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Emery deposits near Chester, Massachusetts

by E. T. Apfel

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Introduction

A vein containing a disconnected series of lenses of emery extends in an almost due north-south direction, through a point about a quarter of a mile west of the village of Chester in Hampden county in central western Massachusetts (figure 1). Emery was mined from these mineral bodies during several periods until 1913. The vein is nearly vertical, is known to be about four miles long and extends to unknown depth. The trace of the vein ranges over a relief of more than 800 feet, crossing two major hills and the intervening valley of Walker brook, an eastward flowing tributary of Westfield river. The village of Chester lies near the junction of Walker brook with the river and within a quarter of a mile of the largest mine that was worked on the vein. Mills for concentrating the emery were in or near Chester and formerly used the water power from both Walker brook and Westfield river.

History

The history of the discovery and early exploitation of the Chester emery vein has been outlined by B. K. Emerson.[1/] The

Emerson, B. K., The geology of Old Hampshire County, Massachusetts; U. S. Geol. Survey, Monograph 29, 1898, pp. 117-135.

deposit was first worked in 1856 as iron ore, for magnetite composes a large proportion of the veins. The iron ore was smelted in furnaces at Stockbridge and Lenox, Mass., but after about a year the mines were closed. They were not reopened until 1863, when they were used to supply a blast furnace and forge which had been erected at Chester. The refractory nature of the ore caused the furnace to become plugged at first heat and this attempt to melt the ore was abandoned.

In the meantime, Mr. J. L. Smith had examined emery deposits in Asia Minor and described the minerals associated with the emery, among them margarite and chloritoid. Dr. Charles T. Jackson of Boston, in examining the Chester iron ore for its Boston owners, identified the same minerals associated with that ore as Smith had found associated with the foreign emery. He asked Dr. H. S. Lucas of Chester to look for the emery that this mineral association indicated, and this was found by Dr. Lucas on September 6, 1864. Mining of the emery was immediately begun to supply the Northern arsenals with the abrasive needed to replace that which had been cut off from abroad by the Civil War.

The Hampden Emery Company was formed in 1868 to operate the mines. A few years later this company sold what was supposed to be the main vein to the Chester Iron Company (afterward the Chester Emery Company) but continued to work a vein farther west. The Chester Iron Company soon discovered that their property contained only emery boulders, apparently derived from the vein to the west, to which they made claim. Several years of litigation followed with the Chester Iron Company finally winning the principal emery property.

Machinery was installed and the property developed further so that in 1879 thirty-five men were employed and 210 tons of emery were produced, valued at $20,000. Mr. James T. Ames of the

Ames Manufacturing Company of Chicopee Falls, Mass. controlled the Chester Emery Company, but upon his death about 1883 the property was sold for a small fraction of its cost, indicating that the business was not highly profitable. The purchasers had been milling emery imported from Asia Minor and the Greek island of Naxos, and they continued to get their principal supply from these sources because all mining in the Chester area had been discontinued in 1883.

Mining was resumed in 1890 at the old mine just west of Chester, and it continued until 1913, when all operations ceased and the mills that were using the Chester emery were torn down. One emery mill remains in Chester at the present time, that of the Hamilton Emery and Corundum Company. Emery is also milled by the American Abrasive Company in Westfield, Mass., 17 miles southeast of Chester. Both of these companies use ore from Peekskill, N. Y., and imported ore when such ore is available.

There are practically no published records of production from the Chester mines, but the total amount of marketed emery produced there between 1864 and 1913 is believed to be around 25,000 short tons, derived from 100,000 tons of ore.

Uses of emery

The principal uses of emery are in grinding optical glass and in certain metal-finishing work. Pure natural corundum and manufactured abrasives are considered too hard or harsh for some of these uses; the admixture of less hard impurities with corundum, such as occur in emery, serves to tone down the harshness and give more satisfactory results. Emery that contains a higher proportion of corundum is best suited for grinding wheels and that for a lower proportion for polishing and for pastes.2/

2/ Industrial Minerals and Rocks, A.I.M.M.E., New York, 1937, p.18.

A newly developed use for emery consists in mixing it with floor-topping materials in order to provide a non-skid surface. According to reports Peekskill emery aggregate has been mixed with Portland cement and provides a firmly gripping surface even when wet. Greater traction for hand-trucks, etc. is thus obtainable, the load-bearing quality is increased, and durability is markedly greater.

Domestic production

The emery used in the United States has come almost entirely from foreign sources in recent years. Different grades were supplied from Naxos, Greece and from Turkish mines. War conditions shut off the supply from these sources and brought about increased demands for domestic ores and the development of African sources of corundum. Somewhat similar conditions existed during World War I, when the demand for domestic emery was so increased that production climbed to many times that of the pre-war years, as shown in table 1.

Table 1. Emery production in the United States, 1914-1921.

Year	Tons	Value	
1914	485	$ 2,425	
1915	3,063	31,131	
1916	15,282	123,901	(Includes 820 tons of
1917	17,135	241,050	-(corundum valued at $67,461
1918	10,422	112,878	- Includes corundum
1919	2,061	23,203	
1920	2,327	21,685	
1921	305	2,250	

During the present war, production of domestic emery, entirely from the Peekskill, N. Y. area, has increased to cover some of the additional demand, as shown in table 2.

Table 2. Emery production in the United States, 1936-1942 3/

Year	Tons	Value
1936	325	$ 2,900
1937	320	2,780
1938	nil	nil
1939	765	6,828
1940	1,046	9,349
1941	4,876	42,484
1942	5,277	49,413

3/ Data from Minerals Yearbooks, U. S. Department of Interior, Bureau of Mines.

There still remains an active demand for emery of appropriate quality for certain uses. Not all domestic emery can satisy the requirements, but there is reason to believe that the Chester emery, recognized as of high quality when it was marketed, would be suitable.

General geology

General statement:

Emery bodies, consisting largely of a mixture of corundum and magnetite, are found in a restricted, vein-like zone near the eastern edge of a band of amphibolite known as the Chester amphibolite that occupies a stratigraphic position between two beds of sericite or mica schist. The formation boundaries are vertical or nearly so. A geologic map of the area is shown in figure 4. Emerson 4/ traced the amphibolite, locally replaced by serpentine and talc, from the northern edge of the state nearly to the southern boundary. Only a small part of the belt of amphibolite is known to contain emery and at that place, near

4/ Emerson, B. K., Geology of Massachusetts and Rhode Island: U. S. Geol. Survey Bull. 597, p. 41, 1917.

Chester, the amphibolite attains its maximum thickness, and hence greatest outcrop width of about three quarters of a mile. Elsewhere the amphibolite is much thinner and emery has not been found associated with it.

The stratigraphic section in which the amphibolite occurs includes the following formations according to Emerson: 5/

5/ Emerson, B. K., idem. pp. 40-41.

Stratigraphic column in the Chester area.

	Unconformity
	(Hawley schist
Ordovician	(Savoy schist
system	(Chester amphibolite
	(Rowe schist

These formations are closely folded and the upper formations crop out east of the lower in the Chester area.

Rowe schist:

The Rowe schist is a siliceous, greenish-gray, fine-grained mica schist. It is relatively soft, except where quartz is abundant; in such places it is firm and comparatively hard. Numerous stringers of granulated quartz occur in the schist and are parallel with the foliation. Chlorite is visible, mixed with mica, and gives a greenish color to the rock. Garnets are common as well-developed crystals up to one-fourth inch in diameter.

Near the top of the Rowe schist, beds of amphibolite up to 150 or more feet in thickness are interbedded with beds of mica schist, so that in many places it is difficult to determine the base of the main amphibolite formation. Emerson estimated the thickness of the Rowe schist in this area to be 7,000 feet.

Chester amphibolite:

The main mass of amphibolite is a dark, laminated rock that contains hornblende, feldspar and a variable amount of epidote. In a few places the rock is particularly massive, but for the most part it is rather thinly foliated. Quartz, of later introduction, occurs both disseminated in the rock and as stringers; it is abundant in some places and absent, or nearly so, in others.

Near the emery vein, the amphibolite is characteristically coarser-textured and lean in feldspar. This type of rock is in places interlayered with the feldspathic amphibolite as much as a hundred feet from the vein. A somewhat similar coarse-grained amphibolite, which, however, contains feldspar, occurs as patches through the amphibolite.

Associated with the amphibolite along its east side are masses of serpentine and soapstone with some lenses of foliated talc. Some of the serpentine shows olivine structure,[6] and Palache[7] has described relict forms of large terminated olivine crystals from secondary veins in the serpentine. The serpentine is thus to be ascribed to the alteration of one or more intrusives of basic rock along the eastern boundary of the amphibolite. These intrusives may have been peridotites of norites and the formation of the emery was probably related to their emplacement, although both the serpentine and the amphibolite extend north and south far beyond the areas where emery is known to occur.

6/ Emerson, B. K., U.S.G.S. Bull. 597, p. 156, 1917.

7/ Palache, Chas., Am. Jour. Sci. 4th Series, vol. 24, p. 491, 1907.

Savoy schist:

The Savoy schist, stratigraphically above the Chester amphibolite, is a garnetiferous muscovite schist, commonly with more or less secondary chlorite which has partly replaced garnet. Quartz is abundant, both as a constituent of the schist and as beds of sugary quartzite enclosed in the schist. Hornblende schist, much like the Chester amphibolite and apparently of sedimentary origin, forms beds within the Savoy schist. These are numerous in some places; Emerson reports that 40 beds of hornblende schist, one to twenty feet thick, are intercalated with the mica schist near Chester. However, in the Chester area, the contact between the main mass of amphibolite and the Savoy schist is definite and is considered to be at the base of the lowest bed of mica schist.

Geologic structure:

In the vicinity of the principal mines and prospects, near the village of Chester, the outcrop belts of the country-rock schists trend in a general north-south direction. The beds either dip very steeply to the east or are approximately vertical, as inferred from the contacts between lithologic units. Older gneisses occur west of the area mapped, and the beds of schist that enclose the emery deposits are successively younger toward the east. So far as is known, the original stratigraphic sequence in this area is neither broken by faults nor reversed and repeated by regional folding, though several miles southeast of Chester such general repetition by folding has been recognized and mapped by Emerson.8/ Doubtless some minor local folding, thickening and

8/ Emerson, B. K., op. cit., geologic map.

thinning of beds by flowage and stretching has occurred in the Chester emery area, but, owing to sparseness of outcrops, it is not possible to identify most of these features in sufficient detail, size, and continuity to permit mapping them. Surface exposures are insufficient to present a clear picture of the relationships between emery bodies and the determinable minor folds. Such structural relationships, which may be important as indicating the type of structural control of the emery bodies, might well be determined in the underground workings, now inaccessible.

Foliation (schistosity) is well developed. In most places, like the bedding it is nearly vertical, and is indeed, for most practical purposes, essentially parallel with the bedding, though at some places there is marked departure from this condition. Fracture cleavage is apparent in places, and wherever found consistently indicates drag folds that plunge northwest at angles of 35 degrees or more.

As shown by the plane-table map (fig. 4) the foliation of the amphibolite and schist is not everywhere parallel with the contact of the formations. In general the foliation strikes more northwesterly than the contact, although there are many exceptions to this generalization. In some places the foliation may be interpreted as indicating drag along the contact produced by relative movement of the east side toward the south.

Emery deposits

Structural features:

Emery bodies occur as a series of lenses along a more or less continuous, nearly vertical vein within the Chester amphibolite. This vein closely parallels the contact between the amphibolite and the Savoy schist, from which it is separated by a zone of amphibolite, serpentine or talc a few inches to 200 or more feet thick. Individual lenses range in length from 30 feet to 400 feet and in width from 2 to 20 feet, although the average width mined was about 4 feet. In the northern part of the vein, the longest dimension of these lenses pitches to the north; in the southern part the pitch is nearly vertical. It is quite possible that the position of the lenses bears a systematic relation to minor flexures in the amphibolite boundary, but because of the scarcity of accessible exposures of the emery bodies this could not be demonstrated.

Individual lenses are composed of massive emery encased in an envelope of biotite and chlorite 0.1 to 10 inches thick, known locally as "fringe rock." The fringe rock extends some distance beyond the rather blunt ends of the emery bodies, but whether it forms a continuous vein between lenses could not be determined. Commonly parts of the fringe rock have been squeezed into marginal fractures in the emery. Amphibolite surrounds the ore and fringe rock except locally where sheets of talc or serpentine lie between the amphibolite and the ore lenses. (See figure 2.)

The emery itself has been broken into blocks, the largest of which is only a few feet in diameter. The margins of these blocks have been altered to chlorite-margarite rock containing plagioclase and magnetite, and in some places the alteration has penetrated so far into the blocks as to leave only rounded nodular masses of ore surrounded by shells of chlorite-margarite rock. Tapering fractures penetrate both the shells around the ore and to some extent the unaltered emery. In these fractures Margarite is commonly found as plates lying transverse to the fractures.

Where the ore bodies were thin they were complete altered in the same way that the margins of the larger blocks were altered, so that the thinner parts of the lenses grade from a magnetite-rich emery to a magnetite rock in which epidote, chlorite and margarite are present, but corundum is absent. The full transition from emery to the altered phase was not observed, but it is inferred from the distribution of the altered types of vein material in relation to the area from which the ore was removed. This interpretation implies that thin sheets of emery ore are not likely to be found.

Mineralogy of the deposits:

Emery is a physical mixture of magnetite and corundum. The quality of the emery as an abrasive is dependent on the proportion of corundum present, because it is this mineral that provides the abrasive quality for which emery is used.

The Chester emery apparently had a high proportion of magnetite compared to the corundum present in most places where the ore was mined, though the proportions differed from place to place. Attempts were made to collect specimens of the ore both from mine dumps and from the parts of the veins still exposed in the old mine openings. A considerable number of these specimens were crushed, separated by an electro-magnet into fractions, and examined with immersion oils. Very few of the specimens from these sources showed corundum as an important constituent of the rock. Thin sections were made of several of the specimens in the Survey laboratories and were studied by Mr. Bodenlos in the Petrographic Laboratory at Harvard University. E.S. Larsen was consulted in this study. Only one out of five sections expected to show corundum contained that mineral. Small holes in the other slides may represent places from which corundum grains were torn in the grinding. These sections, being made from specimens found on dumps, may, however, represent material rejected in mining; it is improbable that they represent material sent to the mills as emery ore.

Associated with the magnetite are chlorite and in some places feldspar or epidote with lesser quantities of margarite and rutile.

The altered zone around the ore masses contains massive magnetite, around the margins of which are particles of secondary magnetite set in a groundmass of fine-grained chlorite and margarite. The specimens examined were not wholly adequate to indicate the sequence of mineral changes, but it seems probable that an initial magnetite and corundum rock has been altered to a chlorite-margarite rock containing some plagioclase and secondary magnetite.

The fringe rock contains chlorite as perhaps the most abundant constituent. It also contains considerable quantities of biotite and margarite, particles of magnetite, and, in some places, euhedral crystals of tourmaline. In some places the margarite appears to be the last mineral formed because large plates of it cut across the foliation of the chlorite. In the literature on the Chester emery, the term, fringe rock, has been applied also to the chlorite-margarite shells around blocks of massive emery. Former workmen in the mines are not in agreement as to the meaning of the term.

The walls of the vein are formed of amphibolite commonly consisting largely of blue-green hornblende with lesser quantities of oligoclase, apatite, and chlorite. Epidote is present in some places and thin sections show a small amount of calcite associated with the epidote.

Quality of the ore:

Emery is valuable as an abrasive in proportion to the amount of the corundum that it contains. The reported quality of the marketed Chester emery was high, but no definite records are available that would indicate the yield of marketable emery from the Chester ores as mined. One of the former millers has stated that about one keg out of five of the milled product was good grade emery, that the rest was mostly magnetite obtained by magnetic separation, and that the high proportion of waste was one reason for the discontinuance of mining the Chester deposit. This ratio of high-grade concentrate to milled ore, less than 20 per cent by weight, may apply only to ore obtained from part of the known vein, and whether or not the average grade of the entire vein is probably greater or less is not known.

As stated above, the thin sections studied cannot be accepted as truly representative of the milled ores because they were made from specimens obtained from mine dumps and from marginal parts of the vein as exposed in surface openings, and in part at least must represent rejected material. It is apparent that material of the quality indicated by these sections could not have yielded any appreciable proportion of marketable emery.

The mines near Chester

Six named mines have been opened on the emery deposits near Chester; from north to south (figure 1). These are the Snow mine, the Sackett mine, the Macia mine, the Old Mine, the Melvin mine, and the Wright mine. They are distributed for nearly three miles along the traceable vein. The northern limit of the emery is seen in a rock ledge which projects into the right bank of West Branch of Westfield river about 1 3/4 miles above Chester, a short distance above the Boston and Albany Railroad Bridge.

The Snow mine, on the flank of Gobble Mountain south of the above-mentioned exposure, was one of the first to be opened, though the emery had a width of only about three feet and was worked in a small open cut. No additional information is available on the mining from this place.

The Sackett mine lies on the southeast slope of Gobble Mountain about three-quarters of a mile northwest of Chester. This was one of the earliest and most productive mines although the ore was in part nearly pure magnetite. Some of the ore contained corundum as crystals up to one-half inch across, and masses of blue and white corundum weighing a pound or more. The relationship between the pure magnetite ore and the ore containing large corundum masses is not known. The present accessible workings consist of an open cut which shows a northward pitch of about 30° in an elongate lens-shaped body. A 114-foot tunnel driven from the east to intersect the vein about 117 feet below the open cut is now partly blocked with debris and is not accessible.

The Macia mine, along Austin creek, about three-quarters of a mile south of the Sackett mine, is 450' north of U. S. highway 20 which parallels Walker brook west of Chester. The mine consisted of a T-shaped opening with an adit on the west slope which was connected by 75' of tunnel with a north-south drift. The drift was driven northward along the strike of the rock for about 150' then turned to the northwest, cutting across the strike of the foliation. So far as observed, the walls of the drift are solid amphibolite. However, two exploratory shots, apparently made recently in the eastern wall of the curved part of the drift, exposed soft chloritic rock in which are embedded tough nodules of green amphibolite. South from the entrance a short tunnel extends to a stope about 30' high and 10' wide with a length of about 50' north and south. This stope was not accessible but the walls appear to be composed of the amphibolite.

A magnetite-rich vein, with a very thin layer of chlorite along each side, extends to the surface and is to be seen in the rock exposure that forms the south end of the hill in which the mine occurs. The amphibolite exposed on the west side of this vein is very much distorted, with some blocks displaced along small faults. A variation of texture suggests that originally a coarse-grained amphibolite was deformed with stretching and flowing, with a consequent development of finer-textured amphibolite in the zones where the distortion had occurred.

About 175' south of U. S. highway 20 is the lowest opening of the "Old Mine". Several openings along a series of lenses were connected by a tunnel that was driven for more than 2000' southward from this lowest entrance. A series of other openings at higher levels was the means of access to the upper parts of the same ore bodies. (See figures 3 and 4.) Altogether about 2800 feet of vein length was explored in the Old Mine. The most recent work here was done in 1913.

The Melvin mine is located 2200' south of the highest adit of the Old Mine and only a few hundred feet south of the longest drift in the Old Mine. A shaft about 40' deep was sunk at the Melvin mine in a lens of emery ore about 25' in length. The pitch apparently was steep, being nearly vertical as judged from the opening, which is filled with water. The general form of the lens is S-shaped with the middle part the thickest; it was opened to a width of about ten feet. One to six inches of soft fringe rock lines the surfaces of the vein and encloses rock rich in magentite and chlorite. A width of about four feet of this rock shows in the south end of the cut and was apparently such lean ore that it was not excavated.

The Wright mine located 5500 feet south of U. S. highway 20 on the strike of the vein included an 87' shaft sunk near the south end of a 1400-foot open cut that followed ore to an average depth of twenty feet. In most places this open cut was only a few feet wide. A small amount of ore was mined from the shaft, but most of the production is said to have come from the surface workings. Miners who worked in the Wright mine insist that a body of excellent emery ore was exposed when the mine was closed.

Prospecting

More than three-quarters of the probable outcrop of the emery-bearing vein is covered with drift and therefore beyond reach of surface exploration except by expensive trenching. The application of some geophysical method that would utilize the magnetic or dialectric properties of the ore might serve as a convenient means of making the initial exploration for new ore bodies. The indicated sites might then be drilled to determine the extent and character of any ore present.

A plane table survey was made, and the resulting map (figure 4) shows the contours along the trace of the vein, the areas of rock exposure, structural data, and means of access by road to about 6000' of the trace of the vein. This part of the vein was elected for mapping because it has already yielded the greatest amount of ore; it is the part most readily accessible for future prospecting, and it was thought that perhaps structural data obtained here might prove helpful in locating the most likely places to search for ore. The map should prove useful in any further work undertaken in this area and could be extended as desired to include areas to the south along the contact of the amphibolite and the Savoy schist.

The emery-bearing part of the Chester amphibolite may extend much farther to the north and south along the strike of the bed than has hitherto been recognized. Six and a half miles north of Chester, a vein exposure about four feet wide was prospected in the early days, but apparently not enough high-grade ore was found to justify development. The vein material, as judged by available specimens, consists of magnetite with a small amount of corundum. It was probably prospected as iron ore, as were several other exposures in the same belt.

Talc and soapstone, as has been noted, are associated with the emery. These minerals are much more widespread than emery is known to be, but if related either in origin or in structural mode of occurrence these associated minerals may be helpful in prospecting beyond the limits of the emery belt as now known. Where these minerals are found, the stratigraphic, structural and lithologic features apparently are similar to those where emery is known to occur.

The maximum depth to which the emery bodies extend has not been determined by mining or exploration. It is hardly probable that the type of mineralization indicated by the ore would be limited to the very shallow zone that has been so far developed. Deeper exploration, therefore, may be justified in the areas where the largest deposits have been found.

A hindering feature in exploration is the amount of overburden, mostly glacial drift, that covers much of the outcrop belt. Comparatively few of the rock exposures are distributed in such a manner that the stratigraphic position of the emery vein can be closely determined. The northern slopes and summits of the ridges have many rock exposures, but on the southern slopes the drift is particularly thick and continuous. In such covered areas, trenching would be practicable at relatively few places; where the drift cover is continuous for relatively long distances, drilling would be most practicable.