

# MISCELLANEOUS NONMETALLIC PRODUCTS.

## A COMMERCIAL OCCURRENCE OF BARITE NEAR CARTERSVILLE, GA.

By C. W. HAYES and W. C. PHALEN.

### INTRODUCTION.

The original source of barium is to be found in the silicates of the metal contained in the igneous rocks, from which it is derived as the carbonate during the ordinary processes of weathering. Though commonly regarded as one of the less common constituents in the earth's crust, F. W. Clarke<sup>a</sup> has shown that its oxide is the thirteenth in order of abundance, an average of 617 analyses indicating the presence of 0.11 per cent.

One of its commonly occurring forms is the sulphate ( $\text{BaSO}_4$ ) or the mineral barite. This substance is more commonly found in mineral veins than in sedimentary rocks. It has also been observed as a sintery or stalactitic deposit and as the cementing substance in sandstone. All of its occurrences indicate that it is a mineral of aqueous origin and has resulted either from direct deposition in water or as a precipitate when waters of certain composition mingled.

Barite is known to occur at several localities in the vicinity of Cartersville, Bartow County, Ga., and at one place between  $2\frac{1}{2}$  and 3 miles southeast of the town it is mined on a fairly large scale by the Nulsen, Klein & Krausse Manufacturing Company, of Lynchburg, Va., and St. Louis, Mo. Although originally deposited from water its present position is in a residual mantle of clay and gravel.

### GEOLOGY.

The geology of the Cartersville district has been worked out by the senior writer. The district is in the southeastern half of Bartow County, and the outcropping rocks are the older crystalline schists,

<sup>a</sup> Bull. U. S. Geol. Survey No. 228, p. 17. Clarke's more recent figure, contained in an unpublished manuscript and based on an average of 678 analyses, remains the same, namely, 0.11 per cent  $\text{BaO}$ .

gneisses, and granites, and the partially or completely metamorphosed sedimentary rocks of the Ocoee group, including gneisses, schists, slates, and conglomerates, which cover the surface in the southeastern half of the area, and a series of unaltered sediments consisting of quartzite, limestone, shale, and dolomite, all Paleozoic, in the northwestern half. The former rocks make up the more mountainous parts of the area. The Paleozoic rocks outcrop in the valley region to the west. In descending order and as at present differentiated, they are as follows:

- Knox dolomite.
- Conasauga and Rome formations.
- Beaver limestone.
- Weisner quartzite.

All these formations except the Knox dolomite belong in the middle or lower Cambrian, and it is probable that the lower portion of the Knox should also be classed with the Cambrian. Of these formations, only the Weisner quartzite and Beaver limestone are of interest in this connection, for it is in these rocks, or rather associated with them, that the deposits of barite are found.

The Beaver limestone rarely outcrops at the surface. It occupies valleys parallel with the ridges formed by the adjacent harder formations and is generally covered by a heavy residual deposit of clay and wash from the higher land on either side. It contains a large amount of clayey impurities, and its weathered outcrops appear as a clay shale.

The Weisner quartzite forms a fairly continuous belt about 19 miles long, extending from the northeastern nearly to the southern edge of the area. Its greatest width, about 3 miles, is nearly due east of Cartersville, and the average width of the belt is between 1 and 2 miles. It consists chiefly of fine-grained vitreous quartzite, although it contains some beds of fine conglomerate and siliceous shale. The thickness of the formation is probably between 2,000 and 3,000 feet, and may be considerably more; but it can not be accurately determined because of the intense folding which it has undergone and the absence of satisfactory exposures. In addition to the folding, it is doubtless intersected by numerous faults, the evidence of which is seen in its crushed and brecciated condition at many points. The mechanical and chemical conditions resulting from the deformation of the quartzite beds are responsible for the deposition of certain of the iron ore and other deposits of the region which are contained in it, and also originally of the barite deposits.

#### OCCURRENCE OF THE BARITE.

The barite is so intimately associated with certain of the iron ores of this region, particularly with the ocher, that conclusions regarding

the origin of the latter are of importance in this connection. The iron oxide<sup>a</sup> forming the yellow ocher deposits in the Cartersville district is a direct replacement of the silica in the Weisner quartzite. It appears that the faulting of the region, by fracturing the rocks, afforded favorable conditions for the percolation of surface waters to great depths, and that as the faulting was doubtless accompanied by the development of considerable heat, the region was probably characterized by numerous thermal springs. As is well known, silica, under favorable conditions, especially under great pressure and at high temperature, becomes one of the readily soluble rock constituents.

With reference to the barite occurring at the mine of the Peruvian Ocher Company, at the wooden bridge over Etowah River, where perhaps the best opportunity exists to study the past action of the thermal waters and the development of the iron ocher and barite, the following statement is quoted from the paper cited above:

Numerous open passages and cavities penetrating the quartzite and the bodies of ocher are met in mining. The smaller cavities are generally lined with a crust of small quartz crystals, while the larger ones frequently contain beautiful crystals of barite, which were probably deposited after the conditions favorable for the solution of silica and the deposition of ocher had passed. Groups of acicular crystals of this mineral, several inches in length, are not uncommon. It also occurs in white granular veins. The barite is called "flowers of ocher" by the miners. It remains in the residual soil which covers the quartzite outcrops and affords the best means of tracing the ocher deposits. It is found at numerous points on the low quartzite ridge north and south of the Etowah River, and prospecting at these points has never failed to reveal more or less extensive deposits of ocher.

The south end of the quartzite belt above described has a distinct anticlinal structure, as shown in the gap where Etowah River cuts across it. It is on the eastern side of this anticline that the principal barite deposits occur. The quartzite dips eastward at about 45° and the overlying shaly Beaver limestone, although not well exposed, probably underlies the valley occupied by the railroad between the quartzite and the crystalline rocks to the east. At various places along the eastern side of this anticlinal quartzite ridge deposits of limonite have been worked for many years. South of Etowah River these deposits occur well up on the side of the ridge, upon the slope immediately below the outcrop of the quartzite. The limonite is seen to rest directly upon the quartzite, and large exposures of the latter are found in the old ore workings. The limonite appears to have a definite relation to the quartzite and forms a nearly continuous belt of irregular deposits parallel to its outcrop. Parallel to this belt and adjacent to it down the slope is another belt occupied by the deposits of barite. The extent of the barite is not yet proved, and

<sup>a</sup> Hayes, C. W., Geological relations of the iron ores in the Cartersville district, Georgia: Trans. Am. Inst. Min. Eng., vol. 30, 1900, pp. 403-419.

it probably does not extend in workable amount throughout the length of the quartzite ridge, though it is known to be present in variable amount northward to Etowah River and for some distance beyond.

While this belt has not been sufficiently prospected to prove the continuity of the deposits, their thickness is indicated by a tunnel which has been driven into the side of the hill about 300 feet north of the present workings. This tunnel penetrates 120 feet of the barite-bearing clay and then enters the iron ore. (See fig. 26.)

The accompanying sketch shows the relations of the limonite and the barite to the underlying formations, so far as these relations can be determined from the present development. One striking feature is the sharp separation between the two minerals; each appears to occupy a definite horizon, and so far as observed there is no intermingling. While both in their present condition are residual, they

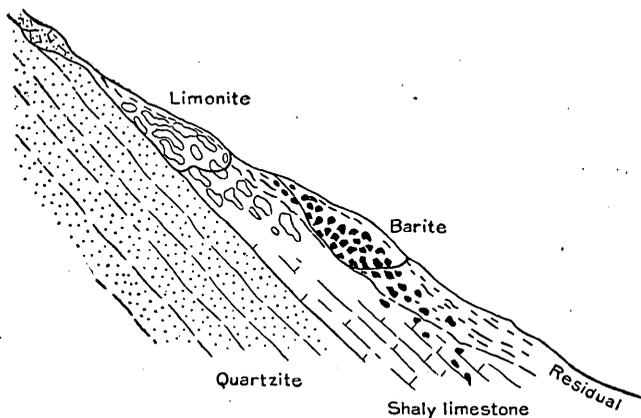


FIG. 26.—Sketch section showing relations of barite and limonite to underlying formations near Cartersville, Ga.

appear originally to have replaced distinct beds in the shaly limestone overlying the quartzite, the iron being deposited immediately adjacent to the quartzite, and the barite, for the most part, at least, in higher beds. It is highly probable that deposition of the barite and limonite took place, in part, at least, simultaneously. It is quite certain that gravity has been largely instrumental in concentrating the former into a workable deposit.

The barite deposit, as shown in the present workings, has a thickness of about 50 feet normal to the slope of the surface. It is intermingled with residual material, chiefly red, brown, and yellow clay, with some fragments of quartzite. The barite itself makes up about one-third of the material removed in mining. It consists of irregular or slightly rounded boulders ranging from a few ounces up to several hundred pounds in weight. It is for the most part of a massive,

compactly granular structure, and of a pure-white or faint-bluish color. As it occurs in the face of the open pit its presence might not be suspected owing to films of ferruginous clay which cover the nodules. The iron stain is confined almost entirely to the surface of the bowlders.

The deposit is worked in an open pit. The ore and accompanying clay are loosened by blasting and shoveled into small cars, which dump into a steeply inclined sluiceway with a stream of water. This carries the ore to a log washer at the base of the hill and at the same time frees it from much of the associated clay. After passing through the washer the ore is separated into three grades by hand picking. The highest grade contains some iron oxide, but merely as a thin film on the outside, which may be removed readily by acid. The inferior varieties contain more or less iron oxide disseminated throughout their mass, making its complete separation expensive and interfering with its utilization for certain purposes.

Work has been in progress about six months, and during this time more than 1,000 tons of barite, valued at approximately \$4,000, have been removed. The deposits will in all probability prove fairly extensive, and the future prospect of the industry seems good.

## GRAPHITE DEPOSITS NEAR CARTERSVILLE, GA.

By C. W. HAYES and W. C. PHALEN.

Graphite is a mineral the demand for which in the United States at present exceeds the supply.<sup>a</sup> A new occurrence, therefore, or the possible extension of an occurrence already known, merits attention. It is quite possible that the utilization of the deposits of graphitic slate in northwestern Georgia may furnish an abundant supply of certain grades of this mineral.

The extreme northwestern portion of Georgia is occupied by sedimentary formations of Paleozoic age—limestones, sandstones, and shales in great variety. To the east and south of these are metamorphic and crystalline rocks whose age is not definitely determined, but which are probably older than any of the determined Paleozoic formations. The contact between these two classes of rocks passes southward from the Tennessee line to the vicinity of Cartersville, and thence westward to the Alabama line a little south of Rock Mart. It intersects in Georgia the following counties: Murray, Gordon, Bartow, Polk, and Tallapoosa. To the east and south of this contact and forming a nearly continuous belt from a few hundred yards to several miles in width occurs a graphitic talcose slate. Similar but less continuous belts also occur to the east within the metamorphic area. This slate, particularly the first-described belt, has been prospected at numerous places for its graphite, and is worked on a considerable scale at two points in the vicinity of Cartersville. The slate was originally, in all probability, a carbonaceous clay shale. The metamorphism to which it has been subjected has converted the carbonaceous material, probably derived originally from plants, into graphite and the clay into talcose minerals of somewhat indefinite composition and mineralogical character. While the color of the rock is generally black, some portions of it contain little if any graphitic carbon and are light bluish gray in color. Selected samples of the rock would probably run as high as 12 or 15 per cent of graphitic carbon, although the content of carbon in the rock as a whole is much lower. The material going to the mill of the American Chemical Mining Company,

<sup>a</sup> Smith, George Otis, Mineral Resources U. S. for 1905, U. S. Geol. Survey, 1906, p. 1265.

in the vicinity of Emerson, Ga., immediately north of the Western and Atlantic Railroad, averages about 4 per cent. In this mine, however, and for the purpose for which the product is used, a high percentage of carbon is not essential. All classes of the slate are, therefore, mined together, both that containing a high percentage of carbon and the bluish bands, which are practically free from carbonaceous matter. At the mine of the Cherokee Chemical Company, about 2 miles south of Emerson, the slate is more uniformly graphitic, and the product runs about 9 per cent of carbon. The slate here contains some stringers of vein quartz with traces of gold and also shows the presence of considerable pyrite, with here and there a distinct copper stain. Oxidation of the pyrite gives rise to an abundant efflorescence of alum and other sulphates.

The rock is mined by open pits and can be delivered to the mill at a very slight cost. Both at the points of present production and elsewhere along the belt of slate above described the supply of raw material is practically unlimited.

The graphite appears to be chiefly if not entirely of the amorphous variety. Examined under the microscope no crystalline outlines could be detected, the graphitic material occurring in irregular fragments, with jagged edges, associated chiefly with quartz. In some of the material collected from the pit of the Cherokee Chemical Company there is a suggestion of crystalline outlines. When the material is fused with alkaline carbonate and caustic alkalies the carbonaceous matter appears to be wholly oxidized and to go completely into solution, whereas high-grade flake graphite, at least, is supposed to resist such treatment.<sup>a</sup> Boiled with nitric acid (specific gravity 1.4) there is apparently no decomposition; at least the solutions were not decolorized as is the case when anthracite, bituminous coal, and charcoal from various sources are similarly treated.<sup>b</sup> It would seem, therefore, that although the material can not be classed as graphite in the sense that Wittstein has determined the chemical behavior of the mineral, it nevertheless has some of the chemical properties of graphite, and for all practical purposes may be so considered.

Even with the very finest grinding practicable in commercial practice it may be questioned whether it will be found possible to effect a separation from the impurities, in so far as they are flaky in character, such as mica and talc. The specific gravity of graphite ranges from 2.1 to 2.5; of talc, 2.7 to 2.8; and of muscovite (mica), 2.76 to 3—all too close to attempt perfect separation. As a lubricant, the presence of the talc can not be regarded as deleterious, though care would have to be exercised to remove even the last traces of quartz and

<sup>a</sup> Wittstein's method for the determination of graphite; Lunge, *Chemische-technische Untersuchungsmethoden*, 4th ed., vol. 2, p. 785.

<sup>b</sup> Classen, *Ausgewählte Methoden der analytischen Chemie*, p. 637.

other gritty material when used for such a purpose. There should, however, be no difficulty in removing the quartz, pyrite, and similar minerals when the purpose to which it is to be applied requires it.

The principal use to which the Georgia product is put is as a filler in fertilizer. It is claimed that when mixed with potash and ammonium salts and the other ingredients which enter into fertilizers it prevents the absorption of moisture and consequent caking of the mass. This facilitates grinding, and the fertilizer retains its powdery state after being ground and may thus be more evenly and economically applied to the land. However this may be, it is quite certain that there is nothing in the graphite itself that enriches the land.

Some of the graphite is also used in paint, and practical tests on iron work, particularly where subjected to high temperatures, are reported to have been highly satisfactory. Its use in stove polish, in electro-typer's powder, and for foundry facings was not reported, though it should prove entirely suitable for any or all of these applications, where low-grade material only is required.

The great extent of the deposits of raw material, their convenience to lines of transportation, and the cheapness with which the graphite can be mined and prepared for use should insure these deposits a large development.

# MEERSCHAUM IN NEW MEXICO.

By DOUGLAS B. STERRETT.

## INTRODUCTION.

Meerschaum has been extensively used for over a century in the manufacture of pipes and other articles for the use of smokers, as cigar holders, mouthpieces, etc. The principal source of supply has been, for many years, the deposits in the plains of Eskishehr, in Anatolia, Asia Minor, about 120 miles southeast of Constantinople. Deposits of the mineral are also reported to occur in Greece, on the island of Eubœa; in Moravia, Austria, near Hrubshitz; in Spain near Vallecas, Madrid, and Toledo; and in Morocco. The meerschaum deposits of Eskishehr have been briefly described by J. Lawrence Smith <sup>a</sup> as occurring in a valley filled with drift material from the surrounding mountains that has been consolidated by lime. The meerschaum is scattered through the drift in rounded nodular masses, with pebbles and fragments of magnesian and hornblende rocks.

The mineral sepiolite, or meerschaum, as it is commonly called, is a hydrous silicate of magnesia with the probable composition  $H_4Mg_2Si_3O_{10}$  or  $2H_2O + 2MgO + 3SiO_2$ .<sup>b</sup> Many analyses of meerschaum only roughly approximate the formula given above. This is probably due largely to the uncertain relation of the water to the other elements of the mineral. A large amount of hygroscopic moisture is driven off below 110°, sometimes amounting to nearly half of the total lost at a red heat.

Pure meerschaum is a white, porous mineral, with a specific gravity of about 2. In much of it, however, the porosity is so great that blocks of the mineral will readily float on water. This property, along with its snow-white color, gives rise to the name, meerschaum, from the German for sea foam. In a similar way the French often call it "écume de mer." It absorbs water strongly and becomes somewhat plastic, but returns to its original condition on drying.

<sup>a</sup> Am. Jour. Sci., 2d ser., vol. 7, 1849, p. 285.

<sup>b</sup> Dana, J. D., System of Mineralogy, 6th ed., p. 680.

When saturated it will not, of course, float on water. The hardness of meerschaum is from 2 to 2.5. It is very tough, breaking with a conchoidal to earthy fracture. Some forms have a leathery or fibrous texture, and in these the toughness is very pronounced. The luster is dull and earthy, somewhat like that of plaster.

The ease with which meerschaum can be carved, its whiteness, and the fine polish it takes with wax render it especially suitable for elaborate carving and artistic treatment in the manufacture of pipes. Meerschaum pipes are prized for the rich cream-brown or brown color which the bowl assumes after being smoked a while. This color is caused by the mixture of the nicotine from the tobacco with the wax used in polishing the pipe, permeating through the mineral. As long as there is absorbed wax in the meerschaum the color of a pipe will grow darker and nearly black with continued smoking. It is, therefore, necessary to "fix the color" of the pipe when the proper shade is obtained. Though the principle employed is the removal of the wax and boiling in linseed oil to harden the mineral and render it less porous, there are trade secrets in the process which the writer is not at liberty to divulge.

The manufacture of meerschaum, together with clay, amber, horn, wood, metals, etc., into pipes and similar articles is a thriving industry in parts of Germany and Austria. The headquarters of the industry in Germany is at the town of Ruhla, in the Thuringian Forest. According to Consul George N. Ifft,<sup>a</sup> of Annaberg, there are between 3,000 and 4,000 workmen employed at this industry, which was started in 1767. It is said that the supply of meerschaum is becoming low and that the manufacturers experience great difficulty in obtaining the necessary material to keep their factories going. This scarcity is said to be caused partly by failure of the mines in Asia Minor to meet the demands of the trade and partly because American and English agents have gained control of the Asia Minor production. Consul U. J. Ledoux, of Prague, reports similar difficulties in the Austrian meerschaum industry.

The treatment that meerschaum receives before reaching the consumer is varied. At Eskişehir the crude mineral is mined by systematic pits and galleries.<sup>b</sup> The nodular masses are first roughly scraped to remove the earthy matrix; then dried, scraped again, and polished with wax. The roughly polished nodules, in almost every conceivable peculiarity of form, are then shipped to the manufacturers. Pipe bowls are first turned out on lathes or carved by hand. The bowls are then smoothed down with glass paper and Dutch rushes, and after being boiled in wax, spermaceti, or stearin, are carefully polished with bone ash or chalk.

<sup>a</sup>Daily Cons. Rept., April 25, 1907.

<sup>b</sup>Encyclopædia Britannica, vol. 15, p. 825.

Artificial and imitation meerschaum are also manufactured for the trade. Artificial meerschaum is made by consolidating waste chips and fragments by pressure. Imitation meerschaum is sometimes prepared by treating hardened plaster of Paris with wax and coloring with gamboge and other suitable materials. Many of these imitations are nearly perfect.

## NEW MEXICO DEPOSITS OF MEERSCHAUM.

### LOCATION.

Two deposits of meerschaum have been located in Grant County, N. Mex. Both are in the upper Gila River valley. One, taken up by the Meerschaum Company of America, lies in the Alunogen mining district, about 23 miles in an air line east of north from Silver City, near Sapillo Creek; the other deposit has been taken up by the Dorsey Meerschaum Company, and lies in the Juniper mining district, about 12 miles northwest of Silver City, in the canyon of Bear Creek.

The Dorsey meerschaum mine, consisting of six claims, was visited by the writer in October, 1907, when the information here given was obtained. The deposit lies in the bottom and walls of the canyon of Bear Creek. This canyon has steep cliffs about 100 feet high at the base and other cliffs above rising to a height of several hundred feet.

### GEOLOGY.

The rock forming the canyon walls is chiefly light and dark gray to brownish-gray limestone, with some sandstone strata included. The limestone contains a large amount of cherty matter in certain beds, both in nodules and small bands up to an inch or two in thickness, lying parallel with the bedding. In some places these smaller cherty bands are very numerous and give the limestone a banded or ribbon structure. The limestone shows the first stages of crystallization and under the microscope numerous small calcite crystals can be seen scattered through the finer homogeneous rock. Such rock contains a notable amount of magnesia, but as it effervesces in cold dilute hydrochloric acid it is not a true dolomite. A sample from a prominent bed of brownish-gray sandstone included in the limestone was found to consist of well-rounded quartz grains with the interstices almost entirely filled with calcite as a cementing material. The slightly brownish color of the stone is due to small patches of ferric oxide inclosed in the cementing material. It is said that granite outcrops in the canyon about half a mile up the creek from the meerschaum deposit. Boulders of a coarse porphyritic granite (or possibly monzonite) with large red feldspar phenocrysts were seen in the creek débris, which contained also boulders of a dark traplike rock resembling diabase.

The structure of the formations is not simple and in the brief examination of the locality was not worked out. At a point about a quarter of a mile below the deposit where the canyon is narrow, the limestone beds have a strike west of north, with a dip ranging from nearly vertical to 60° E. Farther up the creek the dip becomes less until it is nearly flat above a prominent sandstone bed, 15 to 20 feet thick, among the meerschaum deposits. Farther above the sandstone ledge the strike of the beds is northerly and nearly parallel with the course of the creek. The dip seems to be low and in opposite directions on each side of the canyon, which is therefore the axis of an anticlinal fold that apparently pitches slightly to the north. The limestone has been badly broken up by large fractures, with some faulting, and smaller joints. Several prominent fractures filled with vein material were observed in the bottom of the canyon, where the beds have a low dip. These veins had a northerly strike with a nearly vertical dip. There were many other fractures and veins, however, some of them prominent and others merely joints and seams, cutting across the direction of these larger breaks.

The age of the rocks has not been definitely determined. Two fragments of brachiopod shells, from a large angular limestone boulder in the bottom of the canyon, were identified as strophomenoids by Mr. E. M. Kindle; and the rock is probably Ordovician in age.

#### OCCURRENCE.

The meerschaum occurs in veins, lenses, seams, and balls in the limestone. All but the balls are fillings of fractures and joints, which do not seem to be confined to any definite direction. The veins are filled with chert, quartz, calcite, clay, and meerschaum. Chert is the most important gangue mineral and occurs in the veins with meerschaum in bands, lenses, and nodules. Both the crystallized quartz and calcite were observed in small veins, in which also there was a small amount of meerschaum. The largest vein seen contained considerable reddish clay with chert and meerschaum.

The mineral occurs in two different forms—(a) in nodules of irregular shape and (b) somewhat massive, with a finer and more compact texture than the nodular form. Some of the veins and seams are filled with massive meerschaum having practically the same texture as that in the nodules, though not in nodular form. In other veins there is both compact massive and nodular meerschaum, generally embedded in red clay.

The nodules range from less than an inch up to several inches in diameter and are of all shapes, with small, rounded knots and bumps protruding from the surface, which is generally coated or stained with the inclosing clay. The nodules are exceedingly tough and have to be vigorously beaten with a hammer before they will break.

The fracture of this kind of meerschaum is very uneven and the texture is fibrous, or rather leathery and porous. The color is pure white except where iron stains have worked in from the red-clay matrix. Small fragments from the nodules sometimes float for a while when dropped into water, though the greater part sink. Some of the meerschaum that was not light enough to float became so after it had been heated. After absorbing water this meerschaum, like that from other localities, becomes somewhat mushy and has a soapy feeling.

The massive meerschaum is finer grained, less leathery, and heavier. It is very tough, however, and some pieces break with a conchoidal fracture. Small fragments floated on water a minute or two after heating. This variety does not absorb water so rapidly as the nodular varieties.

The occurrence of meerschaum in balls was observed chiefly in one layer of limestone 5 or 6 feet thick. The balls ranged up to 2 or 3 inches in diameter and were irregularly distributed through the limestone. In some places they were plainly connected with one another either by merging or by veins; in other places they were apparently unconnected with other bodies of meerschaum. These balls, so far as observed, did not contain meerschaum of commercial value, but were composed partly of calcite and another fine-textured white mineral. Some whole balls were composed of these minerals; others contained a core or breccia of chert or dark limestone.

#### CHEMICAL PROPERTIES.

A chemical analysis made by George Steiger, of this Survey, on selected mineral showed the composition of the meerschaum from the Dorsey mine to be approximately that called for by the chemical formula previously given ( $2\text{H}_2\text{O} + 2\text{MgO} + 3\text{SiO}_2$ ). In the following table are given (1) the results of Mr. Steiger's analysis, (2) the theoretical composition, and (3) Mr. Schaller's analysis of material from the deposit of the Meerschaum Company of America on Sapillo Creek:

*Analyses of meerschaum.*

	1.	2.	3.
SiO <sub>2</sub> .....	57.10	60.8	60.97
Al <sub>2</sub> O <sub>3</sub> .....	.58		} 9.71
Fe <sub>2</sub> O <sub>3</sub> .....	Trace.		
MgO.....	27.16	27.1	10.00
CaO.....	.17		.22
CO <sub>2</sub> .....	.32		
Water.....	14.78	12.1	19.14
	100.11	100.0	100.04

The water determination in analysis 1 was made on material which had been ground in an agate mortar for several hours. As compared with the theoretical composition of meerschaum the water is too high by 2.68 per cent. Experimental work by Mr. Steiger revealed the fact that during the process of grinding for eighteen hours meerschaum absorbed 2.58 per cent of water. This test was made on other material than that used for the analysis, with the following results:

	Per cent.
Original water in fragmental meerschaum.....	11.75
After six hours' grinding.....	13.48
After twelve hours' grinding.....	13.49
After eighteen hours' grinding.....	14.33

The percentage of water given in column 1 is therefore doubtless too high, as the material probably absorbed water during grinding. A rough determination made on fragments of the same sample also showed, however, more water than is required by the theoretical composition.

The nature of the water in meerschaum is very uncertain. Total water determinations were made at a high heat with calculations for loss of  $\text{CO}_2$ . A special test made by Mr. Steiger on the ground meerschaum as used for analysis 1 gave the following results:

*Water lost by meerschaum at various temperatures.*

Temperature ( $^{\circ}\text{C}$ .)	Loss of water (per cent).
60.....	3.49
105.....	3.17
150.....	1.07
275.....	2.40
Total at 275 $^{\circ}$ .....	10.13

From this test it will be seen that considerable percentage of the water is probably hygroscopic, but just where the line between hygroscopic water and water of composition should be drawn it is impossible to say.

A specimen from the deposit owned by the Meerschaum Company of America was sent to the Survey by Ledoux & Co. of New York. An analysis of this material (No. 3 in the table), made by Waldemar T. Schaller, showed the presence of considerable alumina, which was also found by other chemists, as indicated by analysis published in the report of the company. Though the analysis shows that the specimen was not true meerschaum, the character of the two minerals is very much the same. In fact, the properties possessed by this mineral are so like those of true meerschaum that a company has undertaken to develop the deposit.<sup>a</sup>

<sup>a</sup> Collins, A. F., Mining meerschaum in New Mexico: Mining World, June 1, 1907, p. 688.

## PHYSICAL PROPERTIES.

The meerschaum from the Dorsey mine is very similar in appearance to that from Asia Minor as it appears on the market ready for carving. The Asia Minor meerschaum is a little lighter and more spongy than the surface material from the Dorsey deposit, owing in part, probably, to the fact that the former has been dried before shipping.

The results of tests made by pipe makers on two different pieces of the nodular meerschaum from the Dorsey mine were not highly satisfactory, though probably as good as could be expected from surface material. Small pipes were turned down on a lathe and after treating with wax were polished. Besides the iron stains in certain lines through the meerschaum the wax gave a mottled appearance to the surface by rendering one portion a little more translucent than others. The statement of each pipe maker was that the material was heavier than usual for meerschaum. One of them, Mr. S. Heyman, of Baltimore, reported it to be much harder than any other meerschaum he had ever worked, and mentioned a fine sand or grit in the sample he tested. The sandpaper used in smoothing the pipe down was also worn out more rapidly than is usual with meerschaum. Mr. Heyman turned out a small, thin pipe which was somewhat translucent and mottled. The mottling was apparently caused by fibrous white tufts in a more translucent matrix. These tufts appeared to compose the grit mentioned above, since they remained as little lumps above the surface of the pipe after polishing. These lumps were found to be very tough when cut with a knife, and doubtless caused the sandpaper to wear away rapidly when the pipe was being smoothed down, by dragging the sand grains away from the paper. When tested for coloring qualities the pipe readily absorbed the wax and nicotine, which appeared on the outside of the bowl in its characteristic color.

The specimen of meerschaum from which Mr. E. Butzen, of Chicago, turned out a pipe was evidently more compact and smoother grained. The bowl received a fair polish, though it was badly mottled by iron stains.

Another piece of meerschaum carved into a rough pipe and sent to the Survey by Mr. W. P. Dorsey, of Silver City, N. Mex., appeared to be pure white in color and of an even texture. On boiling in paraffin, however, mottling became prominent, showing irregular seams of rather translucent material in white tufted fibrous meerschaum.

The value of the New Mexico meerschaum has not yet been proved. At the Dorsey mine numerous outcrops of seams and veins of various sizes have been located. In chemical composition the material corresponds closely to meerschaum, though the physical properties of

material from the outcrop have not as yet proved of good grade. Whether valuable meerschaum will be found below the surface can be learned only by opening some veins to a depth where surface movement and weathering have not affected the mineral. It is probable that the fibrous tufts described above are natural to the nodular meerschaum and will not disappear with depth. The more compact massive material should, however, be found free of stains and more sound below the surface.

As to the origin of this meerschaum in the limestone formation, the deposits were not sufficiently studied to permit the expression of an opinion.

## SURVEY PUBLICATIONS ON MISCELLANEOUS NONMETALLIC PRODUCTS, INCLUDING MICA, GRAPHITE, FLUORSPAR, ASBESTOS, AND BARITE.

The following list includes a number of papers, published by the United States Geological Survey or by members of its staff, dealing with various nonmetallic mineral products:

BAIN, H. F. Fluorspar deposits of southern Illinois. In Bulletin No. 225, pp. 505-511. 1904.

BALL, S. H. Mica in the Hartville uplift, Wyoming. In Bulletin No. 315, pp. 423-425. 1907.

——— Graphite in the Haystack Hills, Laramie County, Wyo. In Bulletin No. 315, pp. 426-428. 1907.

BREWER, W. M. Occurrences of graphite in the South. In Seventeenth Ann. Rept., pt. 3, pp. 1008-1010. 1896.

BURCHARD, E. F. Barite. In Mineral Resources U. S. for 1906, pp. 1109-1113. 1907.

——— Fluorspar. In Mineral Resources U. S. for 1906, pp. 1063-1066. 1907.

DILLER, J. S. Asbestos. In Mineral Resources U. S. for 1906, pp. 1123-1129. 1907.

EMMONS, S. F. Fluorspar deposits of southern Illinois. In Trans. Am. Inst. Min. Eng., vol. 21, pp. 31-53. 1893.

FULLER, M. L. The occurrence and uses of mica. In Stone, vol. 19, pp. 530-532. 1899.

HOLMES, J. A. Mica deposits in the United States. In Twentieth Ann. Rept., pt. 6, pp. 691-707. 1899.

KEITH, A. Talc deposits of North Carolina. In Bulletin No. 213, pp. 433-438. 1903.

KEMP, J. F. Notes on the occurrence of asbestos in Lamoille and Orleans counties, Vt. In Mineral Resources U. S. for 1900, pp. 862-866. 1901.

——— Graphite in the eastern Adirondacks. In Bulletin No. 225, pp. 512-514. 1904.

PHILLIPS, W. B. Mica mining in North Carolina. In Mineral Resources U. S. for 1887, pp. 661-671. 1888.

SMITH, G. O. Graphite in Maine. In Bulletin No. 285, pp. 480-483. 1906.

——— Graphite. In Mineral Resources U. S. for 1906, pp. 1139-1143. 1907.

SMITH, W. S. T. (See Ulrich, E. O., and Smith, W. S. T.)

STERRETT, D. B. Mica deposits of western North Carolina. In Bulletin No. 315, pp. 400-422. 1907.

——— Mica. In Mineral Resources U. S. for 1906, pp. 1149-1163. 1907.

STOSE, G. W. Barite in southern Pennsylvania. In Bulletin No. 225, pp. 515-517. 1904.

ULRICH, E. O., and SMITH, W. S. T. Lead, zinc, and fluorspar deposits of western Kentucky. In Bulletin No. 213, pp. 205-213. 1903.

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