Geology of the Virginia Barite-Deposits.

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(Toronto Meeting, July, 1907.)

I. HISTORICAL.

Barite has been mined for many years in various parts of Virginia, probably the earliest mining-operations being in Prince William county, within 600 ft. of the Fauquier county line, about 4 miles south of east from Catlett, a station on the Southern Railway. It is claimed that the mineral was mined here as early as 1845.

Mining-operations in Campbell and Pittsylvania counties in the Piedmont region, and near Marion in Smyth county, in the southwest Virginia Valley region, were begun about 30 years ago. The mining and milling of barite on a commercial scale in Tazewell and Russell counties are more recent, and commenced about 15 years ago.

II. GEOGRAPHICAL AND GEOLOGICAL DISTRIBUTION.

Barite occurs in many counties in the State, as shown in Fig. 1, but the industry has been confined to only a few of them. Its occurrence is noted in two of the three major divisions of the State—namely, the Piedmont region east of the Blue Ridge, and the Paleozoic area west of the Blue Ridge. In the Piedmont region the mineral has been mined in the following counties: Bedford, Campbell, Louisa, Prince William, and Pittsylvania. In the region west of the Blue Ridge, composed of Paleozoic sediments, barite has been mined in Montgomery, Russell, Smyth, and Tazewell counties. Of the counties mentioned, Bedford, Campbell, and Pittsylvania of the Piedmont region, and Russell, Smyth, and Tazewell of the Valley region, have been the principal producers. In 1906, operations were confined to five counties—Bedford, Louisa, Pittsylvania, Russell, and Tazewell—but in the first two counties named there was no production, the work being solely development.

[1]
SKETCH MAP OF VIRGINIA
SHOWING THE DISTRIBUTION OF WORKED AREAS OF BARITE.

BARITE AREAS
1. CAMPBELL-PITTSYLVANIA COUNTIES AREA
2. BEDFORD COUNTY AREA
3. LOUISA COUNTY AREA
4. PRINCE WILLIAM COUNTY AREA
5. RUSSELL-TAZEWEIL COUNTIES AREA
6. SMYTH COUNTY AREA

Fig. 1.—Sketch-Map of Virginia, Showing Barite-Areas.
Geologically, the barite-deposits of Virginia may be grouped into three unlike areas: (1) those deposits of the red shale-sandstone series of Triassic age; (2) those of the crystalline metamorphic area, the age-relations of the rocks being unknown, but probably pre-Cambrian for the most part; and (3) those of the Valley region, associated for the most part with the Cambro-Ordovician limestone (Shenandoah or Valley) or its residual decay. Areas (1) and (2) compose the Piedmont province, which stretches eastward from the Blue Ridge to the fall-line or the western margin of the Coastal Plain sediments.

III. General Mode of Occurrence.

The Virginia barite-deposits of commercial importance thus far developed, which have been worked for barite alone, are associated with limestone as pockets or lenticular masses, largely in the nature of replacements, and as vein-like masses filling fractures in the limestone. In southwest Virginia and elsewhere in the Valley region where the barite occurs in the limestone, it is often found as superficially loose lumps and nodules of irregular shapes and sizes imbedded in the residual clays derived from the limestone. In several instances the barite is not associated with limestone, but occurs directly in siliceous crystalline rocks removed, so far as we know, some distance from limestone. The barite-deposit near Thaxton, in Bedford county, best illustrates the occurrence of barite in siliceous crystalline rocks remote from limestone-masses.

In Campbell and Pittsylvania counties of the crystalline area the barite is intimately associated with coarsely crystalline limestone (marble) and its residual decay. The local differences in the mode of occurrence of barite in Virginia are best brought out in the description given below of the three geologically-unlike areas in which deposits are found.

IV. The Triassic Area.

As yet only one deposit of barite of commercial importance has been developed in the numerous areas of Triassic rocks occurring in Virginia east of the Blue Ridge. About 4 miles south of east from Catlett station, in Prince William county, and within 600 ft. of the Fauquier county line, barite has been mined at different times since 1845. It was last worked in
1903, with a production of 1,500 tons of ore. The opening of this deposit probably marks the first mining of barite in Virginia.

The ore was mined by shafts and open cuts, the greatest depth reached in mining being 108 ft. The grinding and preparation of the ore for market were conducted in a mill built for that purpose on the property. This mill was afterwards burned, and in its place now stands a partly-completed crushing-house, located near the main shaft.

The area forms a part of the eastern Piedmont region, characterized topographically by a gently undulating surface, without marked relief. The geological position of this deposit is within the eastern margin of the red shale-sandstone series of the Triassic area which crosses the Potomac river west of Washington and terminates about 10 miles south of Culpeper, the Virginia portion of the New York-Virginia area as defined by Russell.¹

The rocks of the immediate barite locality consist of ferruginous red sandy shales and a light-colored crystalline limestone. Measured at numerous points west of the mine the dip varies from 10° to 15° west of northwest. Between Catlett station and the mine the shales are penetrated by occasional masses of diabase.

Much of the material composing the dumps at the mine is a limestone breccia, in which red shale fragments are cemented by an impure crystalline limestone. Fractures are frequent, and are filled with barite and occasionally with calcite-crystals. These facts suggest that the barite-deposit occupies a crushed or fractured zone in the Triassic sediments, induced probably by faulting, although no evidence for such is apparent on the surface. In view of these facts, and since faulting is a characteristic structure of the Triassic areas in Virginia and of the similar eastern areas in general, it seems reasonable to ascribe the brecciation in the Prince William county locality to this cause.

The barite is associated with both the red shales and the impure limestone, usually as a deposition-product from the solution which filled fractures in the red shale. The widest of the

barite-filled fractures, reported to be from 4 to 8 ft., form the chief source of the minable mineral. The barite occurs also as thin tabular cleavable masses in the limestone. It is of good white grade, both finely and coarsely crystalline, massive, and, judging from the ore on the dumps, quite free from most of the common impurities, especially manganese. I did not have access to the shafts, but it is reliably reported that the association of ore with limestone increases with depth.

V. The Crystalline (Piedmont Plateau) Area.

The Virginia-Piedmont province forms a part of the eastern crystalline region which extends southwestward from New York to northern central Alabama. Its limits in Virginia are from the Blue Ridge on the west to the fall-line, western margin of the Coastal Plain, on the east; and it widens southward. Excepting the Triassic areas the rocks are all crystalline, and comprise greatly altered sedimentary and igneous masses. The region is made up of a complex of schists, gneisses and granites, with, in places, interfoliations of slates, quartzites and limestones. This complex is further intersected by intrusions of basic eruptive rocks belonging, so far as they have been studied, to the diabasic, dioritic and gabbroic types. The bulk of the rocks composing this region, the oldest in the State, were mapped by the older geologists as Archean, but more recent studies reveal the fact that a part of them are as late as Ordovician.

The occurrence of barite has been noted in nine counties in the crystalline area, but the principal production has been from Campbell and Pittsylvania counties, with Bedford next in point of production. The ore has been mined in these counties for 30 or more years.

1. The Campbell-Pittsylvania Counties Area.

Beginning in the middle western portion of Campbell county, several miles east of Evington and about 15 miles south of Lynchburg, a belt of barite-deposits is traced southwestward to 3 or more miles south of Sandy Level in the northwestern part of Pittsylvania county, a distance of about 50 miles. Numerous openings have been made at different points on the belt, many of which have been extensively worked and have pro-
Barite.

Scale, 1 in. = 7.5 m. approximately.

Fig. 2.—Barite-Deposits of the Bedford-Campbell-Pittsylvania Counties Area.

[6]
duced large quantities of excellent ore. Fig. 2 is a sketch-map of the belt, showing the location of the various openings made.

This area, occupying a part of the middle western Piedmont region, presents no unusual features in topography from that of the Piedmont in general.

The most extensively-worked deposits on the belt are grouped about two centers, Evington in Campbell county, at the NE., and Toshes and Sandy Level in Pittsylvania county, at the SW. extremity of the belt. Operations were begun in the two counties within a short time of each other, with probably the Hewitt mine in the vicinity of Evington, which dates back to 1874, the first to open. The mines in the vicinity of Toshes and Sandy Level in Pittsylvania county were opened at least 25 years ago, and in both counties the mines have been operated almost continuously from the beginning.

(a) Mode of Occurrence.—Two characteristic occurrences of barite are observed in the Campbell-Pittsylvania area, always in association with each other, and equally as strongly emphasized in one part of the area as in the other. The first and principal occurrence is in intimate association with the crystalline limestone as irregular lenticular bodies or pockets, which measure from 100 to 200 ft. or more, replacing the limestone. At the Hewitt mine in Campbell county some of the barite-pockets were reported entirely inclosed by the limestone. The barite observes the same coarsely-crystalline massive structure as characterizes the limestone, and in several places gradation of the barite into the limestone was observed.

For the depths so far attained, there is immediately below and above the limestone, a variable thickness of a nearly black clayey mass, usually preserving the foliation of the original rock from which it was derived, and colored black from manganese oxide, derived from the decay of a limestone-schist. Through this black clayey mass are usually distributed, in irregular fashion, lumps and nodules of barite of large and small size. Occasionally, barite stringers of slight thickness are formed along the foliation planes of the clay. Figs. 3 and 4 illustrate the two occurrences of barite here described.

(b) Associated Minerals.—Calcite in the form of the coarsely-crystalline marble with which the barite occurs is much the most abundant associate. Pyrite and chalcopyrite are fre-
quently present as thin stringers, and as disseminated small grains and crystals in some of the barite; but more especially in the limestone. These are usually intermingled, and in several instances a green staining of malachite has been observed from the alteration of the chalcopyrite. Manganese oxide and iron oxide are frequent associates in places, but, as a rule, they are not noticeable in the best grades of the barite. These are usually more abundant and, therefore, more troublesome in the barite mined from near the surface. A small amount
of the barite from the Hewitt mine in Campbell county is reported to have been highly charged with manganese oxide. Tremolite occurs both in the black clay and in the fresh crystalline limestone, and in places much biotite accompanies the tremolite in the latter. Biotite also occurs quite freely distributed through portions of the limestone in places not in association with tremolite.

(c) Associated Rocks.—The principal rocks of the Campbell-Pittsylvania barite-area are crystalline schists with intercalated thin beds of coarsely-crystalline limestone. The schists are of two distinct types—mica-schist and quartz-schist. The immediate rocks with which the barite is associated are marked by the essential absence of feldspar. The schists are composed of mica with minimum quartz, and they are unquestionably derived from sediments. Igneous rocks of basic composition occur in the vicinity of Toshes, and an irregular gneiss of granitic composition is found within 0.75 mile NE. of the Bennett mine, the origin of which, whether sedimentary or igneous, has not been determined.

In the Evington portion of the area, the underlying rock immediately in contact with the limestone-masses on the north-
west side is a fine-grained quartzite-schist of considerable purity, and containing small bright scales of white mica developed mostly along the planes of schistosity. The overlying rock immediately in contact with the limestone-masses on the northeast side is a variable mica-schist, always of fine texture and thinly foliated. Variation is from a moderately fine-grained muscovite-biotite schist at the Saunders-Phillips mines to a very fine-grained, lustrous, sericite-schist at the Hewitt mine. A fine-textured mica-schist, heavily charged with minute grains and crystals of black magnetite, forms an additional facies of the schist at the Hewitt mine. The mica-schists are composed essentially of mica without feldspar.

The mines developed on the southwest end of the belt in the vicinity of Toshes indicate an inclosure of the limestone-masses by a much coarser textured biotite-muscovite schist on the two sides. Feldspar is only recognized as a scantily-developed constituent of the rock, but thin stringers of quartz are interleaved at times with the schist, and small dike-like bodies of a coarse crystallization of pink feldspar and quartz frequently cut across the foliation of the mica-schist. The kaolinized equivalents of these dike-like masses are found in the same position in the residual clays derived from the schist.

Where exposed in mining, the limestone is a coarsely crystalline massive marble of considerable purity in places. In color it is generally white, occasionally pink, and sometimes greenish. It contains more or less of the silicate minerals, biotite and tremolite, and is frequently charged with pyrite and chalcopyrite. Manganese oxide and iron oxide are noted in places. The limestone is not of uniform thickness, but thins and thickens, the maximum observed thickness being about 60 ft. It conforms in dip and strike to the structure of the inclosing schists described above.

In composition the limestone is composed essentially of calcium carbonate with small amounts of magnesium carbonate, as shown in the analyses below, made by Dr. Walter B. Ellett, of specimens which I collected:

[10]
1. Per cent. 2. Per cent. 3. Per cent.

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1 and 2. White crystalline limestone from the Hewitt mine, Campbell county.
3. White and pink crystalline limestone from the Ramsay mine, Pittsylvania county.

A third and important type of rock intimately associated with the barite, and whose fresh equivalent is a limestone-schist, is a black manganiferous and ferruginous clay, locally called "umber." It is found at every opening made on the belt, and its position is next to the limestone, occurring, as a rule, on both sides. Openings made near the outcrop usually penetrate a considerable thickness of the black clay, but do not, as a rule, encounter the limestone. When followed down, however, for a short distance in the direction of the dip, the limestone appears inclosed on either side by the dark clay, which apparently thins on depth and ultimately disappears. Like the associated schists, the black clay always contains the foliation planes preserved in it of the original limy schist from which it was derived.

Leached mica-folia and small partly-oxidized areas of light green tremolite are found in the black clay of the Pittsylvania county mines. The relations of the clay to the limestone-masses and the mica-schist, together with its structure and composition, reasonably support the belief that it was derived by decay from a limy schist which was transitional between the well-defined limestone on the one hand and the mica-schist on the other. The kaolinized equivalents of the pegmatite dike-like forms found cutting the schists are observed in similar position in the black clay, as shown in Fig. 3. Much good barite is mined from the black clay, in which it occurs imbedded as nodular masses. Figs. 3 and 4 make clear the above relations of the clay to the limestone and the schist.

Samples of the black clay which I collected from the Bennett mine in Pittsylvania county, and analyzed by Dr. Walter B. Ellett, gave the following results:
Insoluble residue, ........................................ 14.21
Alumina, ........................................ 4.93
Ferric oxide, ........................................ 32.40
Manganous oxide, .................................... 19.49
Lime, ........................................ 2.06
Magnesia, ........................................ trace
Barium oxide, ....................................... trace
Copper, ........................................ trace

(d) Structure.—The rocks are all schistose and preserve a general NE. strike with local variations, which, so far as measured, range from N. 30° to 55° E. The pure limestone masses are more or less massive, becoming decidedly schistose with decreased purity. Greater variations are shown in the dip of the rocks.

At the northern end of the belt, near Evington, in Campbell county, at the Saunders-Phillips mines, the schists dip N. 60° to 65° W. At the Hewitt mine, which is about 2 miles S. 70° W. from the Saunders mine, the dip is toward the SE. and quite steep, affording a distinct synclinal structure, as shown in Fig. 5. Near the southern end of the belt at Toshes, in Pittsylvania county, the openings at the Bennett mine show a variable dip to the SE., which is much flatter than in the Campbell county area, the probable average being about 20°. Outcrops of the schist at other places in this vicinity gave concordant results in dip. As indicated in the measurements of dip on the two ends of the belt, the folding has not been of uniform intensity. At the northeastern end the folding is steeper and of a more closed type, while at the southwestern end it is flatter and of a more open type.

(e) Mines.—In Campbell county the principal mines are the Hewitt, Saunders, Phillips, and Anthony, grouped near together
and within a few miles east and SE. of Evington. Of these, the Hewitt mine has been the most extensively worked. It is located on the west side of Flat creek, about 2.5 miles from Evington, and about the same distance from the Saunders and Phillips mines. It was worked almost continuously from 1874 until 1904, when it was abandoned on account of water. It is developed by numerous shafts and drifts, the greatest depth reached in mining being about 160 ft. This depth extends below the local water-level, making it necessary to pump the water from the openings, which was troublesome, and finally led to suspension of work. The strike of the rocks is N. 55° E., with a steep SE. dip. The limestone with which the barite is associated has a thickness of about 60 ft., and is underlain by a quartzite-schist on the northwest side, locally designated the foot-wall, and overlain by a thinly foliated mica-schist on the northeast side, locally called the hanging-wall. As described above, the ore occurs, here and elsewhere in this belt, as irregular bodies replacing the limestone, and as irregular rounded nodules and masses in a black manganiferous and ferruginous clay, locally called umber.

The Saunders and Phillips mines adjoin each other, and are located on the crest of a well-defined NE.–SW. ridge on the east side of Flat creek, about 3 miles east of Evington. The developments comprise shafts, pits, and tunnels, the deepest one of which does not exceed 100 ft. The first openings were made about 20 years ago. The rock associations are identical with those described at the Hewitt mine. The strike of the schist is N. 30° E. and the dip N. 60°–65° W. About 2 miles SW. of the Saunders mine is the Anthony mine, which has produced a considerable quantity of ore.

The barite area in the extreme northwest corner of Pittsylvania county has been more extensively worked than any other part of the belt. It has been developed by a large number of mines, grouped in two nearly parallel belts on either side of Pig river, just south of its entrance into Roanoke river. Beginning at the northeast end the easternmost belt, trending approximately NE.–SW., has been developed by the following mines: Berger, Ramsay, Bennett, Parker, Thompson, and Dryden Wright. This belt lies approximately 0.75 mile east of Toshes. The westernmost belt is developed by the Tom Wright
mine, 1 mile east of Sandy Level, and by the Hatchet, Meas, and Davis mines SW. of Sandy Level.

The Thompson mine is reported to have been the first one opened in the area; followed by the Parker, Berger, Bennett, and Ramsay, in the order named. The first four of these were worked more than 25 years ago, and the barite produced from each mine was very large in quantity and excellent in quality. Except the Bennett mine, which is operating at present, the others have been idle for some years, and very little could be seen at the time of my examination in September, 1906.

The mines in this area were developed by numerous shafts and drifts and some open work. The greatest depth yet reached in mining is 120 ft., the depth of the working-shaft at the Bennett mine. A description of this mine, one of the most extensively worked in the district, and the only one in operation in 1906, may be taken as typical of the area.

The rock-succession at the Bennett mine is shown in Fig. 3, which represents a vertical section of the 120-ft. shaft. As shown in this sketch, and also in Fig. 4, the wall-rock is coarse-grained, thinly-foliated mica-schist, intersected by pegmatite dikes composed of coarse crystallization of feldspar and quartz. The fresh mica-schist is exposed in the bottom of the shaft, where it is penetrated for a depth of 20 ft., the overlying rock being a black manganiferous and ferruginous clay, usually thinly foliated, and derived from a lime-schist. A similar black clay also underlies the limestone, occurring between it and the fresh mica-schist. The limestone, which is a coarsely crystalline marble and charged to a small degree with both sulphide and silicate minerals, is 40 ft. thick, and occurs between the two layers of black clay.

The barite is associated with both the limestone and the black clay, in part as a replacement of the limestone, and as irregular, rounded masses and nodules in the over- and under-lying clays. The largest concentration of the barite is between the limestone and the schist, and it has an average thickness of about 10 ft. The contact between the barite layer and the limestone is very irregular, the ore often penetrating far into the limestone, as shown in Figs. 3 and 4. The contact between the barite and the mica-schist is sharply contrasted with that made with the limestone, and is sharply defined and quite
The barite is massive-granular, moderately coarsely crystalline, and of good white color. Five grades of the ore are made and marketed.

As indicated on map, Fig. 2, numerous other openings have been made between the Evington group of mines and the Toshes-Sandy Level group. Of these, perhaps the Maddox mine is one of the most important if not the most important. It is located about one mile SW. of Otter river station. Barite of excellent quality and in large quantity was mined, but the mine has not been operated in recent years on account of water, which makes the mining too expensive.

2. Bedford County Area.

Barite occurs and has been mined at a number of different points in Bedford county. Several mines near the Campbell county line have yielded large quantities of the mineral. In the western part of the county, between Bedford City and Roanoke, a recent operation shows an interesting occurrence of the mineral. The deposit lies about 3 miles NW. from Thaxton, and is reported to have been first opened in 1866, when a small quantity of the barite was shipped to Baltimore. It was re-opened again during the fall of 1906. The barite occurs in a completely-schistose coarse-grained granite filling a fracture. Some distance away from the fracture the granite is entirely massive and porphyritic, the feldspar phenocrysts being of large dimensions.

As nearly as could be determined, the fracture has a N. 10° to 20° E. course, and dips about 60° SE. An open cut about 20 ft. deep has been made along the course of the fracture for a distance of about 450 ft. The granite in the vicinity of the fracture is deeply decayed, although the fracture is distinctly shown at one end of the cut where it carries no barite.

The barite is crystalline, and varies in color from white to deep blue-gray. In places, much galenite in small grains and occasional sphalerite are disseminated through the barite. It seems quite probable that the source of the barium has been from the feldspar of the granite. The associated galena and sphalerite indicate that they were deposited contemporaneously with the barite. Whether they were introduced as soluble sulphides and deposited as such, or whether they were intro-
duced as sulphates and subsequently reduced to the sulphide form, there is no evidence.

3. Louisa County Area.

Barite occurrence and mining in Louisa county are limited to the Walker place, 0.75 mile south of Mechansville, and 3 miles south-of east from Lindsay, the nearest railway-point. The openings comprise a number of test-pits and several shafts, the deepest one of which is between 70 and 80 ft. Mining had been temporarily suspended for several months prior to my visit and the openings were filled with water, which prevented entering them for study of the ore-and rock-relations.

The area, which forms a part of the crystalline region east of the Blue Ridge, is topographically a nearly flat, gently undulating surface, averaging about 500 ft. above mean tide-level.

The rocks are metamorphic crystalline schists of probable sedimentary origin. They are very thinly foliated micaceous schists, considerably altered, the foliation-planes of which are so regular and closely spaced as to be called, locally, slates. They strike approximately NE.-SW. and observe a general southeast dip, with a probable average of about 45°. Exposures of the rock are rare because of the considerable depth of residual decay, chiefly gray and red clays. Quartz-fragments, both large and small, frequently litter the surface, indicating quartz-veins or vein-like masses interleaved with and cutting across the foliation of the schists. Careful search failed to indicate the presence of limestone, and close inquiry further confirmed its absence.

Examination of the ore was necessarily confined to the dumps. The ore is a moderately white grade of coarsely crystallized barite, remarkably free from impurities other than the usual discoloration from the red iron oxide. Several lumps of the ore showed cavities filled with nearly perfect quartz-crystals. Drused surfaces of large tabular barite-crystals are abundant. The ore was traced from the surface downward in the openings, observing a general but variable dip toward the southeast. It is reported to be pockety in mode of occurrence, widening and narrowing sharply and frequently, but having a thickness of about 3 ft. where worked in the deep shaft.

Evidence is apparently lacking for regarding the ore as a re-
placement-deposit. It probably represents a filling of an irregular fracture in the crystalline schists, the barium salt of which was probably derived from some mineral or minerals composing the surrounding rocks.

VI. THE VALLEY (PALEozoIC) REGION OF SOUTHWEST VIRGINIA.

The Virginia Valley region lies west of the Blue Ridge and comprises a vast thickness of Paleozoic sediments, the principal member of which is the Valley or Shenandoah limestone, separable into several divisions, of Cambro-Ordovician age. Barite occurs in a number of counties in the middle and northern parts of the Valley, but mining of it in the Valley province has been confined largely to Russell, Smyth, and Tazewell counties in southwest Virginia. Wherever commercial deposits of barite have been opened in this province they have been found in association with the Shenandoah limestone or its residual decay. Within recent years, mining-operations have been limited to Tazewell and Russell counties.

1. Mode of Occurrence.

In southwest Virginia the barite is in association with the Shenandoah limestone or its residual decay. It observes certain minor variations of occurrence from place to place. It fills in part, at least, fractures in the limestone, and in part it replaces the limestone. These occurrences of barite in the limestone are fairly well shown in the southeastern part of Wythe county. Here the mineral associations with barite are limonite, sphalerite, galenite, pyrite, and occasional fluorite, in certain openings named below, from which iron- and zinc-ores have been mined. In the Tazewell-Russell counties area the common associates are limonite and calcite, with some siderite, and occasional fluorite.

In addition to its occurrence in the fresh limestone, the barite is found as small and large nodules irregularly distributed through the red clay resulting from the decay of the limestone. Variation in local occurrence and in mineral association is brought out in the following description of the individual areas.
2. Wythe County Area.

In the southern part of Wythe county, and near the eastern margin of the Shenandoah limestone, barite occurs in association with the metallic ores in some of the zinc- and iron-mines. No attention has been given to the mining of barite in this locality, nor is it known whether commercial deposits of the mineral exist.

In several of the brown-iron-ore pits at Ivanhoe, barite has been observed in some of the limestone pinnacles as irregular porous or cellular masses intimately associated at times with pyrite, sphalerite, and galenite. These latter minerals, sulphides, were noted in several instances as inclusions in the barite, and the barite replaces in part the limestone. Northeast of Ivanhoe, at the Bertha zinc-mines, which have been operated for several years for iron-ore, barite is found in places as loose nodules imbedded in the red clay derived from the limestone decay.

About 0.5 mile NE. of Bertha, at the Barren Springs iron-ore pits, barite is again found similarly occurring. The mode of occurrence and the associations of the barite in the above localities suggest the introduction of the barium salt along fracture-lines in the limestone and part replacement of the limestone by barite. Moreover, there is every reason for regarding the barite, sulphides, and the little fluorite found as having been brought in and deposited at the same time. Whether the sulphides were carried as soluble sulphides, or as sulphates and deposited as sulphides, there is no convincing evidence.

3. Smyth County Area.

Barite was extensively mined some years ago near Marion, the county-seat of Smyth county. Mining and shipping of barite in this county were begun about 1877, and the work was continued more or less energetically until about 1885. Some mining on a small scale has since been done from time to time. Barite mining in this county was largely confined to an area about 3 miles west from Marion, with but a small amount of material mined on the east side of the town. Most of the barite mined was prepared by several local mills, the greater part being prepared by the mill at Marion.
The mining of barite was largely confined to the lumps and nodules of the mineral imbedded in the residual red clays derived from the Shenandoah limestone. The barite nodules were often mixed with cherty masses and broken or detached pieces of limestone. The mining did not reach 100 ft. in depth. In some instances mining was extended into the fresh and hard limestone. Gradation from the barite into the limestone was shown, and in such cases much care and labor were necessary to separate the two. The exposures of limestone in some places showed more or less barite mixed with it.

4. The Russell-Tazewell Counties Area.

Extensive deposits of barite are found in Russell and Tazewell counties, these being the largest producers of barite at present in the State. Geographically, the distribution of the barite in these two counties is chiefly along the southern slope of Kent Ridge and its prolongation NE.-SW. along the valley of Clinch river, extending from near North Tazewell to near Lebanon, a distance of more than 30 miles, partly shown in Fig. 9.

Barite has been mined at numerous points along this NE.-SW. belt, the principal mines being near North Tazewell; 3 miles south of Richlands; 3 miles from Honaker on the Clinch river; and on the southwestern end of the belt near Lebanon.
Throughout this belt the barite is found in the upper portion of the Knox dolomite and its residual decay. Sections, Figs. 6 and 7, show the structural relations of the Knox dolomite and the adjacent rocks on the northwest and southeast, near Sword creek and Richlands, in Tazewell county.

The barite occurs as small and large lumps of irregular shapes assembled in the residual clay of the limestone, and in pocket-form and vein-like bodies filling spaces in the limestone, and in part replacing the limestone. Fig. 8 illustrates one of the principal modes of occurrence of barite in this area. The barite is crystalline, of good white quality, and in most places is quite free from impurities. The mines of the Clinch Valley Barytes Co., near Honaker and Gardner, show a coarsely-crystalline white barite, in platy, more or less radiate masses—

![Diagram](image-url)

**Fig. 8.—Principal Mode of Occurrence of Barite in Russell and Tazewell Counties.**

a structure which is strongly emphasized on weathered surfaces of the ore. The commonest impurity at these mines is iron oxide, mostly in the form of limonite. Manganese oxide occurs but sparsely, or not at all. In one of the pits a little violet fluorite and small fragments of green chert were noted in association with the ore.

The greatest depth attained in mining is 103 ft. at the mines of the Pittsburg Baryta & Milling Corporation on the northeast end of the belt. Most of the mining done has been for the lump or nodular ore occurring in the limestone clays, won from shallow open pits and cuts. Some hard-rock mining in the
Contour interval, 500 ft. Scale, 0.25 in. = 1 mile, approximately.

Fig. 9.—Map of a Part of Tazewell and Russell Counties, Showing Position of Greater Part of Barite Zone. Checkered Area Through Center of Map is Barite. Adapted from the Economic Geology Sheet of the Tazewell Folio, U. S. Geological Survey.
limestone has been done in places. It is probable that in the future much limestone-ore will be mined, since large bodies of excellent grade material are exposed at several places along the belt, especially on the properties of the Pittsburg Baryta & Milling Corporation.

At the NE. end of the belt an ore-body 4 ft. wide has been mined to a depth of 22 ft. and for a distance of more than 300 ft. The ore has been tested to a depth of more than 100 ft. without indications of its exhaustion. Preparations are being made to mine this ore-body to a greater depth. The barite occurs in vein-like bodies in the limestone, is very white, free from impurities, and makes the best "snow-flake" grade manufactured by the company. On the extreme southwest end of the belt, near Finley, the properties of the same company show ore-bodies in the limestone of the same white and otherwise excellent grade of ore as that described above on the northeast end. Three miles south of Richlands this company has mined more than 6,000 tons of barite from its property. Unlike the ore described above on the two ends of the belt, that south of Richlands is lump ore mined from the red limestone clays.

VII. GENESIS OF THE BARITE-DEPOSITS.

The work of F. W. Clarke, Sandberger, and others, demonstrates the wide distribution of barium in rocks, usually present only in minute traces, but not infrequently in appreciable quantity. In the absence of necessary chemical work on the Virginia rocks in which the barite-deposits are found, but from the field-character and relations of the deposits, it seems reasonable to assume that the source of the barium was largely if not entirely the rocks in which the deposits are now found. There is no evidence in support of a deep circulation.

The barium of the Valley barite-deposits is believed to have been derived from the Shenandoah limestone, the rock in which the deposits are found. Of that forming the deposits east of the Blue Ridge in Piedmont, Virginia, it is not possible to say whether the barium was derived from the crystalline schists or from the associated limestone-masses, or from both. It is reasonably certain, however, that the source of the barium in the deposit near Thaxton, Bedford county, was the silicate minerals of the granite, probably the feldspar.
The barium was probably liberated and carried in solution as the soluble bicarbonate when, under proper conditions, it was precipitated as the insoluble sulphate. Some recent laboratory experiments made by Dickson with solutions of barium carbonate on selenite crystals and pure anhydrite in the presence of \( \text{CO}_2 \), and on pyrite crystals in the presence of an oxidizing agent, \( \text{H}_2\text{O}_2 \), resulted in each case in the precipitation of barium sulphate. The presence of pyrite in the Virginia rocks may suggest the possibility of its connection as a precipitating-agent in the formation of the barite-deposits, but lack of sufficient data renders it impossible at this time to state the conditions under which the precipitation of the barium sulphate took place and the agents involved.

**VIII. Methods of Mining.**

Mining of barite in Virginia is surface-work, with no deep mining in any part of the State. The greatest depth yet reached in any of the mines is 160 ft., in a shaft recently operated at the Hewitt mine, in Campbell county. In the crystalline area east of the Blue Ridge the ore is won by vertical timbered shafts and drifts which follow the direction of the ore-bodies. The machinery employed is simple, light, and inexpensive. In the limestone belt of southwest Virginia the mining is shallow and largely by open-pit work. Blasting is necessary for breaking down the ore in the fresh limestone.

**IX. Preparation of the Ore.**

For the removal of impurities from the better grades of merchantable ore, washing, bleaching, and grinding, and occasionally jigging, are the only necessary operations. The common impurities in the best grades of ore include the iron oxide and manganese oxide, limestone, clay, and sand. The ore in the limestone in the Valley region of southwest Virginia is both jigged and washed before bleaching and grinding. The preparation of barite has been described by Higgina.\(^2\)

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X. BARI-TÉ-MILLS.

The barite mined in Virginia is prepared for market at the following plants: The plant at Lynchburg, owned by Nulsen, Klein & Krausse; the plant at Honaker, owned by the Clinch Valley Barytes Company; the plant at Richlands, owned by the Pittsburg Barytes & Milling Corporation; and the plant at Bristol, owned by John T. Williams & Sons.

All except the Lynchburg plant are situated in southwest Virginia. These mills are modern, of large capacity, and fully equipped with machinery.

XI. Conclusions.

From the description detailed above of barite occurrence in the Virginia areas the following general facts are deducible:

(1) With two exceptions, the barite-deposits are associated with limestone or its residual decay. These exceptions show the occurrence of the barite in crystalline siliceous rocks more or less remote from limestone masses.

(2) The occurrence of the barite in the limestone is partly as a replacement, and partly as vein-like masses filling fractures; and in the residual clays as loose nodular masses irregularly assembled and of different sizes and shapes. In each of these occurrences the barite is crystalline in texture, and is the result of solution and deposition.

(3) The barite and associated minerals suggest deposition from reasonably-shallow circulations. The barite is believed to have been largely, if not entirely, derived, in most cases, from the rocks in which the concentrations are now found.