A SYMPOSIUM ON PENNSYLVANIA MINERALOGY IN THE EIGHTIES

PROGRAM AND GUIDE

held at
West Chester University
West Chester, Pa.

April 20-22, 1990

Symposium Chairman:	Arnold Ramsey Mogel
Symposium Committee:	Juliet Reed, Jay Lininger, Arthur Dorne, Margaret Matula, William Lorah, Rodger Mitchell.
Special thanks are extended to:	Dr. William A. Jordan, Dr. William Crawford, Clyde Schmell and Senn Brothers for their time and contributions for the field trip and location information.

FRIENDS OF MINERALOGY, PENNSYLVANIA CHAPTER
incorporated 1990

FRIENDS OF MINERALOGY SPRING SYMPOSIUM

FRIDAY 4/20

7:00 P.M.	Social Hour *"What's New in Pennsylvania"*

SATURDAY 4/21

8:30 A.M.	Registration, coffee & donuts
9:15 A.M.	Welcome to West Chester State University
9:25 A.M.	Roland Bounds *"Fissure Minerals of Cedar Hill Quarry"*
10:15 A.M.	Break
10:35 A.M.	Vince & Marge Matula *An Occurrence of Matulite* *Near Hellertown, PA.*
11:00 A.M.	Joseph Daque *"Brimstone & Blackjack"* *"A New Occurrence of Native Sulphur* *Crystals Along the Bellefonte Ledge, Wurtzite* *Occurrences in the Coal Fields of Western Pennsylvania"*
12:00 P.M.	Lunch—On Your Own
1:30 P.M.	Donald Hoff: Curator William Penn Museum *Copper & Uranium Minerals of Lycoming and Sullivan Counties, Pennsylvania*
2:30 P.M.	Speaker to be announced
3:15 P.M.	Announcements & mineral specimen auction
7:00 P.M.	Banquet: Lawrence Center Speaker: Robert Middleton, Academy of Natural Sciences *"James Dana in Australia, 1838-1840"*

SUNDAY 4/22

10:00 A.M.	Sunday field trip Locations to be announced

SUMMARY OF THE GEOLOGY OF THE GRAPHITIC ROCKS OF THE HONEY BROOK UPLAND, PA.

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The Precambrian rocks of the Honey Brook Upland, part of the Pennsylvania Piedmont Province, are bounded on the north by the Jurassic-Triassic Lowland and on the south by Cambro-Ordovician rocks of the Chester Valley. The hilly Upland is located some 45 km west-northwest of Philadelphia.[1]

From 1880 to 1960, and for a short while during World War II, several graphite mines, of which few traces remain, were in operation in the eastern part of the Upland. Florence Bascom, founder of the Department of Geology at Bryn Mawr College, and Benjamin Miller, of Lehigh University, were able to visit these localities in the early 1900's. The mines and geology were described by Miller (1912 a and b), and the localities were accurately plotted on the geologic map of the Honey Brook and Phoenixville quadrangles by Bascom and Stose (1938). Metamorphic and igneous rocks were mapped according to the standards of the day, long before the advent of high pressure/high temperature experimental petrology.

Bascom assigned all graphite-bearing rocks to the Pickering gneiss: that name was taken from that of a local Creek, and the graphite-bearing marble was assigned the name of the Franklin limestone first described in New Jersey. At that time a sedimentary origin for the graphite was taken for granted, as the source of the carbon was assumed to be organic. Bascom describes the Pickering gneiss as a rock rich in quartz and feldspar. In addition to graphite, it may contain minor amounts of biotite, hornblende, muscovite, and calcite, with accessory pyrite, pyrrhotite, magnetite, garnet, allanite, sphene, zircon, and secondary epidote, chlorite, and limonite. Bascom also noted that the Franklin marble always crops out in association with the Pickering gneiss. Calcite is combined with graphite in addition to accessory quartz, feldspar, diopside, pyrite, muscovite and secondary epidote, zoisite, and chlorite. The relative abundance of these minerals affects the texture, either schistose or gneissic, of the layered rock. Some graphite also occurs with feldspar and other minerals in pegmatitic bodies.

In 1939, Peritti Eskola of Finland introduced the concept of mineral assemblages whose presence indicates a certain pressure-temperature field of formation under the conditions of regional metamorphism. Each P-T field was called a facies. By 1970 sufficient experiments were carried out to permit the placement of real P-T boundaries about the P-T stability field at the mineral assemblages characteristic of each metamorphic facies (Fig. 1).

Maria Luisa Crawford and William Crawford (1980), summarized work on the Pennsylvania Piedmont through the nineteen-seventies, as well as initiating several new ideas on the metamorphic and tectonic history of the Province. The Bryn Mawr College professors stated that the Honey Brook Upland rocks belong to two metamorphic facies. The amphibolite facies represents generally lower pressure and temperature and the granulite facies higher

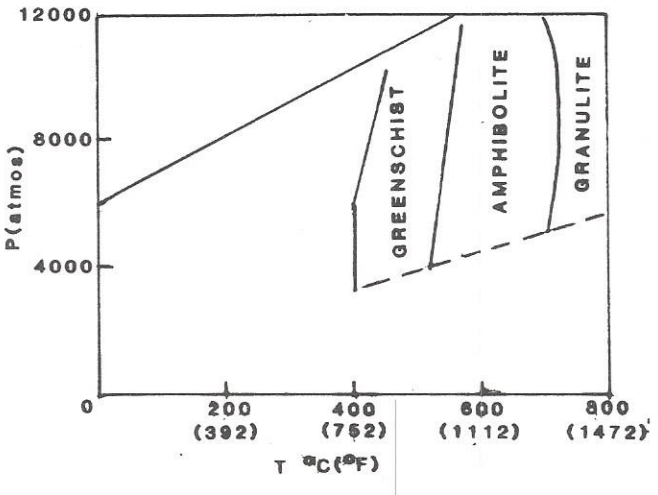

Figure 1. Pressure-Temperature diagram of the metamorphic facies of the Honey Brook Upland. Drawn by William A. Crawford.

[1]The material in this summary is drawn from the references listed.

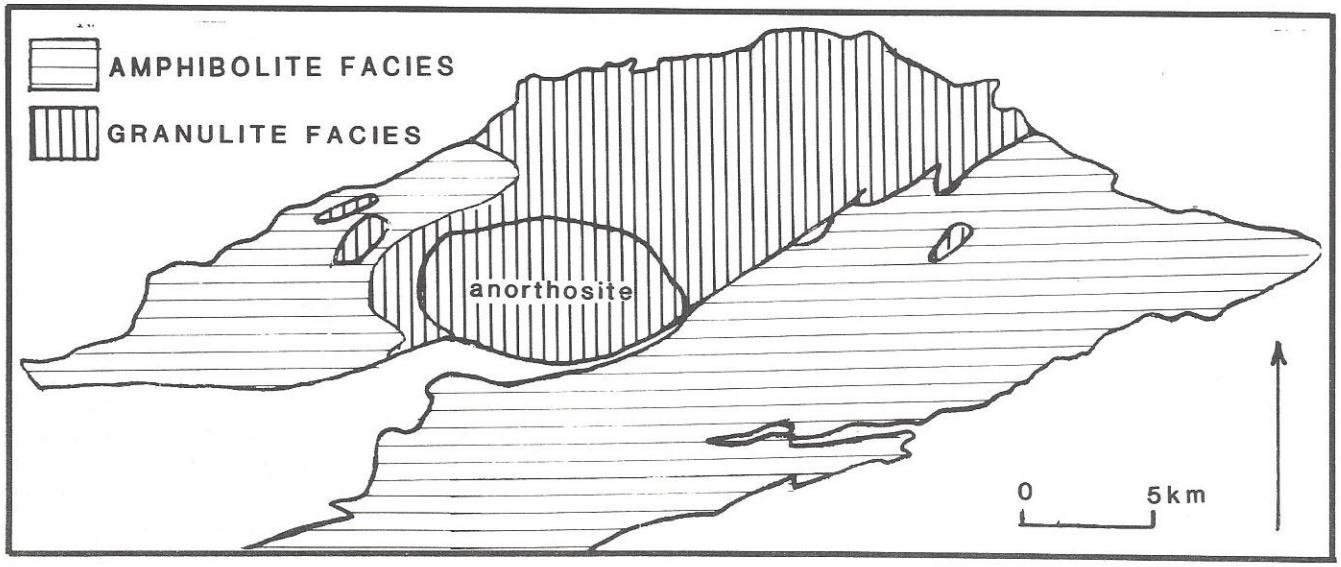

Figure 2. Generalized map of the Honey Brook Upland. Geological boundaries taken from the Geological Map of Pennsylvania (1980). Drawn by William A. Crawford.

temperature and pressure. Both facies may contain graphite (Fig. 2).

In general, north of the Brandywine Manor Fault, the granulite facies rocks are gneisses termed charnockite (a metamorphic rock with the composition of a pyroxene-bearing granite), with minor metabasalts, and felsic, light-colored graphitic gneiss (metasediments and meta-volcanics). These gneisses are intruded by a plagioclase-rich anorthosite pluton, and cut by meta-diabase dikes younger than the high-grade metamorphics. South of the Brandywine Manor fault and west of the anorthosite a volcanic suite ranging in composition from basalt to rhyolite was metamorphosed to amphibolite facies conditions. Since metamorphic grade increases northward, from amphibolite to granulite facies, the Upland probably represents a single gradational metamorphic terrane. Isotope dating reveals that a high temperature and pressure Precambrian event metamorphosed the area about one billion years ago, and a later Lower Paleozoic (Ordovician) event slightly altered, or over-printed, the high P-T mineral assemblage with a lower P-T greenschist facies assemblage.

Crawford and Hoersch (1984) describe the geology and petrology of the Honey Brook Upland in more detail, contrasting the early work of Miller, Bascom, and Stose with later findings of their own and other researchers. The two geologists, William Crawford, of Bryn Mawr College and Alice Hoersch, of La Salle University, used the results of petrographic, geochemical, and field work to further define the metamorphic facies. The origin of the dark-colored granulite facies gneisses and all the amphibolite facies gneisses were calc-alkaline volcanic rocks similar to those of the Cascades; those of the felsic facies gneisses closely resemble charnockite.

A Precambrian plagioclase-rich anorthosite intruded charnockite, followed by extrusion of volcanic rock and deposition of volcanic clastic sediments. These were buried and metamorphosed. Precambrian uplift during the Grenville orogeny was followed by subsidence and basin-filling by Cambro-Ordovician sediments, which were buried and metamophosed during the Taconic Orogeny of the Appalachians. Post-Taconic uplift was accompanied by movement along the Brandywine Manor fault. The origin of the graphite was unknown to Crawford and Hirsch at that time.

These interpretations, based on the relatively new concepts of metamorphic petrology, and observations using modern equipment, as well as field observations and optical work, are necessarily different from those of earlier, well-respected, geologists. However, Bascom, Miller, and Stose would find the portrayal of the geology of the Honeybrook Upland very little changed on the Pennsylvania Geological Map, published by the Pennsylvania Geologic and Topographic Survey in 1980, as the new findings were not published until later. The geology of this area of the

Piedmont will, however, be updated in the forthcoming volume on the geology of Pennsylvania (Pittsburgh Geological Society, in press), in which the new ideas will be presented in text and on maps.

William Crawford collaborated with John Valley, of the University of Wisconsin, on a paper (in press) on the origin of graphite in the Pickering gneiss and Franklin marble. The Pickering gneiss, contemporaneous with the Franklin marble, can be divided by appearance and mineral content and major element chemistry into two metamorphic facies, granulite and amphibolite.

The Pickering gneiss from the amphibolite facies region contains major plagioclase feldspar and quartz, with minor cummingtonite,[2] muscovite, and biotite, graphite to about 5%, and trace allanite, rutile, and spinel. The Pickering gneiss from the granulite facies localities contains quartz and feldspar (perthitic microcline and plagioclase), with up to 5% graphite, and minor muscovite, biotite, augite, or hypersthene. Accessories include garnet, zircon, apatite, and opaque minerals. The Pickering gneiss was subjected to P-T conditions sufficient to cause the "low" melting point minerals to form melts which became "granitic" pegmatities. These intrusive bodies are in places parallel with enclosing schists and gneisses and at other places cut across at low angels. The marble always occurs with the gneiss and contains graphite, with quartz, feldspar, diopside, pyrite, and muscovite, as well as secondary epidote, zoisite, and chlorite.

Carbon isotope studies of the graphite show values consistent with a surficial organic source rather than deep-seated mantle rocks. This conclusion requires a sedimentary source for both the Pickering gneiss and Franklin marbles; rocks derived from charnockite and a calc-alkaline volcanic suite are suggested as sources for the Pickering gneisses unit and carbonates for the Franklin marble. When the organic-rich sediments were buried and intruded by an anothosite body, the deeper part of the original charnokite and volcanic sources, some basalts, and some sedimentary rocks attained lower granulite facies condition (Fig. 3). The shallower parts, including some basalts, the volcanic rocks, and the rest of the sedimentary rocks reached upper amphibolite conditions (750°C or 1382°F), at roughly the same temperature (680°C or 1256°F), but lower pressure. Organic matter was changed into fine-grained graphite during this process. Water-rich fluids containing carbon dioxide from the sedimentary calcareous rock produced a coarse-grained graphite in the pegmatites, due to partial melting.

[2]Cummingtonite is a new mineral for Pennsylvania.

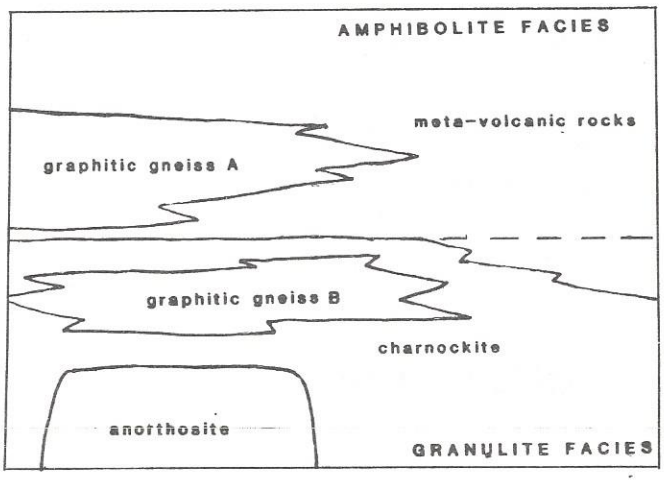

Figure 3. Hypothetical section through the Honey Brook Upland. A = graphitic gneiss (organic-rich sediments derived from meta-volcanic rock), B = graphitic gneiss (organic-rich sediments derived from metamorphic facies charnokite). Drawn by William A. Crawford.

Further research is in progress; the story will be continued.

ACKNOWLEDGEMENTS

Warm thanks are due to William A. Crawford for reviewing the text, making corrections and useful suggestions, and providing the maps and cross-section. Arthur Dorne, Arnold Mogel, and Jay Lininger carefully reviewed the manuscript and made helpful comments from the collector's point of view. Jay Lininger also generously contributed his time and expertise as designer and publisher.

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THE HISTORY OF GRAPHITE MINING IN THE PICKERING VALLEY OF CHESTER COUNTY, PENNSYLVANIA

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Introduction

Starting before 1860 and continuing until 1960, graphite was intermittently but actively mined in Pennsylvania. The earliest mine was in Bucks County, near Langhorne (Miller, 1939), but most of the activity was in northern Chester County. Thousands of tons of separated graphite were produced there by the twenty or so mines that were operated. Many of these and the associated separation mills, although tiny in comparison with the mines typical of the world today, were nevertheless of considerable size and complexity. Substantial sums, in at least one instance equivalent to tens of millions of 1990 dollars, were invested (Miller, 1912).

The graphite deposits of Pennsylvania occur in the metamorphic rocks of the Piedmont Plateau area in the southeastern part of the state. Graphite has been mined in Berks, Bucks, Chester, and Lehigh Counties, but the principal deposits are west of Phoenixville, in Chester County. The most important localities are in the valleys of French and Pickering Creeks, where two nearly parallel northeastward-trending areas of gneisses and schists contain graphitic layers. (Cameron and Weis, 1960)

The deposits near Pughtown (in the French Creek Valley) were the first to be worked. Rogers (1858) reported an active mine, a short distance southwest of Pughtown, then producing material used in weatherproof paint. However, the belt of graphite deposits in the Pickering Valley is the more important. In fact, only the Eynon-Just) in the smaller French Creek belt, produced a significant amount of graphite. Here was found the amorphous variety, which is less valuable than the flake type which predominates in the Pickering Valley deposits (Cameron and Weis, 1960).

Both belts are in the Pickering gneiss of Precambrian age, a metamorphosed sedimentary sequence consisting of orthoclase, plagioclase, quartz and biotite, with hornblende and other minerals as accessories. Variations in proportions of mineral constituents are common. Most of the rock at or near the surface is intensely weathered. Only certain layers contain graphite (Cameron and Weiss, 1960). The gneiss is locally calcareous and grades into a coarsely crystalline Franklin marble in places.

Graphite mining in the United States always had been a small-scale industry and significant expansion has occurred only in wartime under government subsidy (Cole, 1965). Since 1960 there has been almost no mining in the U.S.

a 1990 Friends of Mineralogy, Pa. Chapter, field trip afforded a rare opportunity to visit several of the old mine sites in the Pickering Valley, to collect graphite and associated minerals, and to examine the geology. These localities are not open to collecting except by qualified groups by prior permission. Perhaps tactful investigation of other sites may obtain the necessary permission to collect not only minerals, but further details on the history and geology.

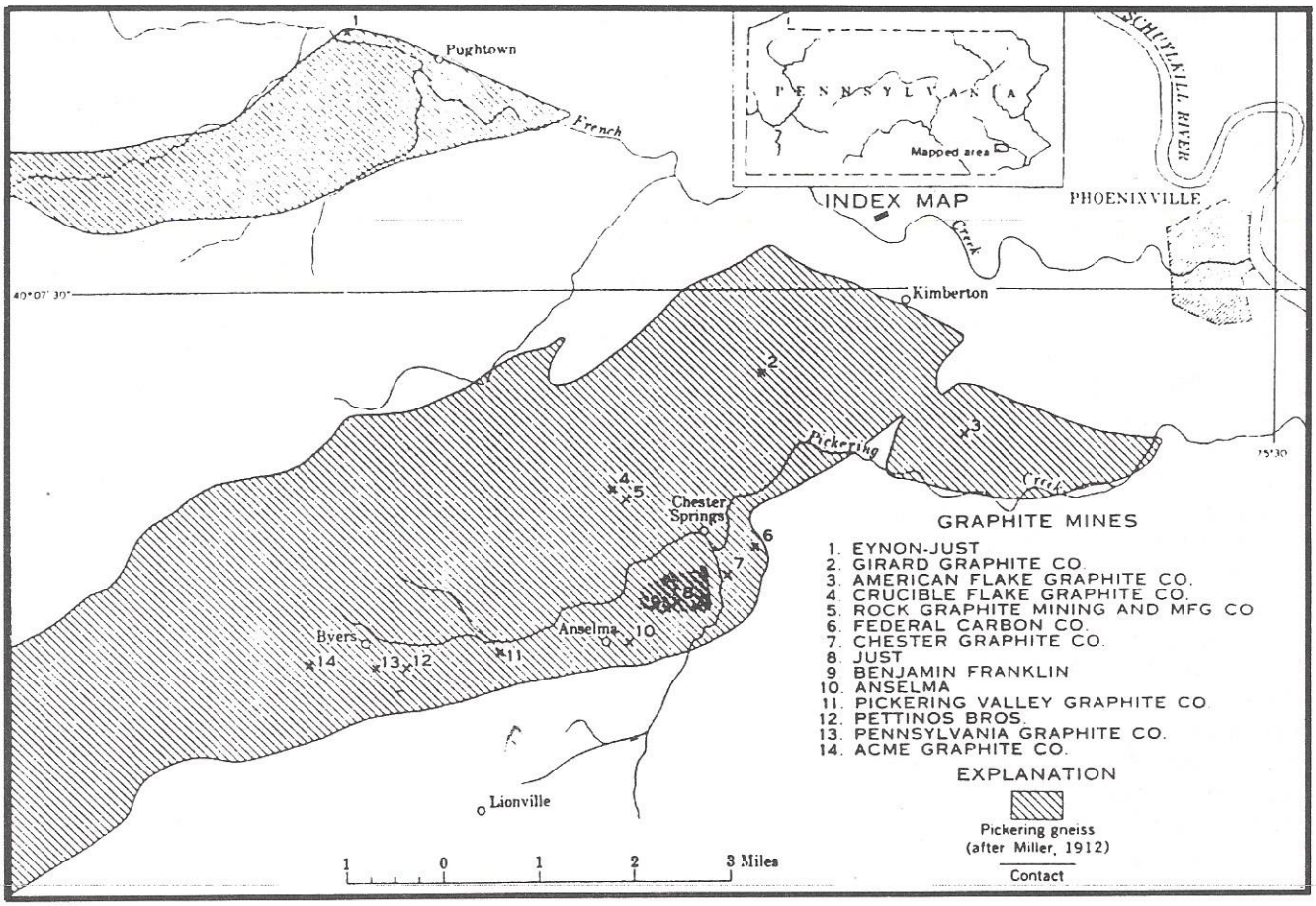

Figure 1. Location map of Pickering Valley graphite mines.

The Mines of the Pickering Valley

Bascom and Stose (1938) provided most, except where indicated, of the following information concerning the mines of the Pickering Valley. Mines are located by number on Figure 1. The names are those most frequently used; almost every mine changed hands many times and had correspondingly many designations. In addition to the fourteen mines covered here, there are others not individually identified in the literature. They are lost in the mists of time.

(1). Pettino Bros. Mine. This mine, the first in the Pickering Valley, is located approximately ¼ mile southwest of Byers. Originally called the Phoenix, it was opened about 1860. The earliest mention of it is in Frazer (1883): "Near the town of Windsor and some quarter mile south of the Phoenixville and Pickering Valley R.R. is a mine opened for graphite and now owned by the Pennsylvania Graphite Company of Reading. This company leased 500 to 600 acres of the estate of Jno. Todd, deceased, and one mine adjoining the mill has been wrought continuously ever since the graphite was discovered by Mr. Berritt and Dr. Thos. Brown lying in flakes on the ground. This belt of conglomerate (sic) with bluish or amethystine quartz containing graphite has been traced all the way to Phoenixville and in the same course but opposite direction to the Brandywine, but its occurrence is confined to a few hundred yards, though its existence can be proved on almost any farm in the district. The mine is opened about 60 feet in depth by open slope along 500 ft. of the outcrop. The report goes on to describe the operation in considerable detail. Twelve miners and twenty-eight mill workers were employed and 30 to 40 tons of ore were dug and processed per day."

Activity continued, with interruptions, under a succession of operators until 1920, apparently on a

substantially larger scale in terms of volume of ore. There was a large open cut, a number of small pits and a shaft with underground workings. The ore bed is described as the same one in which mines (2) and (3) are located and was claimed to be (at least in this mine) from 5 to 6 percent graphite. Furthermore, the calcareous gneiss or crystalline limestone in which it occurs is about ten feet thick 70 feet below the surface. Kaolin, quartz, limonite, marcasite, pyrite, chloropal, chlorite, zoisite and tremolite are reported.

(2). Pennsylvania Graphite Co. (Graphite Products Co.). Located approximately ¼ mile west of the Pettino Bros. operation, this mine opened not long after it and also had a succession of operators until it too closed in 1920. This mine also had several open cuts, one being 400 feet long, and an underground working which was perhaps the largest of any in the valley and stretched 1700 feet from east to west. This extensive report includes the statement: "In the deeper portions of the mine where weathering has not progressed so far, altered crystalline limestone occurs, in which there is so much graphite in large flakes showing no orderly arrangement, in association with calciate, quartz, wernerite, biotite, diopside, epidote, tremolite, garnet, zoisite, and titanite . . . . Some vugs were observed filled with sharp-pointed scalenohedral crystals of calcite."

(3). Acme Graphite Co. This operation began in 1882, about ⅜ mile southwest of Eagle, but was not developed on a large scale until 1906, when a large mill was built and underground workings similar to, but not as extensive as those of the Pennsylvania Graphite Co., were started. Operations ceased in 1910. As indicated previously, mineralization was similar to that at locations (1) and (2) but the calcareous portion was less important.

(4). Pickering Valley Graphite Co. In the early years of mining in the Valley a shaft was sunk and a drift cut at this site about one mile east of the Pettino Bros. mine. It was abandoned soon after.

(5). Anselma Graphite Co. There are old workings about ¼ mile east of Opperman's Corner and ⅜ mile southeast of the Ben Franklin Mine (14). This may be the Anselma Mine of the literature. It was opened in 1905 on a substantial scale, but produced only about one ton of graphite a day because of the hardness of the rock.

(6). Just Mine. This open cut was started about 1912, about ¾ mile northeast of the Anselma Mine and a few hundred feet north of the Horseshoe Trail. From then until about 1919, the Just Mine and an associated mill were operated by the T.O. Just Co. During the 1940's, the mine only was again operated (in conjunction with the Ben Franklin Mill. The pit was ultimately 600 feet long, 25 to 200 feet wide and 40 feet in maximum depth. According to Cameron and Weis (1960), the Just Mine and the Ben Franklin Mine are in the same graphite zone, which has been traced along strike for about 3200 feet, but as neither end of the zone has been located, its total length may be considerably greater. The zone is exposed in trenches and workings over widths ranging from 200 to 400 feet but the width is not known. The graphite rock consists of micaceous quartz schist, nearly pure quartzite, and feldspathic quartz-muscovite gneiss. Thin lenses of coarse granitic to pegmatitic material are abundant in parts of the graphite zone. A few pegmatites as much as five feet in thickness occur. Graphite layers range from a few inches to as much as ten feet in thickness. Individual graphite flakes are 1 to 8 mm. in thickness. Individual graphite flakes are 1 to 6 mm in diameter. Note that there is no indication that there are calcareous zones at this location.

(7). Keystone Graphite Co. (Philadelphia Graphite Co., Chester Graphite Co.) Mine. From 1896 until 1920, open pits, a shaft mine, and several mills were operated intermittently, ⅝ of a mile south southeast of Chester springs P.O. The graphite beds are reported to be about 20 feet thick, and the ore carries about 6 to 10 percent graphite. The rock is a decomposed gneiss and coarsely crystallized limestone striking N.25°E. and dipping 35°SE.

(8). Federal Carbon Co. Mine. This mine, which included an open cut, a vertical shaft, and a tunnel, about ¾ mile east southeast of Chester SPrings, was operated at various times up to 1918. Gneiss, with pegmatitic and aplitic granitic injections, were recorded.

(9) and (10). Rock Graphite Mining and Manufacturing Co. and Crucible Flake Graphite Co. Mine. A graphite mine was opened by Wayne C. P. Parker in 1903 by driving a tunnel 400 to 500 feet in to the hill, about ¾ mile northwest of Chester Springs P.O. in 1903. During the following seventeen years, he and others opened several other mines and mills nearby. Apparently the rock was similar in all of them; a gneiss which has undergone but little decomposition and is composed of quartz, feldspar, biotite, graphite and pyrrhotite.

(11). Graphite Mining Co. Mine. A mine was operated at one time just south of Pikeland. No further

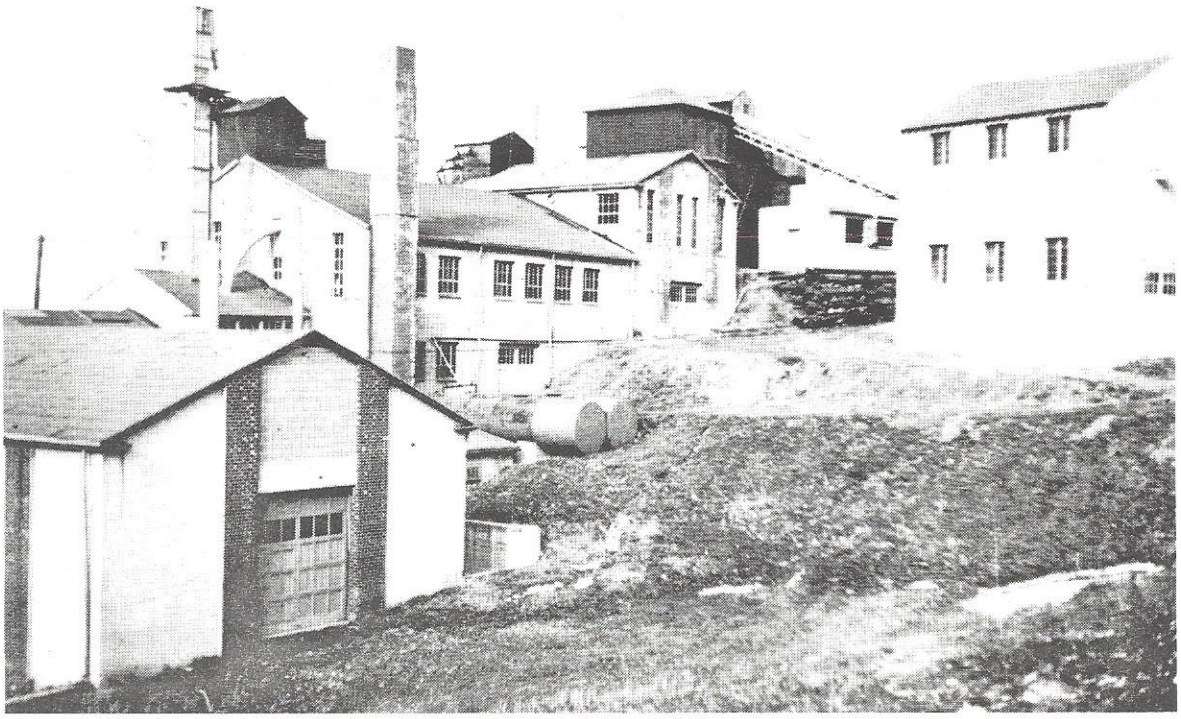

Figure 2. View of Ben Franklin graphite processing mill, taken from the southwest (Courtesy of Clyde Schmehl).

information is available.

(12). Phoenix Hill Graphite Co. Mine. An open-cut mine was operated from about 1908 to 1911, about one mile northwest of Charlestown and about 1/10 mile southwest of the southwest tip of the present Kimball Drive. It was reported that only 9 to 10 tons of rock was required to yield one ton of concentrate.

(13). Girard Graphite Co. Mine. A mine and mill were operated ½ mile northwest of Hallman Station from 1905 to 1911. The graphite occuts in a calcareous limonite gneiss, originally pyritiferous. Large flakes of graphite, a quarter of an inch in diameter have been found here. A limonite ore pit and an outcrop of Franklin Limestone occur just west and north of the graphite mine.

(14). Ben Franklin Mine. In 1943, a mill was constructed about one mile south-southwest from Chester Springs P.O. and ¼ mile southwest of the Just Mine, by the authorization of the War Production Board for the U.S. government (Fig. 2). The mill and the 70-acre tract on which it was located were the leased to the Benjamin Franklin Graphite Co., which also leased the Just Mine. This company then opened the Ben Franklin Mine just north of the mill and operated the mill and both mines for a period of five months during which 398 tons of graphite were produced.

Sandford and Lamb (1960) record that in April, 1946, the Benjamin Franklin Mine and mill and Just Mine were leased by the newly formed North American Graphite Co., which operated the mine and mill for 4 months in 1947 and produced 58 tons of graphite. Messrs. Hess and Schmehl sub-leased the properties in October, 1947, and produced 120 tons of graphite.

According to Cameron and Weis (1960), the operations were shut down in January 1948. In that year, the properties were explored by the U.S. Bureau of Mines, which trenched and diamond-drilled, finding that the zone averaged 1.5 per cent and that the proportion of coarse flakes in the graphite of this area may well be greater than that at any other locality in the United States.

The history of operations after 1948 was furnished by Clyde A. Schmehl (p.c., 1990):

"My father, Harry A. Schmel, who had been plant superintendant from 1946 to 1948, was also plant superintendant for the F.M. Equipment Corp., which

leased the property from the government from 1951 to 1954. My father then leased the mill and mines and operated them from 1955 to 1957. In early 1959 he became plant superintendant for the Graphite Corp. of America and remained so until his death shortly thereafter. At that time I became superintendant and remained so until operations ceased in 1960.

"The operational crew varied. Usually during a 24-hour operation the crew totaled about 165 men. This did not include office or maintenance personnel.

"I worked there every time the plan was operational except during 1942–1943, during which time I was in the Navy. I worked in various positions including lab technician, mill operator, foreman, salesman, and plant superintendant.

"The graphite ore was crushed using a large jaw-crusher and 24*f* rolls. Various screening operations were conducted to assist the procedure. Separation was conducted using ball mills, flotation cells and other equipment. The plant was designed to process 500 tons of ore per 24 hours, but only about 300 tons were ever accomplished. The percentage of graphite was 2 to 5 percent. It was all flake type."

Clyde Schmehl, now retired, worked for the U.S. Bureau of Mines on the development of ore treatment processes, after his activities at the Ben Franklin Mine.

Bascom and Stose (1939) record that previous to his years at the Ben Franklin Mine, Harry Schmehl leased and operated the Keystone Graphite Mine property (1916–1917) and for a year (1919–1920) he leased and operated the mill (and presumably the mine) at the Just property.

The mill and all outbuildings were moved for safety reasons a few years ago by the present owner, Dr. Henry Jordan.

ACKNOWLEDGEMENTS

I wish to thank Clyde Schmehl, not only for supplying the material credited to him above, but also for providing the pictures of the Ben Franklin mill and for reviewing the entire manuscript. Thanks also to Dan Kulp, of Kimberton, for his interest in this project, which led to Mr. Schmehl's participation. Dr. Henry Jordan provided a most interesting tour of his

Figure 3. View of jaw crusher at the Ben Franklin Mine. Note ore conveyor in lower right (Courtesy of Clyde Schmehl).

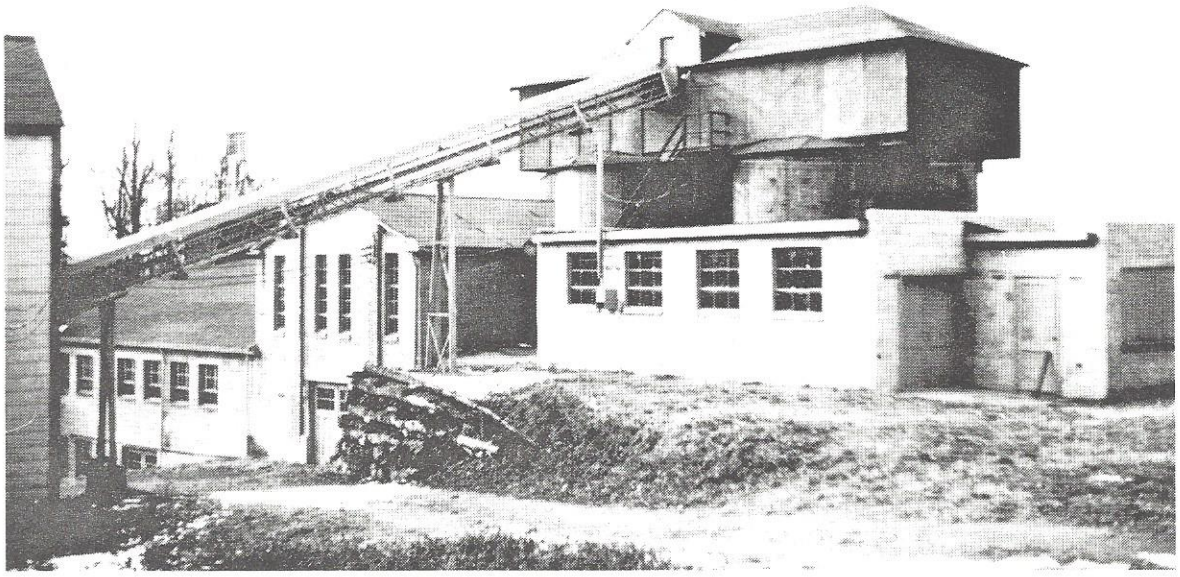

Figure 4. Ore bins and head house at the Ben Franklin Mine (Courtesy of Clyde Schmehl).

Ben Franklin-Just Mine property. Juliet Reed aided in library research and editing; Arnold Mogel and Jay Lininger read the manuscript and commented on it from a collector's point of view. Last, but not least, Jay Lininger designed and coordinated the publication, as well as providing historical background.

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