of the three last mentioned acids should be removed by carbonate of ammonia. Indeed when the tincture of galls is poured upon this white Oxide, recently obtained and still moist, an orange colored compound is also produced. (*Wollaston.*)

Species 1. Oxide of Columbium.*

Columbium has hitherto been found only in the state of an oxide, combined with the oxides of iron and manganese, or with the oxide of iron and the earth ittria. This native oxide, which is rare and but little known, may be described under two subspecies.

Subspecies 1. FERRUGINOUS OXIDE OF COLUMBIUM.†

When recently broken, its color is dark bluish gray or nearly iron black. Its surface, however, is usually blackish, smooth, and sometimes chatoyant. Its streak and powder are brown or brownish gray. It gives sparks with steel; and its spec. grav. appears to vary from 7.95 to 5.92.

It occurs amorphous, or in small masses about the size of a nut, which appear to be imperfect crystals, whose form is that of an octaedron or of a rhomboidal prism with additional faces. It breaks without difficulty; and its fracture is compact or imperfectly foliated, with a shining metallic lustre. It does not move the magnetic needle.

(*Chemical characters.*) If this ore be reduced to powder, and fused with five times its weight of carbonate of potash and twice its weight of borax, a deep green mass is obtained, from which diluted muriatic acid extracts the iron and manganese, leaving the columbium in the state of a white oxide. A specimen from Sweden yielded Vauquelin oxide of columbium 83, of iron 12, of manganese 8. In another from *Connecticut*, Mr. Hatchett found oxide of columbium about 78, of iron 21.

(*Localities.*) This ferruginous Oxide appears to have occurred in only two places, which, however, are widely distant from each other. One is in the parish of Kimito, in Finland, Sweden, where it is imbedded in veins of quartz or feldspar, traversing gneiss. The other locality is in the *United States*, and is said to be at New London, in *Connecticut;* but its precise situation is not known.

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* Tantale oxidé. Hauy.

† Tantale oxidé ferro-manganesifère. Hauy. Tantalite. Ekeberg. Jameson. Tantale Tantalite. Brong. Also the Columbite of *Jameson*.

(Remarks.) It appears, that only a single specimen of this Oxide from the United States has yet been observed. This specimen was transmitted by Gov. Winthrop to Sir Hans Sloane. It was found by Mr. Hatchett in the British Museum in 1801, and enabled him to become the first discoverer of this new metal, which he named Columbium. The ore itself has been called columbite.

Soon *afterwards* Mr. Ekeberg, a Swedish chemist, discovered the white oxide of a new metal, to which he gave the name of Tantalum. The ore, which contains it, he called tantalite.

About the year 1809, Dr. Wollaston, having obtained specimens of the Swedish ore, and a few fragments of the American specimen, instituted a series of comparative experiments. The result was, that both ores yielded white oxides perfectly similar in their most distinguishing properties. Five parts of the tantalite yielded him white oxide 4.25, oxide of iron 0.5, oxide of manganese 0.2. Five parts of the columbite afforded white oxide 4.0, oxide of iron 0.75, oxide of manganese 0.25.—Hence the identity of Columbium and *Tantalum* appears to be perfectly established; and the priority of Mr. *Hatchett's* discovery seems to claim for this new metal the name of Columbium.

Dr. Wollaston remarks, that the external surface, color and lustre of the fracture, color of the streak, and hardness are the same in the Swedish and American ores. The columbite, however, is more easily broken, its fracture is less uniform, and its spec. grav. is only 5.92, while that of the tantalite is 7.95. This low spec. gravity, he suggests, may arise from the state of oxidation, or from the existence of cavities.

According to a notice in v. ii. of the Medical Repository (New Series), the American specimen from New London was found near a spring, not far from the house of Gov. Winthrop.

SUBSPECIES 2. ITTRIOUS OXIDE OF COLUMBIUM.*

Its color is a dark metallic gray, or nearly iron black; its powder is gray. It is less hard than the preceding subspecies, and may be scratched by a knife, though not very easily. Its fracture is granular or uneven, and shining with a metallic lustre.—Its spec. grav. is at least 5.13. It is not magnetic.—It occurs in small masses, often about the size of a hazelnut.

This ore is said to contain about 45 parts of the oxide of columbium, the residue being *ittria*, oxide of iron, and perhaps of manganese.

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* Tantale oxidé Yttrifère. HAUY. Tantale Yttrifère. BRONG. Yttertantal. EKEBERG. Yttertantalite. JAMESON. Yttrotantalite. BROCHANT.

This mineral is found at Ytterby in Sweden. It is imbedded in the same feldspar, which contains the Gadolinite, and is associated with quartz and mica.

GENUS XXIII. *CERIUM.*

Cerium has scarcely been seen in a metallic state, and of course the characters of the pure metal are almost unknown. According to Vauquelin, there are two oxides of Cerium. The first or lowest oxide is white, and soluble in acids, yielding colorless or pale rose colored solutions.—The other oxide is red, and dissolves less easily in acids. In muriatic acid, however, even when cold, it is soluble with a disengagement of oxymuriatic acid gas; the solution is a pale greenish yellow. (*Murray.*)—Both these oxides are infusible by themselves, and their fusion is not effected even by the addition of the pure alkalis.—Solutions of the salts of Cerium are decomposed by the alkalis, yielding a white precipitate, which reddens, when heated. Prussiate of potash also gives a white precipitate in saturated solutions.

This metal was discovered by the Swedish chemists, Hisinger and Berzelius, who gave it the name of Cerium, in allusion to that of the planet Ceres.

Species 1. Oxide of Cerium.*

Its color varies from a pale rose red, or flesh red, sometimes with a tinge of yellow, to a brownish red or even brown. Its streak is grayish, but its fine powder is nearly reddish gray. It is opaque, or sometimes strongly translucent.—It scarcely scratches glass, and with difficulty gives sparks with steel.—It is amorphous, and has a compact or fine grained texture; its fracture is splintery or uneven with a moderate lustre. Its spec. grav. extends from 4.53 to 4.93.

(*Chemical characters.*) It is infusible by the blowpipe, although it loses from 6 to 12 per cent. of its weight, becomes friable, and assumes a bright yellow or reddish color. With borax a globule is obtained, which is greenish, while hot, but colorless when cold. According to Vauquelin, it contains oxide of cerium 67, silex 17, oxide of iron 2, lime 2, water and carbonic acid 12. Klaproth obtained oxide of cerium 54.5, silex 34.5, oxide of iron 3.5, lime 1.25, water 5.0;=98.75.

(*Locality.*) This ore is found in the copper mine of Bastnaes, at Riddarhyttan, in Sweden. It is associated with pyritous copper, the sulphurets of molybdena and bismuth, mica, hornblende, &c.

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* Cerium oxidé silicifère. Haüy. Cerite. Hisinger and Berzelius. Cérium Cérite. Brong.

INTRODUCTION

TO THE

STUDY OF GEOLOGY.

Section 1. *General Remarks.*

1. MODERN geology constitutes a very interesting branch of natural science. Its object is to ascertain the arrangement and mutual actions of the solid, fluid, and aeriform materials of the earth. To effect this object, it investigates the structure, position, direction, and relative situation of those large masses, beds, strata, and veins of minerals, which compose the exterior crust of this globe. Its researches extend also to the various alterations and decompositions, to which the mineral kingdom is subjected by the action of air, fire, and water. These changes may be gradual and slow, or violent and sudden. They are in part effected by rains, floods, tides, by lakes bursting their bounds, by the depression of land near seas, by the fall of mountains, by earthquakes, volcanic eruptions, &c.*

2. The study of geology cannot be pursued in the cabinet. It is not the structure of a single specimen nor of a whole rock, that must be observed; the examination must extend to the structure and relations of whole mountains and even chains of mountains. This study embraces a vast number of facts, extremely diversified in their nature, complicate, and often very difficult to investigate.—Hence one source of the various geological systems, which have been proposed. Hence also, it is obvious, that numerous and extensive observations must be collected, before any general principles can be deduced and received with confidence.

3. Some of the obstacles to geological investigations arise from the interruption or mutual intersection of the strata, and from the difficulty of determining the nature of certain rocks. Others proceed from the gradual disintegration of minerals; or from the more powerful action of torrents, earthquakes, and subterraneous fires,

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* See an enumeration of several important and extensive changes, produced by some of the above mentioned causes, Jameson's Mineralogy, v. iii.

by all which the original arrangement of rocks is more or less disturbed, and their aspect changed. And it must be added, that other obstacles, often by no means the least formidable, arise from the undue influence of some favorite hypothesis, warmly, but prematurely, embraced.

4. It is not, however, to be supposed, that imperfect and premature theories are peculiar to geology. They arise from the infant state of this science, and undoubtedly tend to promote its real progress, as they necessarily produce an accumulation of facts, for the purpose of support or attack.

5. A few of the simple minerals, already described, exist in sufficient quantities to become important subjects of geological inquiry. But most of those extensive masses or strata, with which geology is concerned, are compound minerals or aggregates, composed of two or more simple minerals, mingled in various proportions, and denominated *rocks*.

6. We have seen, that a correct and useful classification, or division into species and genera, may in some good degree be effected in simple minerals. But, in regard to *rocks* or compound minerals, the case is altogether different. These rocks are composed of two or more simple minerals, united in various proportions; and, in many cases, different rocks pass into each other by insensible shades. It is hence obvious, that they cannot admit distinctions, which are strictly *specific*.

7. In some cases, when the characters of two rocks are viewed in their extremes, they appear widely different; but, when examined near the point, where they approach each other, it is sometimes almost impossible to say to which of the two a given specimen belongs. In many rocks, the different ingredients are easily distinguishable by the eye, while, in others, they are so minute and intimately combined, that they can scarcely be discerned even by the assistance of a glass.

8. Advantage may, however, be taken of the two or three predominating and most constant ingredients, or of some one ingredient, which serves as a basis for the others, to establish distinctions between these aggregates; and thus to distribute them into different *sorts* or *kinds* of rocks. This classification of rocks has been effected by Werner with as much accuracy, perhaps, as the nature of the subject permits, in regard to all those rocks, which have fallen under his observation.

Sect. 2. *General view of the structure of the exterior crust of the Earth.*

9. Not only mountains and hills, but even the level and lowest parts of the earth, at a greater or less distance beneath the surface, contain vast masses or extensive strata of rocks. Sometimes only one kind of rock is present. But most commonly two or more different kinds of rocks occur together, and are arranged one *over* another in a *certain order;* or rather, if the strata be highly inclined or nearly vertical, they may be said to lie one *against* another in a certain order. And it is this *order of arrangement* or alternation of different rocks, which constitutes the most interesting point of geological inquiry.

10. One of the most general facts hitherto observed indicates a division of rocks into two great classes, viz. *primary* or *primitive* and *secondary* rocks.

11. Those *rocks*, which are denominated *primitive*, have a texture more or less crystalline, are totally destitute of organic remains or petrifactions, and, when both classes occur together, always lie *underneath* the secondary rocks;—and are hence supposed to have been formed before them. But although, in their *relative* situation, the primitive rocks are always *lowest*, yet, when secondary rocks are absent, the primitive often appear at the surface of the earth, and do in fact constitute the summits of the greater part of the highest mountains.—When primitive rocks are stratified, the strata are seldom horizontal; on the contrary, they are often *highly inclined*, and sometimes nearly or quite vertical. But, whether these strata were originally inclined, or whether, subsequent to their formation, they have been changed from a *horizontal* to an *inclined* position by the action of some powerful cause, is a question, on which the most distinguished geologists are divided in opinion.

12. *Secondary rocks*, on the contrary, though sometimes found on the summits of primitive mountains, are usually placed on the declivities of these mountains, or at their feet, or under the intervening vallies or plains. Their texture, though sometimes in part crystalline, is usually more or less earthy. They are often mechanical mixtures, composed of grains or fragments of primitive rocks, united by some cement. But their secondary character is most decidedly established by the remains of animals and vegetables, which they contain. Thus marine shells appear, not only in the horizontal strata of secondary rocks, but also in those, which are inclined, and placed at an elevation far above the present level of the sea. The shells are often so perfectly well preserved, that their most delicate parts may be recognised; and sometimes they constitute the greater part of certain secondary rocks.

13. In the *higher* secondary rocks, which border on primitive mountains, the strata are usually more or less *inclined*, and sometimes even vertical. But in hills of more moderate elevation, and in the lower and most level parts of the earth, the strata of secondary rocks are in general nearly or quite *horizontal.*

14. If these *horizontal* strata be penetrated in the vicinity of the higher and *inclined* strata, the *former* will always be found *lying over* or covering the *latter.* The same fact occurs, when the examination is made in level countries at a distance from the inclined strata; but, in the latter case, it is necessary to penetrate to a much greater depth to discover the inclined or primitive strata.

15. It is hence obvious, that the *higher* and *inclined* strata *do not rest upon* the lower and horizontal strata; but, on the contrary, the *horizontal* strata are usually *placed upon the declivities* of the higher and inclined strata. For the inclined strata of the higher secondary rocks so decline as to *pass under* the horizontal strata; and the *highest* strata of primitive rocks do in fact so slope and decline, as to *pass underneath* all the secondary strata.

It is also obvious, that those rocks, which have the lowest level, when referred to the sea or the general level of the country, are of the most recent formation; for they really lie over all the other rocks.

16. It is further evident, that the *higher* the level, at which any rock appears at the surface of the earth, the *older* is that rock; for it so declines as to pass under those rocks, which appear at a lower level.—The only exception to this general fact appears in those horizontal strata of secondary rocks, which sometimes rest on the summits of high mountains.

17. Primitive rocks, whether constituting the naked summits of hills and mountains, or covered by secondary rocks, have never exhibited any organic remains of animals or vegetables.—Hence they were undoubtedly formed before the existence of organized bodies.

18. But in the higher and older secondary rocks the remains of marine animals and marine plants begin to appear. These remains are, in general, well preserved, and belong to species and even genera, which do not exist in modern seas, nor even in the more recent of the secondary rocks.

19. As the strata become newer, the shells, which existed in the older secondary rocks, gradually give place to new species and genera of shells and other marine, organic remains; and in the most recently formed strata are found species of shells, &c. perfectly resembling those, which at present exist in the ocean. Remains and impressions of vegetables, belonging to dry land, are not uncommon;

and the most recent strata contain those of birds, quadrupeds, and freshwater productions.—Secondary rocks must therefore have been formed after organized bodies were greatly multiplied.

20. It should here be remarked, that some geologists have established a third class, composed of the newest of the primitive, and the oldest of the secondary rocks, to which they give the name of intermediate or *transition* rocks. In some of these rocks, the texture is partly crystalline, and partly earthy, and some of them contain petrifactions. This class is supposed to have been formed, while the earth was *passing* from a chaotic to a habitable state; and hence the term *transition*.

21. Both the primitive and secondary classes contain several different *sorts* of rocks, distinguished by their ingredients, structure, &c. And not only do the secondary rocks always lie over the primary, but the different kinds of rocks in each class have, in general, *a determinate arrangement*, or order of superposition. The exceptions do not appear to be numerous, and may in some cases be *only* apparent.

22. The same rock is, indeed, sometimes repeated, as in the case of granite, gneiss, limestone, &c. It is also to be remarked, that several members in each class may be wanting, either the highest, or lowest, or an intermediate member; so that any rock may in fact appear at the surface. But the general order of arrangement in each class is so nearly the same, that, though it may occasionally be varied, it can perhaps never be said to be inverted.—In the secondary horizontal strata, a certain series or alternation of rocks is sometimes confined to a small extent; and different series occur in different countries.

23. The preceding appear to be the leading facts, hitherto observed, in regard to the structure of the exterior crust of the globe. And, although more numerous, more extensive, and deeper observations are still necessary, the following general principles appear to be satisfactorily established.

1. The minerals, which compose the external crust of the globe, from the summit of the highest mountain to the lowest point hitherto explored, must at some former period have been in a fluid state;—and the solvent must unquestionably have been caloric or water.

2. There appears to be sufficient reason for believing, that by far the greater number of minerals have been deposited from a state of solution or suspension in water;—and of course that the sea, in a more or less tranquil state, has, at some former period, for a considerable portion of time, covered the tops of the highest mountains. The distinctly crystalline structure of most of the primitive rocks, and the

numerous regular crystals, which they contain, decidedly indicate a previous state of fluidity. And it seems no less certain, that this solvent must have been water.

The numerous organic remains, which exist in secondary rocks, unquestionably prove, that such rocks have been deposited from water. It is well known, that different sorts of secondary rocks have been deposited at different and successive periods. And it is equally evident, from an inspection of the organic remains in secondary rocks, that this ancient sea was *successively* peopled by different races of animals.*

Sect. 3. *Geological systems.*

24. It is, perhaps, universally admitted, that the *fluid agent*, employed in the formation of minerals, must have been either *water* or *caloric*. Hence two geological systems have arisen, according as the principal agency in the production of the mineral kingdom is attributed to water or caloric. Hence the *Neptunian* theory, on the one hand, and the *Vulcanian* theory, on the other. Hence the supporters of these theories are respectively called *Neptunians* and *Vulcanists*, or *Wernerians* and *Huttonians*

Wernerian theory.

25. At some former period this globe has, for a long time, been covered with water to a greater depth, than the original altitude of the highest mountains. This immense body of water was then tranquil, or very nearly so, and contained in solution all the materials, of which the present crust of the earth is composed. In this state, chemical deposites, exhibiting more or less of a crystalline structure, were gradually made, and invested the nucleus of the globe. These chemical deposites constitute the *primitive* rocks, consisting of granite, gneiss, mica slate, granular limestone, &c. and are distinguished by their crystalline structure, and by the total absence of organic remains. During this period most of the highest mountains were formed, for their summits consist of primitive rocks.

26. But, by a gradual subsidence of the waters, the summits of the highest mountains were left naked; the tranquillity of the waters was disturbed, and currents were consequently produced. By these currents, the naked rocks would be worn and partially disintegrated; and the grains or fragments, thus produced, would be diffused through the mass of water. The rocks, formed at this period, would of course consist partly of chemical and partly of mechanical deposites. They

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* See Essay on the Theory of the Earth; translated from the French of M. Cuvier, by Robert Kerr, with notes by Professor Jameson.

would also lie over the primitive rocks; but, in consequence of the diminished altitude of the waters, they would appear at a *lower* level, often resting on the declivities of primitive mountains.—Many of the rocks of this period contain organic remains of marine animals and marine plants.

As organic remains make their first appearance in the rocks of this period, it is supposed, that the rocky shores, which had recently emerged from the great deep, were *passing* to a habitable state. Hence this class embraces what are called *transition* rocks, consisting of gray-wacke, some varieties of limestone, greenstone, argillite, &c.

27. But the level of the great ocean still continuing to sink, more extensive portions of the earth were left exposed to the increasing violence of the currents; and the solution, which was originally chemical, now became in a great degree composed of grains or comminuted fragments, detached from the older rocks.—Hence the minerals of this period consist chiefly of mechanical deposites. They lie over the two preceding classes, but still appear at a *lower* level, in consequence of the greater subsidence of the waters.—Hence also they are found near the base of high mountains, or in hills of moderate height, or in vallies, or under plains, sometimes at a great distance below the earth's surface.—This class is composed of the *secondary* or *floetz* rocks, and embraces sandstone, most varieties of compact limestone and of gypsum, chalk, basalt, some varieties of greenstone, coal, &c.

Extensive portions of the crust of the globe had now become dry; new species and genera of animals inhabited the waters, or dwelt on the land, while numerous vegetables adorned the shores and other parts of the earth's surface. Hence the secondary rocks abound with organic remains both of animals and vegetables. Hence also the abundance of bituminous substances in this class, having proceeded from the decay of organized bodies.

28. There are a few exceptions to the general fact concerning the *low level*, at which secondary rocks usually appear; for they sometimes rest on the summits of mountains highly elevated. Basalt and wacke are among the secondary rocks thus found. These elevated strata of secondary rocks are supposed by Werner to have been deposited during a second and sudden rise of the ocean, after it had once greatly subsided.

29. The preceding deposites of rocks are supposed to have been *universal formations*, entirely surrounding the nucleus of the earth, like the coats of an onion. But various subsequent revolutions and changes have, in many instances, destroyed or concealed the continu-

ity of the strata. This universality in the formations of rocks is an important point in this system.

30. Two other classes of comparatively small extent, viz. alluvial deposites, and volcanic ejections, complete the series of mineral formations.

31. It is obvious, that the preceding theory recognises the general *facts*, which we have already stated (9—23) in describing the structure of the exterior crust of the globe. But, with many positions undoubtedly correct, it has interwoven others of a nature too hypothetical to be received with confidence. In some cases, it descends to a degree of minuteness in determining the arrangement and relative position of the individual rocks in the two great classes, which more recent and extensive observations have found to be inadmissible.

32. It has already been remarked (23), that there appears to be sufficient reason for believing, that most minerals have been deposited from a state of solution or suspension in water. But it is not to be supposed, that the aqueous or Neptunian theory is free from objections. Though its general outlines may be correct, we are yet unable to give its details. It seems, however, to be rather incumbered with difficulties, than absolutely confronted by existing facts. It is obliged to admit the existence of certain operations, which cannot be repeated even on a small scale, and whose processes cannot be described.

33. Among the difficulties, which attend this theory, are the sparing solubility of most minerals in water; the inclined or even vertical position of most of the primitive, and of some of the secondary, strata; and the apparent shooting of some veins *upward* into the incumbent rock.—But our limits confine us to mere outlines, and will not permit any further prosecution of this interesting inquiry.*

Huttonian theory.

34. In the theory of Dr. Hutton, so ingeniously illustrated, but unsuccessfully supported, by Professor Playfair, *caloric* constitutes the most important agent. This theory supposes the solid parts, which form the crust of the *present* globe, to have proceeded from the disintegration and destruction of *former* continents by the gradual action of the atmosphere and water; that the ruins of those *ancient* continents were transported by water and deposited at the bottom of *ancient* seas; and that these heterogeneous materials, thus deposited, were consolidated by the action of subterraneous *fire*, and by the

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* See Jameson's Mineralogy, v. iii.—Also an Outline of Mineralogy and Geology, by William Phillips.—Also Transactions of the Geological Society, v. i. and ii.—Also Essai sur la Geographie Mineralogique des environs de Paris. Par G. Cuvier et Alex Brongniart.

same agent were subsequently elevated to form the *present* continents. It further supposes, that gneiss and other stratified rocks were only softened, elevated, and sometimes variously inclined, while granite and other unstratified minerals were completely fused, and, in many cases, forced upward by this powerful agent through the incumbent strata.—Hence we find granitic summits, surrounded by gneiss, mica slate, &c.—Hence also metallic veins are filled from below by injections of melted matter.

35. By similar processes this theory provides for the disintegration and partial destruction of existing mountains and continents, and for their transportation to the bottom of present oceans, from which, by the action of subterraneous *fire*, they are again to be raised and constitute new and future continents.

36. In regard to the preceding theory we remark, that the materials, of which primitive rocks are composed, have a crystalline and uniform structure, are perfectly distinct from each other, and are frequently few in number. In stratified minerals there is, in general, a remarkably distinct and sudden transition from one stratum to another; and, in many cases, contiguous strata are totally unlike each other. Thus beds of shale, sandstone, limestone, coal, clay, &c. alternate with each other, and, in some cases, several times in succession. Indeed soft strata of clay are sometimes found under beds of limestone, &c. and *loose* sand is sometimes interposed between indurated strata.

It is sufficient to ask, could these facts exist, if minerals had been formed by the fusion of heterogeneous masses of sand and gravel, or consolidated by the injection of melted matter among loose grains of different substances promiscuously mingled? Could, for example, certain varieties of anthracite lose their bitumen by *heat*, and yet retain their pyrites, composed in part of *sulphur*?—On the contrary, the facts just stated would probably result from the formation of minerals in an aqueous fluid.

Sect. 4. *Veins.*

37. All veins appear to have once been open fissures, which have subsequently been filled by substances, that are usually more or less different from the surrounding rock. In some cases they have been filled by *successive* deposites of different minerals. Sometimes indeed only one mineral is present; but, most frequently, several substances occur in the same vein. Many of the saline and earthy minerals, most of the ores, and some aggregates more or less frequently occur in veins.

38. Veins, though sometimes parallel to the direction of the stra-

ta, more frequently traverse it, and may thus be distinguished from beds, which are always parallel to the contiguous strata. It has been remarked, that those veins, which occur in the vicinity of each other and contain the same minerals, are usually parallel; the fissures having probably been produced at the same time, and by the same cause.

39. In most cases, veins are much inclined to the horizon, and sometimes are almost vertical. They frequently dip in the direction of the declivity of the mountain.—It is an important character of veins, that they are often divided into several branches, which sometimes terminate in the contiguous rocks, and sometimes wind and return into the principal vein.

40. The *walls* of a vein are the rocks, contiguous to its two *sides* or saalbandes; and in many cases are undoubtedly the sides of the original fissure. The upper and lower sides of inclined veins are also called the *roof* and *floor* of the vein, or the *hanging* and *lying* sides.

The sides of veins, especially of metallic veins, are in general very determinate, being marked by a delicate seam, or by a layer of some indurated, argillaceous substance. In many cases, the walls of a vein appear to have undergone some alteration, and differ more or less from the same rock at a distance from the vein. Sometimes indeed the substance of the vein is intermixed with that of the walls.

41. The breadth of veins, more particularly of metallic veins, usually lies between a few inches and a few feet. But, in some instances, veins of calcareous spar, &c. have been observed more than 100 feet in breadth.

The length of veins, which, according to Jameson, seldom exceeds 6000 ft. may, however, vary from a few feet to several miles.

Few veins have been explored to so great a depth as that at Küttenberg, in Bohemia, where a shaft has been sunk 3000 feet. In the metallic veins of Cornwall are two or three mines about 1300 ft. deep.—Many veins cease to be metalliferous at the depth of 1200 or 1500 feet.

42. The different minerals, which fill some veins, are irregularly aggregated. But it is often the case, that veins have a regular structure, being composed of a greater or less number of layers of different substances parallel to the walls. The same order or alternation of layers exists from both walls to the middle, like the leaves of a book, so opened as to form an acute angle. Thus, if quartz be contiguous to the wall on one side, it will have the same situation on the other; if sulphuret of lead be the second layer on one side, it will also be the second on the other, and so on. And further, each succeeding layer, estimating from the walls, is *impressed* by the crystals of each preceding layer.

43. Veins are of different ages; that is, some fissures were formed, after others had been filled. Hence veins often intersect each other; and the *intersecting* vein is obviously the newest. Sometimes one vein either meets, or barely enters another, to which it runs parallel for a while, and then diverges at the same angle, at which it met or entered. Indeed, when one vein traverses another at a certain angle, it sometimes runs parallel on the other side, and then diverges at the same angle.

44. Sometimes the beds or strata on the opposite sides of a vein, or on its roof and floor, have the same direction, and lie in the same plane, whether inclined or horizontal. But, in other cases, the strata on the *roof* or *upper* side of the vein are *depressed* to the depth of many feet or yards below the corresponding strata on the other side. This is called a *shift* of the strata; those on one side of the vein seeming to have *slidden down*, while those on the other have retained their original position.—Sometimes also, when one vein is intersected by another, the two portions of the intersected vein, together with the rock, which contains them, are separated to the distance of several yards in a *lateral* direction.

45. Veins sometimes contain cavities from a few inches to several feet in their dimensions. These cavities, called *druses* by the miners, have their interior studded with crystals, and are sometimes filled with water.

Water-worn pebbles and even petrifactions sometimes occur in veins. In Thuringia is a vein of marl, containing shells of a different kind from those in the limestone, which the vein traverses.

46. Geologists are not agreed in regard to the cause of those fissures, which now constitute veins. Some attribute them to unequal support in different parts of the same mountain, in consequence of which the unsupported part separates and sinks; others ascribe them to the desiccation and cracking of strata; while others suppose, that the agency of earthquakes and subterraneous fire has been employed.

Both Neptunians and Vulcanists are ready to admit, that veins were once open fissures. But while the *former* would introduce the contents of these veins from a solution of water *above*, the *latter* would inject them from a fiery furnace *beneath*.

Sect. 5. *Strata and Beds.*

47. When a single rock, or a mountain, composed of only one kind of rock, is divided by seams into parallel layers, it is said to be *stratified*, or divided into strata. But, when tabular masses of different rocks lie contiguous to each other, or when one tabular mass

is contained in another rock, such masses are said to occur in *beds.* Thus beds of limestone or feldspar occur in gneiss. Beds are parallel to the strata, which contain them, are themselves often stratified, and seldom contain a great variety of minerals.

Strata are sometimes straight, and sometimes curved or undulated; and their upper extremities, which appear at the surface of the earth, are called their *outgoings.*

In examining stratified rocks, it is important to ascertain their *dip*, or inclination to the horizon, their general direction, &c.*

Sect. 6. *Mineral Formations.*

48. The word *Formation* may signify a single mass of one kind of rock, more or less extensive, or a collection of mineral substances, formed by the same agent, under the same or similar circumstances; —or it may convey the idea, that certain masses or collections of minerals were formed not only by the same agent, but also at the *same time.* In this latter sense, indeed, the term is almost always employed. The agent and time are to be determined by a careful examination of the external and internal relations of the whole formation.

Sect. 7. *Wernerian arrangement of Rocks.*

49. The following Tabular View of rocks, and of such simple minerals, as occur in large masses, is extracted from Prof. Jameson's System of Mineralogy, v. iii.

Class I. *Primitive Rocks.*

Granite.
Gneiss.
Mica-slate.
Argillite. (Clay-slate.)
Primitive Limestone.
Primitive Trap.†
Serpentine.
Porphyry.
Sienite.
Topaz Rock.
Quartz Rock.
Primitive Siliceous Slate.
Primitive Gypsum.
White-Stone.

The first four of the preceding rocks are the most extensive and important; and in them, many of the other primitive rocks occur in *subordinate* beds.

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* See queries, proposed by the London Geological Society; published in Bruce's Min. Journal, v. i. p. 43.

† See remarks on the word *Trap.*

CLASS II. *Transition Rocks.*

Transition Limestone.
Transition Trap.
Gray-Wacke.
Transition Siliceous Slate.
Transition Gypsum.

CLASS III. *Secondary or flœtz Rocks.*

First, or Old Red Sandstone.
First, or Oldest Flœtz Limestone.
First, or Oldest Flœtz Gypsum.
Second, or Variegated Sandstone.
Second Flœtz Gypsum.
Second Flœtz Limestone.
Third Flœtz Sandstone.
Rock-Salt.
Chalk.
Flœtz Trap.
Independent Coal formation.*
Newest Flœtz Trap.†

CLASS IV. *Alluvial Deposites.*

CLASS V. *Volcanic Productions.*

The Wernerian nomenclature of rocks is undoubtedly susceptible both of addition and improvement. There are, in fact, a number of aggregates, which have never received distinct names; but most of them, especially when connected with a short description, may be referred to some of the aforementioned rocks.

50. It has been already remarked (5), that most of the minerals, which occur in sufficient quantity to be the subject of geological investigation, are rocks, or aggregates, composed of different simple minerals.

The following is a *Tabular View* of the different kinds of rocks, described in this volume, and also of certain simple minerals again mentioned.

1. Granite.
2. Gneiss.
3. Mica-Slate.
4. Argillite.
5. Limestone.
6. Trap, or Hornblende.
7. Greenstone.
8. Porphyry.
9. Sienite.
10. Topaz-Rock.
11. Gray-Wacke.
12. Amygdaloid.
13. Sandstone.
14. Pudding-stone.
15. Breccia.

A notice of Alluvial Deposites, and Volcanic Productions will be subjoined.

1. GRANITE.‡ *KIRW. JAM. BROCH.*

This rock is composed of *feldspar*, *quartz*, and *mica*, united to each other without the intervention of any cement. Its structure is

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* See the species *Coal.*

† Among the rocks, belonging to this formation, are basalt, wacke, clinkstone, greenstone, &c.

‡ Granit. WERNER. Roche feldspathique. HAUY.

granular; but the grains are extremely variable both in size and form, not only in different masses, but often in the same mass.

Most frequently, perhaps, the size of the grains lies between that of a pin's head and of a nut. Sometimes, however, the grains are several inches or even more than a foot in some of their dimensions, and sometimes they are so minute, that the mass resembles a sandstone, or even appears almost homogeneous to the naked eye.

The form of these grains is, in general, altogether irregular, like that of the fragments of most minerals. Sometimes the length, breadth, and thickness are nearly equal, and sometimes the length much exceeds the other dimensions. In some Granites the feldspar, or quartz, or even the mica is in crystals more or less regular.

The ingredients of Granite vary much in their proportions; but, in general, the feldspar is most abundant, and the mica is usually in the smallest proportion. Their arrangement also is various; sometimes, while the feldspar and quartz are mingled with considerable uniformity, the mica appears only in scattered masses, or is found investing grains of feldspar and quartz on all sides. In other cases, the feldspar and mica, or quartz and mica, are mingled, while the third ingredient appears in small distinct masses.

One of the ingredients of this rock, most frequently the quartz or mica, may be entirely wanting through a greater or less portion of the mass; so that specimens of true Granite sometimes contain only two ingredients.

In some Granites, quartz, or feldspar, or sometimes mica forms tabular masses of considerable extent, or even veins.

The predominant color of Granite usually depends on that of the feldspar, which may be white or gray, sometimes with a shade of red, yellow, blue, or green, and sometimes it is flesh red.—The quartz may be white, grayish white, or gray, sometimes very dark; but it is usually vitreous and translucent.—The mica may be black, brown, gray, silver white, yellowish, violet, &c.

The ingredients of Granite, though seldom in regular crystals, are in most cases very obviously the result of crystallization. The feldspar is sometimes impressed by the quartz, and sometimes also the quartz by the mica.

The simple minerals, which enter into the composition of Granite, are, in general, so intimately united, that the mass is firm and solid; but some varieties are brittle, and easily become disintegrated. The feldspar sometimes undergoes a partial decomposition, losing its lustre, hardness, and foliated structure, while, at other times, it is converted into porcelain clay.—The mica also, when exposed to the air, is subject to alteration or even decomposition.—Sulphuret of iron, which is sometimes disseminated in Granite, furnishes by its own decomposition sulphuric acid; and this acid acts upon the mica in its vicinity, thus producing a soft substance resembling steatite, and diminishing the firmness of the Granite. Indeed the beauty and utility of many Granites are sometimes almost destroyed by sulphuret of iron.—Granite, which embraces schorl, is often liable to disintegration.—Some varieties are divisible into imperfect columnar concretions.

The spec. gravity of Granite generally lies between 2.5 and 2.6; but is sometimes higher.

Granite with fine grains often embraces large grains of feldspar or quartz irregularly disseminated, or contains small masses or veins of coarse-grained Granite; and, on the contrary, Granite with coarse grains sometimes contains small irregular masses or even veins of fine-grained Granite.

Among the varieties of Granite, a few deserve particular notice.

1. GRAPHIC GRANITE. This very beautiful variety of Granite is composed chiefly of feldspar and quartz. The feldspar is very abundant, forming a base, in which quartz under various forms lies imbedded. When this Granite is broken in a direction, perpendicular to that, in which the quartz traverses the feldspar, the surface of the fracture ordinarily presents the general aspect of *letters*, arranged in parallel lines; and hence its name. Sometimes the quartz is not arranged in any determinate order, but appears in points, triangles, imperfect crystals, &c. irregularly scattered in the feldspar. The transition from this to the common variety is often very sudden.

These letters of gray, vitreous quartz on a shining and polished tablet of white or flesh colored feldspar appear extremely beautiful.—It is principally this variety of Granite, which, by its decomposition, furnishes porcelain clay. (See kaolin.)

This Granite is found in the Uralian Mountains, France, Portsoy in Scotland, &c.

It occurs in various parts of the *United States;* but is found peculiarly beautiful in *Maine*, at Topsham, and Bowdoinham.

2. GLOBULAR GRANITE. This is composed of large, globular distinct concretions, which are sometimes several feet in diameter. These concretions are united by a kind of Granite, which is readily disintegrated, thus leaving the globular masses detached from each other.—Fine specimens of this variety occur in the island of Arran.

3. PORPHYRITIC GRANITE. This variety is produced, when large crystals of feldspar are interspersed in a fine grained Granite.

(Geological remarks.) Granite is always a primitive rock; and never embraces any organic remains of animals or vegetables. In

fact, its relative situation entitles it to the rank of the *oldest* of the primitive rocks.

This rock occurs in masses, which are often extremely large, and sometimes in veins. Sometimes also its masses appear to be stratified, presenting thick beds or strata.

But, although Granite is always a primitive rock, it appears to have been deposited at different periods.

When associated with other rocks, Granite is, in *most cases*, the lowest rock; hence we so often find it covered by gneiss, mica-slate, &c. The oldest formations of Granite are sometimes traversed by veins of Granite, which of course are more recent, than the rock, which contains them.

The latest formations of Granite are found resting on other primitive rocks, or alternating with them, as gneiss, mica-slate, argillite, &c. or in veins, traversing these rocks. These veins are sometimes insulated, and sometimes connected with masses of Granite. Indeed these veins often contain fragments of other primitive rocks.—It should, however, be remarked, that apparent veins of Granite, which seem to traverse gneiss, &c. may sometimes arise from great inequalities on the surface of the lowest formation of Granite; for these inequalities, projecting upwards, must in fact penetrate the gneiss, or other superincumbent rock, which has been deposited *upon* the Granite, and of course *around* the aforesaid inequalities.

A remarkable example of veins of Granite is said to exist at New Galloway, &c. in Cornwall, where the Granite is covered by gray-wacke. Portions of the Granite project into the incumbent rock, like the roots of a tree penetrating into the earth; and these granitic branches or veins are entirely surrounded by the gray-wacke, except at their thickest extremities, where they are united to the mass of Granite.*

In some instances Granite is entirely covered by other rocks; but very frequently it rises into peaks, or forms the summits of mountains; and, in this case, other rocks appear at a lower level, resting on the declivities of the Granite.

Granite is a rock, which exists very extensively; and, in many countries, it occurs in immense quantities. It constitutes a large portion of many of the highest mountains, of which it appears to form the central parts, as well as the summits.—It also occurs in situations comparatively low, either having never been covered by other rocks, or having been left naked by the disintegration and removal of those rocks, which once rested upon it.

* Edinburgh Review, v. xix. p. 219.

Masses of Granite often present high and steep precipices. They are frequently traversed by fissures, which imbibe moisture; and hence, in consequence of the varying temperature of the weather, fragments of various sizes separate from the mass, and accumulate on the sides, or at the foot, of the mountain.

Various simple minerals are sometimes disseminated in Granite. Among these are schorl or tourmaline, garnets, emerald and beryl, pinite chlorite, talc, steatite, topaz, hornblende and actynolite, sulphate of barytes, fluate and phosphate of lime, &c. Fine crystals of quartz, adularia, &c. are found in the cavities of Granite.—Sometimes also this rock embraces large masses or even beds of feldspar and quartz.—Indeed at Mt. Perdu in the Pyrennees, according to Lapeyrouse, masses of limestone are sometimes contained in Granite, or the two minerals alternate with each other.*

The various metals, which occur in Granite, are sometimes in beds, but more frequently in veins, or disseminated through the mass. Among the ores, thus found, are those of tin, iron, molybdena, tungsten, uranium, titanium, and sometimes those of manganese, arsenic, cobalt, zinc, lead, bismuth, copper, silver, and gold.

(Localities.) On this subject it is sufficient to remark, that Granite presents itself more or less abundantly in the mountains of Scotland and Germany, the Alps, the Carpathian, Uralian, and Altain mountains, the Andes, the *United States*, &c. &c. &c.

(Uses.) Granite, in most of its varieties, constitutes a very valuable, and frequently a very beautiful, building stone.

Granitic aggregates.

We have already remarked, that one of the ingredients of Granite may be wanting; and also that various simple minerals may be disseminated through Granite. Hence specimens of this rock may occur, containing only two of the ingredients of Granite, although, at the same time, three or four simple minerals may be present.

Thus we often find aggregates of feldspar and mica—quartz and feldspar—quartz, mica, and garnet—quartz, feldspar, and schorl—feldspar, mica, and hornblende—quartz, mica, schorl, and garnet, &c.

But, by *granitic aggregates*, we more particularly intend those granular compounds, consisting of two, three, or four simple minerals, among which only *one* of the essential ingredients of Granite is present. It is true, that specimens of this kind may sometimes proceed from a real Granite; but, in many cases, they certainly belong to aggregates, forming large masses, or even whole mountains, and ought without doubt to receive distinct names.

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* Journal des Mines, Tom. VII, No. 37.

Among the granitic aggregates, which contain only one ingredient of Granite, we mention quartz and hornblende—quartz and actynolite—feldspar and schorl—mica and hornblende—quartz, hornblende, and garnet—quartz, hornblende, and epidote, &c. &c.

A remarkable example of an aggregate of quartz and hornblende occurs between Bodmin and Truro, in Cornwall. This aggregate, which is there called the *Roach Rocks*, covers nearly an acre of ground, and rises in steep precipices to the height of 60 ft. The quartz is predominant, and both ingredients are much crystallized.*

That, which has been called the *globular granite of Corsica*, presents itself in small oval, or globular masses, composed of concentric and alternate layers of quartz and hornblende or deep green actynolite. These globules are united by a paste, composed chiefly of the same ingredients, confusedly mingled.

In fine, granular aggregates, which contain no ingredient of Granite, and which have hitherto received no distinct name, are sometimes found, and can be made known by description only.

Mr. Kirwan has proposed for those granular aggregates, which differ from true granite, certain *specific names*, to which, however, the names of the several ingredients must be subjoined. Thus, a compound, embracing only *two* ingredients, as quartz and schorl, he calls a *granitell*—if *three* ingredients are present, but different from those of granite, he calls it a *granatine*—but, if there be *more than three* ingredients, he proposes the name of *granilite*.

2. GNEISS.† *WERNER.*

This rock, like granite, is composed of *feldspar*, *quartz*, and *mica*. But its structure is always more or less distinctly *slaty*, when viewed in the mass; although individual layers, composed chiefly of feldspar and quartz, may possess a granular structure. The layers, whether straight or curved, are frequently thick, but often vary considerably in the same specimen; and, when the mineral is broken perpendicularly to the direction of its strata, its fracture has commonly a striped aspect.

This rock, though always more or less slaty in its structure, is but seldom perfectly *fissile*. It however splits most easily in the direction of the strata, and especially when the separation is made in a layer of mica.

There is in Gneiss less feldspar and more mica, than in granite; but even in Gneiss the feldspar appears in many cases to be the predominant ingredient. When Gneiss is broken in the direction of the

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* Edinburgh Review, v. xix. p. 217.

† Gneiss. KIRWAN. BROCHANT. JAMESON.

strata, the mica often seems to be more abundant, than the *other* ingredients; but, when seen on the cross fracture, it obviously exists in less proportion than the feldspar or quartz.

When Gneiss approaches granite, the feldspar becomes more abundant, and the structure more granular; but, when it is passing into mica slate, the feldspar diminishes, and the quartz and mica increase in quantity, and the texture becomes more slaty.

The plates or foliæ of mica are usually arranged parallel to the direction of the strata, and in some varieties are chiefly collected into thin parallel layers, separated by those of feldspar and quartz. The grains of feldspar are often flattened in the direction of the strata.

The feldspar is usually white or gray, sometimes with a tinge of yellow or red. The quartz is ordinarily grayish white; and the mica is often black, sometimes gray, &c.

The hardness of Gneiss is variable; and the feldspar and mica are subject to the same changes, as when they exist in granite.

1. GLANDULOUS GNEISS. This variety, in which the mica is sometimes arranged in undulated layers, presents numerous small masses of feldspar or quartz, of a globular or elliptical form, interspersed, like *glands*, through the mass. Sometimes its structure is almost granular.

(Geological remarks.) Gneiss, like granite, never embraces any petrifactions, and is always a primitive rock. It, however, appears to have been deposited at different periods.

When Gneiss occurs with granite, it usually lies immediately over the granite; or, if the strata be highly inclined, it appears rather to rest against the granite, than to be incumbent upon it. Hence Gneiss is to be considered the oldest rock, next to granite. Hence also, when it thus rests on the sides of mountains of granite, its outgoing, or the level, at which it appears, is lower than that of the granite.

The more recent varieties of Gneiss sometimes alternate with other primitive rocks. They are sometimes covered by the later formations of granite; and sometimes they rest on mica-slate, or even on argillite.

Gneiss is always more or less distinctly stratified, and the strata are often inclined to the horizon at a very great angle; indeed they are sometimes nearly or quite vertical. The inclination and direction of the strata often continue the same over a very considerable extent of country.

This rock, as already intimated, sometimes assumes a granular structure, and passes by imperceptible shades into granite.

In the older varieties of Gneiss, the three ingredients are often in distinct layers, which have an undulated direction.—In varieties more recent, the ingredients are more mingled;—and, when passing into mica-slate, the layers become thinner, the structure more perfectly slaty, and the mass more fissile.

Mountains, composed of Gneiss, are seldom so steep as those of granite; and their summits are usually rounded.

Gneiss often contains schorl or tourmaline, garnets, hornblende, actynolite, and sometimes emerald, beryl, zircon, chrysoberyl, talc, &c. The hornblende is sometimes very abundant; and some varieties of Gneiss gradually pass into hornblende-slate or greenstone-slate.

But, in addition to the aforementioned simple minerals, scattered through the mass, Gneiss often embraces *beds* of both simple and compound minerals. Among these are beds of granular limestone, hornblende, hornblende-slate, greenstone, greenstone-slate, porphyry, potstone, quartz, anthracite, &c.

Few of the primitive rocks are so metalliferous as Gneiss. Its ores occur both in beds and veins; but more frequently in the latter.

Gneiss, like granite, is somewhat irregular in its composition. Sometimes the mica almost entirely disappears, and is replaced by hornblende or actynolite. In some cases beds of Gneiss pass into an aggregate of feldspar, mica, and hornblende—or quartz, feldspar, and hornblende, &c.

(Remarks.) This rock exists very abundantly in many countries. It is very common in some parts of the *United States.*—A large number of the Saxon and German mines are situated in Gneiss. —It is a useful rock for many purposes, in consequence of the facility, with which it splits into masses of a regular form.

3. MICA-SLATE.* *JAMESON.*

Mica-slate is essentially composed of mica and quartz, which are, in general, more or less intimately mingled; but sometimes the two ingredients alternate in distinct layers. Although the proportions of mica and quartz are variable, the mica usually predominates.

The quartz is most frequently grayish white; but the mica may be whitish or gray, greenish or bluish gray, brownish or yellowish gray, deep blue, or nearly black.

Its structure is always distinctly slaty, usually more so than that of gneiss; and its masses are often very fissile. The layers are sometimes straight, and sometimes undulated. In some varieties the

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* Glimmer-Schiefer. WERNER. Schiste micacé. BROCHANT. Schistose Mica. KIRWAN. Quartz micacé. HAUY. Micaceous Schistus.

texture is very fine, and the foliæ of mica so small, that they are scarcely discernible by the eye, unless their aggregation be previously destroyed by heat.

This rock has often a very high lustre, when viewed by the reflected rays of the sun. It is, however, subject to decomposition, by which its aspect is much altered.

(Geological remarks.) Mica-slate is always a primitive rock, and never contains any petrifactions. But, like the other primitive rocks, it appears to have been formed at different periods.—In some of the older varieties, which pass into gneiss, the texture is somewhat coarse, and the mass imperfectly fissile; while, in more recent varieties, which approach very nearly to argillite, the texture becomes very fine, and the mass completely fissile.

When Mica-slate occurs in the same mountain or district with gneiss, or with granite and gneiss, it ordinarily rests on the gneiss, or, if granite only be present, it rests upon that. This relative situation gives it the third rank, in point of age, among primitive rocks. Its strata are often highly inclined, and sometimes even vertical.

When this rock exists in the same mountain with gneiss, it appears at a lower level, than that of the gneiss; and of course it ordinarily occurs at a considerable distance from the principal summit of the mountain.—It sometimes alternates with gneiss, or other primitive rocks.

Mica-slate seldom appears in high and steep cliffs, like those of granite. When it forms whole hills, the summits are usually much rounded; and the general aspect of those districts, in which this rock abounds, is often undulated, presenting long elevated ridges, separated by vallies of a moderate breadth.

The older varieties of Mica-slate sometimes contain a little feldspar, and very frequently embrace garnets, among which the precious garnet is often found. Schorl or tourmaline, hornblende, staurotide, cyanite, and carbonate of lime are sometimes disseminated through this rock.

Beds of various simple minerals, among which are granular limestone, hornblende, hornblende-slate, serpentine, and sulphate of lime, sometimes occur in Mica-slate, or even alternate with it.

Mica-slate abounds with ores, which exist both in beds and veins, but more frequently in beds. Garnets and actynolite often occur in these metallic beds.

This rock sometimes passes into chlorite-slate, and sometimes resembles hornblende-slate, or an argillaceous slate containing hornblende.

(Remarks.) This rock is abundant, but less so than gneiss. It

occurs more or less in several parts of the *United States.*—Many of the Saxon, Bohemian, and Hungarian mines, and those of Delicarlia and Fahlun in Sweden are situated in Mica-slate. (*Jameson.*)

It is sometimes split into tabular masses, and employed for many common purposes.—When free from garnets and other foreign minerals, it is very difficultly fusible, and is extremely useful in constructing the hearths and sides of furnaces for melting iron, &c.

4. Argillite.

Argillite has a homogeneous aspect, and is generally supposed to be a simple mineral. Some mineralogists, however, are inclined to consider it an aggregation of simple minerals in a state of very minute division. It occurs in extensive strata, and forms not only whole mountains, but even chains of mountains. Its geological relations are important, and have already been briefly mentioned, p. 360, &c.

Argillite, it will be recollected, is not always found in primitive mountains. It is sometimes associated with transition or even with secondary rocks.—When primitive, it very often rests on mica-slate, but occurs at a lower level, or lies nearer to the foot of the mountain.—The oldest varieties have the strongest lustre, and alternate with beds of other primitive rocks.

In common with gneiss, Argillite contains beds of granular limestone, hornblende, greenstone, &c. and, in addition to these, it sometimes embraces beds of novaculite, chlorite-slate, indurated talc, potstone, aluminous slate, graphic slate, and siliceous slate.

5. Limestone.

This very interesting mineral has already been described under the species, carbonate of lime, and its geological characters there given. We here add or repeat a few general remarks.

Limestone is found in the three great classes of rocks, primitive, transition, and secondary, but most abundantly in the last; it is also not uncommon in alluvial deposites.

Primitive Limestone has always a granular structure; but the size of the grains or granular concretions is variable, and seems in some degree to correspond with the relative age of the mineral.—Thus the Limestone, which occurs in beds in gneiss, and which, of course, is supposed to belong to the oldest formation, has usually a coarse texture, and large granular concretions. But, when its beds exist in mica-slate or argillite, its texture becomes more or less fine grained, and its color is often less uniform, than in the older formations. Indeed in some of the more recent formations of primitive

Limestone, the texture is so compact, that the distinct concretions can be discovered only by the glimmering lustre of the foliated fracture.

Limestone has, in but very few instances, been observed in connexion with *granite;* nor is it certain, that this granite belongs to the lowest or oldest formation of this rock.

Transition Limestone has a texture more or less compact; its colors are much variegated; and it often contains a greater or less number of petrifactions.—It sometimes rests on primitive argillite, and is associated with gray-wacke, and other rocks of contemporaneous formation. It often occurs on the sides, or near the foot of mountains.

As primitive and transition Limestones gradually unite, so also the latter passes by imperceptible shades into that, which is decidedly secondary.

Secondary Limestone has a compact texture, a dull fracture, and usually contains a greater or less number of shells, and sometimes other organic remains. It is always stratified; but the strata are sometimes inclined, and often horizontal. It is associated with sandstone, gypsum, marl, clay, &c.

Limestone, under the name of calcareous tufa, is often found in alluvial deposites. It is sufficiently characterized by its structure and situation, and by the vegetables, fluviatile shells, and remains of quadrupeds, which it often contains.

The term *calcareous* is applied to those beds or mountains, which are composed of *carbonate of lime,* under any of its forms.

6. TRAP OR HORNBLENDE.

The word *Trap* has been often employed in so loose and indeterminate a sense, that it has been productive of much ambiguity and misunderstanding among mineralogists. This word is derived from the Swedish *Trappa,* which is said to signify a stair, or series of steps. It was hence originally applied to certain rocks, whose beds or strata, in consequence of the action of the weather on their edges, assumed the form of steps or stairs, and retreated in ascending.

But, without attempting to ascertain the various substances, to which the word Trap has been applied in different countries, and by different writers, two remarks, in regard to the present acceptation of this term, will be offered.

Mr. Kirwan, in his mineralogy, has employed the word Trap as the name of a *species,* which he has divided into two families, viz. common trap—and figurate trap or basalt. Both these families are described in this volume under the name of *basalt.* In fact, the two varieties, called *common* or *amorphous trap*—and *figurate* or *columnar trap*, or *basalt*, do not differ in any one important character, excepting form; they are composed of the same ingredients, and, according to Bergman, in the same proportions.

But, in modern geological inquiries, the word *Trap* is usually employed to designate a simple mineral, composed of *hornblende* nearly or quite pure, and also those aggregates, in which *hornblende* predominates. Hence, the *presence of hornblende*, as a predominating ingredient, characterizes those minerals, to which most geologists apply the name, *Trap*.

Trap rocks are found in primitive, transition, and secondary mountains.

In *primitive Trap*, the hornblende occurs nearly or quite pure, or is united chiefly with feldspar, forming several varieties of greenstone. But more recent formations of Trap, found among transition rocks, are contaminated by a ferruginous clay; and in some of the *secondary* traps, this blackish, indurated, ferruginous clay seems to take the place of hornblende.

Among Trap rocks may be enumerated hornblende, hornblende-slate, greenstone, greenstone-slate, amygdaloid, basalt, wacke, and clinkstone porphyry.[*]

It is hence obvious, that the word, *Trap*, is not uniformly confined to those rocks, in which hornblende predominates; but is also extended to some other rocks, which have similar geological relations to those, which are more strictly called Trap.

It is also obvious, that, although Trap may be a convenient word to designate a certain series of rocks, of which a greater or less number are often associated, it in fact conveys no definite idea of any one species or sort of rocks.

7. GREENSTONE.[†] *JAMESON*.

Greenstone is essentially composed of *hornblende* and *feldspar* in the state of grains, or sometimes of small crystals. The proportions are somewhat various; but the hornblende predominates, and very frequently gives to this aggregate more or less of a *greenish* tinge, especially when it is moistened. Hence the name of this rock.—Sometimes the tinge of green is considerably lively, and may arise either from the hornblende, or from epidote disseminated through the mass. Sometimes also its color is dark gray, or grayish black. In fine, its

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[*] The Pierre de Corne of the French often belongs to hornblende, or is a very fine grained greenstone.

[†] Grunstein. WERNER. BROCHANT. Roche amphibolique. HAUY. Diabase of some French mineralogists.

color, especially at the surface, is often modified by the presence of oxide of iron.

This rock presents a considerable diversity of aspect, depending on the general structure, or on the size, proportion, disposition, and more or less intimate mixture of its constituent parts.

In some of the more common varieties, the two ingredients are in distinct grains of considerable size, like those of granite; and the foliated structure both of the hornblende and feldspar is often distinctly visible. The proportion of feldspar is sometimes very small.

From Greenstone with a coarse granular structure to those varieties, whose texture is so finely granular, that the two ingredients can scarcely be perceived, there is a gradual passage, exhibiting every intermediate step. Indeed the grains are sometimes so minute and so uniformly and intimately mingled, that the mass appears altogether homogeneous, and the different ingredients are hardly perceptible, even with a glass.—Hence the texture of this rock is sometimes distinctly crystalline, and sometimes almost compact and earthy.

Greenstone, like basalt, sometimes presents itself in *prisms* or *columns* of various sizes. These prisms may have from three to seven sides, and are sometimes as regular as those of basalt.

The general aspect of Greenstone is sometimes much diversified by the foreign ingredients, which it admits into its composition. Among these are quartz, epidote, mica, talc, carbonate of lime, and almost always sulphuret of iron, which is sometimes magnetic.—The quartz is, in some cases, abundant, and seems almost to take the place of feldspar.—Iron frequently enters into the composition of this rock. Hence, by exposure to the weather, its exterior becomes brownish or reddish brown; and some greenstones are gradually decomposed.

Many Greenstones are susceptible of a polish;—and that variety, which admits *epidote* into its composition, often forms a very beautiful mineral, when polished, especially if it is porphyritic. Its color is often a fine dark green, resembling serpentine. The epidote, either crystallized or compact, is sometimes in very narrow veins; and sometimes it is uniformly disseminated in very minute grains. In other cases, the epidote and feldspar form a kind of base, containing acicular crystals of hornblende; or the three ingredients are distinct, as in granite.

Var 1. PORPHYRITIC GREENSTONE. All the varieties of greenstone are occasionally rendered porphyritic by containing crystals of feldspar, which are sometimes considerably large. Crystals of quartz also are sometimes imbedded.

When these crystals of feldspar are imbedded in a blackish greenstone, whose texture is so fine, that the general aspect is homogeneous, a porphyry is produced, which appears to be one variety of the *black porphyry* of the ancients.

OPHITES OR GREEN PORPHYRY. This is a greenstone, which to the naked eye appears homogeneous, and varies in color from blackish green to pistachio green. It contains greenish white crystals of feldspar, which on the polished surface often appear in parallelograms, and are sometimes cruciform. Its texture is very compact, and its fracture often splintery.—In many cases, its fine green color is undoubtedly produced by epidote.—This belongs to the *green porphyry* of the ancients.

Specimens of this porphyry occur in the vicinity of Boston.

(Geological remarks.) Greenstone occurs in beds more or less large, and sometimes forms whole mountains. It often appears in conical hills, or presents high, mural precipices, whose fronts are frequently composed of numerous columns or *prisms* of various sizes, like basalt. These columns are intersected by seams, often horizontal; and hence result those prismatic fragments, into which this rock spontaneously falls, or may easily be broken. Hence also the numerous fragments, which are usually found at the foot of such precipices.—Sometimes it forms only the summits of mountains, which are composed of rocks very different from Greenstone.

Small veins of quartz, epidote, actynolite, feldspar, prehnite, zeolite, calcareous spar, &c. often traverse Greenstone.

Beds of argillaceous iron, and of other metals are sometimes contained in this rock.

Greenstone appears among primitive, transition, and secondary rocks.

Primitive Greenstone occurs in gneiss, mica-slate, and argillite; in the last of which it often forms very large beds. It frequently alternates with sienite; and is sometimes associated with petrosilex, porphyry, &c. Its structure is often more or less distinctly crystalline, and its ingredients easily distinguishable by the eye. Sometimes also its aspect is almost homogeneous.

Transition Greenstone is associated with amygdaloid, graywacke, &c.—It sometimes occurs in globular distinct concretions, which have a lamellar structure.*

Secondary Greenstone is associated with sandstone, basalt, wacke, amygdaloid, &c. It often covers wacke and basalt, into both of which it obviously passes. Its structure is sometimes so fine grained, that the distinct ingredients can scarcely be perceived. Indeed its texture is sometimes almost earthy. Sometimes also it is vesicular, or even forms the base of amygdaloid. Like transition greenstone, it may occur in globular concretions.—It is frequently in veins, and is sometimes distinctly stratified.—In some instances this rock contains shells, or other organic remains.

(Localities.) Greenstone is by no means an uncommon rock in the *United States*. Fine examples of *columnar* Greenstone occur in several parts of the range of secondary mountains, which extend from Newhaven in *Connecticut* to Northampton in *Massachusetts*. At Mount Holyoke, near Northampton, the columns, which are nearly perpendicular, sometimes vary in height from 60 to more than 100 feet; and are frequently *articulated*, like those of basalt. These prisms are very often hexagonal; and their diameter sometimes extends to four feet.[*]—Other examples of *columnar* Greenstone, apparently forming the summits of several mountains, sometimes from 200 to 300 ft. high, have been observed by J. Merrick, esq. in *Maine*, about 100 miles above Hallowell, on the Kennebec. The prisms present from 3 to 6 sides; their edges are straight and well defined; and their general aspect is that of bricks standing on their ends.—A secondary Greenstone is found also at Belfast, Jackson, Brownville, and other towns west of the Penobscot river. This Greenstone, which has hitherto been observed in detached, insulated masses, abounds with shells and impressions of shells. Some specimens much resemble gray-wacke slate. The same rock occurs nearly on the height of land between the Kennebec and Penobscot.—At Harpswell, in Cumberland Co. is found an uncommon variety of Greenstone, through which numerous balls or spheroidal masses, apparently of *garnet*, are disseminated. These balls, of which nearly a hundred sometimes occur in a cubic foot, are easily separable from the mass, and are usually somewhat larger than bullets. This rock has not yet been observed *in situ*.

(Uses.) When this rock breaks into prismatic fragments, it forms a very useful building stone.—Most varieties of Greenstone, when heated red hot, plunged into cold water, and pulverized, become a good substitute for puzzolana in preparing water-proof mortar for the construction of wells, cellars, docks, piers, &c.

Var. 2. GREENSTONE-SLATE.[†] *JAMESON.* The structure and fracture of this variety are slaty. The hornblende and feldspar, which is compact, are nearly in equal proportions. It also contains a little quartz or mica.

Greenstone-slate is usually a primitive rock. Sometimes it forms

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[*] See Bruce's Min. Jour. v. i, p. 139. Also North American Review, v. i. No. 3, p. 337.

[†] Grunstein schiefer. WERNER.

large beds in argillite; and sometimes it constitutes extensive strata, or whole hills. In some instances, it contains beds of primitive limestone, or even alternates with it.

According to Jameson, the mines of Gersdorf in Saxony, and of Adelfors in Sweden are situated in this rock.

In the *U. States*, extensive strata of Greenstone-slate occur in *Connecticut*, a few miles westward from Newhaven.

8. Porphyry.* *Kirwan. Jameson.*

Porphyry is a rock, presenting a compact and homogeneous basis, in which are imbedded other minerals in the form of insulated crystals, or grains. The *basis*, from which the kind of Porphyry is denominated, may be *petrosilex*, or *feldspar* nearly compact, or *claystone*, or *pitchstone*, or *clinkstone*, &c. Indeed many other minerals are sometimes *porphyritic*; but the name Porphyry, is for the most part limited to the bases already mentioned.

The imbedded substances are most frequently *feldspar* and *quartz*, both of which are usually crystallized, the former in prisms, and the latter in pyramids. The feldspar is more common than the quartz, and may often be recognised by its oblong, quadrilateral form. Crystals of hornblende and mica also are sometimes present.

The colors of Porphyry, or rather of its bases, are considerably various; but they very frequently present some shade of red or purple, and sometimes also of brown, green, gray, and black.

The imbedded minerals are supposed to have a contemporaneous origin with the base, and not, as in some other cases, to have been deposited in pre-existing cavities.

Porphyry has generally a compact texture. Sometimes, however, it is composed of tabular, columnar, or globular distinct concretions; and not unfrequently it is traversed by numerous, accidental rents and seams.

The following are some of the more common and important varieties.

Var. 1. PETROSILICEOUS PORPHYRY.† Its base is Petrosilex, a simple mineral already described. Its colors are reddish, brownish red, purple, greenish, black, &c. Its fracture is generally somewhat conchoidal and splintery. It gives fire with steel; and is susceptible of a good polish.

By exposure to the weather, the feldspar is often decomposed,

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* Porphir. Werner. Porphyre. Brochant.

The word, Porphyry, is derived from the Greek, Πορφυρα, Purple, in allusion to the reddish or purple color, so common in porphyry.

† Hornstein Porphir. Werner. Hornstone Porphyry. Jameson.

and sometimes small cavities are thus produced. The base itself is also liable to decomposition, and becomes invested with a whitish crust.—This Porphyry, altered by decomposition, often resembles a volcanic product.—A polish protects it from the action of air and moisture.

The base of this Porphyry has sometimes been called jasper; but its fusibility at once detects the error.

In *Massachusetts*, this variety is found in the vicinity of Boston, at Malden, Lynn, Chelsea, &c. It is associated with sienite, and simple petrosilex; and is sometimes equal in beauty to the best antique Porphyry. (GODON.)

2. FELDSPAR-PORPHYRY. Its base is a feldspar, whose texture is nearly compact, and whose fracture is uneven, or splintery, and sometimes a little foliated or granular; it is nearly or quite dull. Its hardness is at least equal to that of the preceding variety. Its color has frequently a shade of red, as reddish brown, flesh red, and sometimes it is yellowish brown, &c.

3. ARGILLACEOUS OR CLAYSTONE PORPHYRY.* Its base is claystone or indurated clay. It has a dull, earthy fracture; is moderately hard, and sometimes adheres to the tongue. Its colors are gray, greenish gray, brown, reddish brown, yellowish, &c.—It sometimes contains balls of a harder porphyry, with chalcedony at their centre.—All the ingredients of this Porphyry are subject to change or decomposition; and, in this state, the mass often resembles a volcanic product.

The mines of Schemnitz, &c. in Hungary are situated in argillaceous Porphyry.

There is one variety of this Porphyry, which is more earthy than common, and contains petrified branches, roots, and trunks of trees. It sometimes occurs near coal.

4. CLINKSTONE PORPHYRY.† Its basis is Clinkstone. The fracture of its masses, in one direction, is generally slaty; but that of small specimens is splintery, or a little conchoidal, and nearly dull. Its hardness is such, that it gives fire with steel, but not so copiously as petrosiliceous porphyry.—It sometimes contains hornblende, quartz, zeolite, &c. as well as feldspar.—Its color is gray, often tinged with green, yellow, or blue, and sometimes it is blackish green, reddish brown, &c.

(*Geological remarks.*) Some Porphyries are decidedly primi-

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* Clay Porphyry. KIRWAN.

† Porphir-schiefer. WERNER. Porphyry-slate or Clinkstone Porphyry. JAMESON.

tive, while others appear to belong to transition, or even secondary, rocks.

The oldest Porphyry is that, whose base is petrosilex or feldspar. It forms large masses or beds in gneiss, and is found also in mica-slate and argillite. The petrosiliceous Porphyry is sometimes associated with sienite, greenstone, and even with gray-wacke.

Argillaceous Porphyry is supposed to be, in most cases, more recent, than the two varieties just mentioned. It lies *over* most of the primitive rocks; but sometimes it alternates with sienite.—In some instances, it contains chalcedony, agate, and hornstone in small masses or layers, and also opal, either in its fissures or disseminated.

Clinkstone Porphyry is often decidedly secondary, being associated with basalt, wacke, amygdaloid, &c. It is sometimes in veins, traversing sandstone and greenstone; and sometimes it rises into insulated, conical hills.

(Remarks.) According to Jameson, there is an immense deposite of Porphyry, extending from Norway nearly to the Black sea. —A compound porphyry, composed of fragments of petrosiliceous and feldspar porphyries, is sometimes observed.—Some porphyries much resemble granite.

Porphyry is, in general, susceptible of a good polish, and is manufactured into various articles both for ornament and use. Its hardness is such, that it is sometimes formed into mortars, &c.

9. SIENITE.* *KIR. BROCH. JAM.*

This rock has often the general aspect of a granite. *Feldspar* and *hornblende* may be considered its two constant and essential ingredients; but it not unfrequently contains quartz and mica, and sometimes talc and epidote.

The feldspar is the most abundant ingredient, and the quantity of hornblende is sometimes small. It is, however, the presence of hornblende, as a constituent part, which distinguishes this rock from certain granites, that accidentally contain hornblende.

The structure of Sienite is usually granular; but the grains are sometimes coarse, and sometimes very fine. In some instances its structure is slaty.—When this rock is very fine grained, and, at the same time, contains large crystals of feldspar, it constitutes *sienitic porphyry.*

The feldspar, whose foliated texture is often very distinct, is most frequently reddish or whitish; but sometimes it receives a greenish tinge from the hornblende, or from epidote.

Sienite and greenstone are essentially composed of the same in-

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* Sienit. WERNER. Roche feldspathique. HAUY.

gredients, viz. *feldspar* and *hornblende*,—and the two rocks do in fact pass into each other by insensible shades. But, in well characterized specimens of greenstone, the hornblende predominates, while, in those of Sienite, the feldspar is the most abundant ingredient. It is often much more difficult to distinguish some varieties of Sienite from granite, than from greenstone.

(*Geological remarks.*) Sienite is sometimes found resting on granite, gneiss, mica-slate or argillite; and sometimes it is associated with greenstone, petrosilex, petrosiliceous and argillaceous porphyries, and even with gray-wacke.

Sienite is sometimes distinctly stratified. Metallic veins, containing ores of copper, silver, iron, lead, &c. sometimes traverse this rock. Some of the Hungarian mines are in Sienite.

This rock is often much altered at the surface by the action of the weather, more especially in those varieties, which contain an uncommon proportion of feldspar.

Sienite is less abundant, than most of the preceding rocks already described.

In *Massachusetts*, this rock is found in Weymouth, Quincy, Brighton, and other towns in the vicinity of Boston. At Malden, &c. it is intimately connected with petrosilex and with petrosiliceous porphyry. At West-Cambridge, &c. it is sometimes in powerful veins, traversing greenstone. Sometimes its masses are interposed in those of gray-wacke. (*Godon.*)

(*Remarks.*) Sienite often receives a good polish; and may be employed for the same purposes as porphyry. Its name is derived from that of Siena, a city of Egypt, where this rock occurs abundantly, and whence the Romans obtained it for statuary and architecture.

10. Topaz-Rock.* *Jameson.*

This very uncommon rock appears to be composed of fine granular quartz, prismatic schorl, and gray topaz in grains. These ingredients are arranged in alternate layers, producing a slaty structure. But the larger masses of this rock are composed of granular distinct concretions. Hence its structure is both slaty and granular. The cavities or fissures of this aggregate are often lined with regular crystals of Topaz, quartz, and schorl. Sometimes also lithomarge is present.

This rock is found near Auerbach, in Voightland, where it forms an extensive, stratified mass, resting on granite or gneiss, and cover-

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* Topaz-fels. Werner.

ed by argillite. A similar aggregate, admitting beryl into its composition, has been observed at Mt. Odontschelon, &c. in Siberia.

11. Gray-wacke.* *Jameson.*

This rock is somewhat remarkable in its structure and geological relations. It is, in fact, a kind of sandstone, and is composed of grains or fragments of different minerals, but chiefly of quartz, feldspar, siliceous slate, petrosilex, and argillite.

These fragments are sometimes angular, and sometimes their edges and angles are rounded, thus forming nodules or globular masses. Their size is extremely variable, even in the same mass, passing from nodules one foot in diameter to grains, which are scarcely perceptible by the naked eye.

The several ingredients of this rock are united by an indurated, argillaceous substance, resembling argillite; or, what is more probable, at least in some cases, the interstices between the larger fragments are filled by the same materials, which compose the larger parts of the rock, but in grains so extremely comminuted, that they resemble a homogeneous cement;—and of these minute grains argillite may perhaps constitute a large proportion.—It sometimes contains a little mica.

This rock, although composed of substances of various colors, usually exhibits some shade of gray or brown, as bluish gray, reddish brown, &c. It is sometimes very considerably hard, and is often susceptible of a high polish.

Var. 1. GRAY-WACKE SLATE.† *Jameson.* In this variety the grains are so minute, that they are scarcely perceptible by the eye. The mass has an aspect nearly homogeneous, a slaty structure, and much resembles some varieties of argillite. But its gray color, its glimmering lustre, arising from scales of mica, and frequently its geological relations will serve to distinguish it from primitive argillite.

(*Geological remarks.*) Gray-wacke is usually arranged among the *transition* rocks, with which, or with the *latest* of the primitive rocks it is always associated. Thus it is sometimes contiguous to sienite, porphyry, greenstone, argillite, and petrosilex, and is entirely destitute of organic remains. In other cases, it alternates with siliceous slate, amygdaloid, and limestone nearly or quite compact, and contains organic remains of animals and plants.—Sometimes it occurs near the foot of mountains, and sometimes at a very considerable elevation.

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* Grau-wacke. Werner. Brochant. Rubble Stone. Kirwan.

† Grau-wacke Schiefer. Werner. Grau-wacke schisteuse. Brochant.

Gray-wacke is often distinctly stratified; but the strata are not usually parallel to those of the subjacent rocks. The common and slaty varieties often alternate with each other; and both are traversed by veins of quartz.

This rock is remarkably metalliferous; and its ores occur both in beds and veins, the latter of which are sometimes very large. Most of the mines of the Hartz, which furnish silver and lead, are contained in Gray-wacke.

(*Localities.*) This rock, although less common than many of the preceding, is found abundantly in some countries, as in the Hartz and other parts of Germany. In Scotland, at the Lead Hills; and indeed nearly all the mountains in that country, north of the Frith of Forth, are chiefly Gray-wacke. (*Jameson.*)—It is found also near Valorsine, in the environs of Mt. Blanc, and at many other places in the Alps, and is composed of fragments of primitive rocks, forming a kind of pudding-stone. It there occurs at a very great elevation, forming large masses in vertical beds. Indeed, according to the observations of Saussure, it appears to be a general fact, that, in the Alps, Vosges, and Cevennes, the primitive rocks are separated from the secondary by a kind of sandstone or pudding-stone, which belongs to Gray-wacke.

In some parts of the *United States* this rock is abundant.—In *Massachusetts*, it is one of the predominant rocks in the vicinity of Boston, in the towns of Brighton, Brookline, Roxbury, Milton, and Dorchester. It is composed of fragments and nodules, which belong chiefly to quartz, petrosilex, argillite, and feldspar, and which vary in size from one foot in diameter to mere grains. The spaces between the larger nodules are filled with minute grains of minerals of the same nature, as those, which compose the larger parts of the rock. It is often traversed by veins of white quartz; and sometimes it contains large masses of greenstone, sienite, argillite, or amygdaloid. At Brighton, it lies contiguous to amygdaloid. By exposure to the weather this rock is gradually decomposed, and the nodules of quartz sometimes fall out, leaving empty the cells, in which they were inclosed. This rock resembles the pudding-stone of Valorsine, already mentioned; and is in Massachusetts often known by the name of *plum pudding-stone.* When not decomposed, it is susceptible of a high polish. (*Godon.*)

12. Amygdaloid.* *Kirw. Jameson.*

Amygdaloid is a compound rock, composed of a basis, in which are imbedded various simple minerals. But these imbedded minerals

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* Mandelstein. Werner. Roche amygdaloïde. Brongniart.

are not crystals and grains, apparently of contemporaneous origin with the basis itself, *as in the case of porphyry.* On the contrary, their form, though sometimes irregular, is usually spheroidal or oval, like that of an *almond;* and hence the *name*[*] of this rock.

The *basis* of this rock is usually more or less argillaceous, and may be wacke, fine grained greenstone, basalt, indurated ferruginous clay, or some other rock belonging to the Trap formation. Its color is commonly some shade of gray or brown, as greenish or brownish gray, reddish brown, &c. Its hardness is sometimes moderate, and sometimes enables it to give sparks with steel. Sometimes the base is a little stratified.

The *imbedded* substances are calcareous spar, quartz, chalcedony, agate, epidote, steatite, lithomarge, green earth, chlorite, zeolite, hornblende, feldspar, sulphate of barytes, &c.

Hence the general aspect of this rock is that of a basis, which once contained cavities or vesicles, that have subsequently been filled, either entirely or in part, by the minerals, which now appear imbedded. Sometimes these imbedded minerals are easily separable. Sometimes the cavities are only in part filled, their interior being lined with a crust;—and sometimes they are entirely empty, in consequence, at least in many cases, of the decomposition of the once imbedded minerals.—In general, only one substance is imbedded in the same cavity; but sometimes two or three minerals are united in the same nodule, one being contained within another. Some of the nodules have a cavity at the centre, lined by minute crystals of quartz and epidote.

Sometimes the base undergoes decomposition, while the quartz, epidote, or other imbedded substance remains, projecting above the surface. This rock is then often called a *Variolite;*[†] but other aggregates have received the same name.

Some Amygdaloids, in consequence of their vesicular structure and a partial decomposition, resemble lava.

TOADSTONE. The name of this variety of Amygdaloid is suggested by the general aspect of the rock, which somewhat resembles the exterior of a *toad.*

(*Geological remarks.*) Amygdaloid is sometimes found contiguous to greenstone and sienite, or resting on gray-wacke, or alternating with compact limestone. In such cases, it must belong to the transition class, or to the latest of the primitive rocks.—In other cases, it is associated with wacke, sandstone, and other rocks of re-

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[*] From the Latin, Amygdala, an almond.

[†] This term is derived from the Latin, Variola, small pox, in allusion to the spotted aspect of the mineral.

cent formation. It is sometimes traversed by veins of quartz and feldspar.

(Localities.) Amygdaloid, though not very common, is abundant in some countries, as in the Hartz, Derbyshire, &c.

The Toadstone of Derbyshire deserves particular notice.—Its ordinary colors are brownish gray, purplish brown, bluish, or greenish; and its vesicles are either empty, or filled with white or greenish carbonate of lime. The lowest bed of *Toadstone*, which is sometimes 80 yards thick, rests on a very thick bed of stratified *limestone*, containing ammonites, &c. and some ores in its veins.—This bed of Toadstone is also covered by a bed of compact *limestone*, which contains numerous veins of the sulphurets of lead and zinc, calamine, &c, also fetid carbonate of lime, nodules of hornstone, and numerous organic remains. And it is a remarkable fact, that the metallic veins which traverse both these beds of limestone, have rarely, if ever, penetrated the Toadstone. A number of rents, however, which proceed from the limestone into the upper and lower sides of the bed of Toadstone, contain sulphuret of lead, &c.—Over the second bed of limestone, already mentioned, are found *two* beds of Toadstone, and two of limestone, alternating with each other.—The limestone, which is the highest of these *four* beds, contains elastic bitumen; and is itself covered by a thick bed of *shale*, which embraces beds of sandstone, limestone, clay, &c. and presents some vegetable impressions.—The shale is covered by a thick deposite of *sandstone*, which exhibits impressions of reeds, flags, &c. and, in the upper part, becomes softer and micaceous.—Over this sandstone are placed 18 beds of *sandstone* and *shale*, constituting the Independent coal formation of Werner.* *(FAREY*, in Nich. Jour. v. xxxv.)

In the *United States*, several varieties of Amygdaloid are found in *Maryland*, &c. on the Blue Ridge.—In one variety, the base is brown, has a texture like that of petrosilex, gives fire with steel, and contains spheroidal masses about the size of an ounce ball, of a ferruginous aspect, and easily separable from the base.—In another variety, the base is gray, brown, and greenish gray, and contains small greenish masses, which appear to be epidote. This base is subject to decomposition, leaving the imbedded substance projecting above the surface, and constituting a *variolite*.—In a third variety, the imbedded substance is white, and liable to decomposition, thus rendering the

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* For several interesting details in regard to secondary rocks, consult Essai sur la Geographie Mineralogique des environs de Paris; par CUVIER et BRONGNIART.—Also Transactions of the Geological Society, London, v. ii. on the chalk basins of the Isle of Wight and of London. See also Outline of Mineralogy and Geology, by William Phillips.

base vesicular.—The last two varieties belong to transition rocks, (*HAYDEN.*)—In *Massachusetts*, at Mt. Holyoke, a variety of Amygdaloid is found, which resembles the Toadstone of Derbyshire.—At Brighton, near Boston, an Amygdaloid is found contiguous to sienite and greenstone, and sometimes it rests on gray-wacke. Its base is commonly reddish brown; and the imbedded nodules are quartz, feldspar, carbonate of lime, epidote, &c. Some of the nodules of quartz appear as if enchased in epidote. This rock, which has sometimes a slaty texture, and even exhales an argillaceous odor, when moistened, is analogous to the toadstone of the English. (*GODON.*)

13. SANDSTONE.* *JAMESON.*

Sandstone is, in most cases, composed chiefly of grains of quartz, united by a cement, which is never very abundant, and often, indeed, is nearly or quite invisible. These grains are sometimes scarcely distinguishable by the naked eye, and sometimes their magnitude is equal to that of a nut or an egg, as in those coarse sandstones, called *conglomerate*, and sometimes pudding-stone or breccia.

The cement is variable in quantity, and may be calcareous or marly, argillaceous, or argillo-ferruginous, or even siliceous. When siliceous, the mineral often much resembles quartz.

The texture of some Sandstones is very close, while that of others is so loose and porous, as to permit the passage of water. Sometimes, indeed, this rock is vesicular.

Some varieties are sufficiently solid to give fire with steel, while others are friable, and may be reduced to powder even by the fingers; but this powder discovers the hardness of quartz by the ease, with which it scratches glass or steel. Sandstones with a marly cement are often very friable.

Its fracture is always granular or earthy, although, in some instances, it may, at the same time, be also conchoidal or splintery. Some Sandstones have a slaty structure, arising from scattered and insulated plates of mica, and have been called *Sandstone-slate.*

Its most common color is gray or grayish white, sometimes with a shade of yellow, brown, or green, and sometimes it is reddish or reddish brown, &c. In some cases, the color is uniform; in others, it is variegated.

In addition to quartz, some Sandstones embrace grains of feldspar, flint, and siliceous slate, or plates of mica. The mica is sometimes in considerable quantities in those friable sandstones, which accompany coal.

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* Sandstein. WERNER. Grès. HAUY. BROCHANT. Some varieties are called *Free-stone*.

Some varieties of this rock deserve particular notice.

Var. 1. RED SANDSTONE.* The grains of this variety are usually coarse, and united by an argillaceous cement, which is at the same time ferruginous; hence the dark reddish or reddish brown color, which it presents.—It sometimes contains scales of mica, or embraces petrified wood.—It is abundant in many countries; and by the miners is sometimes called *Red Dead Lier*.

2. VARIEGATED SANDSTONE.† *JAMESON.* This Sandstone presents a diversity of colors, as yellow, green, brown, red, and white, which are usually arranged in stripes, or zones, either straight or winding. It has commonly a close texture and fine grain; but it very often embraces oval or rounded masses of clay. These argillaceous masses, called *stone-galls* or *clay-galls* by workmen, often fall out, when exposed to the weather, and much diminish the value of this variety for the purposes of architecture. Its cement is usually argillaceous.—Sometimes it contains beds of oolite.

3. WHITE SANDSTONE.‡ This includes many of the more common and valuable varieties of Sandstone. Its color is whitish gray, or gray, and generally uniform; but sometimes is accidentally marked with yellowish, reddish, or brownish spots, &c. It is sometimes solid and firm, and sometimes friable even between the fingers. Its cement is often calcareous.—This variety, which seldom contains clay-galls, is well adapted for various uses in the arts.

4. FLEXIBLE SANDSTONE.§ This rare variety, though friable, has a slaty texture, and is flexible, but not elastic. If a plate or layer of this Sandstone be held horizontally, it bends by its own weight. Its flexibility is attributed to the presence of grains of quartz so flattened and elongated, that they resemble plates of mica.—This variety is found at Villa-Ricca, in Brazil.

5. QUARTZY SANDSTONE.‖ Its texture is very fine and close, and its fracture conchoidal with some lustre. Its granular structure, however, is perceptible in consequence of its translucency.—It much resembles some varieties of quartz.

A variety of Sandstone (Grès pulvisculaire of Haüy) occurring in Turkey, is composed of very minute grains, has a close texture, a splintery fracture, and does not appear granular, until the rock has been exposed to the action of fire. It hardens in oil.

(Geological remarks.) Sandstone, although most decidedly a

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* Rother Sandstein. WERNER. Grès rouge. BRONGNIART.

† Bunter Sandstein. WERNER. Grès bigarré. BROCHANT. BRONGNIART.

‡ Grès blanc. BRONGNIART. § Grès flexible. BRONGNIART.

‖ Grès lustré. HAUY. BRONGNIART.

secondary rock, has been formed at different periods, under different circumstances, and is hence associated with different rocks.

The coarse *red* Sandstone is sometimes found resting on graywacke, or even on primitive rocks. Sometimes also it is covered by bituminous marlite, compact limestone, greenstone, &c. It must therefore belong to the oldest and lowest deposites of this rock.—It is sometimes connected with coal; and, according to Von Buch, large beds of coal, in Silesia, are embraced in red sandstone.—It is however asserted, that, in Scotland, the occurrence of a red or reddish brown sandstone, especially if it contain beds of pudding-stone, is not so indicative of coal, as is a reddish yellow or yellowish brown sandstone.

The *variegated* Sandstone appears to be a later deposite than the preceding. It sometimes *rests* on gypsum, and is, at the same time, *covered* by shell limestone. It contains sandstone-slate, and beds of oolite.—This Sandstone is abundant in Thuringia, Franconia, &c. where a bed or layer of granular argillaceous oxide of iron is interposed between the sandstone and limestone.

Other formations of Sandstone are still more recent. Thus in the vicinity of Paris, Sandstone is found covering a deposite of gypsum, which is obviously of later formation, than the gypsum, on which the variegated Sandstone rests.

Sandstone is, in general, more or less distinctly stratified. Its beds are very often nearly or quite horizontal; but sometimes, especially in the older varieties, they are much inclined or even vertical. Sometimes also, when in the vicinity of primitive mountains, its beds are thin, and much bent or waved.—Beds of Sandstone are sometimes intersected by fissures perpendicular to the direction of the strata, and hence fall into tabular masses, which are often very large.

In addition to beds of oolite and compact limestone, Sandstone sometimes embraces thin beds of coal, distinct from those, which may be said to constitute a coal formation. Some Sandstones, which appear to belong to the older varieties, are traversed by veins of quartz.

Sandstone is sometimes found near the summits of mountains highly elevated; but more frequently its beds appear in level countries, or constitute hills of a moderate altitude, but with a rapid ascent.

Those countries, in which Sandstone abounds, often present many interesting and impressive views. Sometimes its beds seem to have been broken into large tabular masses, which are promiscuously scattered, or heaped on each other in wild disorder.—Sometimes it rises in a series of high pillars, or of conical hills, high and acute; and placed at only a small distance from each other. The summits of these hills and pillars are often nearly at the same level, and the seams, which separate the strata, correspond through the whole series. It is hence highly probable, that such a series of hills or pillars once constituted a continuous mass, traversed by perpendicular fissures; and that subsequent alterations have arisen from the action of the atmosphere and water. A striking example exists at Adersbach in Bohemia, where these cones and pillars of sandstone, sometimes insulated, and sometimes united at their bases, rise to the height of 200 or 300 feet.—Insulated masses of Sandstone sometimes remain in the midst of banks of sand.

Sandstone, more particularly in the older formations, sometimes contains metallic substances, disseminated through the mass, or in beds, or in veins. Among these are the sulphurets of iron, mercury, lead, and copper, pyritous copper, and arsenical cobalt.

Various organic remains occur in Sandstone, among which are reeds, impressions of leaves, trunks of trees, and shells, both fluviatile and marine. Sometimes the wood is scarcely altered.—Near the lake of Geneva, fossil bones occur in sandstone.

(Localities.) Sandstone is found in various parts of the *United States*. A deposite of *red* sandstone, which appears to belong to the oldest formations of this rock, extends, with a few interruptions, from Connecticut river to the Rappahannock, a distance of about 400 miles; its average breadth is between 15 and 25 miles.' It is sometimes covered by beds of greenstone, wacke, &c. *(Maclure.)*—A singular deposite of Sandstone is found on the *summit* of the South Mountain or Blue Ridge, 8 or 10 miles east from Hagarstown, in Washington Co. *Maryland*. It occupies an extent of about 4 or 5 miles in length by about half a mile in breadth, and is there called the *black rocks*, in consequence of being covered with a dark brown lichen. This Sandstone does not present itself in regular stratified beds, but in tables or large masses, which seem to have been rent from their original bed by some powerful concussion, and thrown promiscuously together in wild confusion.—Its masses are variable in size; but some of them weigh several hundred tons. They discover no marks of alteration or disintegration.—This Sandstone does not contain plates of mica, and is destitute of stratification; but the veins of crystallized quartz, which traverse it, and some other circumstances seem to indicate, that it belongs to the oldest formations of this rock. —Limestone and slate probably constitute the base of this mountain. *(Hayden.)*

(Uses and Remarks.) Sandstone in some of its varieties is very

useful in the arts, and is often known by the name of *Free-stone.* When sufficiently solid, it is employed as a building stone. In most cases, it cuts equally well in all directions; but some varieties naturally divide into prismatic masses.—Some varieties are used as millstones for grinding meal, or for wearing down other minerals, preparatory to a polish. These stones, while rapidly revolving, sometimes burst with a loud and dangerous explosion. This phenomenon occurred no less than four times, in the course of forty years, in the millstones, employed at Oberstein for grinding agates; they were red sandstone. The same accident has taken place in grinding meal.—When the texture is sufficiently loose and porous, Sandstone is employed for filtering water.—Some varieties are used for whetstones.

Some Sandstones absorb moisture, and, by exposure to the changes of the atmosphere, are gradually disintegrated; others become more solid by such exposure.

14. Pudding-Stone.*

This rock is only a very coarse sandstone. It is composed of siliceous pebbles of quartz, flint, siliceous slate, &c. united by a cement, which is usually siliceous, sometimes both siliceous and ferruginous, and sometimes a little argillaceous. These pebbles vary in size from that of a pea to that of an egg. Their form is ordinarily rounded or oval; and it is, in fact, chiefly by the more or less rounded form of these pebbles, that Pudding-stone is distinguished from a breccia.

This rock, though always secondary, is found in various situations relative to other rocks, and has been formed at very different periods.

It is sometimes employed for millstones; and some varieties receive a good polish.—The term *conglomerate* is sometimes applied to Pudding-stone, as well as to the less coarse varieties of sandstone.

15. Breccia.

A Breccia is an aggregate, composed of *angular* fragments of the same mineral or of different minerals, united by some cement. Sometimes, however, a few of the fragments are a little rounded. The different fragments almost always present a variety of colors.—Some breccias are traversed by metallic veins.

Var. 1. siliceous breccia. This may consist of fragments of agate or of jasper, differently colored—or of fragments of flint and jasper—or of quartz, flint, siliceous slate, &c. united by a sili-

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* Le Poudingue. Brochant.

ceous cement. Sometimes the cement itself appears to be quartz, jasper, or flint.—It often receives a good polish.

2. CALCAREOUS BRECCIA. This is composed of fragments of limestone or marble, united by a calcareous cement.

The *Nagelfluh* of some mineralogists is a breccia, composed chiefly of fragments of limestone, sometimes with rounded pebbles of quartz, united by a calcareous cement. It sometimes forms large beds near the foot of calcareous mountains.

Calcareous Breccia frequently receives a high polish, and is employed in works of ornament.

3. TRAP BRECCIA.* This is composed of fragments of basalt, amygdaloid, hornblende, and sandstone, cemented by an argillaceous basis, which appears to be decomposed basalt or wacke. The fragments, extremely variable in size, are sometimes very large.

This Breccia occurs in beds, usually horizontal, varying in thickness from a few inches to many yards, and sometimes alternating with basalt.

This rock constitutes a considerable portion of Arthur's Seat, near Edinburgh, where it rests on inclined strata of rocks, belonging to the oldest coal formation. (JAMESON.)

ALLUVIAL DEPOSITES.

Those beds of clay, sand, gravel, pebbles, &c. which constitute so large a portion of the earth's surface, are called *Alluvial Deposites.* These substances, which originally proceeded from the disintegration of rocks and simple minerals by the action of the atmosphere and water, have been subsequently transported by *water,* and deposited in nearly horizontal beds in vallies, or on plains, or on the beds of rivers, or on the margin of seas. Hence they occur not only near the level of the sea, but also in hollows or on planes highly elevated in mountainous countries.

All these Alluvial Deposites are comparatively of recent formation. Many of them have been formed within the memory of man; and others have appeared, or are still daily forming, under our own observation.—They are peculiarly interesting in geological inquiries, being indicative of important changes, produced on the surface of the earth. Indeed, in the examination of alluvial earths the farmer is in no small degree interested; and not unfrequently the miner finds their contents highly valuable.

The more common Alluvial Deposites are gravel, sand, clay, loam,

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* Trap-Tuff. JAMESON.

peat, bog iron ore, and calcareous tufa or incrustations. These substances are often much mixed with decayed vegetable matter.

Beds of gravel and sand, when in the vicinity of mountains or connected with them by rivers, sometimes contain grains or fragments of native gold, oxide of tin, or magnetic iron in sufficient quantities to be explored with advantage. It has already been remarked, that much of the gold of commerce proceeds from alluvial earths.—In a branch of Falmouth harbor, Eng. a shaft was sunk 50 feet through a bed of alluvial matter, which had proceeded from the disintegration of granite; and at the bottom was found a bed, from two to ten feet in thickness, composed of rounded masses of the oxide of tin. The profit of this undertaking was at least 50,000*l.* (PHILLIPS.)

In addition to these *ores*, the sapphire, ruby, chrysolite, hyacinth, diamond, &c. having by their hardness been enabled in a great degree to resist attrition, while carried by the waters from their original situations, constitute no small part of the riches of Alluvial Deposites.

Beds of sand sometimes contain ferruginous clay, which operates as a cement; and a friable sandstone is thus gradually produced.—It ought also to be remarked, that important changes in the face of a country are often produced by the action of wind on deposites of loose and fine sand.

Numerous organic remains occur in Alluvial Deposites. Large beds of bituminous wood, and even trunks of trees, in which the wood is very little altered, are sometimes found, and seem to constitute a subterraneous forest.—Among animal remains are shells of oysters and muscles, teeth of sharks, and the bones of the horse, ox, stag, elk, elephant, &c. Some of these animals belong to extinct species, while others resemble those now living.

The North of Europe from Holland through Prussia, Pomerania, &c. to Russia—and the south eastern coast of the *United States* from New York to Florida, and thence to the Mississippi, furnish interesting examples of Alluvial Deposites.

VOLCANIC PRODUCTIONS.*

Many parts of the external crust of the Earth are subject to the action of subterraneous fires. In some cases, these fires are comparatively mild, and produce no important effects, excepting the destruction of the combustible, which feeds them, and a slight altera-

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* In preparing this article on volcanic productions, the opinions of Dolomieu, Spallanzani, Faujas, Kirwan, and others have been consulted.

tion of the contiguous earths and stones. These are often called Pseudo-volcanoes; and are nothing more than coal mines in a state of combustion.

But, in other cases, these subterraneous fires rage with resistless impetuosity, produce important changes in the minerals, which cover or surround them, and eventually burst through the incumbent crust of the Earth; thus constituting a true volcano.—From the mouth or crater of the volcano, thus produced, are ejected various substances, some of which are perfectly unchanged by the fire; some are partially changed; and others are more or less completely *fused*, and converted into lava, scoria, glass, &c.

But, notwithstanding volcanoes are confined to a few points on the Earth's surface, very important changes have been produced in their vicinity; and many whole islands have been brought into existence by submarine volcanoes.*

Few questions have produced more collision among mineralogists, than that, which regards the proper application of the term *lava*. This word, according to Kirwan, is derived from the Gothic, *lopa* or *lauffen*, to run, and is applied to the melted or liquefied matter, discharged from the mouths of volcanoes.

It seems highly probable, at the first view, that large masses of rocks, which had been subjected to the action of volcanic fire, and which had been so melted as to *flow*, would retain distinct and evident indications of their fusion. But, whatever may be the fact, the two extremes, at which different mineralogists stand in the use of the word lava, are widely distant. While some confine this term to certain substances, more or less porous or tumefied, others extend it to such minerals as basalt, wacke, pitchstone, obsidian, and some varieties of petrosilex, compact feldspar, amygdaloid, porphyry, &c. —It will be sufficient here to remark, that every rock, found in volcanic mountains, must not, *for that reason only*, be pronounced lava, especially if it exhibits very few, or even no internal marks of previous fusion.

As real volcanic productions are merely *alterations* of other minerals, they cannot, strictly speaking, constitute distinct species. They must, on the contrary, exhibit a great diversity of external aspect and chemical composition, according to the nature of the *original* substances, the degree of heat, and the consequent calcination, fusion, tumefaction, or vitrification. Hence the different products of volcanic fire pass into each other. The lava, which Dolomieu ex-

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* According to Jameson, about 193 active volcanoes have been observed; of which 13 belong to Europe and its islands—66 to Asia and its islands—8 to the islands of Africa—and 106 to America and its islands.

amined, yielded silex 40 to 60, magnesia 3 to 16, lime 1 to 5, iron 6 to 25.

Lava, scoria, enamel, and glass comprise by far the most important and interesting volcanic productions; but all those substances, which have been actually *ejected*, although they may have suffered little or no alteration by volcanic fire, deserve attention.—The following arrangement will therefore be observed.

1. Ejected substances, more or less modified by volcanic fire.
2. Substances, ejected without alteration.
3. Substances, sublimed by volcanic fire.
4. Alterations in volcanic productions, after ejection.
5. Pseudo-volcanic productions.

1. *Substances, more or less modified by volcanic fire.*

1. *Compact Lava.* It is very certain, that some real lavas are much more compact than others; that is, they contain fewer and smaller pores or cavities. Thus the lower parts of a current of lava, being subjected to the pressure of the incumbent mass, may possess pores too minute for the naked eye to perceive, or may, *for a small extent*, be altogether compact;—and such lava will more or less resemble the original stone.

It is, however, very difficult to admit the existence of *entire* currents of lava, uniformly solid and compact through the whole mass, entirely destitute of every *internal* mark of fusion, and even containing in their interior the impression of leaves.—It will be understood, that these remarks are confined to those currents, which are supposed to have flowed on the surface of the earth; and of course do not extend to the lava, which may have been produced by submarine volcanoes, under the immense pressure of the incumbent mass of water and earth.

M. Dolomieu enumerates four kinds of compact lava.—The first has for its base an argillo-ferruginous rock; and comprehends basalt, and some varieties of wacke, greenstone, amygdaloid, siliceous slate, and hornblende in mass.—The second has a petrosiliceous base, and comprehends some varieties of common petrosilex, pitchstone, compact feldspar, &c. Both the preceding contain crystals or grains of feldspar, augite, hornblende, mica, leucite, &c—The base of the third kind is feldspar or granite—and that of the fourth is leucite.

It is worthy of notice, that Dolomieu has remarked, that *compact* lavas are much more common in the vicinity of ancient and *extinct* volcanoes, than in the currents of those, which are now active, and whose real products may of course be ascertained. Indeed Gioeni says that *modern* volcanoes seem to have lost their power of producing perfectly compact lava.

Local circumstances are often extremely important in determining the existence of volcanic productions; for several minerals are known to be susceptible of certain alterations, by which they become porous, &c. and strongly resemble those substances, which have been ejected from volcanoes. This is sometimes the case with amygdaloid, wacke, porphyry, serpentine, greenstone, hornblende, and argillite in a decaying state.

Real lava does, without doubt, sometimes resemble basalt, greenstone, and other trap rocks. But it may be considered as a universal fact, that, although *calcareous spar* is often found in greenstone and basalt, it is never imbedded in those lavas, which have actually flowed on the surface of the Earth.

The color of compact lava, when unchanged, is most frequently brown, yellowish or reddish brown, bluish, or blackish, and sometimes gray. Its fracture is dull, and earthy or splintery. It often gives fire with steel; and almost always moves the magnetic needle. Its spec. grav. is variable.—It abounds with crystals of feldspar, schorl, leucite, &c. which have been very little affected by the heat.

2. *Cellular Lava.* This lava, which is connected with the compact variety by imperceptible shades, is characterized by the pores and small cavities, which it contains, and which, according to Dolomieu, are larger near the surface, than toward the centre of the mass. These cavities may be irregular, spherical, or elongated; those of the same current being usually elongated in the same direction. They are produced by the disengagement of elastic gases, while the lava is fluid; and hence also the greater or less degree of tumefaction, which this lava always undergoes.

This lava usually moves the needle; and is sometimes sufficiently solid to give fire with steel. Its surface is rough and irregular; its color is some shade of brown, black, or gray; and its fracture earthy and dull.

It is sometimes in spherical masses, having assumed that form, when projected from the volcano into the air.

Lava, on account of its lightness, is sometimes employed in the construction of arches.—It is also used in the manufacture of green glass bottles.

Cavernous Lava. This singular lava exists in Iceland, on the great plain below Hecla. It seems to have been much tumefied, so as to produce large bubbles or blisters, of various forms, from a few feet to forty or fifty feet in diameter. Some of them are burst, and discover the *cavern*, which exists in their interior. (*MACKENZIE.*)

3. *Volcanic Scoria.* This more or less resembles the scoria of a forge in its texture, color, and form. It is more altered by the fire than cellular lava, more vitreous, more tumefied and expanded by sulphureous gas, &c. Its cavities are more numerous, larger, and more irregular, than those of cellular lava, and its surface is more uneven. It often floats on water.

Its forms are various, and sometimes much contorted. Its colors are black, brown, or gray. It has the hardness of cellular lava; but is very brittle.

Different scoriæ, from whatever mineral they may have proceeded, much resemble each other; and all the specimens, examined by Dolomieu, contained at least 8 per cent. of iron. It is highly probable, that the original stone abounded with sulphuret of iron; and hence the sulphureous gas, which has produced so great a tumefaction.

Volcanic scoria unites by insensible shades with cellular lava; and often contains crystals of schorl, feldspar, leucite, augite, and hornblende.

These scoriæ sometimes occur on the surface of currents of lava; and sometimes they are ejected from the volcano in fragments, often about the size of a nut, and fall like a shower of hail around the crater. Sometimes indeed they are ejected in such quantities, that they form little conical summits or even small hills on the sides of the volcanic mountain. Thus Monte Rosso, on the side of Etna, is composed in a great degree of scoria, and was formed during an eruption, which took place in 1669, and which continued three months. Its perpendicular height is about 150 paces. (*SPALLANZANI.*)—Large quantities of scoriæ are seen floating on the Mediterranean, in the vicinity of Stromboli, during eruptions of that mountain.

4. *Volcanic Slags.* These contain much metallic matter, are heavy, and resemble the dross of a forge.

5. *Volcanic Enamel.* This is an *imperfect* vitrification; and undoubtedly proceeds from some mineral, which is not easily vitrifiable, or which has not been exposed to a degree of heat sufficient to produce a perfect glass. It is brittle, and has the hardness of glass; but is nearly or quite *opaque.* Indeed its opacity is the principal character, in which it differs from glass. It has considerable lustre, and its colors are white, gray, brown, &c. and sometimes spotted. Its texture and fracture sometimes approach those of glass, and sometimes resemble those of porcelain.

Some enamels contain crystals of feldspar and scherl imperfectly fused.

6. *Pumice.* This has already been described, page 245.

7. *Volcanic Glass.* The occasional production of glass by volcanoes must arise either from an uncommon intensity in the heat, or from the more vitrifiable nature of the materials, which compose this glass.

Volcanic glass has a strong resemblance to common glass, but is sometimes so hard as to scratch it. It is more or less translucent, or even transparent in thin fragments; and has a conchoidal, shining fracture.—Its texture is sometimes perfectly compact, and sometimes more or less porous or frothy. Its colors are black, green, bluish, gray, &c.

Volcanic glass is rare, and usually occurs in small, detached pieces; it is rarely found in large continuous masses. Some volcanoes, among which is Etna, seldom or never produce perfect vitrifications. —Obsidian is by some mineralogists considered a volcanic glass.

Capillary Volcanic Glass. This is exceedingly rare. It occurs in delicate, capillary, transparent filaments, like hair, and sometimes moveable by the impulse of the breath.—It has been found in the Isle of Bourbon—at Vesuvius—at Vulcano—and in the island of Lipari. At the last mentioned place, it was observed in considerable quantities by Spallanzani.

8. *Volcanic Sand.* This sand consists of hard grains of various sizes, which appear to be chiefly fragments of scoria. These scoriæ were probably so highly tumefied by the action of elastic gases, that the aggregation of their parts was weakened or even destroyed; and, in this state, being ejected from the volcano with extreme violence, they were in some degree triturated by collision against each other.

This sand contains also fragments of lava, and crystals of schorl, feldspar, augite, &c.

Volcanic sands often cover a great extent of ground. Thus in the eruption of Etna, in 1669, when Monte Rosso was formed, a space of about fifteen miles in diameter was covered with this sand so deep, as to destroy vines and shrubs. (SPALLANZANI.)

9. *Volcanic Ashes.* These are extremely fine and light, dusty, and smooth to the touch. Their color is gray, sometimes a little brownish or reddish.—They sometimes contain 50 per cent. of alumine, the remainder being chiefly silex; and are hence slowly diffusible in water.

Their properties are, however, different in different volcanoes, and sometimes even in different eruptions of the same volcano.

Some mineralogists consider these ashes a very fine volcanic sand; but others suppose them to be real ashes, resulting from the combustion of coal.

The ashes of Etna, transported by the winds, have sometimes covered Malta to the depth of 2 or 3 inches;—and, according to some ancient writers, they have reached even Egypt. They are so fine, that, like dust, they enter the closest apartments.

10. *Puzzolana.* This usually occurs in small fragments or friable masses, which have a dull, earthy aspect and fracture, and seem to have been baked. Its solidity does not exceed that of chalk. It is seldom tumefied; and its pores are neither so large nor numerous, as those of scoria. Its colors are gray or whitish, reddish, or nearly black.

By exposure to heat, it loses its power of affecting the needle; and melts into a black slag. A variety, examined by Bergman, yielded silex 55 to 60, alumine 19 to 20, iron 15 to 20, lime 5 to 6. It often contains distinct particles of pumice, quartz, and scoria.

Some mineralogists suppose the black Puzzolana to be altered scoria;—the white to be pumice, minutely divided and decomposed; —and the red to be some mineral, which has suffered merely calcination.—Others believe, that Puzzolana, in consequence of the large proportion of alumine, which it contains, has never been converted into scoria or pumice; but has proceeded from argillaceous minerals, baked or calcined in the interior of the volcano.

But, whatever may have been its origin, it is extremely useful in the preparation of a *mortar*, which *hardens* quickly, even *under water*. When thus employed, it is mixed with a small proportion of lime, perhaps one third.—Mr. Kirwan supposes, that the rapid induration of this mortar arises from the very low oxidation of the iron.— If the mortar be a long time exposed to the air, previous to its use, it will not harden.

The best Puzzolana is said to occur in old currents of lava; but when too earthy, it loses its peculiar properties. That, which comes from Naples, is generally gray.

11. *Trass* or *Terras.* The nature of this is similar to that of some varieties of puzzolana; and it contains, according to Bergman, nearly the same principles, but with a greater proportion of lime. Its hardness, however, is much greater, than that of puzzolana. Its color is brownish or yellowish; and its fracture earthy and dull.

It often embraces fragments of argillite, hornblende, mica, a substance resembling pumice, branches of trees, &c.—It has been found chiefly near Andernach, in the vicinity of the Rhine.—It is perhaps sometimes the product of pseudo-volcanoes.

Like puzzolana, this substance is useful in the preparation of mortar. It was employed by Mr. Smeaton for this purpose in the construction of the Eddystone Light-house.

12. *Volcanic Tufa.* This name is applied to several different substances, some of which have never suffered the action of fire, although they have proceeded from volcanoes.

1. This tufa is sometimes an aggregate of sand, volcanic ashes, and fragments of scoria and lava, united by an argillaceous or muddy cement.

2. Sometimes it is composed of volcanic ashes and sand, transported and deposited by rain-water. Such tufas are constantly forming in volcanic countries.

3. The *earthy deposite*, which proceeds from muddy eruptions, has also received the name of volcanic tufa.

Tufa presents various shades of gray, brown, red, yellow, &c. or is spotted. It has a variable, but moderate, degree of hardness; and its fracture is earthy and dull. It has sometimes a uniform texture, and sometimes it embraces fragments of limestone, basalt, hornblende, schorl, feldspar, &c. &c.—The tufa of the Solfaterra, near Naples, sometimes contains impressions, or even the leaves, of a species of sea-weed. (SPALLANZANI.)

It is easy to suppose, that eruptions of *slimy earth* and *muddy water* may occasionally proceed from reservoirs in the sides or body of volcanic mountains. But it appears, that many of the volcanoes of South America often discharge vast quantities of water, and of an earthy, slimy substance, called *Moya* by the natives, and *Koth* by the Spaniards. In addition to this Moya, these volcanoes eject ashes, pumice, and slags, but seldom any lava.

Moya has a blackish brown color, an earthy texture, and but little coherence. It contains fragments of feldspar, and frequently also great numbers of fishes (*Pimelodi Cyclopum*). Some varieties are combustible, and burn without flame.—A specimen yielded Klaproth silex 46.5, alumine 11.5, water, containing ammonia and empyreumatic oil, 11.0, oxide of iron 6.5, lime 6.25, coal 5.25, soda 2.5, hidrogen gas 14.5 cubic inches, carbonic acid 2.25 cub. inches.

A similar current of slimy, argillaceous earth appears to have once flowed from a volcano in the island of Lipari. (SPALLANZANI.)

Some naturalists suppose this water to be derived from the sea or from lakes by subterraneous passages; and that the eruptions of volcanoes are effected chiefly by the expansion of aqueous vapor. The necessary heat may be furnished by the combustion of immense beds of coal.

Peperino. This appears to be a kind of tufa, or concretion of volcanic ashes. Its base is argillaceous, has a dull earthy fracture, a moderate hardness, and embraces grains or fragments of limestone, mica, feldspar, and scoria; also garnets, augite, schorl, &c. Its colors are gray, reddish brown, &c. It often resembles a breccia.

In addition to the volcanic productions, already described, others are found, which have suffered calcination only—sometimes in consequence of contact with the flowing lava.

2. *Substances, ejected without alteration.*

Among these some varieties of tufa might be arranged. But volcanoes often eject fragments of granite, argillite, porphyry, greenstone, limestone, &c. and various crystals, which are sometimes scattered in the vicinity of the volcano, or enveloped in currents of lava, or of muddy eruptions. These substances are, in general, most abundant at the commencement of the eruption, and have suffered very little or no change from the action of fire. Sometimes also fragments of rocks, containing idocrase, meionite, sommite, garnets, mica, and carbonate of lime, are ejected without alteration.—Crystals of feldspar, leucite, augite, and hornblende, though enveloped in the lava, often remain nearly, or even perfectly, unchanged by the action of volcanic fire. These crystals most probably pre-existed in the rock, which yielded the lava. Hence Mr. Kirwan infers, that the heat of volcanoes, excepting when vitrifications are produced, seldom equals 120° W.

3. *Substances, sublimed by volcanic fire.*

The minerals, sublimed by volcanic fire, are condensed in the fissures or cavities of the lava and scoria, or are attached to the interior of the crater. They consist of sulphur, muriate of ammonia, sulphuret of arsenic, specular oxide of iron, &c. The first two are sometimes in sufficient quantity to be collected for use.

4. *Alterations in volcanic substances, after ejection.*

The heat of volcanic mountains, even when not in a state of great activity, is sufficient to produce a continual disengagement of sulphurous acid gas, which, by combining with more oxigen, may pass to the state of sulphuric acid. These acids attack and penetrate the lava, render it lighter and more brittle, and usually change its color to white or yellowish white; in fine, by their combination with some of the ingredients of the lava, several saline compounds are produced. Among these are the alkaline sulphate of alumine, and the sulphates of lime, magnesia, and iron.—Crystals of augite are sometimes rendered whitish and friable by sulphurous acid, but still preserve their form.

Even volcanic glass suffers change of color and decomposition, when attacked by the acids of sulphur. (SPALLANZANI.)

Lavas are also subject to a gradual decomposition by the action of the atmosphere and water, and are thus rendered friable, or converted into an earthy substance, which is remarkably favorable to vegetation, and which is often transported by water to a considerable distance.—As some lavas decompose much more rapidly than others, it is impossible to form any accurate opinion of their age by the degree of decomposition.

5. *Pseudo-volcanic productions.*

The accidental or spontaneous combustion of coal mines often continues for a great length of time, and produces a greater or less change in the contiguous rocks and earths. Some of these pseudo-volcanic productions have already been described under the names of porcellanite, tripoli, and polishing slate. Beds of clay are thus converted into a substance, resembling a brick in color and hardness.—In fine, tufa, scoria, and a kind of porous lava are sometimes the productions of pseudo-volcanoes. On the other hand, it is obvious, that true volcanoes may sometimes produce those substances, which are usually called pseudo-volcanic.

APPENDIX.

Meteoric Stones. Aerolites.

Those *stony* substances, which have fallen from the atmosphere, at different times, and in different parts of the world, have received the name of *Meteoric Stones* or *Aerolites.* But, for a more full account of these interesting substances, than could possibly be inserted in this volume, the reader is referred to the Appendix to the American Editions of Henry's Chemistry, by Professor Silliman.

REMARKS

on the Geology of the United States, explanatory of the subjoined geological map. (Pl. VI.)

The object of this Article is to give a brief and general view of the present state of our knowledge in regard to the geology of the United States, and to explain the subjoined map. For most of the observations, here given, the writer is indebted to a printed memoir by W. Maclure, and to written communications from H. H. Hayden of Baltimore. The geological boundaries on the map, taken chiefly from the aforesaid memoir by Mr. Maclure and from the geological map of the United States, published by him in Paris, are applied to the geographical map, recently published by Cummings and Hilliard. —The principal variation from Mr. Maclure's map appears in the extension of the alluvial deposite on Long Island, as suggested by Dr. S. L. Mitchill, in Bruce's Min. Journ. v. i.

There are several reasons, which render it important, that the geological relations of the various and extensive formations of minerals, which occur in the U. States, should receive peculiar attention, One important reason is the facility, with which geological observations may be here made, in consequence of the great extent, uniform structure, and regular stratification, which so often appear in rocks, belonging to the same formation. For it is obvious, that, under such circumstances, general principles can be more easily and satisfactorily established, than in those countries where the strata are often broken and discontinued, and where the action of earthquakes, volcanoes, torrents, &c. has produced irregularity and confusion in the arrangement of the strata.

The United States present extensive masses and strata, not only of *primitive*, *transition*, and *secondary* rocks, but also of *alluvial* deposites.—On the *eastern* side of Hudson's river, there is very little of alluvial deposite; and the rocks, with a few exceptions, belong to primitive formations. But, between the Hudson and the Mississippi, are found alluvial deposites, primitive, transition, and secondary rocks, so arranged, that the direction of their length is from north-east to south west and nearly parallel to the line of the sea coast. Hence a traveller, in the middle or southern States, passing north-west from the Atlantic toward the Lakes, would meet successively the preceding four great classes of mineral substances in the order just mentioned.

The geological boundaries and characters of these several classes require more particular description.

Alluvial Deposite.

Painted on the map gamboge yellow.

The northern extremity of this deposite is at Long Island, all of which appears to be alluvial, excepting the margin of the shore at Hurlgate, where primitive strata appear for the distance of four or five miles. On the east and southeast, this alluvion is bounded by the Atlantic; and on the south, by the Gulph of Mexico to the Mississippi. Its northwestern or interior boundary passes near Amboy, Trenton, Philadelphia, Baltimore, Washington, Fredericksburg, Richmond, a little west of Halifax and Fayetteville in N. Carolina, and of Camden in S. Carolina, near Columbia, Augusta on the Savannah, and thence, bending to the west, it crosses the Ogeechee, Oakmulgee, Alibama, and Tombigbee rivers, and reaches the Mississippi a little below Natchez.

The elevation of this deposite above the level of the sea gradually diminishes in passing from Georgia to New York. From the Mississippi to the Roanoke, the tide does not reach the northwestern boundary of this alluvion; but, from the Appomatox to the Delaware, it enters the primitive range.

This very interesting Deposite has been examined in but few points, and in no one, perhaps, to a sufficient depth. Through its whole extent, there is very little, which deserves the name of a rock. In Maryland, about 15 miles south from the *granitic ridge*, or border of the primitive, is a bed of sandstone, whose direction is parallel to that of the ridge. In N. Carolina also a bed of limestone and shells commences about 20 or 30 miles from the border of the primitive, to which it runs parallel through S. Carolina, Georgia, &c. In some points, as in Georgia, a variety of buhrstone is found.

The great mass of this alluvial deposite, below the soil, is composed of sand, gravel, pebbles, and clay, the last of which, either white or variously colored, sometimes forms extensive beds. These beds of sand, either brown and ferruginous, or white and pure, often present an undulated or wavy appearance; and sometimes, especially in their higher parts, embrace extensive beds of pebbles of quartz, &c. Sometimes also the gravel or sand is converted into a kind of ferruginous pudding or sandstone.

This Deposite contains numerous and valuable beds of the argillaceous oxides of iron; and sometimes also of the sulphuret of iron.

Beds of shells, teeth and bones of sharks, whales, birds, &c. and remains of vegetables are found in various parts of this alluvial deposite, sometimes at the depth of nearly 100 feet, and sometimes enveloped in a kind of mud, which appears to be the alluvion of an ancient sea. Beds of marl, which seem to have derived their calcareous ingredient from shells, are sometimes observed.

When this alluvial deposite is composed of fine sand, and destitute of any incumbent soil, very important changes are often produced by the action of wind. Thus at Cape Henry, in Virginia, hills are formed, and trees buried beneath the sand, which is gradually transported by the winds.

Primitive Rocks.

Painted on the map vermillion red.

The primitive formations extend from northeast to southwest through nearly the whole territory of the United States. *Eastward* of the Hudson, the rocks are, with a few exceptions, entirely primitive, and have the Atlantic for their eastern boundary. The apparent breadth of this primitive tract is much diminished in the middle states; but in the southern states is again enlarged.—From the Hudson to the Tombigbee, its visible boundary, on the southeast, is, with a very few exceptions, the aforementioned alluvial deposite; under which, however, it undoubtedly extends more or less. Its northwestern boundary on the map (for the whole of New England is not there colored), after crossing Connecticut river and entering New York, runs nearly parallel to the Hudson, passing about twelve miles east from Poughkeepsie; it then bends to the southwest, crosses the Hudson, passes ten or fifteen miles eastward from Easton on the Delaware, a few miles eastward of Reading on the Schuylkill and of Middletown on the Susquehannah, where it joins the Blue Ridge, along which it continues to Magothy Gap; and thence passes in a southwesterly direction, till it meets the alluvial deposite near the river Tombigbee.

The strata of this primitive region vary in direction from north and south to northeast and southwest; they almost invariably dip or incline to the southeast at a greater angle than 45°, and are sometimes almost vertical.

Within the limits, already assigned to the primitive strata, are found several transition and secondary formations, of comparatively small extent, resting upon the primitive;—as is obvious from an inspection of the colored map.—Thus, transition rocks *(rose red)* extend from Rhode Island to Boston. They again appear on the southwest side of the Delaware, and, traversing Lancaster, &c. extend to the upper branches of the Great Pedee in N. Carolina, forming a narrow deposite of uncommon length, and varying in breadth from two to fifteen miles.—Secondary rocks *(pale blue)* extend from Newhaven to Northampton, lying principally on the western side of Connecticut river. They appear again southwest of the Hudson; at the Delaware their breadth is much diminished; they pass a few miles west of York in Pennsylvania, and, crossing the transition rocks already mentioned near Fredericktown in Maryland, they terminate a little southwest of the Rappahannock.—A coal formation, composed of secondary rocks, is also found a little west of Richmond, in Virginia.

One of the most remarkable circumstances, connected with these primitive rocks, is the *granitic ridge*, which forms the boundary between the primitive and alluvial regions. This granitic ridge appears to have been the ancient line of the sea coast in the southern and middle states, and very probably through Connecticut. It commences at least as far south as Georgia; and its general direction is from southwest to northeast, sometimes varying to almost north and south or east and west. The Roanoke crosses it near Halifax; James River at Richmond; the Rappahannock at Fredericksburg; the Potowmac at Georgetown; and the Petapsco between ten and fifteen miles from its influx into Chesapeak Bay. It sometimes disappears under the soil; but at the point, where it crosses the Susquehannah, it rises to a greater height and is more rugged, than usual. At Trenton it crosses the Delaware, and traverses New Jersey to the Hudson, where its highest point is near Hoboken. After crossing York Island, it again appears near Hurlgate on Long Island. From Hurlgate, this granitic ridge, in the opinion of Mr. Hayden, extends along the north shore of Long Island, dips under the passage between that Island and Fisher's Island, which it crosses; and again dipping under the passage between Fisher's Island and the Continent, appears once more at Watch Hill Reef, not far below Stonington in Connecticut.

It is obvious, that this opinion of Mr. Hayden is by no means at variance with the facts, stated by Dr. Mitchill, according to which, nearly the whole of Long Island is colored on the map, as alluvial. For this *ridge*, while traversing a part of the northern boundary of Long Island, may so dip as to be covered by 70 or 80 feet of alluvial earths.—On the other hand, if this opinion is correct, it is exceedingly probable, that this granitic ridge once formed the southern boundary of what is now the States of New York and Connecticut.

It has already been remarked, that many formations of rocks in the United States are distinguished by their great extent and remarkable uniformity. An example of this exists in the vicinity of the granitic ridge just described. For, if a particular mineral occur two or more miles north of this ridge in Virginia or Maryland, it may generally be found at about the same distance north of the ridge in Pennsylvania, &c. This is the case with certain magnesian minerals, chromate of iron, &c.

Transition Rocks.

Painted on the map rose red.*

The greater part of the transition rocks, found in the U. States, lie northwest of the primitive, and form a long and narrow zone, extending from a little northeast of the Hudson to a little southwest of the Tombigbee. The breadth of the zone is from twenty to forty miles. The strata generally dip to the northwest; and their inclination is, in many places, less than 45°.

Among these rocks are found limestone of various colors, gray-wacke, gray-wacke slate, siliceous slate, amygdaloid, breccias, both siliceous and calcareous, and several other aggregates, not hitherto named or described.

Secondary Rocks.

Painted on the map pale blue.

This great secondary deposite lies northwest of the transition rocks, extending from them to the Lakes, and from the Hudson to the Mississippi. This deposite is, in fact, equally remarkable both for the extent and uniformity of the formations, which it embraces, and which consist of limestone and sandstone in strata nearly horizontal, on which often rests the Independent coal formation.

According to Mr. Maclure, there is reason to believe, that this secondary deposite extends westward of the Mississippi nearly to the foot of the Stony Mountains, thus presenting an area, whose diameter from east to west is about 1500 miles, and from north to south about 1200 miles.—In fine, it is suggested by this celebrated geologist, that all this extent of secondary rocks was once the bottom of a great Lake or Sea;—and that the waters of this Lake have been gradually discharged by the Mississippi, the Hudson, and the St. Lawrence, the only rivers, that have completely broken through the mountains, which once surrounded this immense basin of water.

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* Between the transition and secondary rocks a space is left without color to indicate, that the common boundary is not ascertained, or rather that the two classes of rocks are somewhat intermingled, and require further examination.—In other places, as on the eastern part of the District of Maine, want of color indicates, that such portions of the United States have not been examined.

VOCABULARY,

*containing an explanation of certain terms, used in the preceding volume; more particularly those, which relate to the Chemical Nomenclature.**

Acids. Substances, formed by the union of oxigen in certain proportions with a combustible base. Thus *sulphur*, united with a given quantity of oxigen, forms *sulphuric* acid. The name of the acid is derived from that of the *base*, or from that of the substance, which furnishes the acid, and always terminates with the syllable *ic*, as in the preceding example, unless the same base be capable of furnishing *two* acids. When this is the case, the two acids differ from each other by containing different proportions of oxigen; and the name of that acid, which contains the smaller proportion of oxigen, terminates with the syllable *ous*, as *sulphurous* acid. Hence the sulphur*ous* acid, by the addition of oxigen, passes to the sulphur*ic*.—Some acids exist in the state of a gas; some are liquid; and others are solid. They change a vegetable blue color to red; and most of them have a taste more or less distinctly *sour*.—They combine with alkalis, earths, and metallic oxides; and thus form alkaline, earthy, and metallic *Salts*. The number of acids is nearly 40.

Alkalis. Certain substances, which, when pure, have an acrid or a burning taste, and are caustic, when applied to the flesh. They are very soluble in water and rapidly combine with acids, thus forming *alkaline salts*, of which sulphate of soda is an example. They change a vegetable blue to green.—There are three alkalis, viz. potash, soda, and ammonia; the first two of which are solid and *fixed*, and the last is gaseous and *volatile*.

Alloy. A combination of any two or more metals in a metallic state.

Amalgam. A combination of any two metals, of which mercury is one.

Arseniate. A salt, formed by the union of *arsenic* acid with any

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* For an explanation of terms, employed in describing the imitative forms and other external characters of minerals, see Introduction, chap. 2, sect. 2.

base. Thus, Arseniate of copper is composed of arsenic acid and oxide of copper.

Arsenic Acid. A compound of about 64 parts of arsenic and 36 parts of oxigen.

Base. A chemical term, applied to one of the ingredients of a compound. Thus in carbonate of lime, the lime is said to be the *base* of this earthy salt.

Boracic Acid. A compound of oxigen with a base, which is supposed to be metallic, and has received the name *Boracium.*

Borate. A salt, formed by the union of *boracic* acid with a base; as Borate of magnesia, composed of boracic acid and magnesia.

Calcareous. This epithet is applied to carbonate of lime, that is, to all substances, composed of carbonic acid and lime.

Calcination. The exposure of metallic and other substances to that degree of heat, which drives off their volatile parts, and produces some other changes, but does not effect fusion.

Carbon. A simple, combustible substance. Charcoal, recently and carefully made, is *carbon* nearly or quite pure. Carbon also exists native in the diamond.

Carbonate. A salt, formed by the combination of *carbonic* acid with any base. Thus, Carbonate of lime is composed of carbonic acid and lime.

Carbonic Acid. A compound of about 29 parts of *carbon* and 72 parts of oxigen.

Carburet. This name is given to certain compounds, of which *carbon* forms one ingredient; as Carburet of iron, composed of carbon and iron.

Carburetted Hidrogen Gas. A variety of hidrogen gas, holding *carbon* in solution. See page 386.

Chromate. A salt, composed of *chromic* acid united with some base. Thus, Chromate of lead is a compound of chromic acid and oxide of lead.

Chromic Acid. A compound of about 60 parts of *chrome* and 40 parts of oxigen.

Combustion. In this process, *oxigen* combines with the combustible, or with some of its ingredients; and the product of combustion is either an *oxide* or an *acid.* The oxigen is usually furnished by the air.

Disintegration. When a mineral, by the action of air and moisture, is rendered friable, or actually crumbles, it is said to be *disintegrated.* Hence it is a different change from that, which is called decomposition.

Decrepitation. When a salt or other mineral, thrown into a red hot crucible, or exposed to the action of the blowpipe, yields a crackling noise and splits, or is even dispersed in small fragments, it is said to *decrepitate*.

Earths. The number of earths is nine, viz. barytes, strontian, lime, magnesia, alumine, silex, glucine, zirconia, and ittria.

Earthy Salts. Those salts, which have an *earth* for their base; of which sulphate of *lime* is an example.

Effervescence. An intestine motion, like boiling, in a fluid, being produced by the escape of some gas in the form of little bubbles. Effervescence may appear during the solution of certain minerals in acids, or during their fusion by the blowpipe.

Efflorescence. A salt is said to *effloresce*, when, by exposure to the air, it loses its water of crystallization, and falls into a powder.—It is also said to occur as an *efflorescence*, when it exists native in the form of a crust or powder on the surface of other minerals.

Fluate. A salt, formed by the union of *fluoric* acid with any base. Thus, Fluate of lime is composed of fluoric acid and *lime*.

Fluoric Acid. It has not been satisfactorily analyzed; but its base is probably metallic.

Gallate. A salt, composed of *gallic* acid and a base.

Gangue. See page 420.

Gas. A substance, which exists permanently, or at least usually, in the state of an elastic, aeriform fluid. Solids and liquids are converted into gases by combining with caloric.

Hepar. **Hepatic.** See pages 386 and 479.

Hidrate. A compound, of which *water* in a solid state forms an essential ingredient. Thus Hidrate of iron is a compound of water and oxide of iron.

Hidrogen. A simple, combustible substance. It forms an ingredient of water, which is composed of about 15 parts hidrogen and 85 parts oxigen, by weight.

Hidrogen Gas. Solid hidrogen, rendered gaseous by combining with caloric. It is very light, and highly inflammable.

Lixiviation. The dissolving of an alkali or a salt in water, thus forming a lixivium or lie.

Matrix. See page 420.

Mellate. A salt, in which the *mellitic* acid is combined with any base; as the Mellate of alumine.

Metallic Oxide. A metal, combined with *any* proportion of *oxigen*, is called a *metallic oxide*, provided it do not possess the properties of an acid. Hence the same metal, by uniting with different quantities of oxigen, often furnishes two or more oxides, which differ in color and other properties. Thus there are different oxides of iron, &c.—All metals must be converted into oxides, before they can combine with acids to form *metallic salts.*

Metallic Salts. Those salts, which have a *metallic oxide* for their base; of which carbonate of *lead* is an example.

Molybdate. A salt, in which *molybdic* acid is united with some base; as Molybdate of lead, composed of molybdic acid and oxide of lead.

Molybdic Acid. A compound of about 77 parts of *molybdena* and 33 parts of oxigen.

Muriate. A salt, composed of *muriatic* acid and some base. Thus, Muriate of soda is a compound of muriatic acid and soda.

Muriatic Acid. This acid has not hitherto been decomposed.

Nitrate. A salt, formed by the union of *nitric* acid with some base; as Nitrate of potash, composed of nitric acid and potash.

Nitric Acid. A compound of about 30 parts of *nitrogen* and 70 parts of oxigen.

Nitrogen. A simple, incombustible substance, formerly called azote.

Oxide. Any substance, which contains oxigen, is an *oxide*, provided the compound do not possess the properties of an acid. Hence water, composed of oxigen and hidrogen, is an oxide. But the term oxide is applied chiefly to metals, combined with oxigen. (See metallic oxides.)

***To* Oxidate.** To cause oxigen to combine with any substance.

Oxidation. The act of combining oxigen with any substance.

Oxigen. A simple substance, which is essential to combustion, during which it combines with the combustible. It is an essential ingredient of acids.—*Oxigen* constitutes, by weight, about 23 per cent. of *air*, and is necessary to the support of animal life; the remaining 77 parts of air consist of nitrogen. *Oxigen* also forms, by weight, about 85 per cent. of *water;* the remaining 15 parts being hidrogen.—Hence the *cause* of most of the changes, which minerals undergo by exposure to the weather, that is, to air and moisture; the *oxigen* of the air, or of the water, or of both, combines with the metallic or combustible ingredients of the minerals, thus exposed, and produces oxides or acids, both of which may also enter into new combinations.

Oxigen Gas. Solid oxigen, rendered gaseous by combining with caloric. This gas has been called *vital air.*

Phosphate. A salt, composed of *phosphoric* acid, united with some base. Thus, Phosphate of lime is a compound of phosphoric acid and lime.

Phosphoric Acid. A compound of about 45 parts of *phosphorus* and 55 parts of oxigen.

Phosphorus. A simple, combustible substance, which burns at the common temperature of the air.

Phosphuret. This name is given to certain compounds, of which *phosphorus* forms one ingredient; as Phosphuret of iron, composed of phosphorus and iron.

Precipitate. Any substance, which, being previously dissolved in a fluid, is *disengaged* by the addition of another substance, and gradually falls to the bottom of the vessel.

Reduction. When a metal, existing in the state of an *oxide*, either pure, or combined with an acid, is brought into a *metallic state*, it is said to be *reduced*. This reduction is effected by simply fusing the oxide, or by fusing it on charcoal, which abstracts the oxigen, or by fusing it with fluxes.

Regulus. See page 422.

Salt. A compound, produced by the union of an *acid* with an alkali, or an earth, or a metallic oxide. The alkali, or earth, or oxide is called the *base* of the salt. If the name of the acid terminate with the syllable *ic*, the name of the salt terminates with the syllable *ate*. Thus carbon*ic* acid, united with lime, forms carbon*ate* of lime; and sulphur*ic* acid, united with oxide of lead, forms sulph*ate* of lead. But, if the name of the acid terminate with *ous*, that of the salt terminates with *ite*. Thus sulphur*ous* acid, combined with iron, forms sulph*ite* of iron.—Sometimes the acid and base do not saturate each other, so as to produce a *neutral* salt. In this case, if the *acid* be in excess, *super* is prefixed to the name of the salt, as Super-phosphate of lime; but, if the base be in excess, *sub* is prefixed, as sub-borate of soda.—It is obvious, that, in Chemistry, carbonate of lime (limestone, chalk, &c.), or sulphate of iron (copperas), &c. is to be considered a salt, as well as muriate of soda (common salt).

Siliceous. An epithet, applied to those earths or stones, which are characterized by the presence of silex, one of the earths.

Sublimation. That process, by which a solid, as sulphur, is converted by heat into a gaseous state, and again condensed by cold.

Sulphate. A salt, formed by the union of *sulphuric* acid with any base; as Sulphate of lime, composed of sulphuric acid and lime.

Sulphuret. This name is given to certain compounds, in which *sulphur* forms one ingredient. Thus, Sulphuret of iron is composed of sulphur and iron.

SULPHURETTED HIDROGEN GAS. A variety of hidrogen gas, which holds sulphur in solution. It has a fetid odor, like that of putrid eggs.

SULPHURIC ACID. A compound of about 42 parts of sulphur and 58 parts of oxigen.

SULPHUROUS ACID. Its ingredients are the same as those of sulphuric acid, but with a less proportion of oxigen.

USTULATION. The roasting of ores to drive off the sulphur or arsenic, or to volatilize any of the ingredients.

EXPLANATION OF THE PLATES.

PLATE I.

Fig. 1, 2, 3, 4. Mechanical division of a hexaedral prism of carbonate of lime. (See Introd. Art. 38, *p.* 10.)

Fig. 5, 6. Mechanical division of a cubic crystal of fluate of lime. (See Introd. Art. 39, *p.* 11.)

Fig. 7, 8. Mode of obtaining integrant particles by mechanical division. (See Introd. Art. 45, 46, *p.* 13.)

Fig. 9, 10, 11. Construction of a secondary dodecaedron around a cubic nucleus; affording an example of decrements, parallel to the edges of the nucleus. (See Introd. Art. 55, *p.* 15.)

Fig. 12. An Electrometer. (See Introd. Art. 140, *p.* 58.)

PLATE II.

Fig. 1 to 11. Construction of a secondary octaedron around a cubic nucleus; affording an example of decrements on the angles, or parallel to the diagonals of the faces of the nucleus. (See Introd. Art. 61, *p.* 18.)

Fig. 12. A Goniometer. (See Introd. Art. 69, *p.* 21.)

Fig. 13 to 18. These figures are designed to illustrate the mode of describing crystals. (See Introd. Art. 74, 76, 78, 79, 80, *p.* 25.)

Fig. 19, 20. These figures relate to hemitrope or twin crystals. (See Introd. Art. 82, *p.* 26.)

Fig. 21. Nicholson's Portable Balance for estimating specific gravity. (See Introd. Art. 146, *p.* 61.)

PLATE III.

Crystalline Forms.

Fig. 1, 2, 3, 4.	Sulphate of Barytes.	Fig. 25, 26, 27.	Topaz.
5, 6.	Sulphate of Strontian.	28, 29.	Sapphire.
7.	Phosphate of Lime.	30, 31.	Staurotide.
8.	Fluate of Lime.	32.	Chrysoberyl.
9, 10, 11.	Sulphate of Lime.	33, 34, 35,	Zircon.
12 to 22.	Carbonate of Lime.	38, 39.	
23.	Siliceous Borate of Lime.	36, 37.	Quartz.
24.	Borate of Magnesia.		

PLATE IV.

Crystalline Forms.

Fig. 1, 2, 3.	Schorl.
4 to 8.	Feldspar.
9.	Wernerite.
10, 11.	Axinite.
12, 13, 14.	Garnet.
15, 16, 17.	Epidote.
18.	Idocrase.
19, 20.	Stilbite.
21.	Analcime.
22.	Chabasie.
23.	Harmotome.
24.	Chrysolite.
Fig. 25.	Tremolite.
26.	Diopside.
27, 28.	Augite.
29, 30.	Hornblende.
31.	Macle.
32, 33.	Sulphur.
34.	Diamond.
35, 36, 37.	Sulph. Antimo. Silver.
38.	Argental Mercury.
39.	Sulphuret of Mercury.
40, 41.	Gray Copper.

PLATE V.

Crystalline Forms.

Fig. 1.	Azure Carbonate of Copper.
2, 3.	Sulphate of Copper.
4.	Arsenical Iron.
5 to 10.	Sulphuret of Iron.
11, 12, 13.	Specular Oxide of Iron.
14.	Sulphate of Iron.
15.	Carbonate of Lead.
16.	Sulphate of Lead.
17, 18.	Molybdate of Lead.
19, 20, 21.	Oxide of Tin.
22.	Oxide of Zinc.
23.	Sulphuret of Zinc.
Fig. 24.	Arsenical Cobalt.
25.	Gray Cobalt.
26.	Oxide of Manganese.
27.	Sulphuret of Arsenic.
28.	Sulphuret of Antimony.
29, 30.	Ferruginous Oxide of Tungsten.
31, 32, 33.	Red Oxide of Titanium.
34 to 38.	Silico-calcareous Oxide of Titanium.
39.	Octaedral Oxide of Titanium.

PLATE VI.

Geological map of the United States.

In this map, *geological* boundaries are applied to the *geographical* map, recently published by Cummings and Hilliard.

Alluvial Deposites are painted *gamboge yellow.*
Primitive Rocks - - - - *vermillion red.*
Transition Rocks - - - *rose red.*
Secondary Rocks - - - *pale blue.*

Where no color is applied, the limits are uncertain, or rather the rocks, belonging to the two contiguous classes, are more or less intermixed.

INDEX.

Whenever a subspecies or variety has received a distinct name, it is arranged under the initial letter of that name. Thus, Apatite, though a variety of Phosphate of lime, is placed under A.—Compound names are also arranged under the initial letter of the first word, of which the name is composed. Thus, Red oxide of copper stands under R.—Those French and German names, which have not been adopted, as English words, in this volume, are printed in Italics.

ERRATA.

VERY few of the following errors materially affect the sense. They were occasioned in part by want of sufficient opportunity for inspecting the proof-sheets, in consequence of the distance, at which the author resides from the place, where the printing was executed.

Page 9, line 3 from bottom, dele 38.
—— 15, — 7 from bottom, for in, read is.
—— 32, — 12 from bottom, for *contracté* read *contracté*.
—— 84, — 13, for Lemetherie, read Lametherie.
—— 88, — last, for strontain, read strontian.
—— 94, — 9, for Allenite read Allanite.
—— 96, — 14, for petrolium, read petroleum.
—— 98, — 24, for hematitc, read hematite.
—— 135, — 8 from bottom, for phosphate, read fluate.
—— 226, — last of note, for commune read commun.
—— 236, — 18, for tihs, read this.
—— 238, — 2 of note, for opal ligniforme, read opale ligniforme.
—— 259, — 12, after Schorl add *
—— 327, — 2 of note, for La read Le.
—— ib. — 4 of note, for Hotz, read Holz.
—— 352, — 11, dele , after distinctly.
—— 353, — 1 of note, for commune read commun.
—— 383, in the analysis of Haüyene, read alumine 15, potash 11.
—— 464, — 1, for osmetimes, read sometimes.
The name of Thomson is, by mistake, several times spelled Thompson.

NOTICE.

THE *sparry* and *compact* varieties of Anhydrous sulphate of lime, mentioned in the Tabular View, are described, page 146, under the names of *cubic spur* and *anhydrite*.

That, which is called the *common* variety of marl in the Tabular View, is described, page 177, under the name of *earthy marl*.

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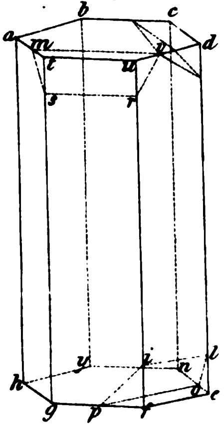

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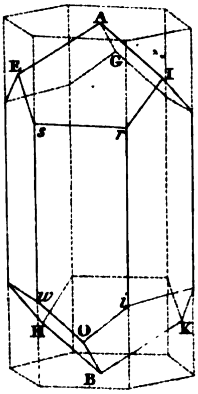

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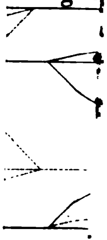

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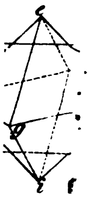

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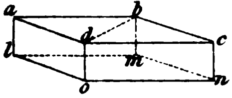

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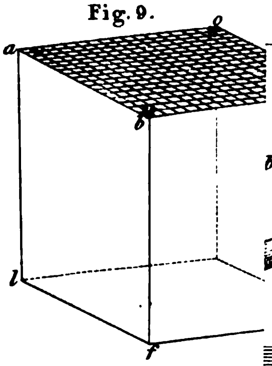

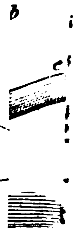

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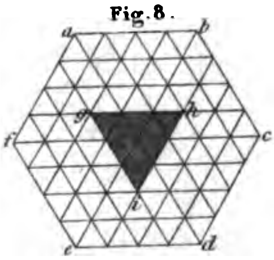

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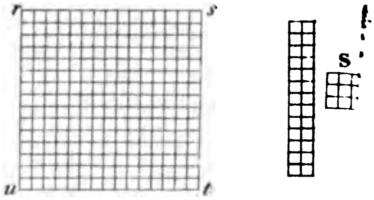

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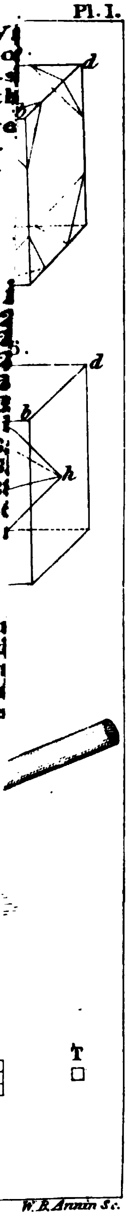

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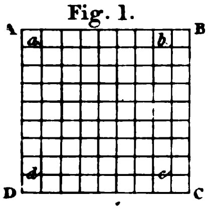

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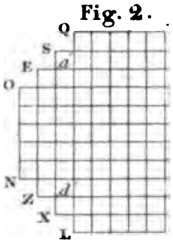

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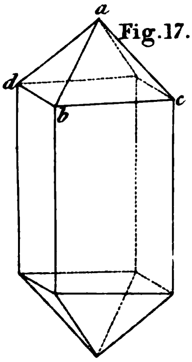

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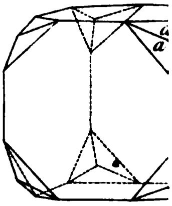

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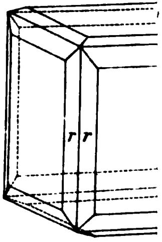

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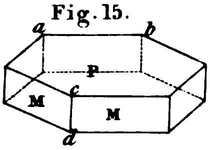

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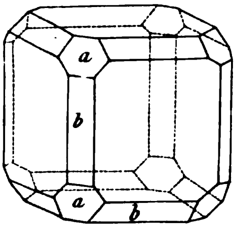

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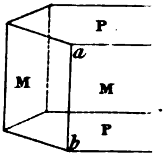

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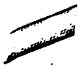

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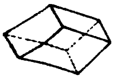

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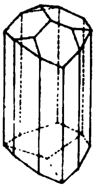

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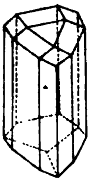

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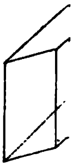

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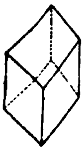

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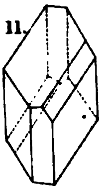

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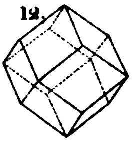

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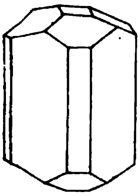

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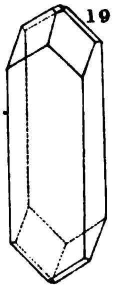

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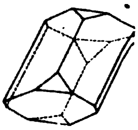

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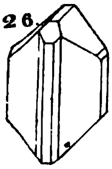

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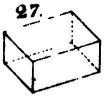

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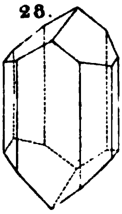

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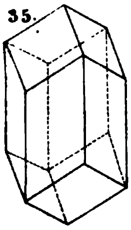

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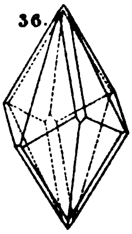

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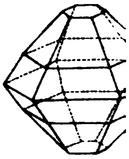

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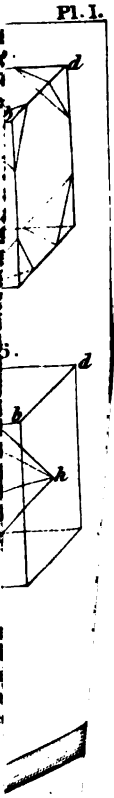

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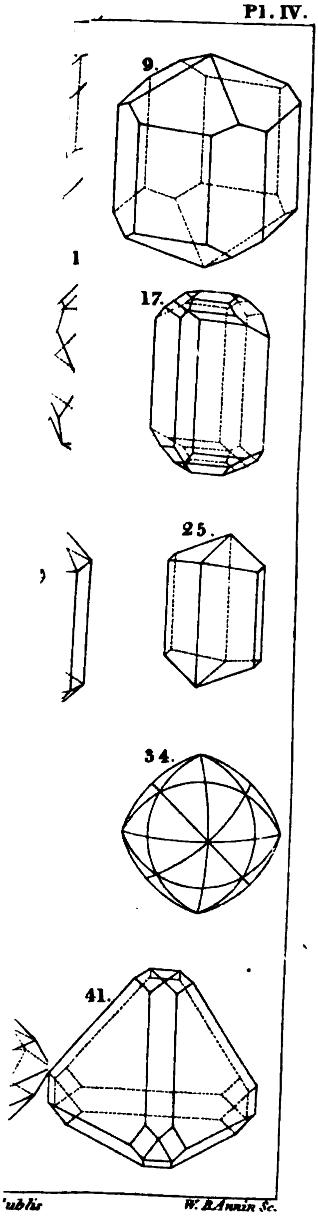

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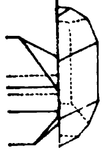

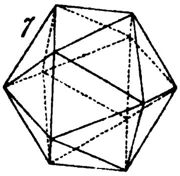
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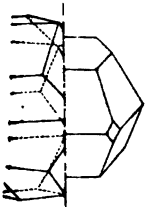

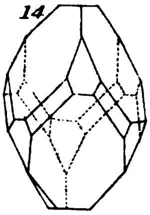
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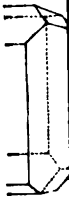

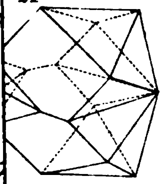
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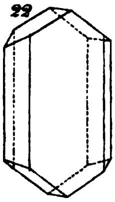
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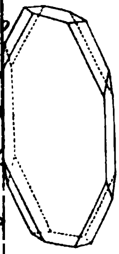

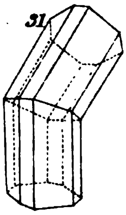
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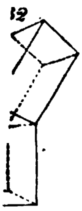
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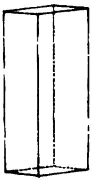
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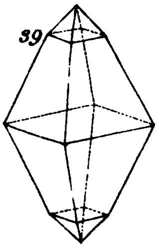
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