COMMONWEALTH OF VIRGINIA

VIRGINIA CONSERVATION COMMISSION

VIRGINIA GEOLOGICAL SURVEY

ARTHUR BEVAN, *State Geologist*

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Barite Deposits of Virginia

By

RAYMOND S. EDMUNDSON

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LETTER OF TRANSMITTAL

COMMONWEALTH OF VIRGINIA

VIRGINIA GEOLOGICAL SURVEY

UNIVERSITY OF VIRGINIA

CHARLOTTESVILLE, VA., June 1, 1938.

To the Virginia Conservation Commission:

GENTLEMEN:

I have the honor to transmit and to recommend for publication as Bulletin 53 of the Virginia Geological Survey series of reports the manuscript and illustrations of a report on the *Barite Deposits of Virginia,* by Dr. Raymond S. Edmundson, Associate Geologist of the Virginia Geological Survey.

This report is the first issued on barite in Virginia. It describes in detail the known barite deposits in six areas: Campbell and Pittsylvania counties, Bedford County, Grayson County, Fauquier County, Roanoke and Botetourt counties, and Russell, Tazewell and Smyth counties. More than eighty mines and prospects are described. The geology, mineralogy, and origin of the deposits are discussed. A brief account of the properties of barite, history of the barite industry, and uses of barite is also given. Suggestions are made for prospecting the areas and for commercial development of the deposits.

Respectfully submitted,

ARTHUR BEVAN,
State Geologist.

Approved for publication:
Virginia Conservation Commission,
Richmond, Virginia, June 14, 1938.
R. A. GILLIAM, *Executive Secretary and Treasurer.*

CONTENTS

	Page
Abstract	1
Introduction	3
Purpose and scope of the report	3
Field work and acknowledgments	3
General features of barite	4
Chemical and physical properties	4
Distinguishing characteristics	4
History of the barite industry in the United States	4
Uses	6
General statement	6
Ground barite	7
Lithopone	7
Barium chemicals	8
Barite in Virginia	9
Location of deposits	9
Minerals of the deposits	9
General statement	9
Sulphates	9
Barite	9
Gypsum	11
Sulphides	11
Pyrite	11
Chalcopyrite	11
Oxides	12
Quartz	12
Limonite	12
Haloids	12
Fluorite	12
Carbonates	12
Calcite	12
Silicates	13
Tourmaline	13
Hornblende and biotite	13
Sericite	13
Epidote and chlorite	13
Paragenesis of the minerals	14
Types of deposits	14
General statement	14
Fissure veins	14
Replacement masses	15
Breccia zones	15
Residual deposits	16

PAGE
Origin ---- 16
General statement ---- 16
Meteoric origin ---- 18
Associated minerals ---- 18
Alteration of wall rock ---- 18
Barite in fossils and concretions ---- 18
Absence of nearby igneous rocks ---- 18
Source of the barium ---- 18
Magmatic origin ---- 18
Associated minerals ---- 19
Alteration of wall rock ---- 19
Source of the barium ---- 20
Solution and deposition of barium salts ---- 21
Relation of barite to fracture zones ---- 23
Barite in pegmatites ---- 24
Time of mineralization ---- 24
Conclusions ---- 24
Suggestions for development ---- 25
Prospecting ---- 25
Mining and washing methods ---- 25
Commercial factors ---- 26
Distribution ---- 27
Campbell-Pittsylvania counties area ---- 27
Location ---- 27
History ---- 27
Geology ---- 28
Associated rocks ---- 28
Cockeysville marble ---- 29
Wissahickon formation ---- 29
Pegmatite ---- 30
Principal mines and prospects ---- 30
Carson mine ---- 30
Saunders mine ---- 31
Phillips mine and prospect ---- 32
Hewitt mine ---- 33
Haden mine ---- 34
Mattox mine ---- 35
Cundiff prospect ---- 35
Bragg mine ---- 35
Wood prospect ---- 36
Arthur mine ---- 36
Hamner mine ---- 36
Tuck mine ---- 37
Berger mine ---- 38
Ramsay mine ---- 39
Bennett mine ---- 39
Parker mine ---- 39

PAGE

Thompson mine 41
Mease mine 41
Witcher mine 41
Hurt prospects 42
Bedford County area 42
Location 42
History 43
Geology 43
Associated rock 43
Marshall granite 43
Principal mines and prospects 44
Saxton-McMillan mines 44
Grayson County area 45
Location 45
History 45
Geology 45
Associated rocks 46
Porphyritic granite gneiss 46
Mylonitized granite gneiss 46
Pegmatite 47
Principal mines and prospects 47
F. Vaught prospect 47
S. Vaught, Porter, and Rhudy prospects 48
Martin prospect 48
Poole prospect 49
Moore prospect 50
Cox prospect 50
Phipps prospect 50
Fauquier County area 51
Location 51
History 51
Geology 51
Associated rocks 52
Bull Run shale 52
Diabase dikes 52
Principal mines and prospects 52
St. Stephens mine 52
Cedar Run mine 54
Botts prospect 54
Gear mine 55
Kemper mine 55
Roanoke-Botetourt counties area 56
Location 56
History 56
Geology 56
Associated rocks 57
Principal mines and prospects 58

PAGE
Crush mine and prospect 58
Williamson mine 59
Caldwell prospect 60
Gusler-Austin mine 60
Huffman prospect 62
Reynold mine 62
Rucker mine 62
Reed mine 63
Russell-Tazewell-Smyth counties area 63
Location 63
History 64
Geology 66
Associated rocks 66
Principal mines and prospects 68
Fudge mine and prospect 68
K. Peery mine 68
M. L. Peery mine 68
Hubble mine 68
Hopkins mines 69
Taylor mine 69
Earl mine 69
Altizer prospects 70
Steele mine 70
Ringstaff mine 70
Nipper prospect 70
Clifton mines 71
Fletcher mine 71
Thomas mine 71
Harman mine 72
McGraw mine 72
Counts mine 72
Stump mine 73
Honaker mine 73
Hubbard mine 73
Meade mine 74
Blumer mine 74
Ward prospect 75
Buckles mine 75
Leonard mine 75
Hughes-Cowan mines 75
Groseclose prospect 76
Henderlite mine 76
McDonald mine 76
Eller mine 77
Cornett-Hull mines 77
Shanklin mine 77
H. P. Copenhaver mine 77

PAGE

Miles-Gardner mines ---- 78
Myers-L. Copenhaver mines ---- 78
Faris mine ---- 79
Orr mine ---- 79
Other deposits ---- 79
General statement ---- 79
Principal prospects ---- 79
Johnson prospect ---- 79
Becktel prospect ---- 79
Shorter prospect ---- 80
Earhart prospect ---- 80
J. C. Groseclose prospect ---- 80
Walker prospect ---- 80
Index ---- 81

ILLUSTRATIONS

Plate		Page
1.	A, Group of barite crystals; B, Barite cleavage fragment from Smyth County; C, Banded character of a small vein at the McGraw mine, Russell County	8
2.	A, Barite in silicified Bull Run shale, Fauquier County; B, Tourmaline (t) and quartz (q) in a groundmass of finely crystalline barite (b), Campbell County	12
3.	A, Barite vein on the Cundiff prospect, Campbell County; B, Bladed crystals of hornblende (h) and biotite (bi) probably replacing barite (b) and quartz (q), Campbell County	12
4.	A, Tourmaline (t), hornblende (h), epidote (e), and chlorite (ch) in a groundmass of finely crystalline barite (b) and quartz (q), Campbell County; B, Barite (b) replacing feldspar (f) and occurring as small veinlets cutting quartz (q), Grayson County	16
5.	A, Gradational contact between barite vein and hydrothermally altered wall rock, Bedford County; B, Tabular crystals of barite (b) and epidote (e) associated with quartz (q), Grayson County	16
6.	A, Hydrothermally altered marble along barite vein showing bladed crystals of chlorite (ch) associated with quartz (q) and calcite (c), Campbell County; B, Fine-grained barite (b) and quartz (q) associated with large crystals of muscovite (m) and feldspar (f), in pegmatite, Pittsylvania County	24
7.	A, Fractured quartz vein (q) cemented by barite (b), Fauquier County; B, Vein of barite in granite, Grayson County; C, Replacement veins of barite in limestone, Russell County	24
8.	Map showing barite deposits in Campbell and Pittsylvania counties, Virginia	32
9.	A, Replacement mass of barite in limestone, Smyth County; B, Barite replacing included fragments of granite, Grayson County; C, Mica schist almost completely replaced by barite, Grayson County	40
10.	A, Limestone breccia cemented by barite, Russell County; B, Barite within pyritized cephalopod shells; C, Former washing plant at the Hewitt mine, Campbell County	40
11.	A, Intersecting barite veins which originally contained angular fragments of limestone, Roanoke County; B, Barite vein about 4 feet wide, Grayson County	56
12.	A, The Hewitt mine, Campbell County, northeast along the strike; B, Brecciated limestone pinnacles cemented by barite, Botetourt County; C, The Goodell-Copenhaver barite mill, Smyth County	56
13.	Sketch maps showing barite deposits in Russell, Tazewell, and Smyth counties, Virginia	68

PLATE PAGE

14. A, Light-colored barite masses in bedrock, Russell County; B, Dump pile of the McGraw mine, Russell County; C, Thin layers of limonite formed from pyrite, Russell County ---------- 72
15. A, Radiating structure common in replacement masses of barite, Smyth County; B, Barite cleavage fragments united parallel to the crystallographic "b" axis, Smyth County; C, Radiating structure of coarsely crystalline barite, Smyth County ---------- 72

FIGURE PAGE

1. Trends in domestic sales, imports, consumption, and average value f. o. b. mines, of crude barite, 1921-36 ---------- 6
2. Index map showing distribution of the known barite deposits in Virginia ---------- 10
3. Probable period of formation of barite and associated vein minerals ---------- 14
4. Flow sheet of typical barite washing plant ---------- 27
5. Cross section of the Carson mine, Campbell County ---------- 31
6. Sketch map of the Phillips mine, Campbell County ---------- 32
7. Diagrammatic section at the Hewitt mine, Campbell County ---------- 34
8. Section in largest open cut of the Arthur mine, Pittsylvania County ---------- 37
9. Cross section at the Berger mine, Pittsylvania County ---------- 38
10. Plan and section at the Bennett mine, Pittsylvania County ---------- 40
11. Map showing location of the Saxton (1) and the McMillan (2) barite mines in Bedford County, Virginia ---------- 42
12. Map showing location of barite deposits in Grayson County, Virginia ---------- 48
13. Map showing location of barite deposits in Fauquier County, Virginia ---------- 53
14. Map showing location of barite deposits in Rockbridge, Botetourt, and Roanoke counties, Virginia ---------- 58
15. Plan and generalized cross section of the Gusler-Austin mine, Botetourt County ---------- 61

TABLES

PAGE

1. Content of barium oxide in rocks associated with barite deposits in Virginia ---------- 20
2 Bedrock of Roanoke-Botetourt counties barite deposits ---------- 57

Barite Deposits of Virginia

By Raymond S. Edmundson

ABSTRACT

Barite deposits are abundant in the Piedmont and Appalachian Valley and Ridge provinces of Virginia, but the most extensive mines and prospects occur in Bedford, Botetourt, Campbell, Fauquier, Grayson, Pittsylvania, Russell, Smyth, and Tazewell counties.

The barite occurs as fissure veins, replacement masses, breccia zones and residual deposits. The wall rock includes pre-Cambrian marble, schist and gneiss; Paleozoic limestone and dolomite; and Triassic shale, sandstone and diabase. Replacement bodies of barite in the calcareous rocks range in width from a few inches to 20 feet, whereas in the other occurrences they have a maximum width of 4 feet. The lower limits of the deposits have not been determined, but actual testing proves that many deposits extend to a depth of 150 feet.

The barite is believed to have been formed by rising solutions of magmatic origin. The principal criteria which favor this origin for the barite deposits in the Piedmont province are (1) the occurrence of hydrothermal minerals in the barite veins and replacement masses; (2) the hydrothermal alteration (propylitization) of many of the wall rocks; (3) the small barium content of the enclosing rocks; (4) the presence of barite in pegmatites; (5) the close association of barite deposits with fracture zones; and (6) the lack of leaching of the rocks adjacent to the barite deposits. It is also thought that magmatic solutions, better than meteoric solutions, can transport the barium and supply the sulphate radical necessary for large concentrations of barite. Exclusive of the hydrothermal minerals in the veins and wall rocks and the occurrence of barite in pegmatites, the criteria given above apply also to the deposits of the Appalachian Valley and Ridge province.

Barite mining in the United States probably began in 1845, when a small deposit was operated in Fauquier County, Virginia, near the Prince William County line. Virginia was the chief producer of barite for 48 years, and continued to be an important producer until about 1908. Barite mining never has been abandoned in Virginia, but during the past 25 years the principal production has come from three mines: one in Campbell County and one in Pittsylvania County, and a smaller quantity from one mine in Botetourt County.

In Virginia there are abundant small bedrock occurrences of barite, but it is doubtful if, under the present market conditions, any of these deposits can be worked profitably. The residual deposits can be developed more easily, and it is likely that certain small quantities of barite in Grayson, Botetourt, Campbell, and Pittsylvania counties could be mined profitably.

INTRODUCTION

PURPOSE AND SCOPE OF THE REPORT

Renewed interest in Virginia barite has created a demand for geological information beyond the scope of earlier reports. In 1930 a new study of the Virginia barite deposits was planned by Dr. Arthur Bevan, State Geologist, as a project of the Virginia Geological Survey.

It is the purpose of this report to discuss the distribution, types of deposits, origin, and probable economic value of barite in Virginia. The report contains descriptions of the mines and prospects, brief mention of the associated rocks, and a section on mining methods and suggestions for prospecting.

FIELD WORK AND ACKNOWLEDGMENTS

The field work was done during parts of the summer of 1930, 1931, and 1933, and the laboratory investigations were made at Cornell University from 1933 to 1935. In order to include recent mining activities, the barite areas were revisited during the winter of 1937-1938.

The writer is greatly indebted to Dr. Arthur Bevan who supervised the field work and made many suggestions regarding the preparation of the report. Special acknowledgment is due Professor H. Ries, Cornell University, for his timely advice and criticism during all of the laboratory investigations. He wishes also to express his thanks to Professors J. D. Burfoot and C. M. Nevin, Cornell University, for helpful suggestions; to Professor W. A. Tarr, University of Missouri, and Dr. Oliver Bowles and Mr. Paul M. Tyler of the United States Bureau of Mines, for reading and criticizing the report; to Mr. William M. McGill, Assistant State Geologist, who edited the report for publication, and to Mr. Linwood H. Warwick, Chief Clerk of the Virginia Geological Survey, who assisted in editing the manuscript and illustrations. He wishes to acknowledge also the assistance of Dr. D. T. Ries, of Ithaca, New York, and Professor J. K. Roberts, of the University of Virginia, in making many of the photographs. Many citizens of the State have been of assistance in the collection of data and have extended every courtesy to the writer.

GENERAL FEATURES OF BARITE

CHEMICAL AND PHYSICAL PROPERTIES

Barite, sometimes known as barytes, heavy spar, cawk, or tiff, has the chemical formula $BaSO_4$. It contains, when pure, 65.68 per cent barium oxide and 34.32 per cent sulphur trioxide. Modifications of these percentages are frequently due to variable amounts of $CaSO_4$ and $SrSO_4$, which are closely isomorphous with barium sulphate.

The mineral is fusible at 3, coloring the flame yellowish-green. It is highly insoluble in acids. At a temperature of 18.4° C., the solubility of barite is one part in 429,700 parts of water.[1]

Barite crystallizes in the holohedral class of the orthorhombic system, and the usual forms are tabular parallel to the base and bounded on the sides by short prisms (Pl. 1, A). Other crystals show both macrodomes and brachydomes in combination with the above forms. No less than 119 different forms of barite have been described by Herschenz.[2] Barite may also occur,[3] "in globular forms, fibrous or lamellar, crested; coarsely laminated, laminae convergent and often curved; granular, resembling white marble, and earthy . . . ."

Cleavage is perfect parallel to the basal pinacoid and prism, and imperfect parallel to the brachypinacoid. The specific gravity varies between 4.3 and 4.6, and the hardness between 2.5 and 3.5.

The diaphaneity ranges from translucent to opaque in hand specimens, whereas in thin sections it is transparent. Color is the most indefinite property of barite, and may be white, black, or varying shades of yellow, gray, blue, red and brown.

DISTINGUISHING CHARACTERISTICS

Barite may at times be confused with calcite, aragonite, albite, celestite, anhydrite, and other minerals, but it is usually quite readily distinguished by one or more of the following properties: hardness, lamellar structure, perfect prismatic cleavage, high specific gravity (4.5), occasional fetid odor when rubbed, insolubility in acids, and lack of solution effects.

HISTORY OF THE BARITE INDUSTRY IN THE UNITED STATES

Barite mining in the United States probably began in 1845,[4] when a small deposit was operated in Fauquier County, Virginia, near the

[1] Bärtling, R., Die schwerspatlagerstatten Deutschlands: Stuttgart, p. 5, 1911.

[2] Herschenz, O., Untersuchungen über Harzer baryte: Inaug.-Diss., 1881.

[3] Dana, E. S., A textbook of mineralogy, 4th Edition, p. 748, John Wiley & Sons, Inc., New York, 1932.

[4] Watson, T. L., Geology of the Virginia barite deposits: Am. Inst. Min. Eng. Trans., vol. 38, pp. 710-733, 1907.

County line. The next state to produce barite was Missouri, where according to Weigel[5] production probably began about 1860. During the early period of operation Virginia was the leading producer, but by 1893 Missouri was producing almost an equal amount.[6] The output of this state continued to grow and in 1914 furnished 65 per cent of the total production of the United States. In the meantime production began in Kentucky about 1903, in Alabama about 1906, and in Georgia and Nevada about 1907. The trend of the production since 1914, is briefly summarized by Santmyers[7] as follows:

"In 1915 the production of Missouri was almost equaled by that of Georgia, which in 1916 became the chief producing state, with an output nearly twice that of Missouri, although the production of Missouri had almost doubled. The shifting of the greatest production of crude barite from Missouri to Georgia was due to the cessation of imports of barite and barium chemicals from Germany, lower freight rates to eastern factories making lithopone and barium chemicals, and the geological character of the deposits which permitted mining by means of steam shovels.

"War developments, although greatly increasing the output and consumption of crude barite in this country, left the industry divided between two distinct localities: (1) The middle western district, with Missouri as the chief producer, and (2) the southern or Appalachian district, represented chiefly by Georgia and Tennessee."

Statistics[7a] show that from 1916 to 1921 the crude barite produced and marketed in the United States decreased from 221,952 short tons to 66,369 short tons, due in part to the post-war depression. This slump was temporary: the crude barite sold or used by producers increased to 277,269 short tons in 1929, and then gradually decreased to 129,854 short tons in 1932. Since 1932 there has been a steady increase, reaching an all-time peak of 355,888 short tons in 1937. (See Fig. 1.)

In 1919 the chief producing states listed in order of their importance were Georgia, Missouri, and Tennessee. Missouri surpassed Georgia in 1920 and has since continued as the chief producing state. Production in recent years has also come from California and Nevada. The mine production of crude barite in 1937 came from California, Georgia, Missouri, Nevada, Tennessee, Texas, and Virginia.

---

[5] Weigel, W. M., The barite industry in Missouri: Am. Inst. Min. and Met. Eng. Tech. Pub. 201, pp. 1-26, 1929.

[6] Tarr, W. A., The barite deposits of Missouri and the geology of the barite district: Univ. Missouri Studies, vol. 3, no. 1, p. 3, 1918.

[7] Santmyers, R. M., Barite and barium products: U. S. Bur. Mines Inf. Circ. 6221, pp. 6-7, 1930.

[7a] U. S. Bureau Mines, Mineral resources of the United States: (Annual reports), Washington, D. C.

U. S. Bureau Mines, Minerals Yearbook: (Annual reports), Washington, D. C.

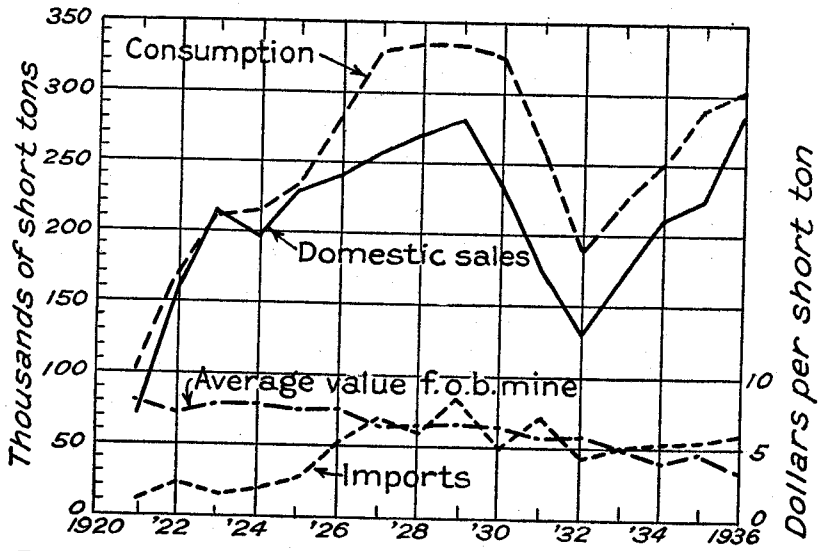


FIGURE 1.—Trends in domestic sales, imports, consumption and average value f. o. b. mines, of crude barite, 1921-36. (From U. S. Bureau of Mines, Minerals Yearbook, Fig. 111, p. 1371, 1937.)

USES[8]

GENERAL STATEMENT

Metallic barium has little commercial value at present, although it is finding some use in spark plugs and similar parts requiring electron-emitting properties, and in the manufacture of barium-aluminum alloys.

Numerous compounds of barium, which owe their chemical and physical properties to the element, are important commercially. For example, the average annual value of such products as ground barite, lithopone, and barium chemicals sold or used by producers in the United States from 1933 to 1937 was approximately 15 million dollars.

[8] U. S. Geol. Survey, Mineral resources of the United States: (Annual reports), Washington, D. C.

U. S. Bureau Mines, Mineral resources of the United States: (Annual reports), Washington, D. C.

U. S. Bureau Mines, Minerals Yearbook: (Annual reports), Washington, D. C.

U. S. Bureau Mines, Inf. Circ. 6223 (Revised), Barite and Barium Products, pt. 2, Barium products, 1930.

Bayley, W. S., Non-metallic mineral products, p. 448, Henry Holt and Company, New York, 1930.

Hardy, C., Barium and strontium *in* The minerals industry, pp. 57-59, McGraw-Hill Book Company, Inc., New York, 1937.

Ladoo, R. B., Non-metallic minerals, pp. 77-79, McGraw-Hill Book Company, Inc., New York, 1925.

Lilley, E. R., Economic geology of mineral deposits, pp. 724-725, Henry Holt and Company, New York, 1936.

Tarr, W. A., Introductory economic geology, p. 582, McGraw-Hill Book Company, Inc., New York, 1930.

Weigel, W. M., Barium minerals, *in* Industrial minerals and rocks, pp. 97-110, New York, Am. Inst. Min. Met. Engr., 1937.

During this five-year period, of the total crude barite processed about 28 per cent was ground, 53 per cent was used in lithopone, and 19 per cent was used for the manufacture of barium chemicals.

GROUND BARITE

The manufacture of many products which require weight, chemical inertness, white color, and other desirable properties consumes annually large quantities of ground barite. Particular uses require barite of various degrees of fineness and purity.

Ground barite is widely used as an inert filler in the manufacture of rubber goods, paper, oilcloth, linoleum, resins, and plastics. It is also used to add weight to textiles and leather. Bleached or unbleached ground barite is employed as a rubber filler where soft rubber articles are desired, whereas the bleached form is used in paper products requiring a high finish and weight.

Ground barite is used in paint as a white pigment and as an inert extender. Although it does not have the covering capacity of lead compounds, it has the advantage of not being discolored by gases.

Finely ground barite, often mixed with some suspending medium such as bentonite, produces a heavy mud which is used in controlling high gas pressures in the drilling of deep oil wells. This important use is of comparatively recent development.

Barite of high purity is finding extensive use in the manufacture of glass, ceramic enamels, and as a flux in brass smelting and the founding of gray iron.

Small quantities are used for X-ray protection purposes, in acid-proof packing in joints of sulphuric acid works, in storage batteries, in the manufacture of inside-frosted electric-lamp bulbs, for making artificial ivory for buttons and poker chips, and as an impervious coating for cloth used as a covering for hams and certain cheeses.

LITHOPONE

Lithopone, a mixture of approximately 70 per cent barium sulphate and 30 per cent zinc sulphide, is by far the most valuable barium product manufactured in the United States. It is used extensively as a white pigment in paints for both interior and exterior use. In addition to its most important use in the paint, varnish, and lacquer industries, it is employed as a filler in rubber goods, oilcloth, linoleum, printer's ink, face powder, window shades, and certain kinds of paper. The lithopone used in high-grade rubber goods not only acts as a filler, but is valuable for the curative effect which the zinc sulphide has on the rubber.

BARIUM CHEMICALS

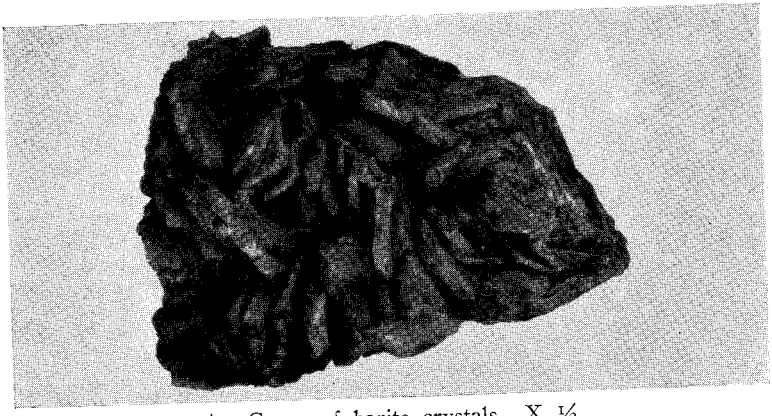
Blanc fixe, the precipitated barium sulphate, is a whiter and finer grained product than the ground natural barite, and for that reason is largely used where a pure white pigment or filler is desired in paints, rubber goods, oilcloth, linoleum, and glazed paper. It is also used as a base for lake colors, in lithographic inks, and as an indicator in X-ray photography.

Precipitated barium carbonate is used in the ceramic industry to prevent the formation of a scum on clay products and for the manufacture of enamels for iron and steel ware. It is also used in the manufacture of paints, optical glass, and in making barium peroxide.

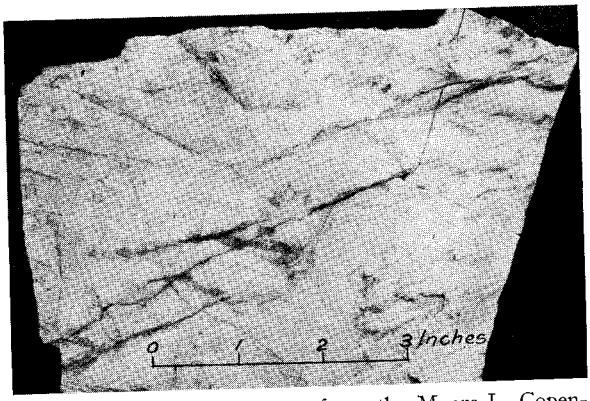
Barium nitrate is used for the manufacture of barium peroxide or dioxide, pyrotechnics, certain explosives, and medicines.

Barium chloride is used in the manufacture of blanc fixe, lake colors, and certain chemicals for photography. It is also used in the purification of salt, as a water softener, a chemical reagent, a mordant for fixing dyes, and to some extent in the ceramics industry.

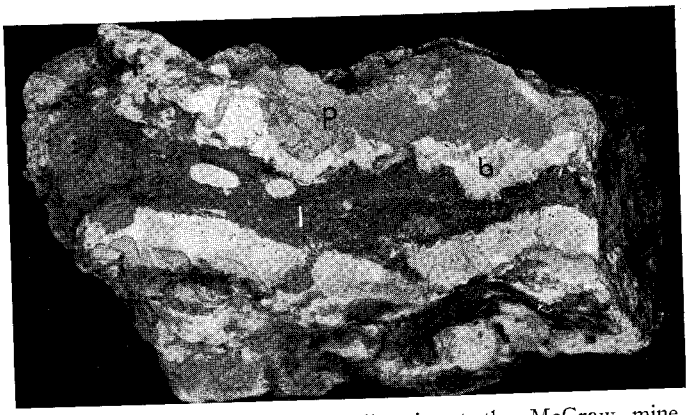
Other barium chemicals are the hydrate, dioxide, peroxide, monoxide, sulphide, chromate, chlorate, manganate, and aluminate. None of these are of major importance, but their aggregate consumption is substantial.



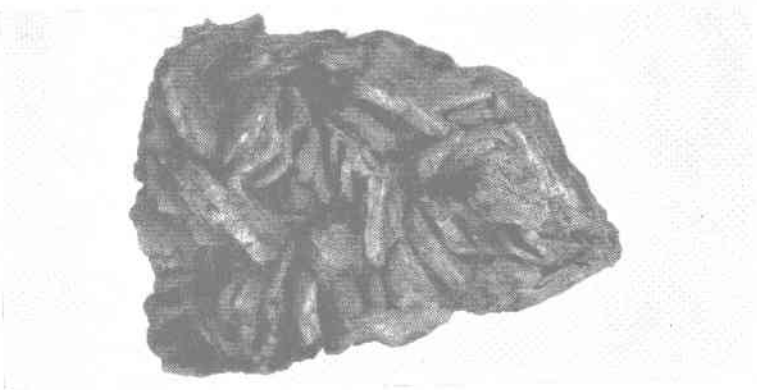
A. Group of barite crystals. X ½.



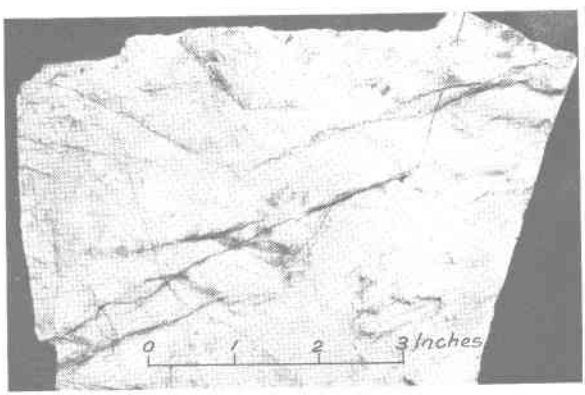
B. Barite cleavage fragment from the Myers-L. Copenhaver mines, Smyth County, Virginia.



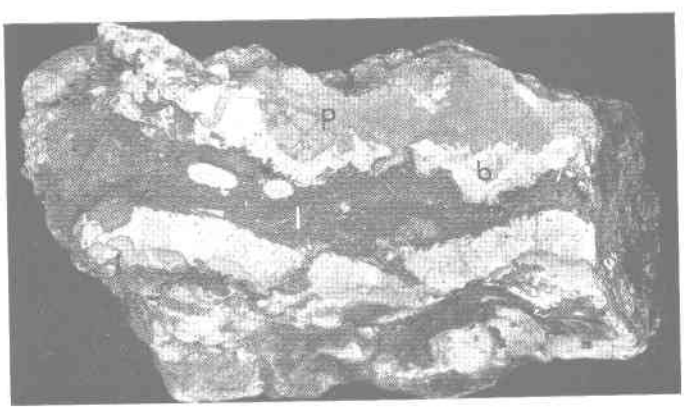
C. Banded character of a small vein at the McGraw mine, Russell County, Virginia; pyrite (p), barite (b), and limonite (l). X 1/3.



A. Group of barite crystals. X ½.



B. Barite cleavage fragment from the Myers-L. Copenhaver mines, Smyth County, Virginia.



C. Banded character of a small vein at the McGraw mine, Russell County, Virginia; pyrite (p), barite (b), and limonite (l). X 1/3.

BARITE IN VIRGINIA

LOCATION OF DEPOSITS

Barite deposits are abundant in the Piedmont and Appalachian Valley and Ridge provinces of Virginia. This extensive distribution includes occurrences in nineteen counties, but for the purpose of description, the more important barite districts may be arbitrarily grouped into six areas, each designated by the county or counties in which the deposits are located. (See Fig. 2.) These areas, listed in the order described, are: Campbell and Pittsylvania counties; Bedford County; Grayson County; Fauquier County; Roanoke and Botetourt counties; and Russell, Tazewell, and Smyth counties.

The first four areas are in the Piedmont province, whereas the last two represent deposits of the Appalachian Valley and Ridge province.

MINERALS OF THE DEPOSITS

General Statement

The minerals associated with the bedrock occurrences of barite are calcite, chalcopyrite, chlorite, epidote, fluorite, galena, gypsum, hornblende, micas, pyrite, quartz, sphalerite, and tourmaline. Some of these as epidote, hornblende, micas, and tourmaline are confined to the deposits occurring in the metamorphic rocks of the Piedmont province. Although any one or all, except barite, may be missing at a given locality, all of them are to be regarded as minerals deposited by the barite-forming solutions.

Sulphates

Barite.—Analyses were not made by the writer, but it is reported that the crude barite shipped from many deposits averaged more than 95 per cent barium sulphate. This represented washed material that had been hand picked.

The barite ranges in texture from coarse cleavage fragments measuring 10 inches in thickness (Pls. 1, B, 15, B, and 15, C), to material that resembles a dense fine-grained limestone. Most of the barite is medium grained, the grains averaging 2 to 10 millimeters in diameter, and occurring as a mass of interlocking cleavage fragments.

The color of the Virginia barite varies from white to different shades of gray and yellow. Iron oxide is usually the coloring

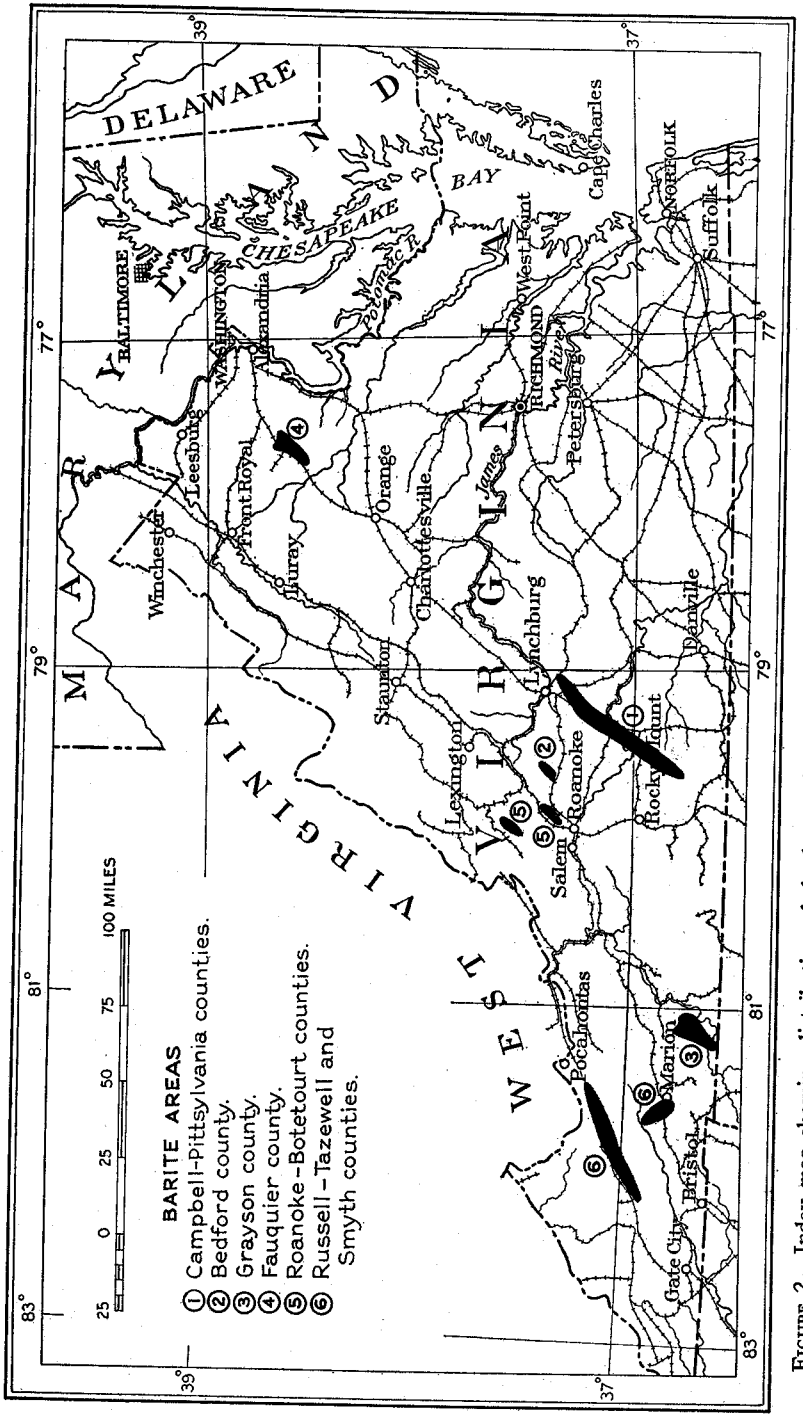


FIGURE 2.—Index map showing distribution of the known barite deposits in Virginia. (Reprinted from Am. Inst. Min. and Met. Eng. Tech. Pub. 725, 1936.)

agent. A deposit of dark gray barite occurs near Fincastle in Botetourt County. The color is similar to that of the enclosing limestone, and may be due to finely disseminated carbonaceous material originally present in the country rock before it was replaced by barite. The form of combination of the carbon was not determined, but it is of a combustible type, since the barite turns white on heating before the blowpipe.

Gypsum.—Gypsum was found at the Poole prospect in Grayson County. Unfortunately nothing is known regarding the relationship that the gypsum bears to the deposit, since all of the specimens studied were collected from the dump. The gypsum varies from fibrous to tabular and the color is light gray with a few darker bands.

Its origin is uncertain, but it is probable that the solutions which deposited the barite likewise deposited small amounts of anhydrite which was subsequently changed to gypsum by the action of surface waters.

SULPHIDES

Pyrite.—Aside from quartz, calcite, and limonite, pyrite is the most abundant and widespread of the associated minerals. It commonly displays varying degrees of alteration to limonite (Pl. 14, C), but large amounts of relatively unaltered pyrite are known to occur. When considering any of the barite areas as a unit, pyrite is not to be considered as a serious impurity. However, some deposits within the area may contain such large amounts of the sulphide that they cannot be profitably worked.

The pyrite may be present as distinct bands (Pl. 1, C), in the veins or as disseminations throughout the deposit. A few poorly defined crystals may be found, but most of the pyrite occurs as irregular grains a few millimeters in diameter. Definite relationships of the pyrite to the barite cannot be satisfactorily determined. Some small veins, presumably fissure fillings, show first a layer of pyrite on the walls, then barite; other veins show an abundance of disseminated pyrite. It is most probable that pyrite both preceded and accompanied the barite deposition.

Chalcopyrite.—Chalcopyrite occurs sparingly as small irregular grains throughout most of the barite deposits. In some cases, small veinlets of it are seen cutting both barite and pyrite. Many deeply weathered deposits show abundant malachite and limonite and it is thought that chalcopyrite was the primary mineral.

OXIDES

Quartz.—With the exception of calcite and limonite, quartz is the most abundant accessory constituent of the deposits. The texture varies from cryptocrystalline to crystals measuring approximately one-half inch in length. The finer-grained quartz most commonly occurs as a replacement (Pl. 2, A), of the country rocks bordering the veins. Other veins, apparently fissure fillings, frequently show first a layer of quartz, then pyrite, and lastly barite. Where both quartz and barite are in association most of the quartz seems to precede (Pl. 7, A), the barite deposition; however, smaller amounts are contemporaneous with or later than the barite.

Limonite.—Limonite (Pls. 1, C and 14, C), in variable amounts was identified in every barite deposit visited by the writer. It occurs both as stains and as distinct bands along the barite veins. The limonite was formed principally by weathering of the sulphides, pyrite and chalcopyrite, and is not considered a primary vein mineral.

HALOIDS

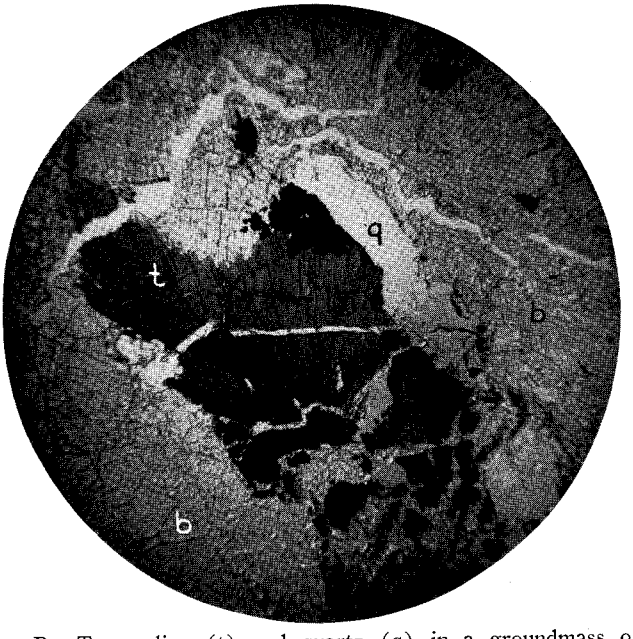
Fluorite.—Fluorite was identified in all of the barite areas, being particularly abundant in the deposits of the Appalachian Valley and Ridge province. In a few deposits in Russell, Tazewell, and Smyth counties, fluorite probably forms 20 per cent of the barite veins and replacement masses. It is most commonly colorless, but various shades of violet were noted. The mineral occurs as irregular cleavable masses and distinct crystals intergrown with calcite, barite, and quartz. In some thin sections, barite had definitely replaced the fluorite.

CARBONATES

Calcite.—Calcite was the only primary carbonate identified in the barite deposits. Dolomite was noted in replacement deposits, but it most likely represents remnants of the enclosing dolomitic limestones. The grains of calcite vary from 1 millimeter to approximately 3 inches in diameter. It is this relatively coarsely crystalline texture that distinguishes it from the original calcite of the enclosing limestones.

Calcite, in variable quantities, occurs in every deposit and probably accompanied the deposition of much of the barite (Pl. 6, A).

A. Coarsely crystalline barite in silicified Bull Run shale; at the Cedar Run Mine, Fauquier County, Virginia. X 30.



B. Tourmaline (t) and quartz (q) in a groundmass of finely crystalline barite (b); at the Cundiff prospect, Campbell County, Virginia. X 30.

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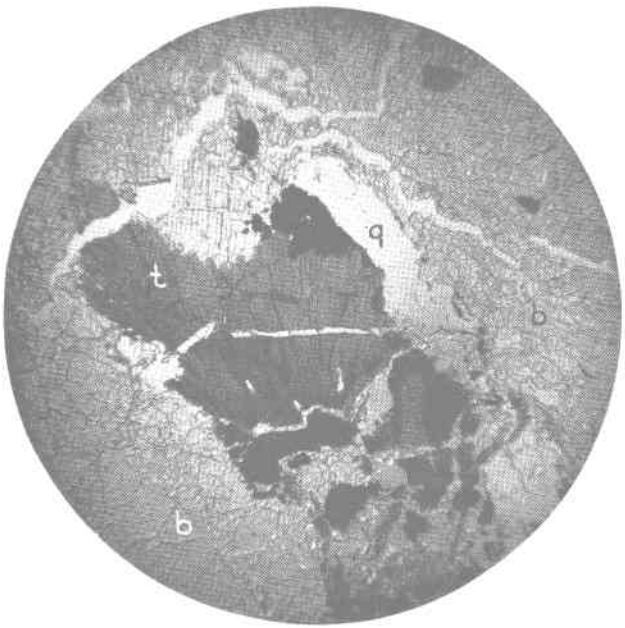
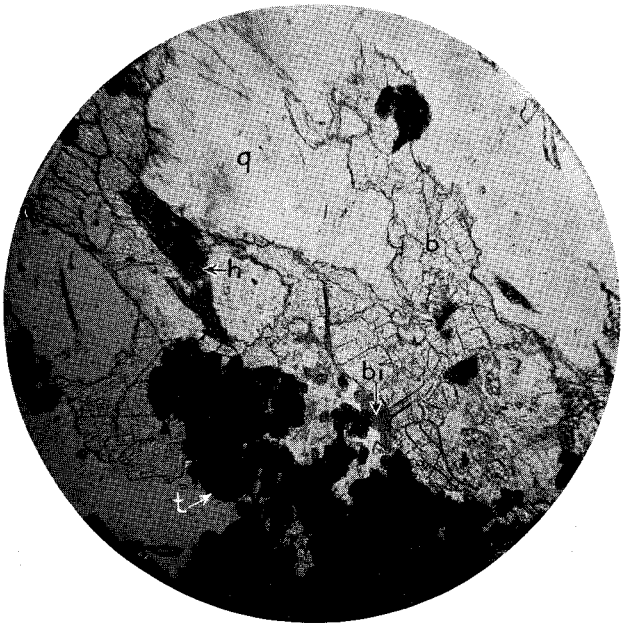
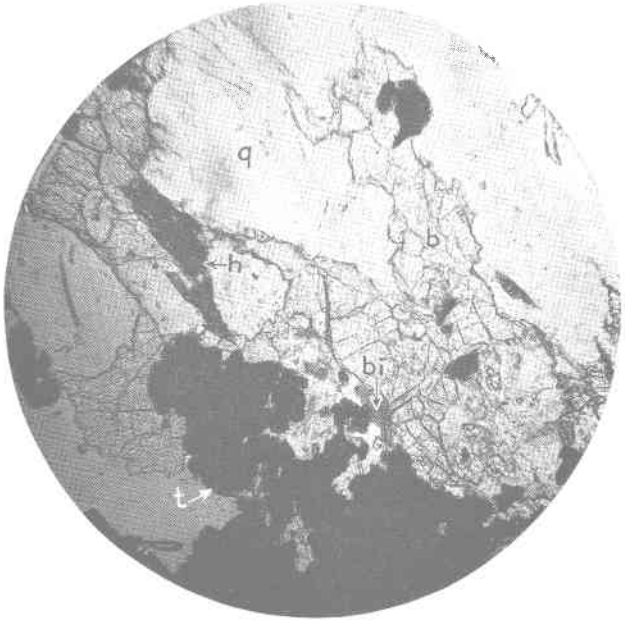


B. Tourmaline (t) and quartz (q) in a groundmass of finely crystalline barite (b); at the Cundiff prospect, Campbell County, Virginia. X 30.



A. Barite vein on the Cundiff prospect, Campbell County, Virginia. Probable order of deposition is quartz (q), barite (b), hornblende (h), biotite (bi), and tourmaline (t). X 30.

B. Bladed crystals of hornblende (h) and biotite (bi) probably replacing barite (b) and quartz (q); at the Cundiff prospect, Campbell County, Virginia. X 50.



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B. Bladed crystals of hornblende (h) and biotite (bi) probably replacing barite (b) and quartz (q); at the Cundiff prospect, Campbell County, Virginia. X 50.

SILICATES

Tourmaline.—Tourmaline was observed in the barite deposits in Campbell and Pittsylvania counties. Some thin sections contained approximately 20 per cent of this mineral, but it is believed that since it was not identified megascopically, the average for the deposits probably would be very small. The tourmaline commonly forms radiating groups of crystals measuring 1 to 5 millimeters in diameter. The color varies from light to dark brown. A few of the crystals are broken across the prism face perpendicular to the *c* axis, and these cracks filled with quartz and barite (Pl. 2, B). The majority of the crystals are undisturbed, and do not show the degree of deformation which the associated rocks have undergone. It is thought that the tourmaline was derived from the same solutions that furnished the barite and other vein minerals, and its formation both preceded and accompanied the early stages of the barite deposition (Pl. 3, A).

Hornblende and biotite.—Hornblende and biotite usually occur in barite veins in approximately the same proportion. They are limited to the occurrences in Campbell, Pittsylvania, Bedford, and Grayson counties. Under the microscope, the hornblende appears as long, slender, or bladed crystals, whereas the biotite is distinctly tabular (Pl. 3, B). Both show varying stages of alteration to limonite and chlorite. The general period of formation of hornblende and biotite appears identical with that of tourmaline, above described (Pl. 4, A).

Sericite.—Sericite was noted in a few deposits in the Piedmont province. It occurs as small flakes associated with barite and also in the silicated portions of the enclosing rocks (Pl. 4, B). In Grayson County, the few barite occurrences that are replacements of schists, show an abundance of sericite and small amounts of biotite, still retaining the schistose structure of the replaced rocks. The sericite in such occurrences is not regarded as a vein mineral.

Epidote and chlorite.—Chlorite and minor amounts of epidote were identified in all the barite deposits of the Piedmont province. The country rocks along some of the veins show a narrow zone of hydrothermal alteration characterized by an abundance of epidote, chlorite and quartz (Pl. 5, A). In the barite veins and other bedrock occurrences, the epidote occurs as irregular masses and well-defined crystals (Pl. 5, B), whereas the chlorite has the usual bladed habit (Pl. 6, A). These minerals appear to have accompanied much of the barite deposition.

PARAGENESIS OF THE MINERALS

Before attempting to establish the order of deposition of the vein minerals, it is necessary to determine the mode of occurrence. For example, if the minerals fill open fissures, the order of deposition is from the walls toward the center, whereas in a replacement occurrence, the order is reversed. Of equal importance is the possibility that many of the minerals have developed simultaneously.

The writer has attempted to show graphically (Fig. 3), the order of deposition of the barite and associated minerals. Obviously the evidence possible from a study of thin sections is insufficient to place definite limitations on the range of any one mineral, but the general period of formation and probable overlap of the minerals can be given in a general way.

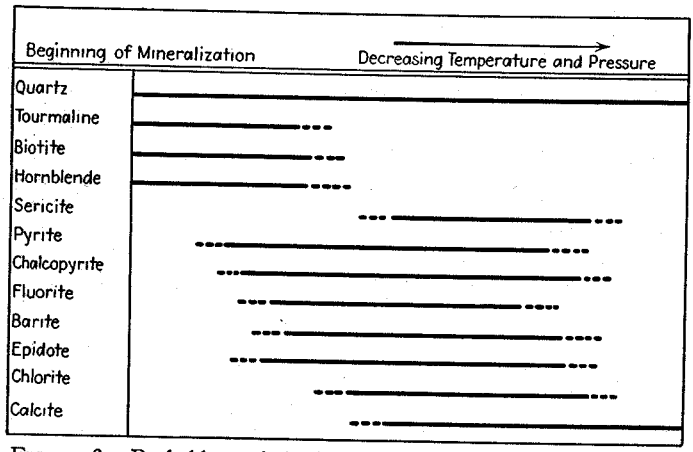


FIGURE 3.—Probable period of formation of barite and associated vein minerals. (Reprinted from Am. Inst. Min. and Met. Eng. Tech. Pub. 725, 1936.)

TYPES OF DEPOSITS

GENERAL STATEMENT

The barite deposits of Virginia occur as fissure veins, replacement masses, breccia zones and residual deposits. The first three are commonly associated and may even grade into each other; nevertheless, in typical cases, it seems desirable to separate the four types for discussion.

FISSURE VEINS

Deposits in fissure veins may represent clear-cut tabular bodies (Pls. 1, C and 7, B), generally banded, formed by the filling of a fis-

sure, or in addition, there may have been some replacement (Pl. 7, C), of the wall rock along the fracture.

The veins formed by filling alone are generally small; those showing some replacement often attain a width of several feet and exhibit an irregular gradation into the enclosing rocks. All of these deposits are associated with fracturing, but in only two or three places was definite evidence of movement along the fractures found. The more important veins have a persistent northeast strike, and dip steeply to the northwest or southeast. Nothing is known regarding the depth of the barite deposits, but in some areas mining and prospecting prove that mineralization extends deeper than 150 feet.

REPLACEMENT MASSES

Replacement masses have gradational boundaries with the enclosing rocks and lack the tabular forms of veins. They include the "lenticular bodies" (Pl. 9, A), and "disseminations" which are most commonly developed in limestones and marbles.

The lenticular bodies are by far the most important occurrences of barite in bedrock. They range from a few inches to a maximum of 20 feet in width, and at one locality in the Piedmont province are reported to have been approximately 100 feet long. In plan view, these bodies have a characteristic lenticular outline. The disseminations are of a much smaller magnitude, and rarely exceed a few inches in thickness.

Gradational boundaries are common features of replacement deposits. (See Pls. 9, B and 9, C.) In the center of the masses is relatively pure barite, then progressively outward a mixture of barite and the enclosing rock, and finally only the country rock. The absence of any well-marked contact points conclusively to the deposition of the barite by replacement.

BRECCIA ZONES

Barite cementing breccias (Pls. 10, A and 11, A), represents a distinct type of deposit, but in considering the relation of the barite to the included wall rock fragments, the deposit is really a combination of fissure filling and replacement. Some of the included fragments of the country rock are angular and have sharp boundaries, whereas others possess gradational contacts characteristic of replacement.

The brecciation of the rocks is not open and the seams of barite are thin, usually a few inches in width. So far as known, breccia occurrences in Virginia have not furnished barite in commercial quantities.

RESIDUAL DEPOSITS

The residual deposits have been the most important in Virginia. This is due to larger concentrations of barite in the residual clay and its greater ease of extraction from the clay.

The residual clay is not equally rich in barite in all portions of a deposit. Moreover, the individual lumps of barite may vary in their purity, due either to iron stains or attached fragments of the country rock. The percentage of barite may, within a few feet, vary from one ton per ten cubic yards of residual clay to material that is practically barren. When it is realized that the lumps and masses are irregularly distributed through the bedrock, and that there is little rearrangement by solution during weathering, the irregular occurrence of the barite in the residual clay is more clearly understood. Because of its high specific gravity, the greatest concentration is commonly some distance below the surface of the residual clay overlying the mineralized zone.

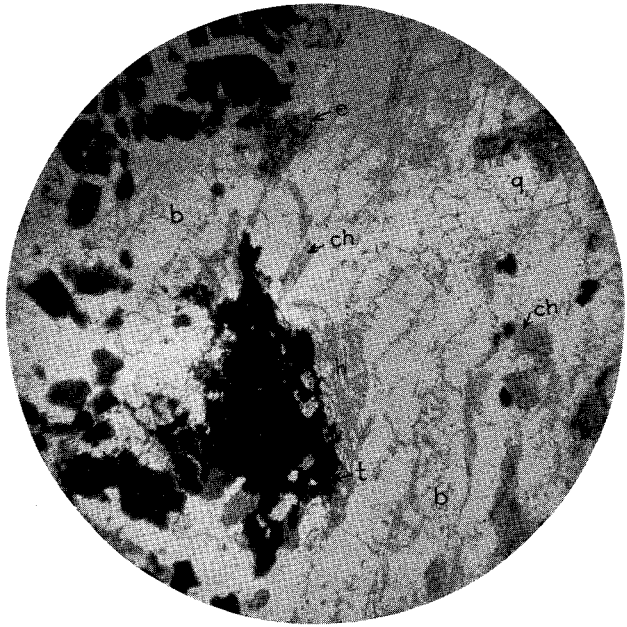
There is much conclusive evidence that the barite now found in the red or black residual clays was mechanically concentrated from the veins and replacement masses during the weathering of the enclosing rocks. The evidence may be briefly stated as follows: The barite shows no solution effects or inclusions of clay such as might exist had it been redeposited in the unconsolidated material; fragments of the country rock and associated vein minerals are often found intact with the residual barite; linear distribution of the residual material is identical with the distribution of the barite in bedrock; and testing through the residual covering shows barite in the bedrock that is identical in all respects, except that the residual material generally has a greater abundance of surface stains.

ORIGIN

GENERAL STATEMENT

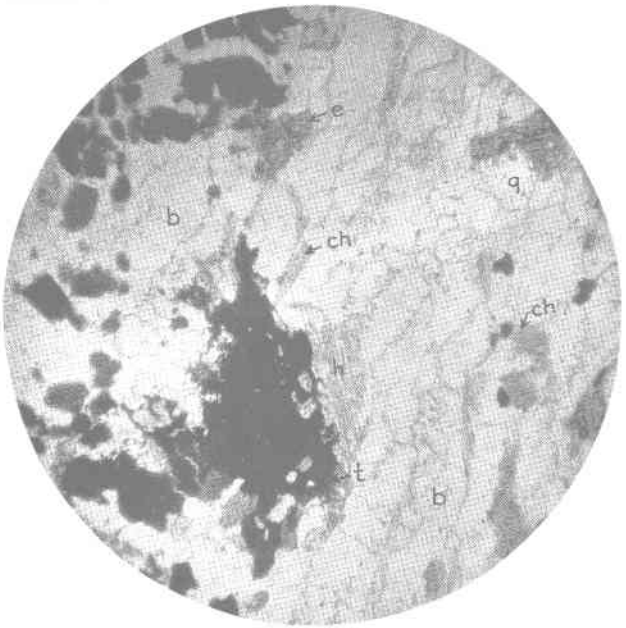
The processes to which the origin of barite deposits are attributed are sedimentation, residual weathering, and deposition by circulating meteoric or magmatic waters. Since no bedded deposits occur in Virginia, and the residual deposits offer no particular genetic problem, the problem of deposition by circulating waters is considered of major importance and hence is discussed in detail.

Before discussing in detail the genesis of the Virginia barite deposits, it seems desirable to mention a few other occurrences of barite. It is a well known fact that barite is a common gangue mineral of ore deposits which owe their origin to ascending thermal solutions. The



A. Tourmaline (t), hornblende (h), epidote (e), and chlorite (ch) in a groundmass of finely crystalline barite (b) and quartz (q); at the Phillips mine, Campbell County, Virginia. X 50.

B. Barite (b) replacing feldspar (f) and occurring as small veinlets cutting quartz (q); at the F. Vaught prospect, Grayson County, Virginia. The mottled appearance of the feldspar is due to partial alteration to sericite (s). X 30.



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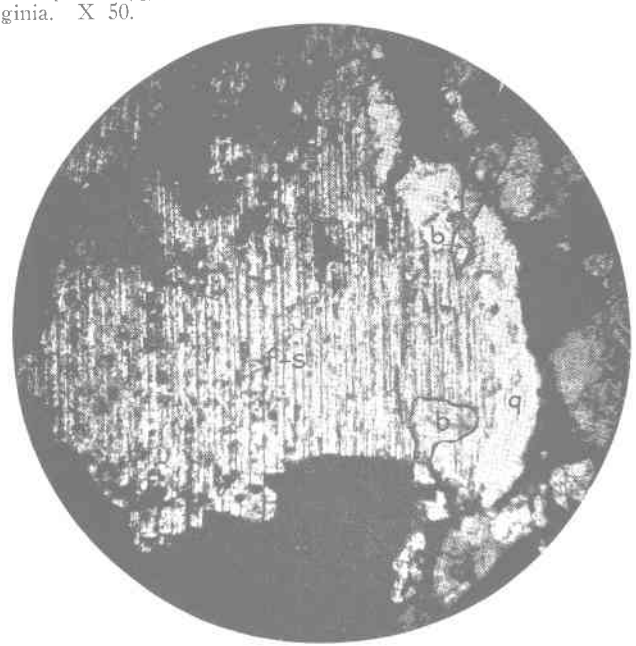

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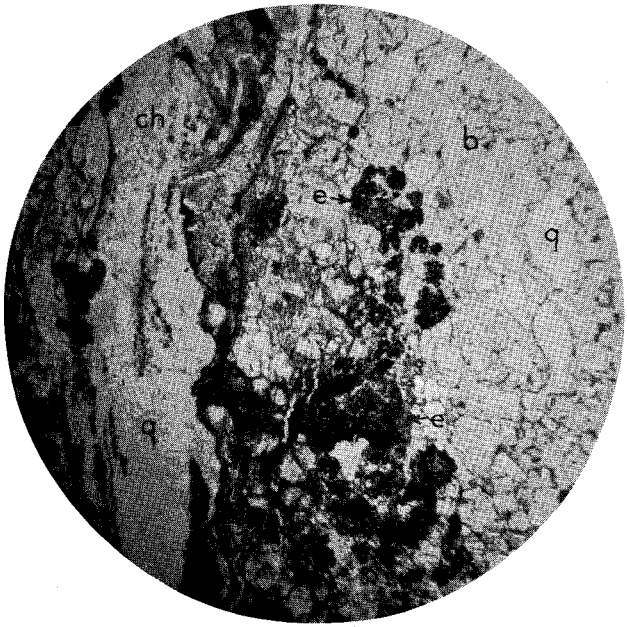
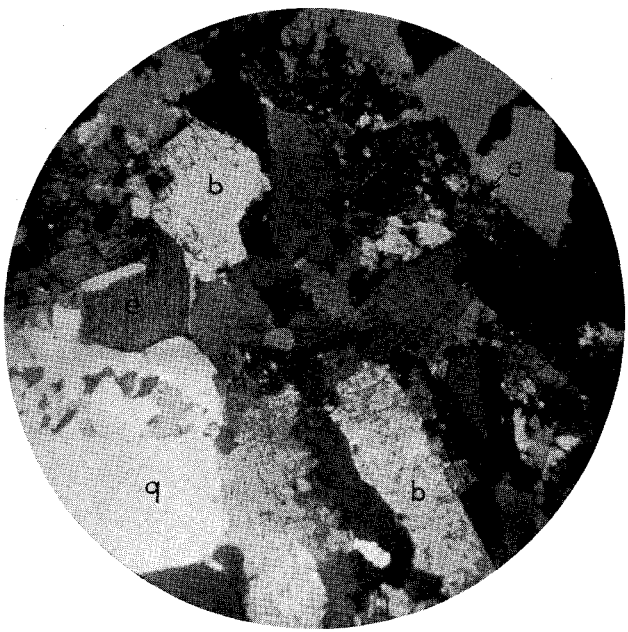
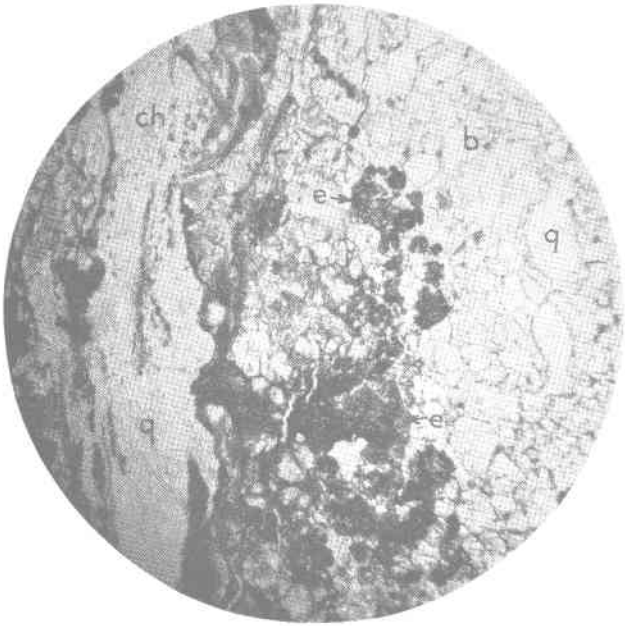


A. Gradational contact between barite vein and hydrothermally altered wall rock; at the Saxton-McMillan mines, Bedford County, Virginia. The minerals are barite (b), quartz (q), chlorite (ch), and epidote (e). X 30.



B. Tabular crystals of barite (b) and epidote (e) associated with quartz (q) at the Poole prospect, Grayson County, Virginia. X 30.



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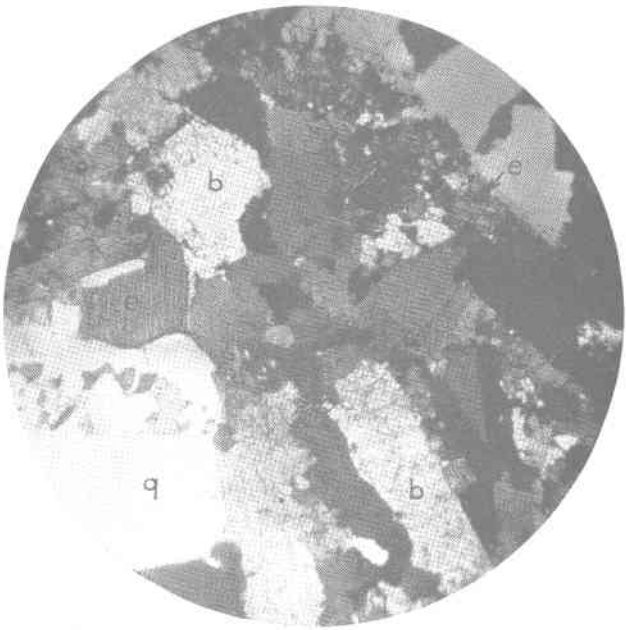

B. Tabular crystals of barite (b) and epidote (e) associated with quartz (q) at the Poole prospect, Grayson County, Virginia. X 30.

Cactus mine in the Frisco district[9] of Utah, and the Gold Hunter mine of the Coeur d'Alene district[10] of Idaho may be cited as examples of this type of occurrence. In addition to the deposits cited above, where barite has been noted as a gangue mineral, veins of solid barite, thought to be formed by magmatic solutions occur in North Carolina[11] and Alabama.[12]

A review of the geological literature shows that the majority of the barite deposits are believed to have been concentrated by meteoric waters. Watson,[13] after a study of the Virginia barite deposits, concluded that the source of the barium was largely, if not entirely, the rocks in which the deposits are now found, with no evidence in support of a deep circulation. Later Watson and Grasty[14] gave much time to the study of barite in the entire Appalachian region, and arrived at similar conclusions. Other summaries favoring the concentration of barium, from the surrounding rocks by meteoric waters could be given for the barite deposits of Georgia,[15] Missouri,[16] Tennessee,[17] Pennsylvania[18] and Kentucky.[19]

Tarr[20] in his instructive papers on the barite deposits of Missouri has discussed in detail barite genesis, and concludes that the bedrock deposits were deposited by waters derived from igneous rocks. As a result of field and laboratory studies, the present writer believes that the Virginia deposits have had a similar magmatic origin.

Since there is a disagreement between the magmatic origin proposed in this paper and the meteoric theory advocated in earlier reports on the Virginia barite, it seems desirable to test the merits of each in explaining the following: Associated vein minerals, alteration of wall rocks, source of the barium, solution and deposition of barium salts, relation of barite to fracture zones, presence of barite in pegmatites, and time of mineralization.

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[9] Emmons, W. H., The enrichment of ore deposits: U. S. Geol. Survey Bull. 625, pp. 229-230, 1917.

[10] Ransome, F. L., and Calkins, F. C., The geology and ore deposits of the Coeur d'Alene district, Idaho: U. S. Geol. Survey Prof. Paper 62, p. 103, 1908.

[11] Stuckey, J. L., and Davis, H. T., Barite deposits in North Carolina: Am. Inst. Min. and Met. Eng. Contr. no. 19, 1933.

[12] Adams, G. I., Hydrothermal origin of the barite in Alabama: Econ. Geology, vol. 26, no. 7, pp. 772-776, 1931.

[13] Watson, T. L., Geology of the Virginia barite deposits: Am. Inst. Min. Eng. Trans., vol. 38, pp. 710-733, 1908.

[14] Watson, T. L., and Grasty, J. S., Barite of the Appalachian States: Am. Inst. Min. Eng. Trans., vol. 51, pp. 514-559, 1915.

[15] Hayes, C. W., and Phalen, W. C., A commercial occurrence of barite near Cartersville, Georgia: U. S. Geol. Survey Bull. 340, pp. 458-462, 1908.

[16] Ball, S. H., and Smith, A. F., Geology of Miller County, Missouri: Missouri Bur. Geol. and Mines, vol. 1, 2d. ser. pp. 148-149, 1903.

[17] Gordon, C. H., Barite deposits of the Sweetwater district, east Tennessee: Tennessee Geol. Survey, vol. 8, no. 1, pp. 48-82, 1918.

[18] Stose, G. W., Barite in southern Pennsylvania and pure limestone in Berkeley County, West Virginia: U. S. Geol. Survey Bull. 225, p. 515, 1904.

[19] Smith, W. S. T., *in* Lead, zinc and fluorspar deposits in western Kentucky: U. S. Geol. Survey Prof. Paper 36, pp. 150-154, 1905.

[20] Tarr, W. A., The barite deposits of Missouri and the geology of the barite district: Univ. Missouri Studies, vol. 3, no. 1, 1918; The barite deposits of Missouri: Econ. Geology, vol. 14, no. 1, pp. 46-67, 1919.

METEORIC ORIGIN

The barite deposits west of the Blue Ridge, which occur in limestones and dolomites, present fewer objections to a meteoric origin than those in the Piedmont region to the east, and for that reason only the Valley occurrences are considered. Within this region some criteria that may favor the concentration of barite by meteoric waters, but not discredit a magmatic source, are discussed below.

Associated minerals.—Some of the widespread associated minerals of the barite are common in deposits formed by circulating meteoric waters. The more important of these gangue minerals include quartz, calcite, fluorite, pyrite, chalcopyrite, galena and sphalerite.

Alteration of wall rock.—Silicification of the wall rock, in many of the barite deposits, may be explained as due to meteoric waters.

Barite in fossils and concretions.—Small amounts of barite, probably deposited by meteoric waters, were identified in some fossils and concretions (Pl. 10, B). However, none of these occurrences were associated with commercial deposits.

Absence of nearby igneous rocks.—With the exception of an acid dike reported to occur in the Smyth County area, igneous rocks are not found in close association with barite deposits. This might be regarded as evidence favoring a meteoric origin.

Source of the barium.—Analyses of the associated rocks (Table 1), show small amounts of barium oxide (BaO), and some investigators believe that this source is adequate to account for the large concentration of barite.

MAGMATIC ORIGIN

In the Piedmont province the criteria which favor a magmatic origin for the barite deposits are the associated hydrothermal minerals, hydrothermal alteration of wall rocks, small barium content of the enclosing rocks, proximity to igneous rocks from which the more favorable magmatic solutions for the transportation and deposition of barium salts could have been derived, close association of barite deposits to fracture zones, presence of barite in pegmatites, and absence of leaching of the rocks adjacent to the barite deposits.

Exclusive of the accessory vein minerals indicative of magmatic waters, definite hydrothermal alteration of wall rocks, and the occurrence of barite near and in igneous rocks, the reasons listed above apply to the deposits of the Appalachian Valley and Ridge province as well as to the Piedmont deposits. The writer believes that these reasons are

sufficiently strong to indicate a magmatic source for the Valley deposits also.[21]

Associated minerals.—The accessory minerals of the barite deposits of the Piedmont province that indicate deposition by hydrothermal solutions are tourmaline, hornblende, biotite, epidote, and chlorite (Pls. 3, 4, 5, and 6). Although these silicates are restricted in their occurrence, their formation contemporaneous with the barite is significant. The remaining associated minerals previously referred to, are common in deposits of both igneous and meteoric origin, and are not to be regarded as having any diagnostic value. Fluorite, which is considered by some to be indicative of magmatic origin, has been found in variable quantities in deposits in the Piedmont and Appalachian Valley regions in Virginia.

It is not improbable that some investigators may conclude that the minerals indicative of magmatic waters were introduced into the rock during some period which preceded the barite deposition. Then as the barite was deposited in fissures and partially replaced the enclosing rock, these minerals being more resistant to the ingressing solutions would remain as impurities of the replaced portion of the rock.

This conclusion is not impossible, but it is thought not to be in accord with the following facts. First these minerals are more abundant along the veins in a narrow zone of hydrothermal activity (Pls. 5 and 6, A), and second, the silicates are not strained and crushed as are many of the primary minerals of the enclosing rocks.

Alteration of wall rock.—A study of field relationships and thin sections shows, in addition to partial replacement of the enclosing rocks by barite, the development of many secondary minerals in the wall rock. These minerals, chiefly quartz, epidote and chlorite, are abundant in and along the barite veins and replacements. Silicification (Pl. 2, A), and propylitization (Pls. 5 and 6, A), are the kinds of alteration recognized.

Silicification, the introduction of quartz, frequently of a cherty character, that clearly preserves the original structure of the rock, is the more widespread type of alteration associated with the Virginia barite deposits. The wall rocks of many magmatic ore deposits are silicified, but since, in some cases, this may be brought about by meteoric waters, the writer thinks that such evidence should not be used to support either theory of origin.

In Virginia propylitization is restricted to the barite deposits in the Piedmont province. In some deposits, such as those in Bedford and Grayson counties, the alteration can easily be recognized in the

[21] Edmundson, R. S., Barite deposits of Virginia: Am. Inst. Min. & Met. Eng. Tech. Pub. 725, pp. 10-17, 1936.

field; however, in other areas propylitization may be determined only by a study of thin sections. The chief minerals, which are significant of propylitization, are abundant chlorite and epidote, and minor amounts of pyrite. The formation of these minerals, indicative of hydrothermal solutions, are regarded as accompanying the deposition of the barite.

Source of the barium.—It is interesting to consider the barium content of the rocks associated with commercial deposits of barite. However, to infer that the associated rocks are a source of the barium is a matter of some conjecture.

Clarke[22] gives the following percentages of barium oxide for some rocks in the lithosphere. The average of many determinations of igneous rocks was .104 per cent; shales, .05 per cent; sandstones, .05 per cent; and 345 determinations of limestones showed no barium. Winslow[23] cites fifteen analyses of dolomites and limestones from Missouri which average about .003 per cent barium sulphate; however, the most careful qualitative tests cited by Tarr[23a] failed to verify the presence of barium oxide (BaO) in the rocks associated with the Missouri deposits. Even if small amounts of barium occur in the calcareous rocks it is not impossible that it was introduced by magmatic waters.

The percentages of barium oxide (BaO) listed in Table 1 were determined from samples carefully selected by the writer. They may serve to indicate the average barium content of some of the enclosing rocks and associated intrusives of the Virginia barite deposits.

TABLE 1.—*Content of barium oxide in rocks associated with barite deposits in Virginia*

(John H. Yoe, Analyst)

No.	BaO	ASSOCIATED ROCKS
1	0.078	Cockeysville marble from Hewitt mine, Campbell County.
2	0.02	Cockeysville marble not associated with any known barite deposits.
3	0.12	Pegmatite dike in vicinity of Thompson mine, Pittsylvania County.
4	0.044	Diabase dike in vicinity of Phillips mine, Campbell County.
5	0.12	Wissahickon mica-schist from barite workings in Campbell and Pittsylvania counties.
6	0.016	Beekmantown limestone and dolomite not associated with any known barite deposits, Smyth County.
7	0.066	Beekmantown limestone and dolomite from Jackson mine and vicinity, Russell County.

A comparison of analyses of samples 1 and 7, of calcareous rocks from barite workings, with samples 2 and 6, of the same formations

[22] Clarke, F W., The data of geochemistry: U. S. Geol. Survey Bull. 695, pp. 28-33, 1920.

[23] Winslow, A., Lead and zinc deposits of Missouri: Missouri Geol. Survey, vol. 7, pp. 480-481, 1894.

[23a] Tarr, W. A., The barite deposits of Missouri and the geology of the barite district: Univ. Missouri Studies, vol. 3, no. 1, p. 78, 1918.

not associated with any known barite deposits, shows an appreciable difference in barium content. Since barite was identified microscopically in the pegmatite, it is not surprising that sample 3 has a relatively high percentage of barium oxide. The barium content of sample 4 is below the average for igneous rocks, and although the analysis of sample 5 appears high, it should be noted that this specimen of mica schist was taken from the wall of a barite deposit.

On the assumption that the analysis of sample 6 represents the average barium content of the limestones associated with the Virginia barite deposits, many arithmetical deductions are possible. For example, it would be necessary to remove the barium from approximately 6,117 cubic feet of limestone to obtain one cubic foot of barite. In other words, a single vein of barite 500 ft. long, 100 ft. deep and 3 ft. wide, would require the extraction of all the barium from one square mile of rock, approximately 33 ft. thick.

It is believed that the exceedingly small amounts of barium in the calcareous rocks are not sufficient to have formed the large deposits. Since the igneous rocks associated with the barite deposits, show a higher percentage of barium than do the calcareous rocks it is thought that the barite solutions were expelled from the same parent magma and rose along fissures until reaching a favorable place for deposition.

Solution and deposition of barium salts.—Since barium salts, in small amounts, occur in the various rocks of the lithosphere, it is interesting to discuss their probable solubility in meteoric waters.

The solubility of barium sulphate is generally given as one part in 400,000 parts of water. Of course, as Tarr[24] has pointed out, this solubility is increased by the presence of alkaline bicarbonate and carbon dioxide in the water, but how much, is unknown. The writer firmly agrees with Tarr that it is not an important increase, since the residual barite which has been subjected to waters probably of this character, does not show any distinguishable solvent effects.

If barium were present as a carbonate in the rocks, particularly limestones, it would be less difficult to account for its solution and transportation. However, it is well established that barium carbonate (witherite), is not a common constituent of rocks or generally associated with barite deposits.

Barium chloride is the most soluble of the barium salts, but its scarcity[25] and even absence in many strongly saline solutions is significant. Tarr,[26] briefly summarizes on somewhat similar evidence as follows:

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[24] Tarr, W. A., Op. cit., p. 81.
[25] Clark, F. W., The data of geochemistry: U. S. Geol. Survey Bull. 695, pp. 176-196, 1920.
[26] Tarr, W. A., Op. cit., pp. 82-83.

"The great insolubility of barite and witherite, and their scarcity in all types of sedimentary rocks, especially carbonate rocks, makes it extremely improbable that barium could be obtained from the surrounding rocks in sufficient quantities to form such large deposits as are found. Its transportation by chloride waters is a possibility, but its scarcity in such waters indicates how small the amount available in the rocks usually is."

Even if we assume that barium chloride or barium carbonate are present in ground waters, it is necessary to account for the sulphate radical. The oxidation of sulphides would contribute the sulphate radical to ground waters, but many sulphides associated with the barite are not altered, and they appear to have been deposited contemporaneously with the barite. Other bedrock occurrences of barite do not contain sulphides or their alterations.

The decay of organic material would be another source of the sulphur, but neither this nor the oxidation of sulphides appears adequate to have furnished the entire sulphate radical essential for the formation of the Virginia barite deposits.

Butler[27] states that, if free oxygen is present in a given magmatic emanation, " . . . the formation of sulphur trioxide would not only be possible but under certain conditions it would be inevitable. For instance, a gas that contained only sulphur or sulphur dioxide and free oxygen, at 1,000° or higher, on cooling would pass through the interval favorable to the formation of sulphur trioxide and that compound would form. At the higher temperatures, where sulphur trioxide is unstable, it would be in low concentration, and the formation and precipitation of abundant sulphates would not be expected, but where temperatures favorable to formation and stability were reached a high concentration might result, and there would be a proportionate tendency to the formation of sulphates. It is natural to suppose that barium present in the form of the more soluble compounds would be the first substance to be precipitated as sulphate on account of the very slight solubility of barite in ore solutions as indicated by its common occurrence."

The same paper also discusses the available supply of combined oxygen for oxidation of sulphur to form sulphuric compounds in the absence of free oxygen in magmatic emanations.

According to Butler,[28] "In veins of moderate and shallow depth ferric minerals are very scarce or absent, whereas ferrous minerals in some deposits are abundant. Sulphides are abundant and the presence of barite, which is by far the most insoluble of the sulphates, indicates

[27] Butler, B. S., Primary (hypogene) sulphate minerals in ore deposits: Econ. Geology, vol. 14, no. 8, pp. 596-597, 1919.
[28] Idem., pp. 601-602.

that sulphates probably formed relatively abundantly but for the most part were carried away in solution. This change from ferric to ferrous minerals, together with the appearance of sulphate minerals associated with the ferrous minerals, may be interpreted as indicating that at the higher temperatures the conditions were favorable to the oxidation of iron and the reduction of sulphur, whereas at the lower temperatures the conditions were favorable to the reduction of ferric compounds and the oxidation of the sulphur."

The chemistry involved in the transportation and deposition of barite is not wholly clear, but it is thought that the theory outlined is not only applicable to the many metalliferous deposits that carry barite as a gangue, but may be extended to explain the origin of the Virginia barite deposits.

Relation of barite to fracture zones.—The bedrock barite deposits in Virginia occur as fissure fillings (Pls. 1, C, 7, A, B, and 14, C), replacement veins (Pls. 7, C, 9, B and C), breccia matrix (Pls. 10, A and 11, A), disseminations, and deposits along bedding surfaces. With the exception of the last two, the deposits are restricted to fracture zones.

In Bedford County the barite occurs as tabular bodies in gneiss which show abundant fault breccia and well-developed slickensides on the vein walls.

The Campbell-Pittsylvania counties area is characterized by replacement veins which have obliterated the original appearance of the fractures. However, the included wall rock fragments and the restriction of barite along narrow parallel zones probably show its relation to zones of fracture.

In Grayson County a few of the deposits occur along a fault zone[29] which is characterized by a mylonitized granite gneiss.

The Appalachian Valley and Ridge province is characterized structurally by pronounced folding and fracturing. There are many faults of large magnitude, but the majority of the fractures, in which the barite occurs, show no recognizable displacement and are probably associated with folding. One exception, however, exists in Smyth County, where the most important deposits, located northeast and southwest of Marion, occur near a thrust fault which may be traced for several miles.

The Fauquier County barite area is restricted to Triassic sediments and diabase. None of the barite was observed in place, but samples collected on the dumps suggest that the barite occurs in a fault breccia. Lewis,[30] after a study of similar occurrences in New Jersey,

[29] Jonas, A. I., personal communication, April 7, 1938.
[30] Lewis, J. V., The magmatic origin of barite deposits (Discussion): Econ. Geology, vol. 14, no. 7, pp. 568-570, 1919.

states that the New Jersey barite as well as other Triassic deposits in the eastern United States were probably related to faulting.

Barite in pegmatites.—A few pegmatite dikes were studied in close association with the barite deposits in the southwestern part of the Campbell-Pittsylvania counties area. These dikes are of special interest, since they contain barite (Pl. 6, B). It is never an abundant constituent, but was noted in several thin sections occurring as irregular fine-grained masses, intergrown with quartz, feldspars, and mica. The barite is apparently an original constituent of the pegmatites, and thus, clearly indicates a magmatic origin.

TIME OF MINERALIZATION

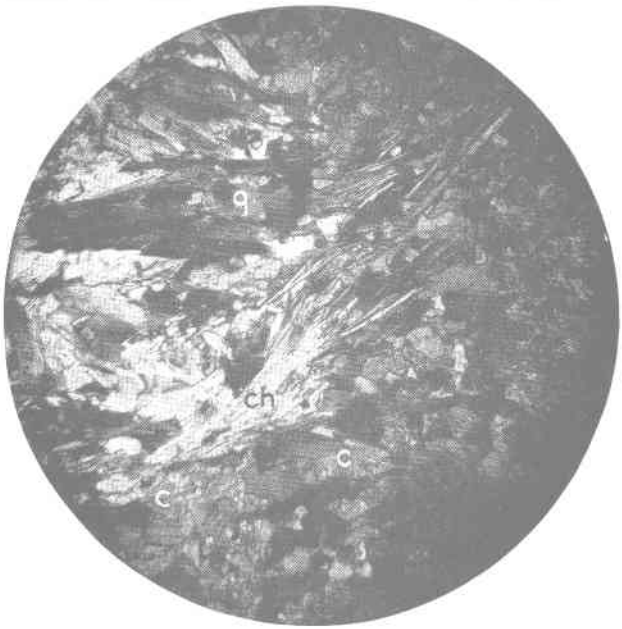
It is not probable that all of the barite deposits were formed at the same time, but it is thought that the mineralization took place after the Appalachian revolution and may be related to Triassic igneous activity. This conclusion is based on the following evidence. Barite of the Valley and Ridge province, in part, occurs in fissures apparently produced during Appalachian folding; in Fauquier County, the barite is associated with faults of Triassic age; none of the barite examined microscopically shows pronounced fracturing. The absence of crushing and other strain effects suggests that the mineralization took place sometime after Appalachian deformation; and dikes of Triassic age are in proximity to many barite deposits of the Piedmont province. These dikes probably have no genetic relation to the barite, but it is thought that the solutions that deposited the barite came from the same source magma and accompanied or preceded the igneous activity.

CONCLUSIONS

In summary, the reasons for believing the Virginia bedrock deposits to be of magmatic origin are: the mineral associations, in part, are indicative of higher temperatures than those found in meteoric waters; hydrothermal alteration (propylitization) of the wall rocks accompanies many of the barite veins; the small barium content of the enclosing rocks is believed inadequate as a source of barium; magmatic solutions are probably better transporting and depositing agents than meteoric solutions; the absence of leaching effects in the rocks adjacent to the barite occurrences is indicative of a deep-seated source; and the presence of barite in pegmatites, believed to be a primary mineral, clearly indicates a magmatic origin.

A. Hydrothermally altered marble along barite vein showing bladed crystals of chlorite (ch) associated with quartz (q) and calcite (c); at the Hewitt mine, Campbell County, Virginia. X 30.

B. Fine-grained barite (b) and quartz (q) associated with large crystals of muscovite (m) and feldspar (f); in pegmatite near the Thompson mine, Pittsylvania County, Virginia. X 40.



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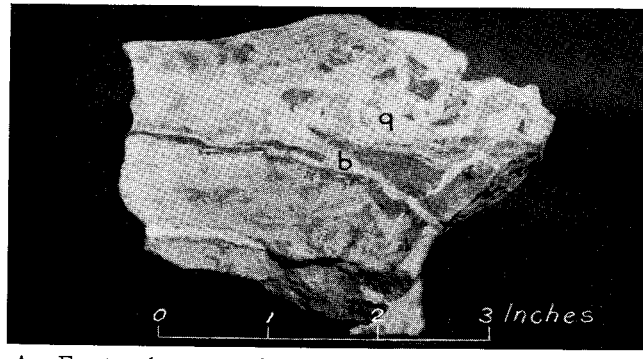
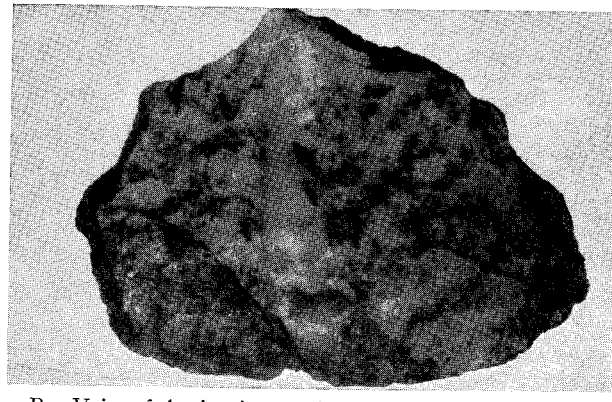
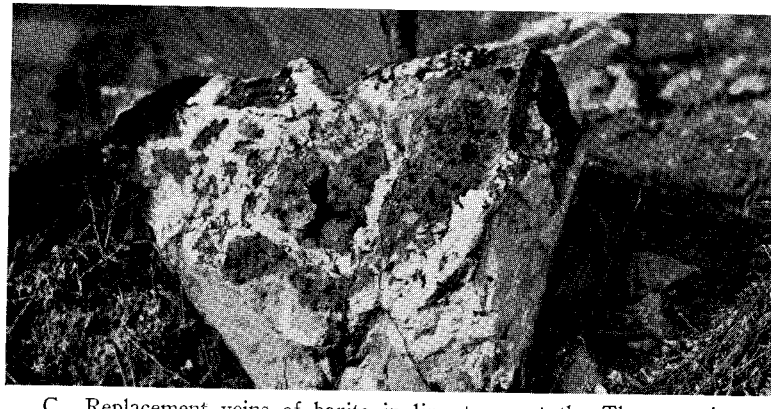


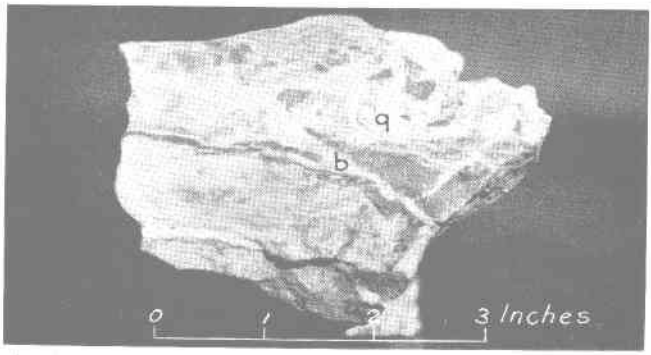
A. Fractured quartz vein (q) cemented by barite (b); at the Gear mine, Fauquier County, Virginia.



B. Vein of barite in granite; at the Poole prospect, Grayson County, Virginia. X ¼.



C. Replacement veins of barite in limestone; at the Thomas mine, Russell County, Virginia.



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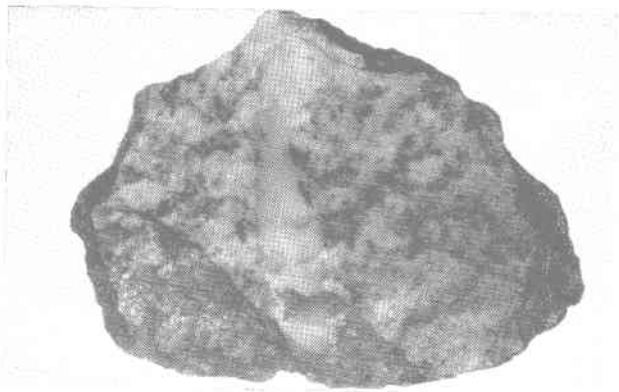

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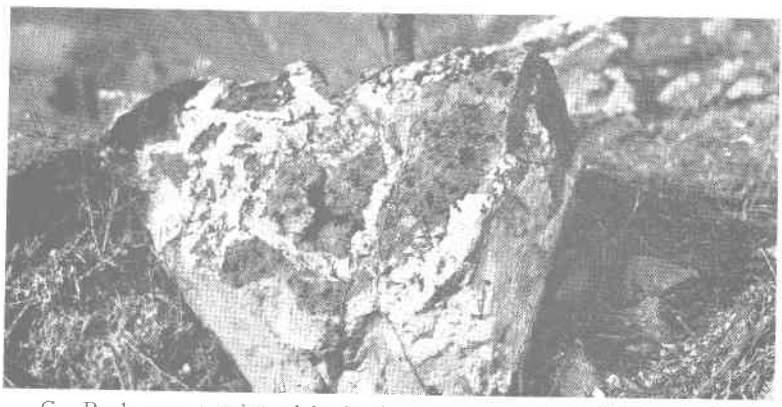

C. Replacement veins of barite in limestone; at the Thomas mine, Russell County, Virginia.

SUGGESTIONS FOR DEVELOPMENT

PROSPECTING

It is not thought that test drilling would be of much help in definitely locating barite deposits in bedrock, because the veins usually dip steeply and are irregular along their strike. It is obvious that drilling is not adapted to the residual occurrences.

In Campbell and Pittsylvania counties, the barite is restricted chiefly to calcareous rocks and associated black manganiferous and ferruginous clay, locally called "umber." Fortunately, the distinctive color of the umber may be traced on the surface where there are no exposures of bedrock. In addition, mining experience has shown that the residual barite usually is more concentrated near the base of a slope and always near the mineralized bedrock. This is illustrated in Figure 7.

In the Piedmont region a study of the northeast alignment of the known deposits and their close parallelism to the trend of the foliation planes of the enclosing rocks would be helpful in future prospecting.

The barite of the Appalachian Valley is limited, for the most part, to the upper part of the Beekmantown limestone and dolomite and its residual clay. Ascertaining from a geologic map the distribution and trend of this formation, in an area where barite is known to occur, would be useful in prospecting for new deposits. Other criteria worth considering in an area of abundant exposures are the usual close association of the barite with fracture zones and in places the local alteration of the country rocks.

Prospecting usually consists of test pits or shafts of variable diameter and depth, scattered at random throughout the area. Since the barite is commonly concentrated within a narrow zone, it would be more advisable to dig trenches across the strike of the rocks at closely spaced intervals for the purpose of locating the barite, and then sink shafts along the strike where barite had been found.

The presence of barite fragments on the surface often indicates a greater concentration at depth, but it is probable that some of this material is transported float.

MINING AND WASHING METHODS

The similarity in the geologic occurrence of the Virginia barite to other producing areas in the United States makes it possible to use mining methods which are of general application. Practically all of the barite produced in Virginia has been from open cuts by hand and mechanical methods of mining.

Large quantities of barite have been produced by hand mining. This method is well adapted to small deposits since owners can work them on a part-time basis. However, unless the mineral occurs in

lumps, an inch or more in diameter, the percentage of recovery normally is too low to be profitable.

The hand methods of recovery are naturally variable, but for the most part extremely simple. The necessary equipment includes a pick, shovel, spade, hand windlass, rope, bucket, and screen. When the pit becomes too deep for the worker to throw out the material, a helper is necessary to operate the windlass.

Frequently the residual barite is followed for many feet laterally by drifts from the bottom of a shaft. The drifts require timbering and are not practical unless there is an unusually large concentration of barite. When the excavated material is thrown out on the surface, the barite is sorted out, and much of the adhering clay removed. The operators in the district usually contract with the miners to buy the barite at the pit, providing it meets certain specifications.

At the present time the entire production, by mechanical methods, is from the Bennett mine in Pittsylvania County in the Piedmont province. This mine, operated by the Barium Mining Corporation of Gretna, Virginia, is equipped with modern machinery. Other similar deposits probably could be worked with equal success.

The barite and residual clay are excavated by power shovels and loaded into narrow gauge dump cars which are hauled by gasoline tractors to the grizzlies. The bars of the grizzlies are four inches apart, and the larger fragments are forced through by sledges. The screened material is carried by a cleated belt to the log washer where the barite lumps are washed free of clay. The washed product is then delivered to a screen with 1¼ inch openings. The oversize is discharged onto a traveling belt for hand picking and the fines are concentrated by jigging. The washing plant is electrically equipped and adequate settling ponds are used for the waste discharge. A flow sheet of a typical washing plant is shown in Figure 4.

COMMERCIAL FACTORS

The following factors enter into the problem of successful commercial development of barite deposits in Virginia: (1) The percentage of recovery of barite exclusive of associated minerals, which rarely occur in quantities of commercial importance; (2) the generally limited extent of barite deposits in consolidated rock; (3) the local concentration of barite and the amount of overburden that must be removed in mining residual deposits; (4) the purity of barite, which depends primarily upon the associated minerals, iron stains, and attached wall-rock fragments; (5) the location of deposits with respect to transportation facilities, electric power, and a constant supply of water; and (6) the geologic relationships of the deposits, which affect the cost of mining and milling.

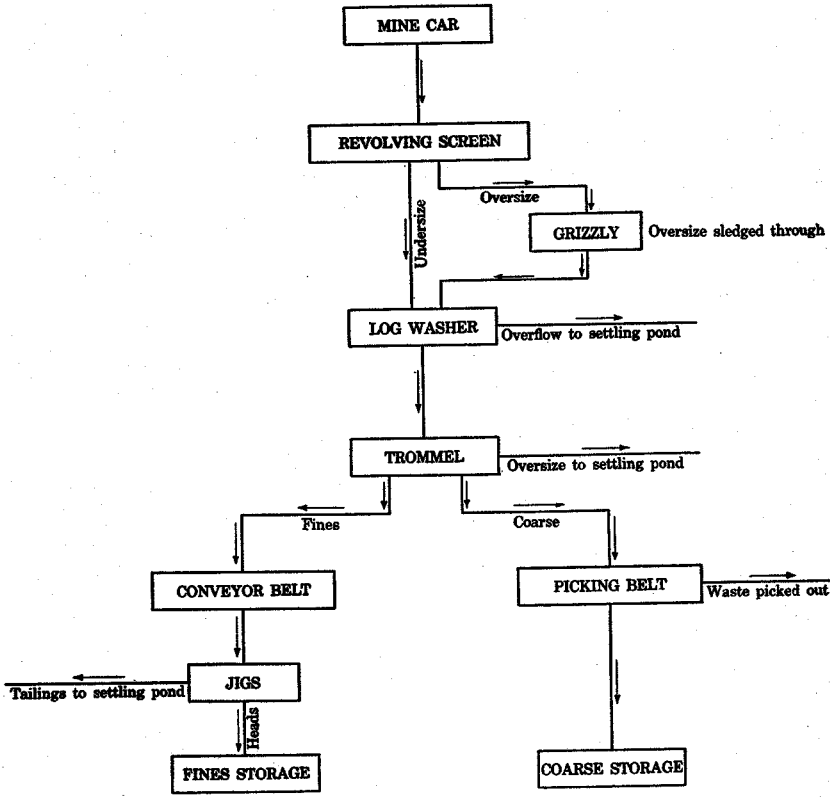

FIGURE 4.—Flow sheet of typical barite washing plant. (From U. S. Bureau of Mines, Information Circular 6221, 1930.)

DISTRIBUTION

CAMPBELL-PITTSYLVANIA COUNTIES AREA

LOCATION

The Campbell-Pittsylvania counties barite belt extends from the Carson mine about 6 miles southeast of Lynchburg, southwestward to Pigg River, a distance of approximately 35 miles. Along this belt numerous openings have been made, but those extensively worked are a few miles southeast of Evington and Toshes. (See Pl. 8.)

HISTORY

It is not known when barite was first discovered in this area. Residents of the region state that small amounts of barite were dug

prior to 1860, but according to Watson[31] the Hewitt mine, which was operating in 1874, probably represents the first systematic mining of barite in this belt. Shortly after this, mining was begun around Toshes and Sandy Level. Most of the important mines were operating about 1882 and produced barite at different times until about 1907. It is not definitely known when the individual operations were abandoned, but in 1910 Virginia was listed[32] as having only one producer. From 1910 to 1933, the Hewitt mine was the chief producer; since then the Ramsay, Berger and Bennett mines have produced practically all of the barite in the area.

GEOLOGY

According to Jonas,[33] the term Piedmont does not define any belt of uniform structure or geology, but "includes the rocks of the Martic thrust block and the eastern part of those of the Catoctin-Blue Ridge anticlinorium." The Campbell-Pittsylvania counties barite area, which includes a small part of the Martic thrust block southwest of Lynchburg, consists mainly of metamorphosed pre-Cambrian rocks of sedimentary and igneous origin. These metamorphic rocks are intruded, in places, by igneous rocks[34] ranging in composition from those that are extremely acid, as the quartz-rich pegmatites, to those that are very basic, as the dikes of hornblende metapyroxenite.

ASSOCIATED ROCKS

The important barite deposits occur in marble and its residual clay. Barite, not of commercial quantity, occurs also in micaceous quartzites, schists, and pegmatites.

The Glenarm series mapped[35] in detail at the northeastern end of the Campbell-Pittsylvania barite area includes the Mount Athos formation, Cockeysville marble, and Wissahickon formation. It seems reasonable to assume that the Mount Athos formation extends farther southwest, but since the field interpretations for this report were based on the nomenclature of the geologic map of Virginia (1928), the calcareous rocks are considered as the Cockeysville marble and the schists and quartzites as a part of the Wissahickon formation.

These rocks have been described in more detail in other reports.[36]

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[31] Watson, T. L., Geology of the Virginia barite deposits: Am. Inst. Min. Eng. Trans., vol. 38, p. 716, 1907.

[32] U. S. Geological Survey, Mineral Resources of the United States, pt. 2, p. 799, 1910.

[33] Jonas, A. I., Kyanite in Virginia: Virginia Geol. Survey Bull. 38, p. 3, 1932.

[34] Pegau, A. A., Pegmatite deposits of Virginia: Virginia Geol. Survey Bull. 33, p. 15, 1932.

[35] Furcron, A. S., James River iron and marble belt, Virginia: Virginia Geol. Survey Bull. 39, pp. 22-37, 1935.

[36] Knopf, E. B., and Jonas, A. I., Geology of the McCalls Ferry-Quarryville district, Pennsylvania: U. S. Geol. Survey Bull. 799, pp. 25-39, 1929.

Jonas, A. I., Kyanite in Virginia: Virginia Geol. Survey Bull. 38, pp. 5-11, 1932; Geologic reconnaissance in the Piedmont of Virginia: Geol. Soc. America Bull., vol. 38, pp. 837-846, 1927.

Pegau, A. A., Op. cit., pp. 15-19.

Cockeysville marble.—The formation crops out in several narrow belts, of variable length, extending through Campbell County southwestward into Pittsylvania County.[37] Exposures in barite workings are not abundant, but at the Hewitt, Bragg, and Hamner mines the marble appears to crop out in closely compressed anticlinal folds which parallel the schistosity of the enclosing rocks. The structure is further complicated by faulting as for example, in the Phillips mine, where the northeast trend of the limestone and its residual clay ends abruptly against a micaceous quartzite.

Near its contact with the overlying mica schist the texture varies from a massive crystalline marble to a calcareous schist, whereas near the barite veins there is usually abundant development of silicate minerals thought to be of hydrothermal origin. These minerals include chlorite, biotite, hornblende, tourmaline, and scattered grains of chalcopyrite and pyrite. The color of the marble is usually white, but, in places, shades of pink and green were noted.

A black manganiferous and ferruginous clay, locally called "umber," is associated with the residual deposits of barite in the marble belts. Watson[38] states that the relations of this clay to the limestone masses and mica-schist, together with its composition and structure, reasonably support the belief that it was derived by decay from a limy schist which was transitional between the well-defined limestone and mica-schist. Many of the barite workings have not encountered the marble, but all have penetrated variable thicknesses of the black clay.

Wissahickon formation.—The Wissahickon formation as shown on the geologic map of Virginia published in 1928, occupies an almost central position across the State, and on the map is described as: "A chlorite-muscovite schist with quartzite in lower part; contains thin greenstone lava flows near base; garnetiferous biotite schist locally containing staurolite, sillimanite, and kyanite."

This formation which crops out in many of the barite workings in Campbell and Pittsylvania counties shows considerable variations in texture and mineral content.

The northeast wall of the Hewitt mine is a fine-grained highly lustrous schist composed essentially of white mica with a few layers containing abundant magnetite grains. Approximately one mile east, in the vicinity of the Phillips mine, the rock is coarse grained and composed chiefly of muscovite and quartz, with minor amounts of biotite, chlorite and magnetite. The northwest wall of the Hewitt mine contains two micaceous quartzite layers, about

[37] See Geologic map of Virginia, Virginia Geol. Survey, 1928.
[38] Watson, T. L., Geology of the Virginia barite deposits: Am. Inst. Min. Eng. Trans., vol. 38, p. 720, 1907.

3 feet in thickness, interbedded with thinly foliated schists. These arenaceous beds are composed chiefly of granulated quartz with small amounts of feldspar and muscovite. More massive layers with similar lithology occur in the Phillips mine.

In the central part of the area, near the Mattox mine, are fine-grained graphitic layers in quartz mica schists. Biotite is the most abundant mineral, but poorly exhibited due to its partial alteration to chlorite.

Southeast of Toshes and Sandy Level the rocks in contact with the marble are medium grained, tough, crumpled, gray schist with thin layers of coarsely crystalline feldspar and quartz. Weathered exposures of this rock are brownish red. Where the feldspathic stringers are fairly regular and closely spaced, the rock has a distinct gneissic appearance. However, this banding is probably the result of lit-par-lit injections of pegmatitic material. Subsequently this injected rock has been closely folded and overturned toward the northwest. The schistose layers are composed principally of muscovite, biotite, feldspar and quartz, with minor amounts of chlorite.

Pegmatite.—The only pegmatites observed, in close association with the barite deposits, were in the Thompson, Berger and Bennett mines. These deposits are in the southwestern part of the barite belt in Pittsylvania County. The largest dike, with a width of 30 feet, crops out in the Thompson open cut and is reported to have been penetrated to a depth of 90 feet by drilling.

The texture of these dikes varies, but the component minerals probably average less than an inch in diameter. The simple mineral composition includes microcline, albite, quartz and muscovite.

The occurrence of barite is of special interest (Pl. 6, B). It is never an abundant constituent of the dikes, but was identified in several thin sections, occurring as irregular fine-grained masses, intergrown with the quartz, feldspar and mica. Pegau[39] records barite in some of the pegmatites in Carroll County.

PRINCIPAL MINES AND PROSPECTS[40]

Carson mine.—The Carson mine is on a tributary of Beaver Creek about 6 miles southeast of Lynchburg. The original development is reported to have consisted of a tunnel 100 feet long, striking N. 45° E., terminated at the southwestern end by a shaft approximately 100 feet deep. When last visited, in November, 1937, the property was being extensively prospected to ascertain if

[39] Pegau, A A., Pegmatite deposits of Virginia: Virginia Geol. Survey Bull. 33, p. 36, 1932.

[40] See Pl. 8.

it contained barite in sufficient quantities to warrant the building of a washing plant. The recent workings included several shallow pits and two tunnels approximately 6 feet wide and 60 feet long. Both tunnels required timbering since they were driven, in part, through unconsolidated material.

A few tons of white coarsely crystalline barite have been recovered and several veins and replacement masses a few inches in width were noted in bedrock. It is reliably reported that at least two veins of barite, of greater thickness, were encountered in driving the tunnels.

The enclosing rocks are interbedded marble and mica schist (Cockeysville marble) which strike N. 45° E., and dip steeply NW. Four layers of marble are shown in the generalized section of the Carson mine (Fig. 5). Since all of the mining and prospecting at this mine have followed closely three of these calcareous beds, it would seem desirable to sink shallow test pits in the black clay associated with the marble which crops out approximately 150 feet east of the present workings.

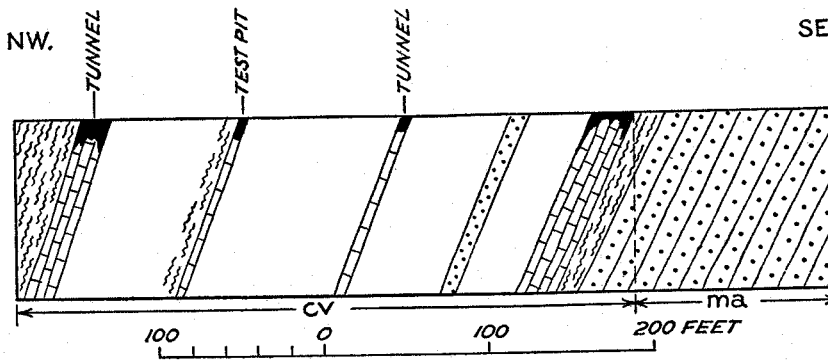


FIGURE 5.—Cross section of the Carson mine, about 6 miles southeast of Lynchburg, Campbell County, Virginia; *ma,* Mount Athos formation; *cv,* Cockeysville marble.

Saunders mine.—The Saunders mine is about 14 miles southwest of Lynchburg and 3 miles southeast of Evington. A great number of shafts and open cuts are along the crest of a narrow ridge trending N. 30° E., for approximately 2,000 feet. Bedrock was not noted in any of the workings, but about 50 feet east of the principal shafts the footwall is a fine-grained mica-schist striking N. 30° E., and dipping 70° NW.

Small amounts of barite containing abundant pyrite were examined on the dumps. This probably represents inferior material discarded during mining. There is no evidence of recent pros-

pecting, and the shallow and scattered nature of the old developments suggest that large concentrations of barite are not to be expected at this locality.

Phillips mine and prospect.—The Phillips mine is about 2½ miles southeast of Evington and about half a mile east of Flat Creek. The Phillips prospect is approximately 1,000 feet west of the mine.

Surface wash and slump have greatly modified the Phillips mine, but the original workings consisted of an open cut not less than 200 feet long, 75 feet wide, and 40 feet deep. The cut is in black clay which can be traced northeast across the road, and probably extends northeast to the Saunders mine. It is reported that considerable quantities of barite were mined here, but when last visited only a few small fragments were noted in the "umber." The face of the cut at the southwestern end is composed of massive quartzites which strike N. 35° E., and dip steeply NW. These massive layers which terminate abruptly against the black clay, along their strike, demonstrate an unusually sharp fault contact (Fig. 6).

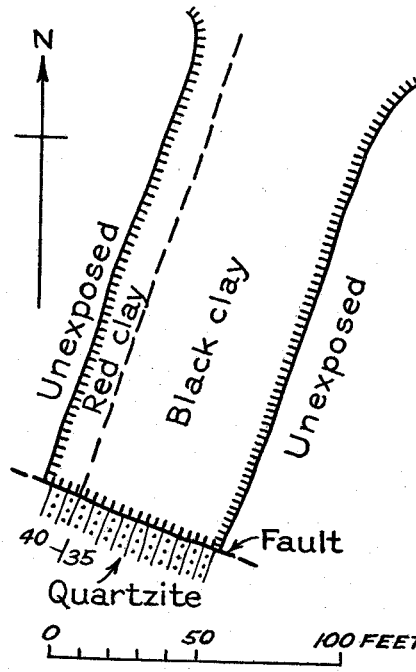
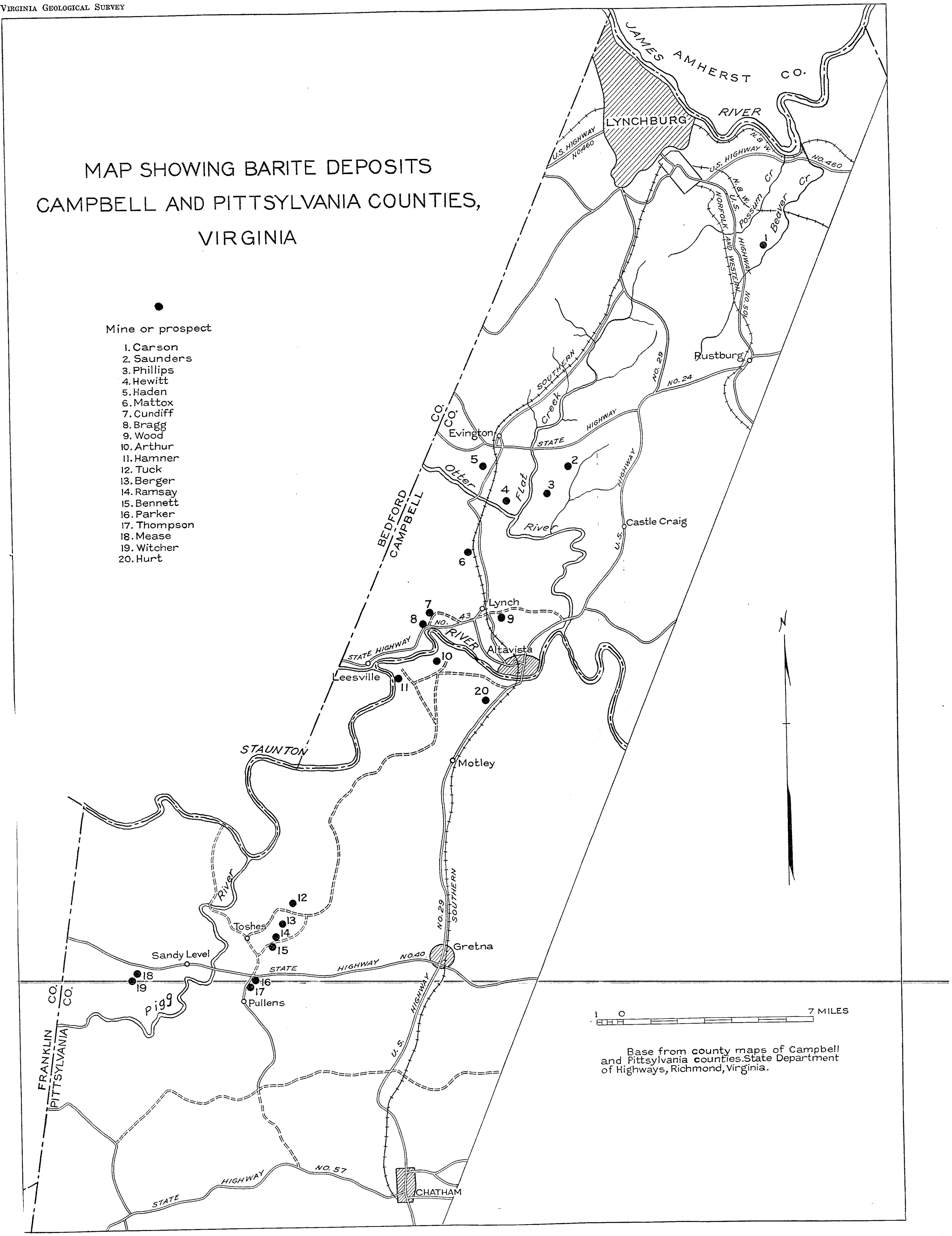


FIGURE 6.—Sketch map of the Phillips mine about 2½ miles southeast of Evington, Campbell County, Virginia.


MAP SHOWING BARITE DEPOSITS
CAMPBELL AND PITTSYLVANIA COUNTIES,
VIRGINIA
Mine or prospect
1. Carson
2. Saunders
3. Phillips
4. Hewitt
5. Haden
6. Mattox
7. Cundiff
8. Bragg
9. Wood
10. Arthur
11. Hamner
12. Tuck
13. Berger
14. Ramsay
15. Bennett
16. Parker
17. Thompson
18. Mease
19. Witcher
20. Hurt
JAMES RIVER
AMHERST CO.
LYNCHBURG
U.S. HIGHWAY NO. 460
N. & W.
NORFOLK AND WESTERN HIGHWAY
Possum Cr
Beaver Cr
NO. 501
Rustburg
NO. 29
NO. 24
SOUTHERN
Creek
Evington
STATE HIGHWAY
Otter
Flat
River
BEDFORD CO.
CAMPBELL CO.
Castle Craig
U.S.
Lynch
NO. 43
STATE HIGHWAY
Altavista
Leesville
STAUNTON
Motley
Toshes
Sandy Level
Gretna
NO. 40
Pigg
Pullens
FRANKLIN CO.
PITTSYLVANIA CO.
NO. 57
CHATHAM
N
1 0 7 MILES
Base from county maps of Campbell and Pittsylvania counties. State Department of Highways, Richmond, Virginia.

The Phillips prospect which was worked on a small scale during the winter of 1930-31 consists of several shafts with a maximum depth of 60 feet, one open cut about 12 feet deep, and several shallow trenches. All of the deeper shafts penetrate a few feet of red clay near the surface and then continue in the characteristic black "umber." No bedrock was noted in the workings, but about 50 feet to the east are exposures of quartz mica-schist striking N. 35° E., and dipping 70° NW.

It is probable that the Phillips prospect represents the continuation of the mineralized zone in the Phillips mine which locally has been offset by cross-faulting.

About four cars of barite were shipped from the Phillips prospect in 1931, but the barite is reported to have contained a relatively high percentage of iron.

Hewitt mine.—The Hewitt mine is 2 miles southeast of Evington, one-fourth of a mile north of Otter River and about half a mile east of the Southern Railway. It was operated on a small scale in 1874, and later developed into the largest and most important producer of barite in Virginia.

The Barium Mining Corporation of Gretna, Virginia, last operators of the property, abandoned the Hewitt mine in 1933 and moved the washing plant (Pl. 10, C), to the old Ramsay mine in Pittsylvania County. Since the last mining at the Hewitt encountered consolidated bedrock containing no commercial quantities of barite, it is most probable that the reserves are largely exhausted. However, as recently as 1932, one lens, about 20 feet in thickness, yielded over 200 tons of barite.

The Hewitt mine is principally an open cut 1,800 feet long, paralleling the schistosity of the enclosing rocks (Fig. 7). The width of the open cut varies from 200 to 300 feet at the top and averages 100 feet at the bottom. In addition to the open cut, there are many small transverse tunnels connecting the larger openings and from which barite has been obtained.

The northwest wall of the cut consists of two thick-bedded quartzites interbedded with mica-schist and conglomeratic layers. The hanging or southeast wall is a thinly foliated mica-schist. Black and red clays, in places surrounding marble pinnacles (Pl. 12, A), crop out along the bottom of the workings. The strike of the rocks is N. 50° E., and the dip 40°-60° SE.

Unless the quartzites lie conformably beneath the marble, a fault must be assumed. The latter view is favored, since visible displacement of the quartzites was noted near the southwestern end of the mine (Fig. 7). On the northwest wall, about 200 yards

northeast of the southern end and 50 feet above the bottom of the cut, is a 12-foot body of marble, which was apparently dislocated by faulting.

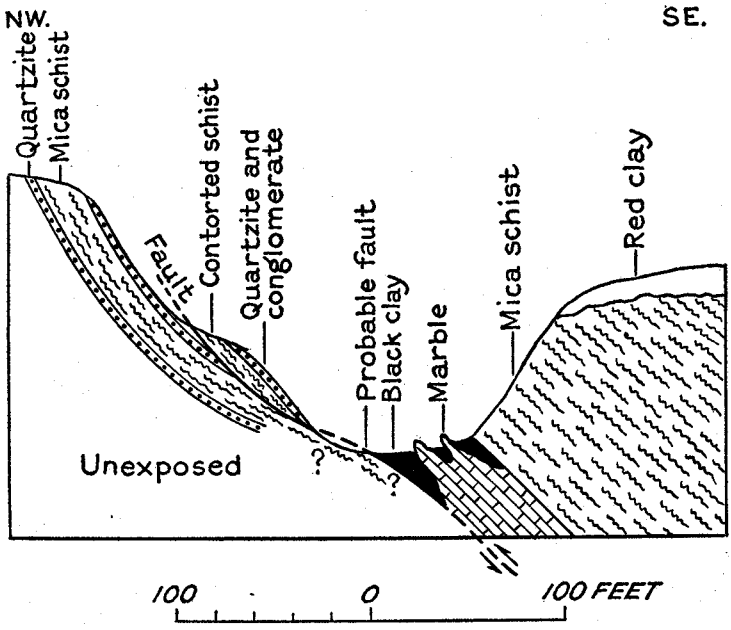


FIGURE 7.—Diagrammatic section at the Hewitt mine 2 miles southeast of Evington, Campbell County, Virginia.

Haden mine.—The Haden mine is 1 mile southwest of Evington and half a mile west of the Southern Railway. It was originally developed as an open cut 200 feet long and 30 feet wide.

No consolidated bedrock is exposed in the workings, but along the same belt southwest of the mine are mica schists striking N. 50° E., and dipping 60° SE. These schists in contact with black soil, usually associated with the barite deposits, can be traced along the strike for several hundred feet. Approximately 100 yards east of the mine are cliffs of micaceous quartzite similar to that which crops out in the Hewitt and Phillips mines.

It is reported that 2,500 tons of exceptionally high-grade barite were recovered from this mine. The supply was soon exhausted and the site has remained idle since that time with the exception of some prospecting during the summer of 1937.

There are no surface indications of commercial reserves of barite here, but systematic prospecting of the black soil just south of the mine and secondary road seems justifiable.

Mattox mine.—The Mattox mine is half a mile southwest of Otter River Station and about a quarter of a mile west of the Southern Railway. It is reported that a large quantity of high-grade barite was mined from the old shafts and open cuts. The mine was reopened in 1931 and a few tons of barite recovered from a shaft and small open cut which were soon abandoned. At the present time these workings are almost entirely filled by debris and there are no indications of commercial reserves.

Contorted mica schist, striking N. 50° E., is exposed along the northwest wall of the principal open cut, but only black soil, derived from calcareous schists, was encountered in the other workings. This residual soil, although completely weathered, still retains the structure of the parent rock. Boulders of basic igneous rock are abundant about 100 feet west of the mine, but they probably bear no relation to the barite deposit.

Cundiff prospect.—The Cundiff prospect, a vertical shaft 12 feet in diameter and 40 feet deep, is about half a mile northeast of the large bend in Roanoke River and 4 miles northwest of Altavista.

Only black residual soil mantle is exposed in the pit, but a few feet to the southwest are schists that strike N. 35° E., and dip 70° SE. Basic igneous rock and abundant quartz float were noted about 100 yards northwest of the shaft.

The vein minerals associated with the barite are quartz, micas, hornblende, tourmaline, chalcopyrite, pyrite, epidote, malachite, and limonite. It is thought that the difficulty in successfully separating quantities of these gangue minerals from barite would probably prevent further development of this property, unless large quantities of barite were discovered. (See Pls. 2, B and 3.)

Bragg mine.—The Bragg mine is along State Highway No. 43 about half a mile southwest of the Cundiff prospect and about 3½ miles northwest of Altavista. The old workings, which include several shafts and open cuts, extend from the highway northeastward to the top of the hill above Roanoke River.

The associated rocks are marble and its residual clay overlain by greenish schist that weathers to a yellow-brown color. All of the workings are in the dark gray to black residual soil near the marble. The overlying red and yellow residual mantle derived from the mica schist has been prospected, but it appears that commercial quantities of barite were not encountered in this material.

Lack of sufficient exposures makes it impossible to give structural details. However, there are at least two tightly compressed

folds overturned to the northwest. The rocks strike N. 40° E., and dip steeply to the southeast and northwest.

Large quantities of barite are reported to have been mined from this locality, but at the present time there are no surface indications of commercial reserves. This property, extending 100 feet above the river, could be easily mined and practically free from water, if systematic prospecting by shafts should discover additional deposits.

Wood prospect.—The Wood prospect in Campbell County is about half a mile east of Lynch Station (Clarion) on the Southern Railway and 100 yards south of the local road. At present the open cut, approximately 12 feet in diameter, is almost filled with debris. No rocks are exposed in the workings, but along the road to the north are mica schists striking N. 30° E., and dipping steeply NW. This reported occurrence of barite east of the principal barite belt probably is not of commercial importance.

Arthur mine.—The Arthur mine, originally operated by E. T. Howell, is half a mile south of Roanoke River and about 2½ miles west of Altavista. It was developed by several deep shafts and open cuts on the southwest side of a narrow valley which drains into Roanoke River. The property is ideally situated with respect to natural drainage and good transportation facilities are available on the nearby Virginian Railway.

It is reliably reported that large quantities of high-grade barite were recovered from the decomposed calcareous rocks which underlie mica schist striking N. 35° E., and dipping 60° SE. In some of the shallow workings this mantle (Fig 8), still retains the foliation planes of the parent rock. Along these schistose surfaces are abundant veins and lenslike bodies of barite that average less than an inch in thickness. It seems reasonably certain that these near-surface, thin occurrences of barite are not of economic importance, but they may serve as a guide for more extensive prospecting.

Hamner mine.—The Hamner mine, 1 mile southeast of Leesville and 4 miles west of Altavista, is on the east side of a large meander in Roanoke River. It consists of an open cut, approximately 800 feet long and 300 wide, trending N. 30° E., into a narrow ridge. This mine, one of the largest in the Campbell-Pittsylvania counties area, was developed principally as a series of benches by power shovels and as vertical shafts by hand methods. The only evidence of recent work are several shallow test pits and a few tons of barite ready for shipment.

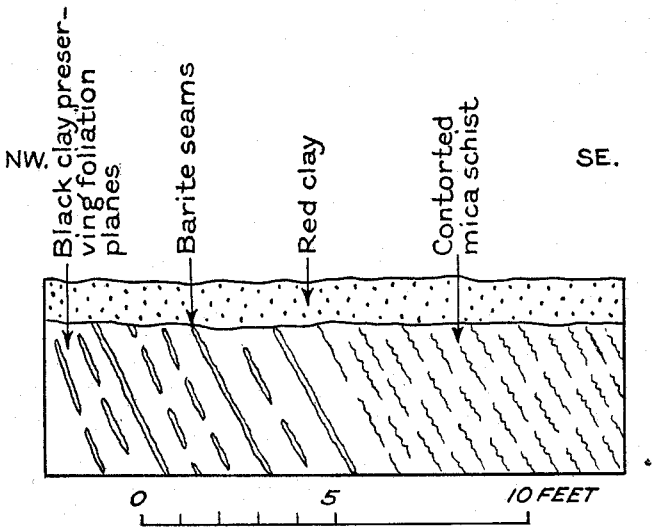


FIGURE 8.—Section in largest open cut of the Arthur mine about 2½ miles west of Altavista, Pittsylvania County, Virginia. The barite seams range from one-fourth of an inch to 1 inch in thickness.

Mica schists with abundant magnetite grains, and varying locally in strike and dip, crop out along the northwest side of the cut. Some of the apparent structural discordance may be due to slumping. In contact with the schists are the usual residual clays associated with all of the barite deposits. A few large blocks of marble containing veins and replacement masses of barite were noted in the residual clays. The minerals associated with these occurrences of barite are chalcopyrite, pyrite and chlorite.

It is most probable that water would be encountered in mining at greater depths, since the present workings are close to the level of the river. At higher elevations along the southeast face of the cut are small fragments of barite in the residual clay, but no surface indications of commercial reserves.

Tuck mine.—The Tuck mine, about half a mile east of Pittsville and 1 mile south of Newtown, marks the northeastern end of the second important barite belt of the Campbell-Pittsylvania counties area. The old workings in the residual clay include several shafts ranging from 20 to 90 feet in depth and averaging approximately 10 feet in diameter. At the time of the writer's visit quartz and barite fragments were scattered over the surface and in the openings, but there were no indications of sufficient concentrations of barite to warrant further exploration.

Berger mine.—The Berger mine is north of Fryingpan Creek, about 1 mile southwest of Pittsville and 1 mile east of Toshes. The old shafts and open cuts are along the crest of a hill trending northeast for several hundred feet, but surface wash and slump made it impossible to determine in detail the geological relationships of these workings.

During the summer of 1937 the Barium Mining Corporation of Gretna, Virginia, developed an open cut about 400 feet long, 150 feet wide, and 50 feet deep at the northeastern end of the old property. On the sides of the cut mica schist contains closely spaced stringers of kaolinized feldspar (Fig. 9). These feldspathic bodies most commonly range from one-fourth of an inch to 6 inches in thickness. However, a few lenses several feet in width occur both in the schist and in the residual clays. Viewed from a distance the rock resembles a poorly banded gneiss, but on closer inspection it reveals distinct micaceous layers. The irregular masses of the decomposed feldspar in the "umber" do not contain barite and are, therefore, avoided during mining.

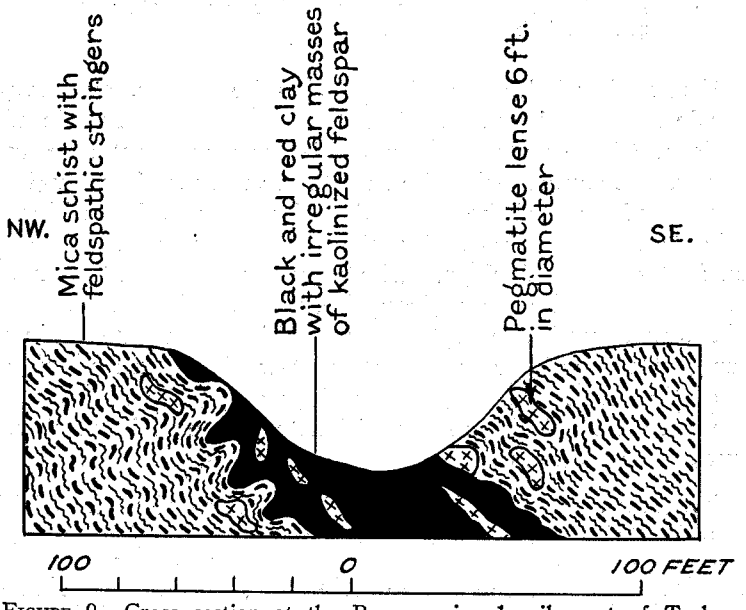


FIGURE 9.—Cross section at the Berger mine 1 mile east of Toshes, Pittsylvania County, Virginia.

Although only hand-methods of mining are employed at the present time, the property probably can be developed on a larger scale.

Ramsay mine.—The Ramsay mine is along Fryingpan Creek, approximately half a mile southwest of the Berger mine and 1 mile southeast of Toshes. After the Hewitt mine was closed in 1933, the Barium Mining Corporation reopened this mine and built a modern washing plant. Several thousand tons of high-grade barite were recovered from the old dumps and a large open cut, but at the present time the workings are abandoned. The open cut, partly filled with water, is about 600 feet long, 150 feet wide, and 20 feet deep. The reported scarcity of barite, in addition to the evident trouble with water, makes future mining highly improbable. The washing plant, however, is used in connection with other nearby barite deposits.

Bennett mine.—The Bennett mine, which originally comprised several shafts, drifts, and open cuts, is 200 yards southwest of Fryingpan Creek and the Ramsay mine. According to Watson,[41] mining was begun here about 1880 and was still in progress in 1906. This mine apparently closed along with the other mines of the district shortly after 1906 and remained idle until the Barium Mining Corporation reopened the property in 1936.

The present open cut (Fig. 10), approximately 500 feet long, 200 feet wide, and 75 feet deep, near the Ramsay washer, is well adapted to power methods of mining and is relatively free from underground water. Along the northwest wall are fresh mica schists with thin layers of coarsely crystalline feldspar and quartz (Fig. 10). The schists are overlain by black residual clays, lenses of decomposed pegmatites, and near the middle of the cut one bed of marble. The southeast wall is chiefly red clay which preserves the foliation of the parent rock.

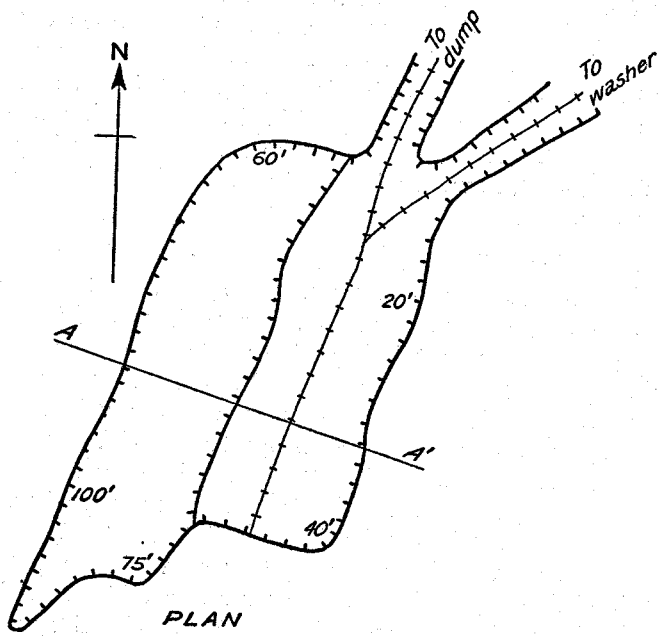
Most of the mining has been in the "umber" along the northwest side of the cut, but at the present time the residual mantle close to the marble is being prospected. Although this necessitates the removal of large quantities of near-surface overburden, experience has shown that, at other similar deposits in the Piedmont, the largest concentrations of barite are to be expected in the residual material close to the marble.

Parker mine.—The Parker mine, along Potter Creek, is north and south of State Highway No. 40 and about half a mile southeast of the Bennett mine.

The shafts and open cuts 300 yards north of the road were filled with debris when the property was last visited, but large fragments of marble and some barite were noted on the dump.

[41] Watson, T. L., Geology of the Virginia barite deposits: Am. Inst. Min. Eng. Trans., vol. 38, p. 723, 1907.

There were no indications of recent work and nothing is known regarding the possible barite reserves. During 1935 the Barium Mining Corporation developed an open cut 100 yards south of the road and recovered several cars of barite of good grade from black



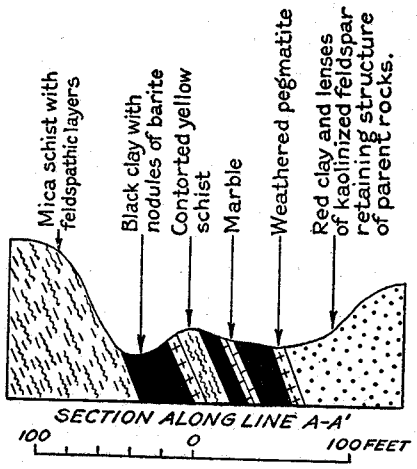
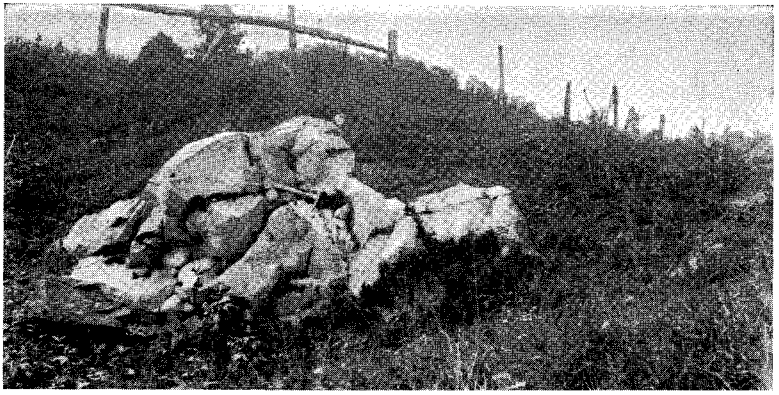
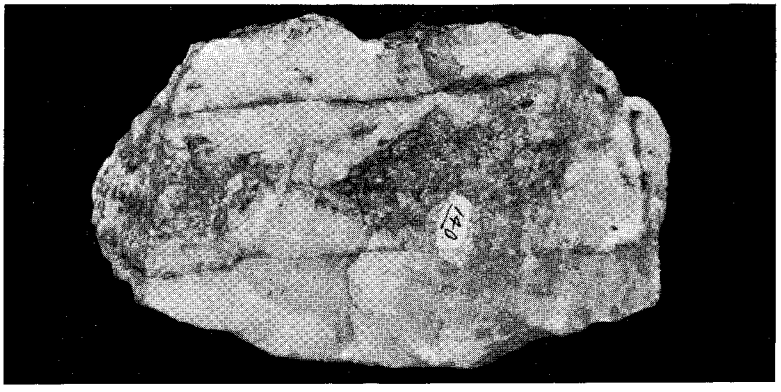


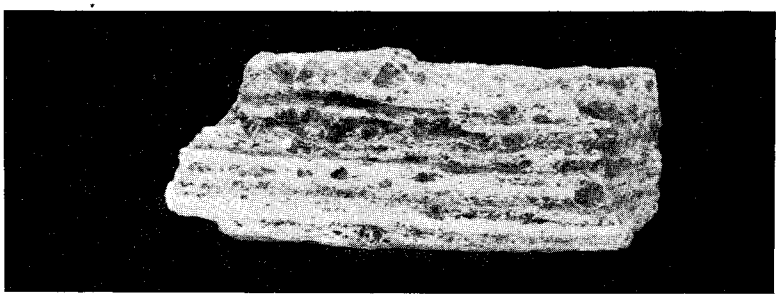
FIGURE 10.—Plan and section at the Bennett mine about 1 mile southeast of Toshes, Pittsylvania County, Virginia.



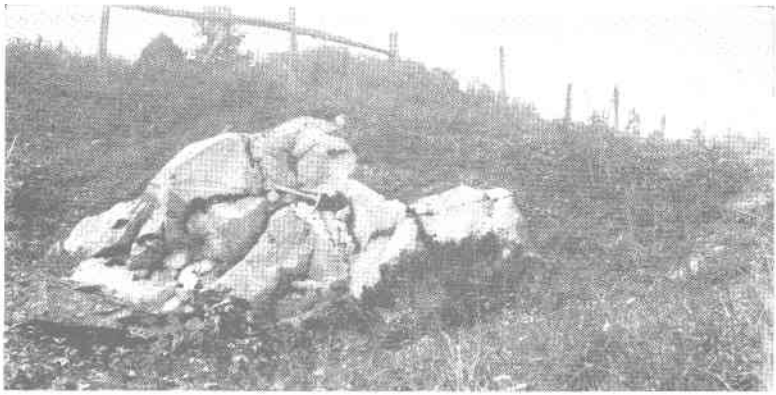
A. Replacement mass of barite in limestone; at the Cornett-Hull mines, Smyth County, Virginia.



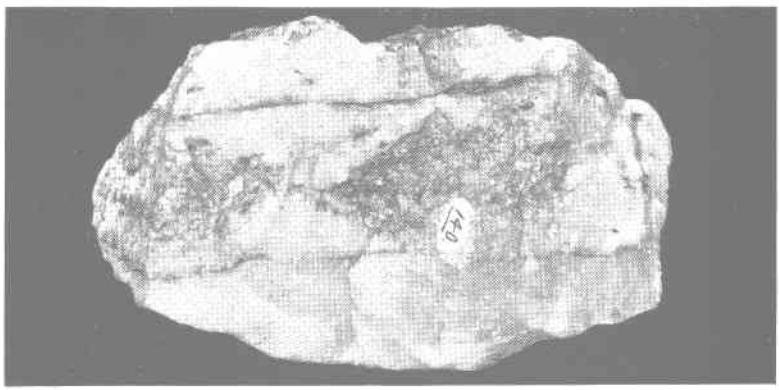
B. Barite replacing included fragments of granite; at the Poole prospect, Grayson County, Virginia. X 1/3.



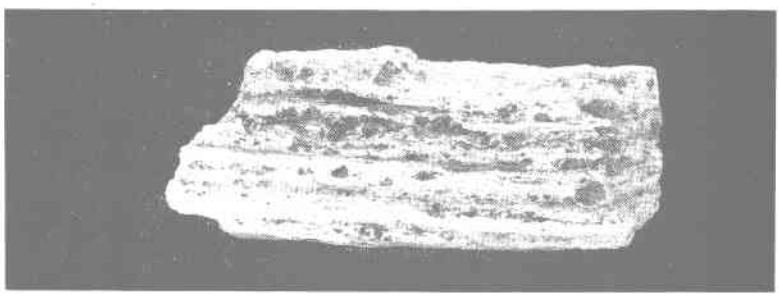
C. Mica schist almost completely replaced by barite; at the Moore prospect, Grayson County, Virginia. X 1/3.



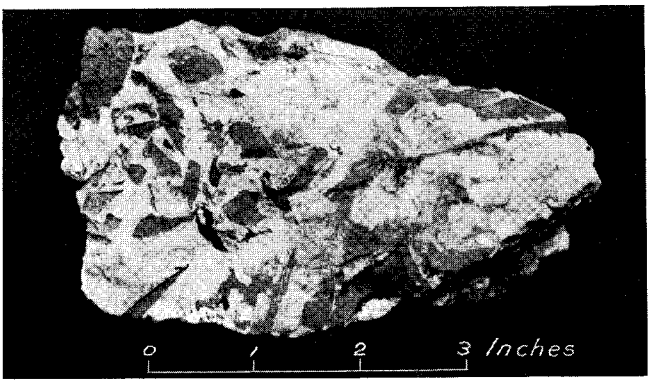
A. Replacement mass of barite in limestone; at the Cornett-Hull mines, Smyth County, Virginia.



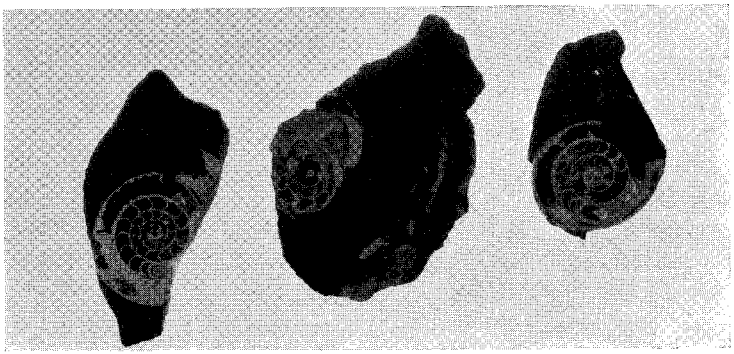
B. Barite replacing included fragments of granite; at the Poole prospect, Grayson County, Virginia. X 1/3.



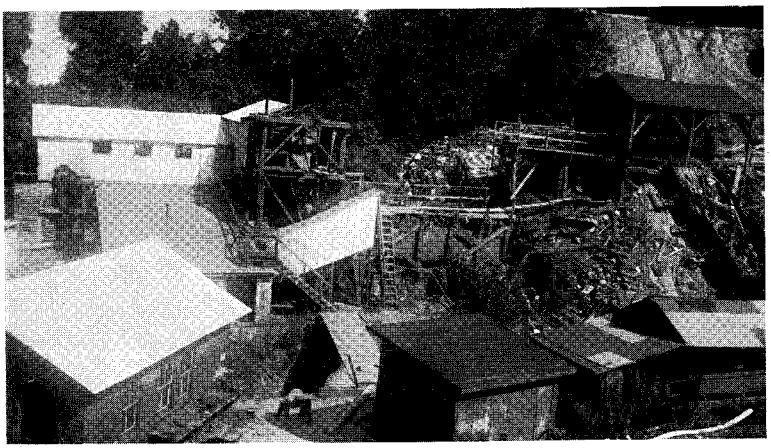
C. Mica schist almost completely replaced by barite; at the Moore prospect, Grayson County, Virginia. X 1/3.



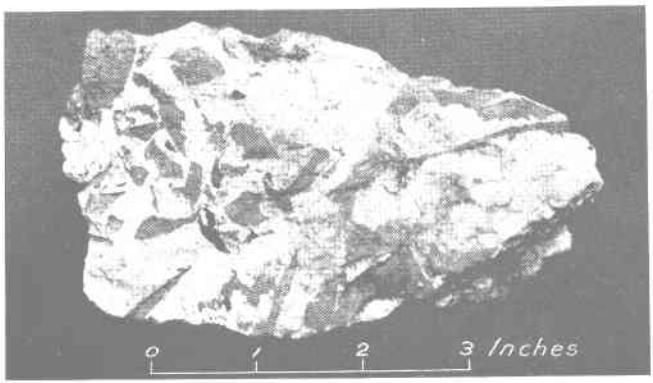
A. Limestone breccia cemented by barite; at the Leonard mine, Russell County, Virginia.



B. Barite within pyritized cephalopod shells. X ½.



C. Former washing plant at the Hewitt mine, Campbell County, Virginia. The plant was dismantled in 1933.



A. Limestone breccia cemented by barite; at the Leonard mine, Russell County, Virginia.

B. Barite within pyritized cephalopod shells. X ½.

C. Former washing plant at the Hewitt mine, Campbell County, Virginia. The plant was dismantled in 1933.

and red clays which contained fragments of mica schist and quartz. These clays containing residual barite can be traced northeastward across State Highway No. 40 just east of Potter Creek. Testing by shallow pits is recommended at this locality, since in no other way can a reasonable estimate be made regarding probable reserves.

Thompson mine.—The Thompson mine, consisting of several shallow open cuts and shafts, adjoins the Parker mine on the southwest and extends several hundred feet in that direction. It is reported to have been the first operation in the area and was soon followed by the Parker, Berger, Bennett, and Ramsay mines.

All of the workings are in white, red, and black clays containing irregular masses of mica schist and quartz. Many of the quartz fragments are intermixed with coarsely crystalline barite. It is reported that marble was encountered in one of the drill holes along the northwest side. In another hole, near the middle of the workings, white clay was penetrated for a depth of at least 90 feet. These relationships cannot be checked at the present time, but the white clay may represent the decomposed part of the same pegmatite which crops out along the road southwest of the mine. (See Pl. 6, B.) All of the clays have been prospected, but only the characteristic black material has furnished commercial quantities of barite. During the past year one dump was reworked in conjunction with operations on the Parker property. It seems probable that some of the other dumps could be profitably worked by mechanical methods similar to those used on the Parker tract.

Since this property has been extensively mined and prospected, it is most probable that the supply of barite of commercial value has been exhausted.

Mease mine.—The Mease mine is south of State Highway No. 40, about 2 miles southwest of Sandy Level and 1½ miles west of Pigg River. It consists of a few shafts which were worked on a small scale during the winter of 1930-1931. Small amounts of barite were noted in the residual clay, but there is no suggestion of commercial reserves.

Witcher mine.—The Witcher mine is about 300 yards southwest of the Mease mine. A few fragments of barite were seen in the small open cut and shallow test pits, but it is most probable that the supply of barite of commercial value has been exhausted.

Hurt prospects.—The Hurt property about three-fourths of a mile southwest of Altavista and a quarter of a mile west of the Southern Railway was recently prospected by the Barium Mining Corporation. At the present time all of the test pits are filled and the results of this work are not available to the writer.

BEDFORD COUNTY AREA

LOCATION

It is reported that barite has been mined at a number of places in Bedford County, but only one occurrence was located by the writer. This deposit is in the western part of the county, about 3 miles northwest of Thaxton and 1 mile northeast of Irving (Fig. 11).

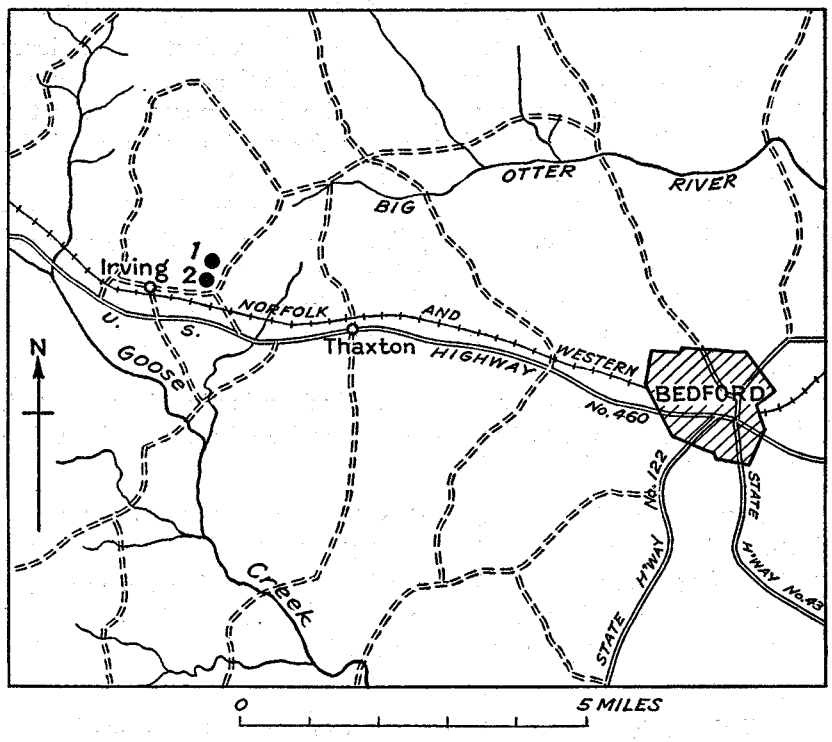


FIGURE 11.—Map showing location of the Saxton (1) and the McMillan (2) barite mines in Bedford County, Virginia. (Base from map of Bedford County by State Department of Highways.)

HISTORY

According to Watson[42] barite was first mined in this area in 1866 and a small quantity was shipped to Baltimore. No record showing the duration of the initial operation is available, but the relatively small area mined and prospected, suggests that operations were abandoned within a few years. Residents[43] of the vicinity state that the property was reopened in 1906 and a few cars of barite recovered. Except for some prospecting the area has remained idle since 1906.

GEOLOGY

The western part of Bedford County, along the east flank of the Blue Ridge, is composed of pre-Cambrian rocks of igneous and sedimentary origin that have undergone structural and mineralogical changes. The thoroughly dissected topography of that area, with a maximum relief of 3,000 feet, affords an unsual number of bedrock exposures. Marshall granite[44] occurs in the vicinity of the barite deposits, and extends northeast through central Virginia. This intrusive body is of pre-Cambrian age.

ASSOCIATED ROCK

Marshall granite.—The texture of the Marshall granite varies from schistose to porphyritic with feldspar phenocrysts measuring more than an inch in diameter. Although bedrock is not exposed in the workings large detached fragments show that the barite occurs in a fissured zone in the schistose phase of the granite. Some distance from this narrow shear zone the rocks appear massive, but show abundant slickensided surfaces. In all thin sections studied the primary constituents show some strain effects and a tendency toward parallel alignment of the tabular minerals.

Quartz, feldspars, biotite, hornblende, chlorite, epidote, and sericite, in variable amounts, were identified microscopically. Crushed and distorted quartz and feldspar grains are the most abundant minerals in the porphyritic granite, with secondary chlorite, epidote, and sericite being more abundant in the schistose phase. The development of the latter minerals, in addition to some pyrite, suggests that they are of hydrothermal origin. Various stages in their alteration to secondary silicates are shown by biotite and hornblende.

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[42] Watson, T. L., Mineral resources of Virginia, Virginia-Jamestown Exposition Commission, Lynchburg, Va., p. 319, 1907.
[43] Messrs. Overstreet and Meadows, personal communication.
[44] Geologic map of Virginia: Virginia Geol. Survey, 1928.

The Marshall granite has a greenish-gray color, except where hydrothermally altered. The altered phase is yellowish-green due to the abundant development of chlorite and epidote.

PRINCIPAL MINES AND PROSPECTS[45]

Saxton-McMillan mines.[45a]—The Saxton-McMillan mines are on adjoining properties in Bedford County, at the head of Goose Creek, about 2½ miles west of Thaxton and about three-fourths of a mile east and slightly north of Irving. The McMillan property contains the larger workings, but open cuts extend northeast for several hundred feet on the adjoining Saxton property. The southwestern limit of the explorations began about 800 feet north of the Norfolk & Western Railway and continued northeast for approximately 1,000 feet. The explorations consisted of several open cuts trending N. 40° E., shallow transverse trenches, and vertical shafts. The largest open cut was approximately 300 feet long, 30 feet wide, and 40 feet deep.

It is reliably reported that in 1906 a barite vein, 30 inches thick, was mined from bedrock. The probable reserves and the original size of the deposit cannot be ascertained at the present time. Samples from the dump show veins of barite several inches thick firmly attached to slickensided surfaces of sheared granite. In addition, the wall rock is hydrothermally altered to epidote, chlorite and pyrite. (See Pl. 5, A.)

It seems reasonably certain to the writer that the barite is of magmatic origin, and that the solutions rose along fractures, probably fault fissures, until they reached a favorable place for deposition. Watson,[46] who visited the property in 1906, says: "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." He also states that it seems quite probable that the feldspar of the granite was the source of the barium.

The few small fragments of residual barite found by the writer appear to be of good quality, but there are no surface indications of commercial reserves.

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[45] See Fig. 11.

[45a] In this report the names of two adjoining small properties are hyphenated.

[46] Watson, T. L., Geology of the Virginia barite deposits: Am. Inst. Min. Eng. Trans., vol. 38, p. 724, 1907.

GRAYSON COUNTY AREA

LOCATION

In Grayson County barite prospects occur 5 miles south of Speedwell on the south slope of Iron Mountain; 3 miles northwest of Hampton P. O., on the east side of New River; and, near the Virginia-North Carolina boundary about 4 miles southwest of Independence. It is reported that barite also occurs along Little Fox Creek northwest of Buck Mountain and on the southwest slope (McLean prospect) of Briar Patch Mountain about one-half a mile north of Elk Creek (Fig. 12).

U. S. Highway No. 21 south of Speedwell offers the best approach to the northern part of the area, whereas U. S. Highway No. 58 west of Galax passes within a mile of the other prospects. This part of Grayson County is not favored with rail transportation, but any barite recovered could be trucked over hard-surfaced roads to the branch line of the Norfolk & Western Railway at Galax.

HISTORY

As far as known, the occurrences of barite in Grayson County have not been described in the literature, but residents relate that the Poole property was prospected about 1850. If this is correct, the Poole prospect was among the first to be opened in Virginia. The prospect was soon abandoned and remained idle until 1926 when it was reopened and additional work done. This development is reported to have consisted of two deep shafts and cross cuts, which are now filled with debris.

Since 1927, C. B. Crabill of Galax, and O. C. Osborne, of Oldtown, have independently studied and prospected all of the known barite occurrences in the county. The writer is greatly indebted to these men for their cooperation in giving him information on each deposit.

GEOLOGY

The Grayson County barite area, containing approximately 36 square miles, includes a small part of the Blue Ridge plateau. Locally it is a well-dissected upland whose maximum relief is 2,400 feet and average elevation about 3,000 feet. Prominent topographic features are Iron, Buck, Briar Patch, and Point Lookout mountains. The area is well drained by New River and its tributaries Fox, Bridle, Saddle, Peach Bottom, Elk, and Knob Fork creeks.

According to Jonas[47] who has done detailed field work in Grayson County, the rocks associated with the barite deposits, with the exception of the Martin prospect, are pre-Cambrian Grayson granite gneiss, mylonitized granite gneiss, and pink pegmatite associated with the Grayson formation. The Martin prospect occurs in an area of Cambrian sediments.

In the porphyritic granite gneiss and pegmatite the barite fills open fissures, whereas in the more schistose types the solutions apparently entered along the schistosity and replaced the rock.

Although no commercial quantities of barite have been shipped from Grayson County, the present known occurrences, in the writer's opinion, should warrant additional prospecting. If the barite is found to be of commercial quality, it seems probable that small-scale mining operations would be successful.

ASSOCIATED ROCKS

Porphyritic granite gneiss.—Porphyritic granite gneiss is exposed on the dumps and in the vicinity of the Poole prospect. Relatively fresh material has a reddish-green color due to abundant pink feldspar and ferro-magnesium silicates, but weathered surfaces are mottled gray. The texture is distinctly porphyrytic with feldspar phenocrysts measuring more than an inch in diameter. Under the microscope all of the primary minerals show variable amounts of crushing and some rearrangement.

Orthoclase and microcline with smaller amounts of plagioclase, chiefly oligoclase, and quartz are the principal light-colored minerals with biotite and hornblende being the important femic constituents. The latter minerals occur as bladed crystals interlocking with the quartz and feldspar. Accessory minerals include sericite, chlorite, and epidote.

The rock along the barite veins, especially at the Poole prospect, is hydrothermally altered (propylitized) to a yellowish-green color and is composed principally of epidote and chlorite. Some of these minerals are commonly mingled with fine-grained barite and fluorite. The association of barite with hydrothermal minerals along the veins suggests that the barite is of igneous origin.

Feldspar and hornblende showing various stages in their alteration to sericite and chlorite, respectively, are abundant in the partially weathered gneiss.

Mylonitized granite gneiss.—Mylonitized granite gneiss occurs in a fault zone[48] at the Moore prospect half a mile east of New

[47] Jonas, A I., personal communication, April 7, 1938.
[48] Jonas, A. I., personal communication, April 7, 1938.

River and about 2½ miles northwest of Baywood. It is straight layered, light colored and composed principally of quartz and feldspar with micaceous partings. In thin section the quartz and feldspar are finely granulated and arranged in thin layers separated by biotite which is partially altered to chlorite. Small amounts of white mica, probably developed from potash feldspar, occur in the fine-grained matrix. There are also a few small grains of epidote, magnetite, and pyrite.

Pegmatite.—The enclosing rock of the F. Vaught prospect is a pink pegmatite associated with the Grayson granite gneiss. In thin section the principal minerals are large phenocrysts of microcline, oligoclase, and quartz, and a few lathes of biotite showing alteration rims of chlorite. All of the crystals show some bending and fracturing, but of more importance are numerous narrow zones which are completely granulated. In these granulated bands are abundant irregular masses of barite, fluorite and chalcedony which fill the interstices and partially replace some of the primary minerals.

PRINCIPAL MINES AND PROSPECTS[49]

F. Vaught prospect.—The F. Vaught prospect is on the south slope of Iron Mountain about three-fourths of a mile south of the Wythe-Grayson county line and 1¼ miles east of U. S. Highway No. 21.

This property was first prospected in 1927 by a shallow trench, which later was enlarged to an open cut 60 feet long, 15 feet wide, and 12 feet deep. A shaft also was sunk to a depth of 50 feet near the southeastern end of the open cut. A solid mass of barite (Pl. 11, B), about 4 feet wide, was encountered in the trench and this body persisted to the bottom of the open cut. Subsequent development proved this body to be a lens which yielded about 20 tons of barite. A larger body of barite was reported to have been discovered later in the shaft.

Bedrock does not crop out in the open cut, but weathered pink pegmatite was encountered in the shaft. Some fragments of this rock from the deeper part of the shaft are dense and contain abundant barite, fluorite and secondary quartz. (See Pl. 4, B.)

Since barite of apparently good quality occurs in the shaft, additional prospecting to ascertain the size of the deposit is recommended.

There is another small occurrence of barite on the F. Vaught property about 1 mile southeast of the prospect described above.

[49] See Fig. 12.

A vein of barite, 18 inches wide, crops out in the bottom of a shallow open cut. The enclosing rock, judging from abundant float material, is the Grayson granite gneiss.

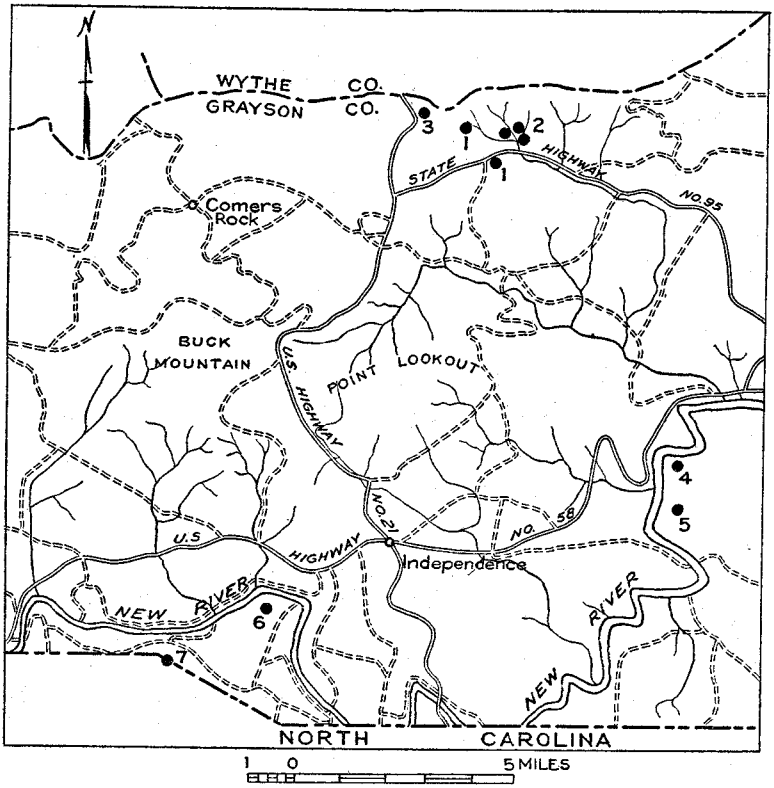

FIGURE 12.—Map showing location of barite deposits in Grayson County, Virginia: 1, F. Vaught prospect; 2, S. Vaught, Porter, and Rhudy prospects; 3, Martin prospect; 4, Poole prospect; 5, Moore prospect; 6, Cox prospect; 7, Phipps prospect. (Base from map of Grayson County by State Department of Highways.)

S. Vaught, Porter, and Rhudy prospects.—The S. Vaught, Porter, and Rhudy prospects are on adjoining farms about 1 mile northwest of Fallville Church. A few fragments of float barite with a maximum width of 12 inches were noted at each of the prospects. The barite appears to be of good quality, but additional prospecting will be necessary before any statement can be made regarding the probable reserve.

Martin prospect.—The Martin prospect is on a tributary of Turkey Ford Creek about 1,000 feet east of U. S. Highway No. 21 and one-fourth of a mile south of the Wythe-Grayson county line.

A few hundred pounds of barite have been recovered from a small trench entirely within the residual clay. Although bedrock is not exposed, the abundant detached fragments of sandstone and conglomerate suggest that this area is underlain by the Cambrian Unicoi quartzite. The known occurrence of barite is small and probably not of commercial importance.

Poole prospect.—The Poole prospect is 5 miles northeast of Independence and about one-fourth of a mile east of New River. This deposit was known prior to the War between the States, but it was not extensively prospected until 1926. At the present time the workings are completely filled with rock debris and the mining equipment removed, but residents who assisted with the exploration state that the workings consisted of two shafts and several shallow open cuts.

One shaft was sunk to a depth of 100 feet and the other, 75 feet southeast of the first, to a depth of about 35 feet. From the bottom of each shaft a tunnel was driven for about 100 feet in a S. 35° E., direction in the granite gneiss, along the reported strike of the barite vein.

A solid vein of barite with a maximum width of 16 inches, and a wider zone of breccia cemented by barite are reported to have been continuous from the surface to the bottom of the deeper shaft. The reported width of the vein probably was not exaggerated, since barite fragments more than a foot in thickness are abundant on the dumps.

The enclosing rock of the Poole prospect is Grayson granite gneiss (Pl. 7, B), which is deeply weathered at the surface and relatively fresh in the lower parts of the deeper shaft. The abundant breccia cemented by barite indicates that this deposit occupies a fault zone.

The barite is fine grained and commonly shows some replacement of the wall rock (Pl. 9, B). Of special scientific interest is the narrow zone of hydrothermal alteration along the barite vein. The minerals characteristic of thermal solutions are abundant epidote and chlorite. Other minerals associated with the barite are fluorite and quartz. Gypsum, probably an alteration of anhydrite, was also noted on the dump, but its relation to the barite is not known. (See Pl. 5, B.)

The fact that apparently extensive developments were abandoned, strongly indicates the improbability of any large future production. It is thought that small quantities of barite exist at this locality, but that the cost of obtaining it from a brecci-

ated zone would be too great to justify further attempted development unless larger reserves of good grade are found.

Moore prospect.—The Moore prospect is 1 mile south of the Poole prospect and half a mile east of New River. A few shallow test pits were dug in 1929. Small tabular and lens-shaped bodies of barite, with a maximum width of 12 inches, were noted near the surface, but little is known regarding their horizontal or vertical extent.

The enclosing rock is a quartz-feldspar-mica schist which occupies a fault zone. The barite solutions apparently invaded this fracture zone and partly replaced the schist (Pl. 9, C). Subsequent weathering has removed many of the platy minerals, but their former presence is clearly indicated by the numerous parallel bands of cavities in the barite lenses (Pl. 9, C). The barite is badly contaminated with iron oxide and included mineral fragments of the enclosing rock.

Cox prospect.—The Cox prospect is about 4 miles southwest of Independence and half a mile south of New River. In 1930, O. C. Osborne, after a reconnaissance study of the distribution of barite float, dug two test pits along the inferred strike of the barite body.

The enclosing rock is a quartz-mica schist, which strikes N. 70° E., and dips steeply SE. Most of the barite occurs as replacement lenses about 2 feet in thickness along the foliation planes and, as irregular fragments in the residual soil. There are also several small stringers of barite and quartz which cut across the foliation.

The barite examined microscopically contains abundant quartz, mica, and iron stains.

Phipps prospect.—The Phipps prospect is 6 miles southwest of Independence, 2 miles southwest of the Cox deposit, and about 200 yards south of the Virginia-North Carolina boundary.

The barite occurs as several closely spaced replacement veins in a quartz-mica schist. The largest vein, only partly exposed in the shallow test pits, is about 3 feet wide and parallels the structure of the enclosing rock. As in the Moore and Cox prospects, the barite here is contaminated with iron stains and fragments of the mica schist.

The fact that there are several parallel veins seems to indicate that the mineralization has followed a fracture zone.

FAUQUIER COUNTY AREA

LOCATION

Barite has been reported from several localities in Fauquier and Prince William counties, but only five occurrences have been mined or prospected. These are in the eastern part of Fauquier County, within a few miles of Catlett and Bealeton, stations on the Southern Railway (Fig. 13). Thin veins not of commercial importance were also noted in an old shale quarry 2 miles south of Manassas in Prince William County.

HISTORY

According to Watson[50] barite was mined along the Prince William-Fauquier county line at different times from 1845 to 1903. The opening of these deposits marks the beginning of the barite industry in Virginia, and probably represents the first barite mining in the United States.

Production figures are not available, but it is reported by Milton Teets of Bealeton, Virginia, that several thousand tons of barite were shipped from the Cedar Run mine and about 2,200 tons from the St. Stephens property. The barite was washed, ground and bleached in a plant near the mine just south of Cedar Run. This plant was burned about 1900, and a reconstructed washing plant was shortly afterwards demolished by a flood. There has been no attempt to work any of the deposits since 1903.

GEOLOGY

The Fauquier County barite area includes a small part of the Potomac Triassic area which, as described by Roberts,[51] "extends from the Potomac River, south to the Rapidan River, an average length of approximately 86 miles and with a width of from less than half a mile to 15.10 miles." Bedrocks include conglomerates, sandstones, and shales which show gradations from one type to another, and stocks and dikes of diabase. The rocks east and west of the Triassic area are chiefly pre-Cambrian schists and gneisses. According to Roberts,[52] "folding throughout the Virginia Triassic is that of the simple monoclinal type, faulted at many places and with from one to three systems of jointing."

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[50] Watson, T. L., Geology of the Virginia barite deposits: Am. Inst. Min. Eng. Trans., vol. 38, pp. 712-713, 1907.

[51] Roberts, J. K., The Geology of the Virginia Triassic: Virginia Geol. Survey Bull. 29, p. 2, 1928.

[52] Idem., p. 71.

Although elevations in the barite area vary from 150 to 350 feet, there are no conspicuous topographic expressions, with the exception of a broad ridge east of and parallel to the Southern Railway.

The Cedar Run, Botts, Gear, and Kemper mines and prospects are in a broad belt of Triassic Bull Run shales, whereas the bedrock at the St. Stephens mine is diabase.

ASSOCIATED ROCKS

Bull Run shale.—The Bull Run shale includes shales and intercalated sandy layers ranging in color from dull red at the Cedar Run mine to various shades of blue and gray southeast of Bealeton. In texture the rocks vary locally from dense fine-grained mudrock to relatively coarse and gritty shale. The bulk of the rock is made up of clay and hydrated iron oxide, with variable amounts of quartz, feldspar, sericite, and calcite.

Silicification of the Bull Run shale was noted along many of the barite veins (Pl. 2, A). The quartz in such occurrences is usually mixed with barite and calcite.

Diabase dikes.—Several diabase dikes intrude the Triassic sediments in the barite area, but only at the St. Stephens mine has barite been found in association with diabase. At this locality, 2 miles west of Catlett Station, the dike, although deeply weathered, can be traced by the abundant concentrically weathered boulders. The relatively fresh diabase has a medium-grained texture and a dark-gray to black color, whereas weathered exposures vary in color from light-brown to red. Minerals identified include plagioclase feldspar, augite, and secondary limonite and chlorite.

PRINCIPAL MINES AND PROSPECTS[53]

St. Stephens mine.—The St. Stephens mine is 2 miles northwest of Catlett Station and 1,000 feet southwest of St. Stephens Church. It includes shallow trenches and open pits trending northwest for approximately one-fourth of a mile. The largest continuous working ranges from 10 to 20 feet in width and has a present maximum depth of 12 feet. It is reported that this mine was operated for a brief period shortly after the War between the States and that about 2,200 tons of barite was recovered.

A few fragments of white coarsely crystalline barite are scattered through the residual clay in all of the workings, but there is no indication of commercial reserves. In fact, due to its long

[53] See Fig. 13.

period of inactivity and poor showing of barite, this property has been considered by some residents as an old metal mine.

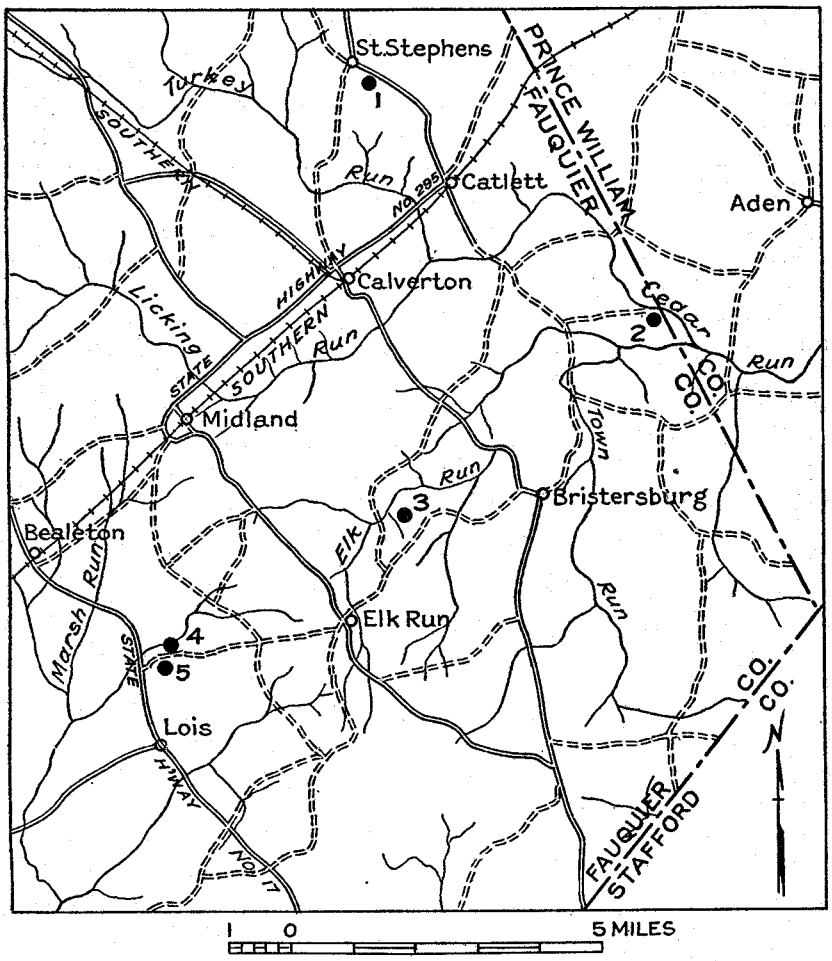


FIGURE 13.—Map showing location of barite deposits in Fauquier County, Virginia: 1, St. Stephens mine; 2, Cedar Run mine; 3, Botts prospect; 4, Gear mine; 5, Kemper mine. (Base from maps of Fauquier and Prince William counties by State Department of Highways.)

All of the workings are in the decomposed part of a diabase dike which can be traced across the barite area east of the Southern Railway. Large spheroidal boulders of diabase are abundant in the open workings and scattered over wide adjacent areas, but no bedrock in place was noted. However, it is most reasonable to assume that the barite represents original fissure filling or replace-

ment of the diabase, and, due to its high insolubility, remained in the decomposed part of the parent rock. As far as known this occurrence in diabase is unique for the Virginia barite, but similar deposits have been noted[54] in New Jersey.

Cedar Run mine.—The Cedar Run mine, owned by the James Walton heirs of Vienna, Fairfax County, is 4 miles southeast of Catlett and about 700 feet south of the Prince William-Fauquier county line and Cedar Run. It was operated at different periods from 1845 to 1903, and was the largest mine in the Fauquier County barite area. However, the total barite production of the Virginia Triassic area was relatively unimportant in comparison with other actively mined areas in the State.

At the present time the works are partly filled with water and rock debris but, according to Milton Teets, who helped with the mining, the original developments consisted of an inclined tunnel 250 feet long which at its southern end connected with a vertical shaft at a depth of 45 feet below the surface, and extensive open cuts northeast of the shaft. The shaft was continued to a depth of about 125 feet. All that remains of the extensive open workings is an irregular open cut about 200 feet long, 20 feet wide, and 15 feet deep.

The red shales exposed near the surface in the shaft dip about 15° NW., and apparently are not intensely fractured. However, specimens of bedrock from greater depths are brecciated and cemented by barite and other vein materials.

Barite is said to have been present in workable quantities at the bottom of the deepest workings. Although large masses of coarsely crystalline calcite and smaller amounts of fine-grained quartz are associated with the barite on the dumps, it is reported that these minerals were not objectionable in mining operations. The large volume of water encountered throughout the workings made mining difficult and finally caused abandonment of operations. In addition to unfavorable local ground-water conditions, the location of the mine with respect to Cedar Run makes it susceptible to flood waters. This consideration is significant when it is recalled that the milling plant was partly destroyed during high water about 1902.

Botts prospect.—The Botts prospect is about 2 miles northeast of Elk Run Village. A few fragments of white barite are scattered over the surface and other fragments of barite were reported at depth in a well.

[54] Lewis, J. V., The magmatic origin of barite deposits [Discussion.]: Econ. Geology, vol. 14, no. 7, p. 570, 1919.

Since this occurrence is aligned with the Cedar Run, Kemper, and Gear mines, there is a possibility of a continuous fracture zone extending northeasterly through the Fauquier County barite area, which is locally mineralized. However, the writer has no additional field data to substantiate this inference.

Gear mine.—The Gear mine, now owned by H. N. Ritchie, is about 3 miles southeast of Bealeton, 1½ miles north of Lois and half a mile northeast of State Highway No. 17. It is reported to have been opened about the same time as the Cedar Run mine, but was not an important producer.

The old workings, when visited in 1938, included two open cuts, each approximately 200 feet long, 15 feet wide, and 12 feet deep, and one shallow shaft. Unquestionably the original workings were more extensive.

Bedrock is not exposed, but scattered over the surface in the immediate vicinity are abundant fragments of red, gray, and blue Bull Run shales cemented by barite, quartz, and calcite. Microscopic examination of these fragments shows the development of secondary quartz crystals, a feature not observed in bedrock a short distance from the mine. It is probable that quartz accompanied the deposition of most of the barite. Exceptions to this contemporaneous deposition are fractured quartz veins subsequently filled with barite and calcite (Pl. 7, A).

In a field southwest of and adjoining the mine are numerous fragments of white coarsely crystalline residual barite. With the exception of an occasional attached fragment of country rock, the barite appears to be of good quality. It is not thought that a large body of barite exists at this locality, however, a shallow trench trending S. 20° W., from the mine may reveal a small deposit.

Kemper mine.—The Kemper mine, one-fourth of a mile south of the Gear mine and just east of State Highway No. 17, consists of two caved circular pits, approximately 20 feet in diameter. At the time visited the openings were largely filled with surface wash and vegetation, but a few small fragments of barite were noted on the surface. The showing at this property is not encouraging, and it is most likely that the deposit has been largely exhausted.

ROANOKE-BOTETOURT COUNTIES AREA

LOCATION

In Roanoke and Botetourt counties the barite deposits which have been most extensively worked are a few miles north of Roanoke and west of Fincastle, in the central part of the Valley and Ridge province[55] of Virginia (Fig. 14). Distinguishing characteristics of this province are a series of broad elongate valleys in the eastern part, the Valley of Virginia, and narrow linear mountains and valleys to the west, in the Valley Ridges section. Elevations of the maturely dissected mountainous ridges generally range from 2,000 to 3,000 feet, whereas the undulatory floor of the Great Valley in this area averages about 1,200 feet.

HISTORY

Some of the old operations in Roanoke and Botetourt counties are comparable in size to other areas, but so far as known they have never been described. It is reported that a shaft was sunk at the site of the present Williamson mine about 1850. Small quantities of barite were shipped to Lynchburg from the Crush deposit about 1894, and the last active mining on the Rucker property was in 1906. With the exception of some prospecting at the Williamson mine in 1917 the entire area remained idle until about 1934, when J. N. and N. S. Hotinger[56] of Lexington, Virginia, began prospecting at various places in the vicinity of Fincastle in Botetourt County and near Vesuvius in adjoining Rockbridge County. Their discoveries led to the construction of a small washing plant at the Gusler-Austin deposit near Fincastle, which began operating in the fall of 1935. The Clinchfield Sand and Feldspar Co., of Baltimore, Maryland, worked the same deposit for a few months beginning in the fall of 1936, but at the present time there is no mining in the Roanoke-Botetourt counties area and most of the machinery has been removed from the old workings.

It is estimated that from 8,000 to 10,000 tons of barite were recovered from four deposits in this area during 1935-1936.

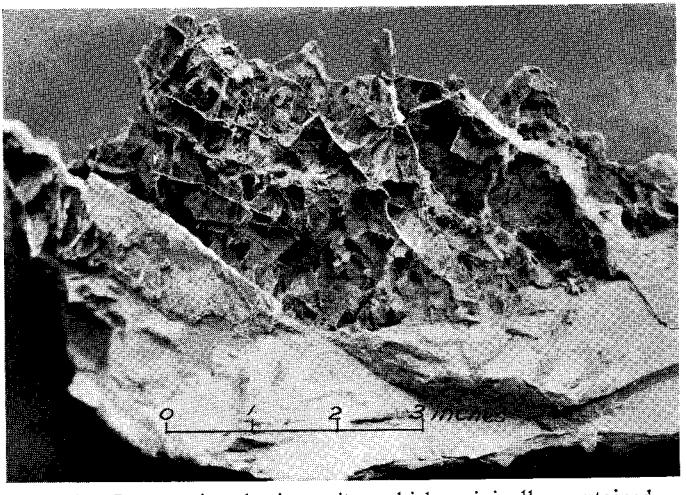
GEOLOGY

The consolidated sedimentary rocks of the Roanoke-Botetourt counties area range in age from Lower Cambrian to Lower Mississippian, and according to Woodward[57] have a total thickness of more than

[55] Fenneman, N. M., Physiographic divisions of the United States: Assoc. Am. Geographers Annals, vol. 18, pp. 296-300, 1928.

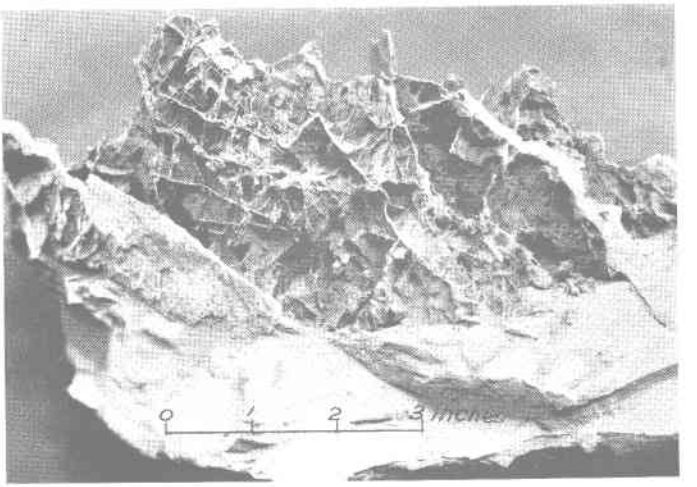
[56] Messrs. J. N. and N. S. Hotinger have given the writer much information concerning the barite deposits of the Roanoke-Botetourt counties area.

[57] Woodward, H. P., Geology and mineral resources of the Roanoke area, Virginia: Virginia Geol. Survey Bull. 34, p. 27, 1932.



A. Intersecting barite veins which originally contained angular fragments of limestone; at the Reed mine, Roanoke County, Virginia.

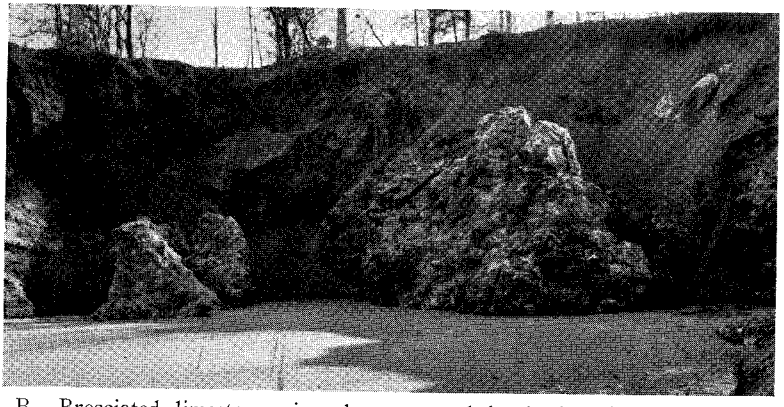
B. Barite vein about 4 feet wide; on the F. Vaught prospect, Grayson County, Virginia.



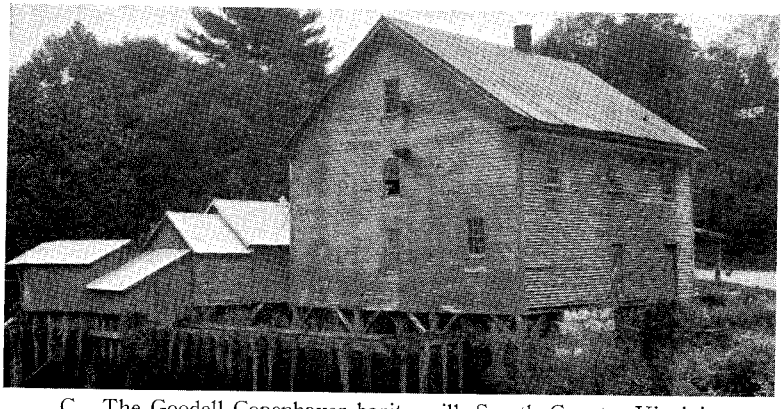
A. Intersecting barite veins which originally contained angular fragments of limestone; at the Reed mine, Roanoke County, Virginia.

B. Barite vein about 4 feet wide; on the F. Vaught prospect, Grayson County, Virginia.

A. The Hewitt mine, Campbell County, Virginia, northeast along the strike. Marble crops out along bottom between micaceous quartzite on left and mica schist on right.



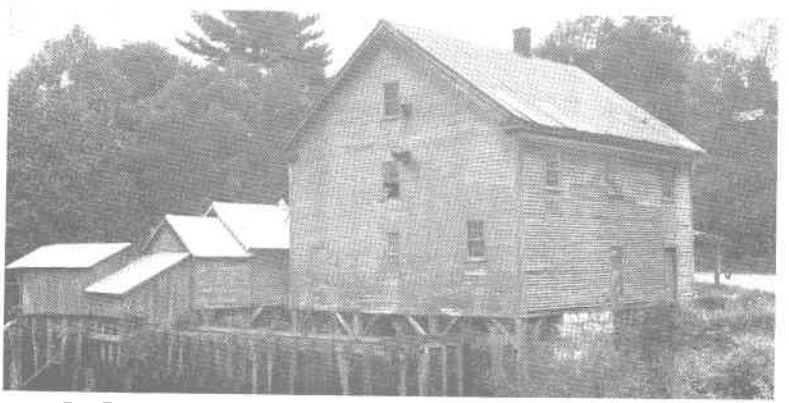
B. Brecciated limestone pinnacles cemented by barite; in the Gusler-Austin mine, Botetourt County, Virginia.



C. The Goodell-Copenhaver barite mill, Smyth County, Virginia.

A. The Hewitt mine, Campbell County, Virginia, northeast along the strike. Marble crops out along bottom between micaceous quartzite on left and mica schist on right.

B. Brecciated limestone pinnacles cemented by barite; in the Gusler-Austin mine, Botetourt County, Virginia.



C. The Goodell-Copenhaver barite mill, Smyth County, Virginia.

17,000 feet. These rocks, principally shales, limestones, and sandstones, crop out in anticlinal and synclinal folds and at many places are dislocated by faults.

It does not appear from preliminary field studies that the barite deposits in this area are limited to any definite stratigraphic horizon, since commercial occurrences were noted in limestones and dolomites of Upper Cambrian, Ozarkian, Canadian, and Ordovician ages. The bedrock in some of the workings, namely, the Reed and Gusler-Austin mines, is traversed by many intersecting fractures filled with barite. This brecciated bedrock suggests to the writer that fracture zones (Pl. 11, A), have been the controlling factor in the barite deposition. In addition to the filling of the fracture zones, bedding planes, and joint surfaces, there is considerable replacement of the calcareous rocks.

Mining in this area has been limited to the residual deposits, and unless additional deposits of this type are discovered it seems most probable that those already known will not be able to compete successfully with others in producing areas. Certainly, the known bedrock occurrences in the Roanoke-Botetourt counties area are not sufficiently extensive to be of much commercial importance.

ASSOCIATED ROCKS

Table 2, prepared from published reports and maps,[58] gives the bedrock and its geologic age for each of the barite deposits of the Roanoke-Botetourt counties area. Brief descriptions of the lithology and structure of the bedrock are included in the descriptions of the individual mines and prospects.

TABLE 2—*Bedrock of Roanoke-Botetourt counties barite deposits*

DEPOSIT	FORMATION OR GROUP	SYSTEM
Shorter	Beekmantown	Canadian.
Johnson	Beekmantown	Canadian.
Crush	Beekmantown	Canadian.
Williamson	Conococheague	Ozarkian.
Caldwell	Athens	Ordovician.
Gusler-Austin	Beekmantown	Canadian.
Huffman	Beekmantown	Canadian.
Reynold	Conococheague	Ozarkian.
Rucker	Beekmantown	Canadian.
Reed	Elbrook	Cambrian.

[58] Butts, Charles, Geologic map of the Appalachian Valley of Virginia with explanatory text: Virginia Geol. Survey Bull. 42, 1933.
Woodward, H. P., Geology and mineral resources of the Roanoke area, Virginia: Virginia Geol. Survey Bull. 34, 172 pp., 1932.

PRINCIPAL MINES AND PROSPECTS[59]

Crush mine and prospect.—The Crush mine is approximately 1½ miles northwest of Kyles Mills and northeast of Flatwood School. It was probably never an important producer, but small quantities of barite are reported to have been shipped to the milling plant in Lynchburg in 1894. Scattered fragments of barite on the surface led to recent prospecting along Slate Creek about one-fourth of a mile southwest of the old mine.

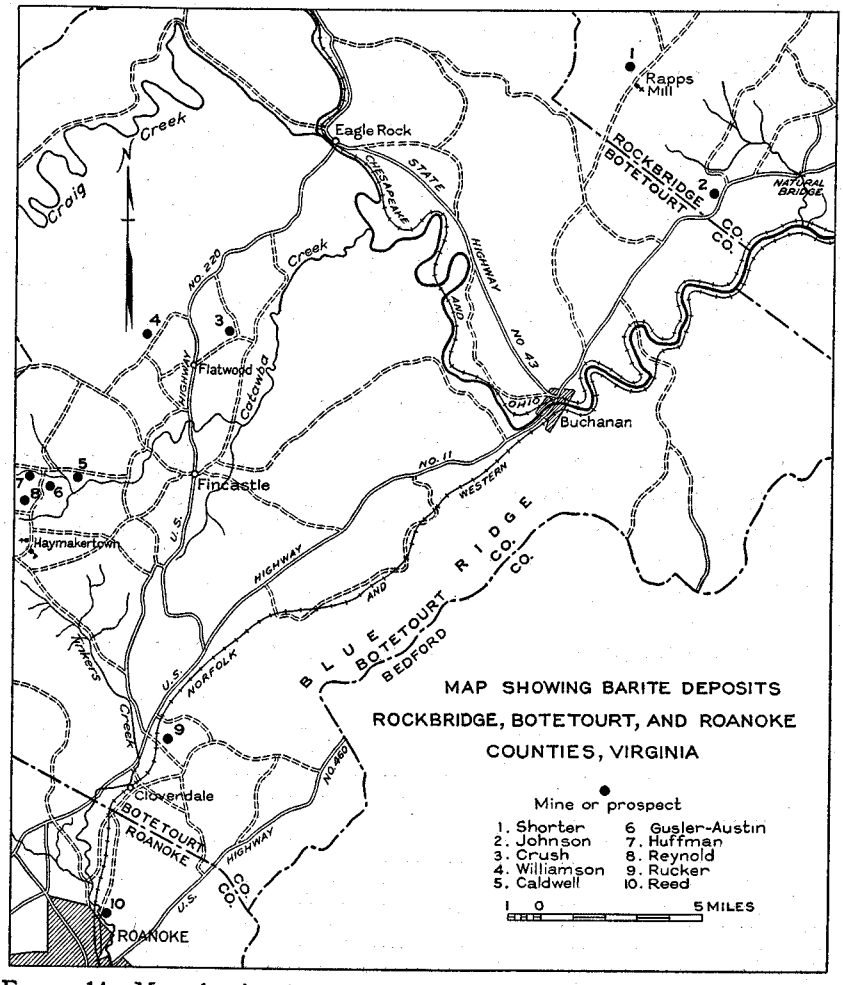


FIGURE 14.—Map showing location of barite deposits in Rockbridge, Botetourt, and Roanoke counties, Virginia. (Base from maps of Rockbridge, Botetourt, and Roanoke counties by State Department of Highways.)

[59] See Fig. 14.

The original open cut is 150 feet long, 30 feet wide, and 15 feet deep with an inclined shaft dipping northwest near the southwestern end. At the time of the writer's visit this shaft was accessible to a depth of only 10 feet. Dove-colored compact Beekmantown limestone striking N. 60° E., and dipping southeast crops out along the northwest wall and forms isolated pinnacles near the southern end of the cut. About 500 feet east of the Crush mine and prospects are exposures of Athens shale which parallel the northeast trend of the barite occurrences. Small stringers of barite with random orientation were noted in the limestone, but they probably are not of commercial importance. It also appears that the residual barite has been largely exhausted.

The several shallow prospect pits and trenches on the north side of Slate Creek have not reached bedrock, but along the stream east of the workings are exposures of Beekmantown limestone striking N. 70° E., and dipping 80° SE. Small quantities of white crystalline barite were encountered in residual mantle in the prospect pits, but the limited extent of the prospecting makes it impossible to comment on the probable reserves.

Williamson mine.—The Williamson mine is about 4½ miles northwest of Fincastle and half a mile west of New Hope School. It is at an elevation of 1,600 feet and near the crest of one of the many ridges which parallels Switzer Mountain.

Reported operations at this locality, about 1850, represent one of the earliest attempts to mine barite in Virginia. This work, including a few shallow prospect pits and one open cut about 20 feet in diameter and 30 feet deep, was entirely in the residual soil mantle. No data are now available concerning the history or production of this early operation, however, the limited extent of the workings indicates that it was of minor importance.

The first systematic prospecting of the Williamson property was by N. S. Hotinger in 1935, although attempts to rework the old mine were made in 1917. The recent prospecting included several trenches across the northeast trend of the deposits. Sufficient barite was found to encourage mining operations during 1936 when about 350 tons were recovered from an open cut 200 feet long, 30 feet wide, and 15 feet deep. The barite was recovered from the red-yellow residual soil derived from the Conococheague limestone and dolomite which just east of the mine strikes N. 30° E., and dips 50° SE. A few pinnacles of brecciated dolomite which did not appear to contain any barite were exposed near the northeastern end of the open cut.

Since only a few small fragments of barite were noted in the open cut, it is most probable that this deposit has been largely exhausted.

Caldwell prospect.—The Caldwell prospect is about 1½ miles west of Howell Mills and 1 mile east of Pleasantdale School. The small amount of residual barite in the shallow workings, which are closely spaced in a N. 50° E., direction for about 300 feet, indicates that near-surface concentration of barite is not present and it is unlikely that commercial quantities occur at greater depths.

The dark-gray to black color is unique for Virginia barite and for that reason a brief mention of this occurrence may be of scientific interest. The mineral is coarsely crystalline, soft, and gives off a fetid odor when two pieces are rubbed together. The odor and color are probably due to the presence of carbonaceous matter. The form of combination of the carbon was not determined, but it is of a combustible type, since the barite turns white on heating before the blowpipe.

Geologic maps covering the Roanoke-Botetourt counties area show the Caldwell prospect to be in a wide expanse of Athens shale and along an oblique fault which can be traced northwest of Fincastle and Howell Mills. Black finely crystalline limestone, which probably represents the thin calcareous beds near the base of the Athens formation, crops out in two of the barite workings.

Gusler-Austin mine.—The Gusler-Austin mine, 1½ miles northeast of Haymakertown and 2½ miles southwest of Howell Mills, which was opened in the spring of 1935 and closed in 1937, represents the most important barite operation in the Valley and Ridge province of Virginia during the past 25 years.

The mine is an almost circular open cut approximately 150 feet in diameter and 70 feet deep (Pl. 12, B). Mining was begun on the Gusler farm, but the greater quantity of barite was recovered from the adjoining Austin property (Fig. 15).

Dolomite of Beekmantown age forms pinnacles in the deeper parts of the cut and is exposed along the southern wall. It is a finely crystalline blue dolomite which appears gray on weathered surfaces. No chert was noted in the bedrock, but the residual red-yellow soil contains an abundance of jagged chert fragments. The bedrock is broken into a mass of large irregular fragments which are, in part, cemented by barite. In addition to these thin veins, there are irregular replacement masses of barite several inches in diameter. The bedding surfaces are not well shown, but it is estimated that the rocks strike N. 35° E., and dip at a low angle to the SE.

The deposit was opened and first mined on a small scale by hand methods, but most of the barite has been mined by a drag-line scraper. Operators report that this method of mining is well adapted to the residual type of deposit, since with one operation the material is ex-

cavated, transported to an elevated platform, and mechanically loaded into cars or trucks that connect with the washer. Trucks were used to transport the crude barite from the shallow workings to the washing plant, but as the open cut was deepened narrow gauge cars drawn by cables were substituted for the trucks.

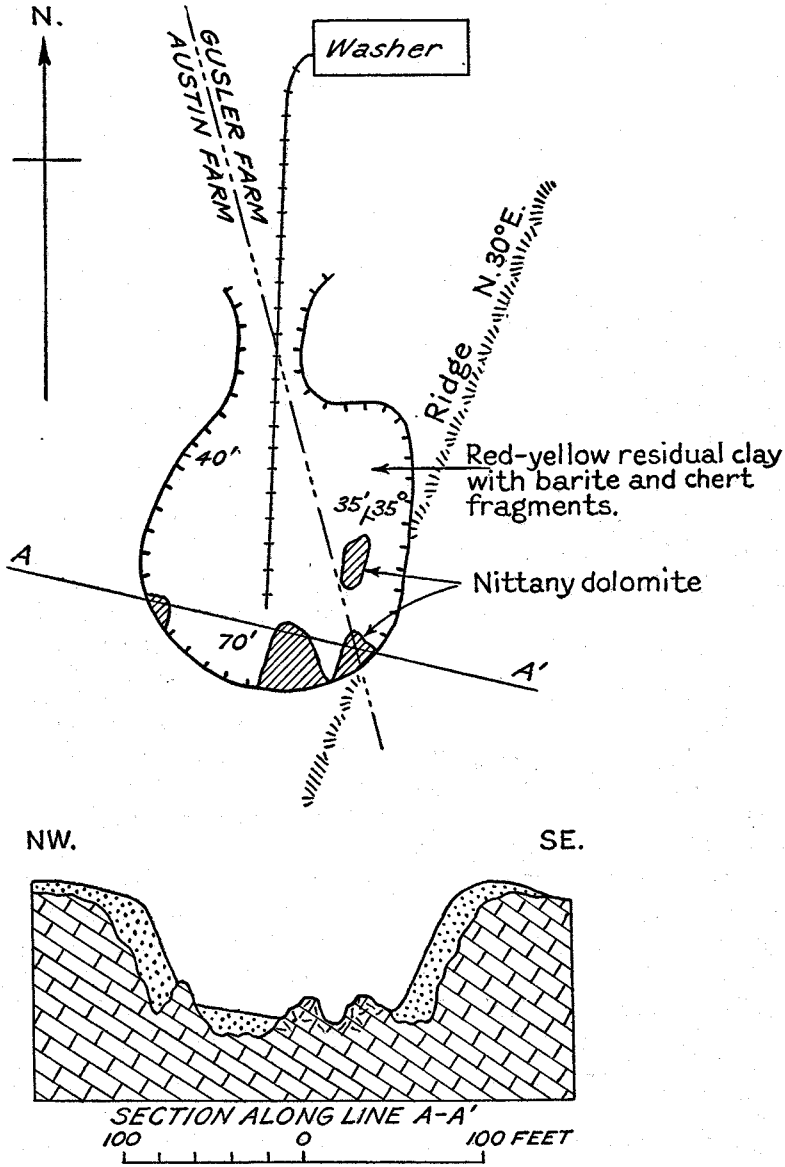


FIGURE 15.—Plan and generalized cross section of the Gusler-Austin mine about 2½ miles southwest of Howell Mills, Botetourt County, Virginia.

Most of the machinery has been removed from the washing plant, but the reported method of concentrating the crude material followed closely a flow sheet of a typical barite washing plant (Fig. 4). A magnetic separator and dryer were installed by the last operators to decrease the objectionable iron content, but the results of this refining technique are not known to the writer.

Independent laboratory tests on some of the Virginia barite containing objectionable amounts of ferric hydroxide consist of heating the finely powdered barite in a reducing environment and then passing it over a magnetic separator. This greatly reduces the iron content, but the present low market value of crude barite probably will not encourage the expense of this additional treatment.

It is reported that the supply of residual barite was not exhausted when the mine was abandoned. The writer was not able to verify this statement, because at the time of his visit the open cut was partly filled with water. However, it is not thought that large commercial quantities of barite remain in this mine, since exposures of bedrock at several places in the open cut indicate a thin remnant of residual soil mantle. The small occurrences of barite in consolidated bedrock are not of commercial importance.

Huffman prospect.—The Huffman prospect is 100 feet south of a sharp bend in Rocky Branch Creek and about three-fourths of a mile northwest of the Gusler-Austin mine.

During 1936 a few irregular fragments of white coarsely crystalline barite were recovered from the residual soil in two shallow pits, but the find does not indicate a reserve of any commercial importance.

Reynold mine.—The Reynold mine is about 1 mile northwest of Haymakertown and 1½ miles southwest of the Gusler-Austin mine. It consists of an open cut approximately 30 feet long and 10 feet deep and a few shallow trenches. The barite is associated with chert fragments in a thick mantle of yellow soil derived from the Conococheague limestone and dolomite of Ozarkian age.

It is reported that 90 tons of high-grade barite were recovered from this mine. Barite has also been discovered in shallow pits on the adjoining Looney farm. Extensive prospecting with the necessary outlay of money is not recommended on either of these farms. However, there is a rather wide distribution of barite fragments on the surface between the two known occurrences, and small trenches located where the residual fragments are most abundant may reveal greater concentrations at depth.

Rucker mine.—The Rucker mine is 1½ miles northeast of Cloverdale and half a mile east of the Norfolk & Western Railway. It

consists of about 25 open cuts that range in diameter from 4 to 20 feet and some of which have a maximum depth of 30 feet. These workings are scattered over an area of several acres, but only two or three openings along a narrow north-south zone are reported to have contained sufficient barite to be profitably mined. The operations were abandoned about 1906 and remained idle until 1934 when a few tons of barite were recovered from a narrow trench 5 feet deep and 50 feet long. This trench, although placed near the southern end of the inferred greatest concentration, does not promise residual barite in sufficient quantities to be recovered commercially.

Bedrock does not crop out in any of the workings, but the property is in an area of Beekmantown limestone and dolomite. Approximately 100 yards east of the pits a blue-gray dolomite strikes N. 45° E., and dips 55° SE. Chert is abundant both in the bedrock and the overlying residual mantle.

The barite is finely crystalline, white, and relatively free from visible impurities, except for clay adhering to the surface and occurring in the cavities left by the solution of included fragments of the enclosing rock.

Reed mine.—The Reed mine is in Roanoke County, about 1 mile southwest of Reed Mountain, and one-fourth of a mile north of Tinker Creek. The workings, four shallow open cuts about 20 feet wide and 40 to 60 feet long, are on the southwest slope of a low ridge that terminates on the municipal golf course.

Thinly bedded bluish-gray Elbrook limestone of Cambrian age crops out along the walls and in the bottom of the cuts. It is broken by abundant intersecting fractures that are cemented by thin seams of barite (Pl. 11, A). In addition to these cavity fillings there are replacement bodies several inches in width along the fractures and bedding surfaces of the limestone. This deposit illustrates clearly the deposition of barite along fracture zones or what has been referred to earlier in this report as breccia zones. The secondary fractures have so completely obliterated the primary structures that it is impossible to obtain accurate strike and dip determinations.

Since the residual barite is largely exhausted, it is most probable that the deposit cannot be considered of commercial value.

RUSSELL-TAZEWELL-SMYTH COUNTIES AREA

LOCATION

Barite has been mined and prospected from near North Tazewell in Tazewell County to Spring City in Russell County (Pl. 13). The deposits are aligned along a narrow belt trending N. 50° E., for a dis-

tance of approximately 35 miles. More specifically they are along Clinch and Little rivers and within a mile of North Tazewell, Maxwell, Pounding Mill, Steeleburg, Clifton, Barrett School, Blackford, Spruce Pine Church, Corner School, and Daughertys Cave. The most extensive operations have been in the vicinity of Pounding Mill, Blackford, and along Cedar Creek 2½ miles northeast of Lebanon.

The principal occurrences of barite in Smyth County that have been mined and prospected are within a 3-mile radius of Marion, the county seat (Pl. 13). In this area extensive open cuts are found along the crest of a prominent ridge 2 miles southwest of Marion, near Mt. Carmel 2 miles northeast of Marion, along the Middle Fork of Holston River northeast of McMullin, and in Wassum Valley within half a mile of Mt. Zion School. In addition to these developments, there have been small shipments from Rich Valley just south of the North Fork of Holston River and about one-half a mile east of Longhollow.

HISTORY

The first barite mining in southwestern Virginia was by G. G. Goodell who developed the deposits northeast of Marion in Smyth County in 1875. Other near-by deposits were subsequently discovered and mined until about 1885. The extent of the work following this period is not definitely known, but it is reported by residents of the area that mining was continued on a small scale until 1906. Watson[60] states that 2 cars of barite were shipped from the Copenhaver property on the west side of Marion in the fall of 1906.

During the period of active mining, the barite was prepared for market by the "Marion Barytes Works" in Marion and a smaller mill (Pl. 12, C), operated by Goodell and H. P. Copenhaver, along the Middle Fork of Holston River about 2½ miles southwest of Marion. The steps involved in the preparation of the mineral at the Marion plant[61] were the removal of the attached limestone and ferruginous impurities, washing, hand-sorting and grading, grinding in buhr mills, air-floating, and finally, packing in barrels. In 1882 this mill produced 2,000 net tons of barite, but when the local supply gradually became inadequate additional material was obtained from other areas in order to continue operation.

Mining and milling of barite in Tazewell and Russell counties were begun on a commercial scale in 1880 and continued intermittently until about 1908. The earliest known mining was by W. W. Peery on the Hopkins and Hubble estates in Tazewell County and by J. Harrison,

[60] Watson, T. L., Mineral resources of Virginia: Virginia-Jamestown Exposition Commission, p. 322, 1907.
[61] U. S. Geol. Survey, Mineral Resources of the United States, pp. 580-581, 1883.

who about the same time developed many of the deposits in Russell County. The barite recovered during this early period was ground in small mills along Lewis Creek and at Gardner in the southwestern part of the belt and at another mill along Cavitts Creek west of North Tazewell. According to W. E. Mutter of Blackford, Virginia, large quantities of barite, especially in Russell County, were profitably mined during this early period of operation.

About 1900, added interest was directed to the barite occurrences in Russell and Tazewell counties and in order to handle the expected production several mills were erected in the area. The Clinch Valley Barytes Company erected a mill along Clinch River three-fourths of a mile southwest of Blackford and a spur line of the Norfolk and Western Railway was extended from Honaker to the plant. Most of the barite in the southern part of the area, particularly that from the Counts, Leonard, and Hubbard mines, was prepared for market at this plant. Within a few years, owing to the gradual diminution of the local supply, barite was imported from Kentucky, Tennessee, and South Carolina to maintain operation of this mill. Following the abandonment of the mill in 1907, the railroad was extended to the village of Blackford.

Between 1900 and 1907, the Pittsburgh Baryta and Milling Corporation erected a modern plant at Richlands in Tazewell County which had a capacity of 50 tons per day. According to Watson,[62] this corporation carried on extensive mining in the northeastern and southwestern ends of the belt, and 3 miles south of Richlands. As in the case of the Clinch Valley Barytes Company, this mill imported barite and feldspar for grinding when the local barite reserves began to diminish.

A mill, between Clinch River and the Norfolk & Western Railway about half a mile southwest of Pounding Mill, was constructed by the Tri-State Mining and Manufacturing Company. After working for a short time the machinery was bought by the Wyman Baryta Company which subsequently operated the old mill at Gardner.

The John T. Williams and Son plant, along the Norfolk & Western Railway 2 miles north of Bristol, operated during the period of active barite mining in Russell and Tazewell counties, but most of the material ground and prepared for market by this mill was obtained from other areas in Virginia, North Carolina and Tennessee.

With the exception of the mills at Gardner and near Marion, the other plants in southwestern Virginia have been dismantled for more than 20 years.

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[62] Watson, T. L., Mineral resources of Virginia: Virginia-Jamestown Exposition Commission, Lynchburg, Va., p. 324, 1907.

Published data concerning the production of individual mines or mills were not available to the writer, but many of the older residents who were familiar with the local barite operations have given him helpful information. The summation of these reports indicates that the largest producers were the Hopkins, Earls, Ringstaff, Counts, Hubbard, Leonard, Copenhavers, and Faris mines.

Small quantities of barite, chiefly in bedrock, were noted in most of the old workings, but it is the writer's opinion that the cost of recovery will not permit successful future operation of most of the old properties. Since practically all commercial production in the Russell-Tazewell-Smyth counties area ceased more than 30 years ago, anyone interested in reviving operations in this area should carefully investigate the old mines and prospects before investing money in new explorations. It is doubtful if any of the old properties in this area can be profitably reworked, however, there is always the possibility that new deposits, some of which may be of commercial importance, may be discovered.

GEOLOGY

In Smyth County the barite deposits occur in the Valley of Virginia which is the eastern division of the Appalachian Valley and Ridge province. Locally the Valley is about 10 miles wide and has an average elevation of 2,200 feet. It is well drained by small streams that flow southwest into the Middle and North forks of Holston River.

In Russell and Tazewell counties the barite deposits are in the western part of the Valley and Ridge province, east of the Appalachian Plateaus. This region is characterized by several linear northeastward-trending ridges which, with the exception of Clinch Mountain, are not persistent across the two counties. Clinch Mountain is sinuous and broadens into a plateau east of Hansonville and south of the Russell-Washington county boundary. Most of the barite is on the southeastern slopes of Whitleys, Smith, Kent, and Copper ridges at an average elevation of about 2,200 feet. The area is drained southwestward by Clinch and Little rivers and their tributaries.

ASSOCIATED ROCKS

The barite in Russell, Tazewell, and Smyth counties occurs as fracture fillings and replacement masses in Beekmantown limestone and dolomite, and as irregular lumps in the overlying residual soil mantle. In Smyth County, Nittany chert containing *Lecanospira,* was noted in association with some of the barite deposits. In Russell and Tazewell counties the barite apparently occurs near and stratigraphically beneath the red shale and pinkish dolomite of the Murfreesboro limestone.[63]

[63] Butts, Charles, personal communication, 1933.

Persistent exposures of red shale and pinkish dolomite, east of the narrow barite belt, from North Tazewell to Blackford, were helpful in locating many of the old deposits and should be a useful guide in future prospecting.

The bedrock occurrences of barite are in thick-bedded, light-gray dolomite that yields an abundance of cavernous chert, and in dense blue-gray and crystalline limestone. The crystalline limestone common in many of the abandoned mines weathers to a brown color and has a rought pitted surface.

According to Cooper,[64] the major structure of the Marion area in Smyth County is an asymmetrical, overthrust dome, which probably accounts for much of the complex faulting in the region. Parts of the Walker and Glade-Pond mountains shingle-blocks are separated by the Seven Springs fault which swings irregularly across the area, dividing typical Appalachian structures with regional trends from the more complicated structures peculiar to the Marion area.

South and southwest of Marion the barite occurs in a narrow wedge of Nittany dolomite which is faulted against the Conococheague on the south and Athens shale to the north. In Wassum Valley one of the largest deposits of the entire area is near the axis of a plunging structure, Marion Dome, which is faulted up against the Athens shale.[65] Barite was not identified in any of the fault surfaces, but the deposits occur in belts of highly fractured dolomite.

In Russell and Tazewell counties the bedrock in most of the barite deposits strikes about N. 55° E., and dips steeply to the southeast. Local structures, such as small folds and fracture zones, were noted in some of the barite workings. The fractures, apparently formed during the folding of the more competent layers, traverse the rocks in all directions. In places in the workings bedrock shows closely spaced intersecting fractures filled with barite and associated gangue minerals. It should not be inferred that the primary structures, bedding surfaces and joints, do not contain barite, but it is thought that the secondary fractures have been of more importance in the localization of the deposits.

In the following individual descriptions the various mines and prospects in the Russell-Tazewell-Smyth counties area are designated mainly by the name of the owner during the period they were operated. (See Pl. 13.)

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[64] Cooper, Byron N., Stratigraphy and structure of the Marion area, Virginia: Virginia Geol. Survey Bull. 46-L, p. 159, 1936.
[65] Idem., p. 139.

PRINCIPALS MINES AND PROSPECTS[66]

Fudge mine and prospect.—The Fudge mine is near the northeastern end of the barite belt in Tazewell County and about half a mile northwest of North Tazewell. This mine which was operated between 1885 and 1890 by Captain Fudge, includes two open cuts, each about 100 feet long, 30 feet wide, and 12 feet deep, and several shallow trenches and pits. Bedrock is not exposed in the old workings, but small fragments of angular chert and barite were noted in the red soil mantle.

About one-fourth of a mile northeast of the Fudge mine are two inclined shafts about 6 feet in diameter and 15 feet deep, and several shallow open cuts, which were dug by the late J. D. Peery in 1917. The bedrock exposed in the prospects is a fine-grained gray dolomite that strikes N. 70° E., and dips 35° SE. Chert layers parallel with the bedding are abundant. Thin seams and replacement masses of barite occur along the bedding and in fractures with random orientation.

K. Peery mine.—The K. Peery mine comprising two open cuts, each about 10 feet deep and 20 feet in diameter, is near the crest of Whitleys Ridge 1 mile west of North Tazewell and half a mile north of Clinch River. The abundant residual barite in the vicinity of the workings suggests that concentrations of barite of possible future importance may be obtained by small-scale mining; however, the barite appears to have a high content of iron which may prove objectionable. Many of the barite fragments are coated with a layer of iron oxide about one-fourth of an inch in thickness.

M. L. Peery mine.—The M. L. Peery mine, a small open cut, is in the bend of Cavitts Creek about one-fourth of a mile west of the crest of Whitleys Ridge. It is reported that most of the barite mined on this property was obtained from several deep openings in the bed of the creek which are now completely flooded and inaccessible. A grinding plant which was operated during the first barite mining in Tazewell County, was located near this mine.

Hubble mine.—The Hubble mine is one-fourth of a mile north of Clinch River and about 200 feet west of State Highway No. 81. It consists of a shallow trench, about 8 feet deep and 200 feet long, extending northeastward to a small tributary of Cavitts Creek. This mine was among the first to produce barite in Tazewell County, but at the present time it contains no showing of residual barite of any importance.

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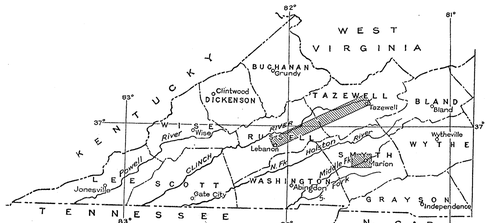
[66] See Pl. 13.



INDEX MAP SHOWING LOCATION OF BARITE AREAS IN RUSSELL, TAZEWELL, AND SMYTH COUNTIES

10 0 50 MILES

SKETCH MAP OF RUSSELL - TAZEWELL COUNTIES BARITE AREAS

5 MILES

MINE OR PROSPECT

1. Fudge
2. K. Peery
3. M. L. Peery
4. Hubble
5. Hopkins
6. Taylor
7. Earl
8. Altizer
9. Steele
10. Ringstaff
11. Nipper
12. Clifton
13. Fletcher
14. Thomas
15. Harman
16. McGraw
17. Counts
18. Stump
19. Honaker
20. Hubbard
21. Meade
22. Blumer
23. Ward
24. Buckles
25. Leonard
26. Hughes-Cowan
27. Groseclose
28. Henderlite
29. McDonald
30. Eller
31. Cornett-Hull
32. Shanklin
33. H. P. Copenhaver
34. Miles-Gardner
35. Myers-L. Copenhaver
36. Faris

Base from Tennessee Valley Authority Quadrangles

SKETCH MAP OF SMYTH COUNTY BARITE AREAS

1 0 3 MILES

SKETCH MAPS SHOWING BARITE DEPOSITS IN RUSSELL, TAZEWELL, AND SMYTH COUNTIES, VIRGINIA

Hopkins mines.—The Hopkins mines comprise one open cut along the Baptist Valley Road one-fourth of a mile northwest of Clinch River and several vertical shafts along the crest of Hubble Hill about one-fourth of a mile farther southwest. The open cut is about 100 feet long, 20 feet wide, and 15 feet deep near the southwestern end. Gray fine-grained dolomite striking N. 80° E., and dipping 35° SE., crops out in the side walls of the cut. At the southwest end of the cut in an end wall, a four-foot zone of red clay is exposed between limestone layers. The clay containing barite fragments extends from the surface to the bottom of the open cut. Thin seams of barite occur in the bedrock and in the overlying soil mantle. This mine was one of the first operated in the area, and it appears that the supply of barite has been largely exhausted.

The shafts were last worked about 30 years ago and then subsequently filled with rock debris. They are reported to have been more than 50 feet deep with horizontal tunnels extending into the bedrock from the bottom of each. The shafts are located in a belt of Beekmantown dolomite, near red shale and dolomite of the Murfreesboro limestone. Locally these rocks strike N. 70° E., and dip 35° SE.

The total production from this property is not known, but records furnished by the son of E. O. Hopkins, who operated the mines, show that 234 tons of barite were shipped to the Tri-State Manufacturing Company during the first six months of 1904.

Taylor mine.—The Taylor mine which produced small quantities of barite about 1904 is three-fourths of a mile northwest of Maxwell and 700 feet northwest of a meander in Clinch River. It consists of two open cuts each about 30 feet long, 10 feet wide and 8 feet deep. The enclosing rock is a dense pearl-gray limestone that strikes N. 70° E., and dips 30° SE. No barite was noted in the workings when this property was visited.

On the north bank of Clinch River about three-fourths of a mile to the southwest are several small openings known as the Beaver mine.

Earl mine.—The Earl mine, which was one of the important barite producers in Tazewell County, is on the south bank of Clinch River one-fourth of a mile north of Cliffield. It is an open cut about 250 feet long, 20 to 100 feet wide, and from 6 to 20 feet deep.

Veins and replacement masses of barite as much as a foot thick are associated with a crystalline limestone which lies between a footwall of blue fine-grained limestone and a hanging wall of gray dolomite. Locally the rocks strike about N. 70° E., and dip 30° SE.

The barite noted in the bedrock and on the dumps is coarsely crystalline, white, and remarkably free from iron stains. Although it ap-

pears that some barite of good quality may remain here the cost of separating it from the attached wall rock will most probably prevent successful operation of this property under present market conditions.

Altizer prospects.—The Altizer prospects, about half a mile southwest of the Earl mine, were operated at different times between 1901 and 1905. Some of these openings, 20 to 30 feet in length, are comparable in size to many of the workings designated mines, but so far as known no barite was shipped from these prospects.

Steele mine.—The Steele mine is about 100 yards northeast of the Ringstaff property and, although a relatively small producer, was operated in 1902. It consists of an open cut 30 feet long, 20 feet wide and 12 feet deep. Fine-grained gray dolomite crops out along the southeast wall, but all of the barite noted by the writer was in the overlying residual clay.

The Ringstaff and Steele mines show that barite occurs in pockets or lenses of variable size and that it is not possible to predict accurately the distribution or limits of barite deposits even within short distances of known occurrences.

Ringstaff mine.—The Ringstaff mine, one-fourth of a mile northwest of Pounding Mill, was one of the largest producers of barite in Tazewell County. It was in operation about 1902. The larger of the two open cuts is about 100 feet long, 60 feet wide at the northeastern end, and 20 feet deep. It was mined chiefly as a residual deposit, but the last stages of development were in limestone and dolomite which strike N. 60° E., and dip 25° SE.

Barite veins and lenses, with a maximum thickness of 2 feet, are abundant along the northeast wall of the cut and appear to occupy a fracture zone. This zone has a width of about 10 feet and a low dip to the southeast. Excellent specimens of limestone breccia are common throughout the opening.

The second open cut on the Ringstaff property is N. 30° E. of the first and is a circular pit about 30 feet in diameter and 20 feet deep.

It seems probable that the Ringstaff property has a barite reserve, but additional prospecting beyond the limits of the old operations will be necessary before any definite information may be obtained regarding its future development possibilities.

Nipper prospect.—The Nipper prospect is about half a mile northwest of Steeleburg and 1½ miles southwest of Cedar Bluff. The property has not been thoroughly prospected but float fragments of barite associated with chert were noted over a considerable surface area. A few of the larger fragments are more than a foot in thickness.

According to Mr. Nipper, barite also occurs on the adjoining Griffitts, Ball, Witts and Barns properties. It is recommended that the Nipper property be systematically prospected since it may contain deposits of residual barite of commercial importance.

Clifton mines.—The Clifton mines and prospects are in Russell County on the northwest side of Little River, between the Russell-Tazewell county line and Bob Hollow, south and east of Kents Ridge School. There are several openings on the Clifton estate of which those along Mill Stone Branch, a tributary to Little River, are the largest.

On the west side of the creek about 1,000 feet northwest of Little River is an open cut 50 feet long, 30 feet wide and 20 feet deep, mainly in solid rock, from which an inclined tunnel extends southeastward down the dip of the Beekmantown dolomite. The dolomite locally strikes N. 60° E., and dips 30° SE. It contains small veins and replacement masses of barite which are not thought to be of commercial importance.

The most extensive workings are between Mill Stone Branch and Little River. They include four open cuts, each about 75 feet long, 20 feet wide and about 10 feet deep, and several small trenches and pits. A few limestone pinnacles were noted in the open cuts, but most of the barite is reported to have been mined from the overlying residual soil. At the time of the writer's visit only a few small fragments of barite were noted in old workings.

Fletcher mine.—The Fletcher mine is in Russell County about half a mile north of Barrett School and 800 feet north of Little River. It consists of two open cuts about 50 feet in diameter and several smaller openings. Small quantities of white coarsely crystalline barite occur as veins and replacement masses in Beekmantown limestone, but it is most probable that the local deposits have been largely exhausted. The barite produced at this mine between 1901 and 1905 was hauled to the mill at Gardner.

Thomas mine.—The Thomas mine is along Little River about half a mile northwest of Barrett School and half a mile southwest of the Fletcher mine. The principal open cut begins a few feet above the river and extends horizontally northeastward for a hundred feet into the side of the hill (Pl. 14, A). The bedrock is fine-grained limestone and dolomite which strikes N. 70° E., and dips 35° SE. About 100 yards northeast of the main open cut are several small openings in the residual soil. Although this property was among the important barite producers in Russell County the present bedrock occurrences do not suggest reserves of commercial value (Pl. 7, C).

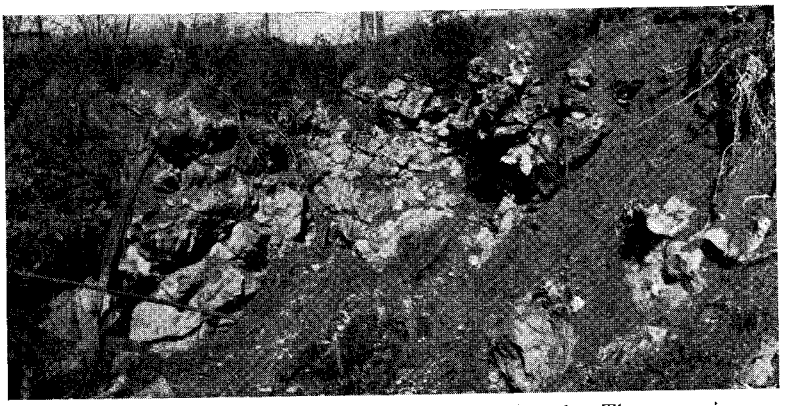
Harman mine.—The Harman mine is half a mile southwest of the Thomas workings and about 1 mile northeast of the junction of Clinch and Little rivers. It consists of two open cuts, each about 100 feet long, and several small shallow pits. Limestone crops out in the workings, but most of the barite was obtained from the red residual clay. At the present time there are no indications of commercial barite reserves. This mine was operated about 1904 and the barite hauled by wagons to Gardner for grinding.

McGraw mine.—The McGraw mine, on the east side of a large meander in Clinch River, is about one-half a mile northeast of Blackford. It includes an open cut about 100 feet long, 50 feet wide and 30 feet deep, and several smaller openings 100 yards to the northeast. Near the northeastern end of the large cut is a deep shaft which was filled with water at the time of the writer's visit. The southeast wall of the open cut is a fine-grained gray dolomite striking N. 70° E., and dipping 30° SE. A few replacement masses of barite and abundant irregular masses of chert were noted in the bedrock, but apparently there are not sufficient concentrations of barite now present to warrant future development. The dump, 100 feet long, 20 feet wide and 8 feet high, is composed of irregular fragments of dolomite containing thin veins and replacement masses of barite (Pl. 14, B). It is estimated that at least 20 per cent of the material in the dump is barite. Some individual cleavage fragments are three inches wide and arranged radially in the form of a rosette. Gangue minerals include pyrite, limonite, chalcopyrite and malachite (Pl. 1, C). It seems probable that the barite in the dump could be profitably recovered by hand methods.

Counts mine.—The Counts mine, half a mile northeast of Blackford Station and one-fourth of a mile north of Blackford School, was one of the largest producers in Russell County. It consists of an open cut about 400 feet long, 30 to 100 feet wide and as much as 40 feet deep. Since the workings are on a hill 200 feet above Clinch River, the mine had natural drainage and excellent facilities to dispose of waste material.

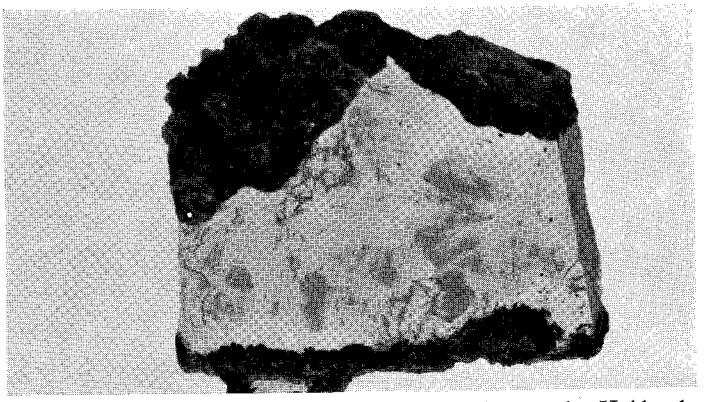
Fine-grained Beekmantown limestone and dolomite crop out in the center and along the northwest wall of the open cut. The strike averages about N. 70° E., and the dip ranges from 5° to 30° SE. A zone of closely spaced intersecting fractures in the bedrock, about 15 feet wide, contains the greatest concentration of barite.

Veins and replacement masses of barite measuring more than a foot in thickness are common along the northwest wall of the cut. Some of the replacement masses occur as rosettes with individual

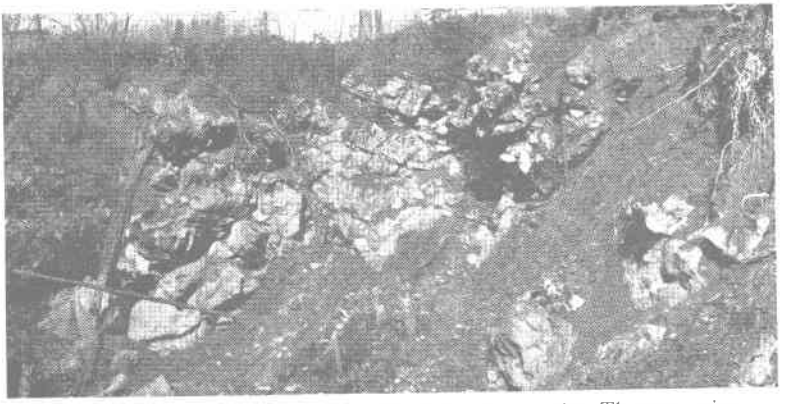


A. Light-colored barite masses in bedrock; at the Thomas mine, Russell County, Virginia.

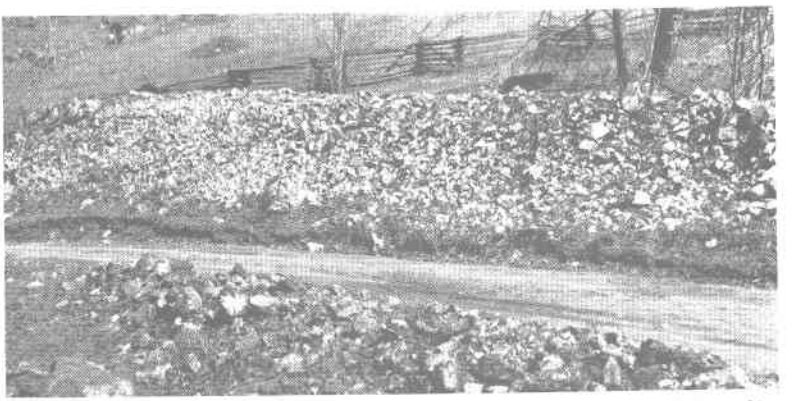
B. Dump pile of the McGraw mine, Russell County, Virginia. About 20 per cent of the material is coarsely crystalline barite.



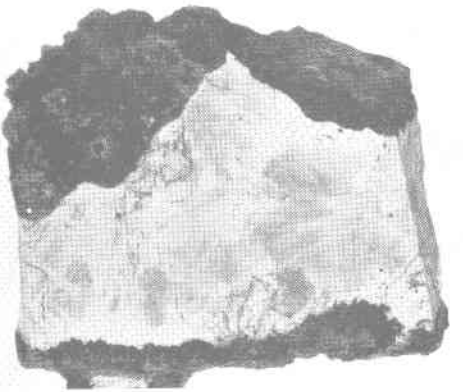
C. Thin layers of limonite formed from pyrite; at the Hubbard mine, Russell County, Virginia. X ½.



A. Light-colored barite masses in bedrock; at the Thomas mine, Russell County, Virginia.



B. Dump pile of the McGraw mine, Russell County, Virginia. About 20 per cent of the material is coarsely crystalline barite.



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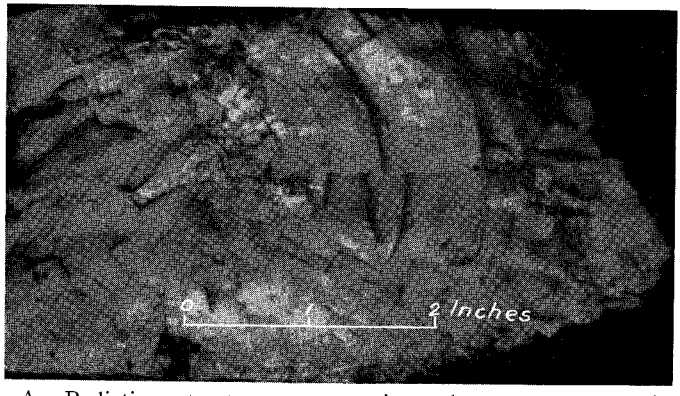
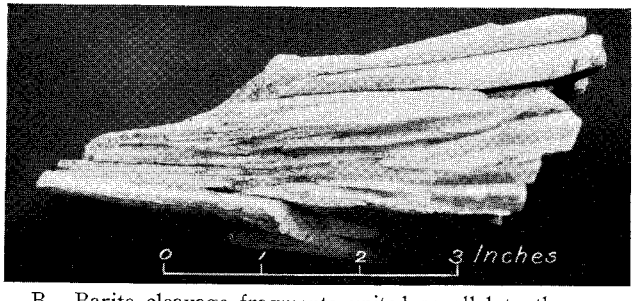
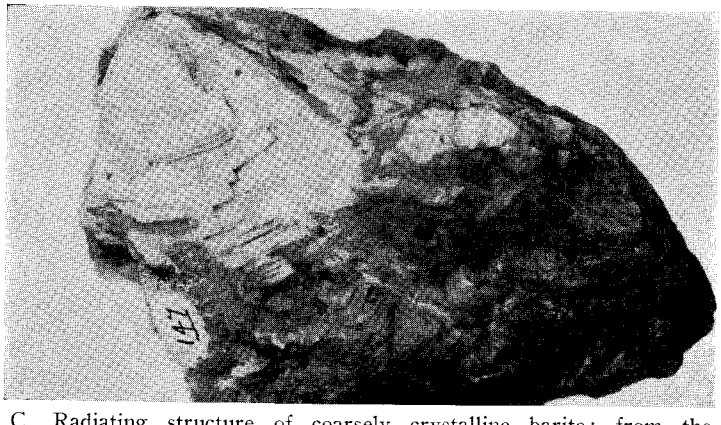


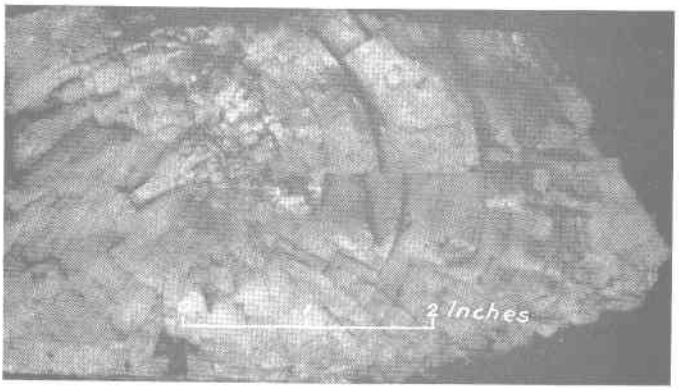
A. Radiating structure common in replacement masses of barite; the Henderlite mine, Smyth County, Virginia.



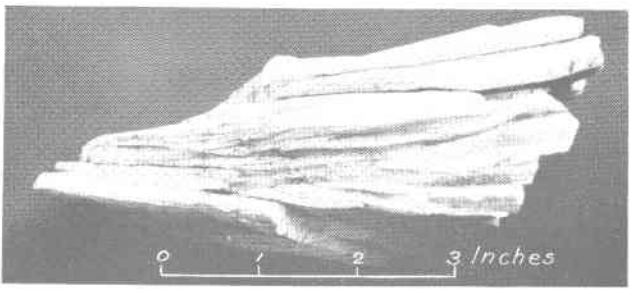
B. Barite cleavage fragments united parallel to the crystallographic "b" axis; from the Myers-L. Copenhaver mines, Smyth County, Virginia.



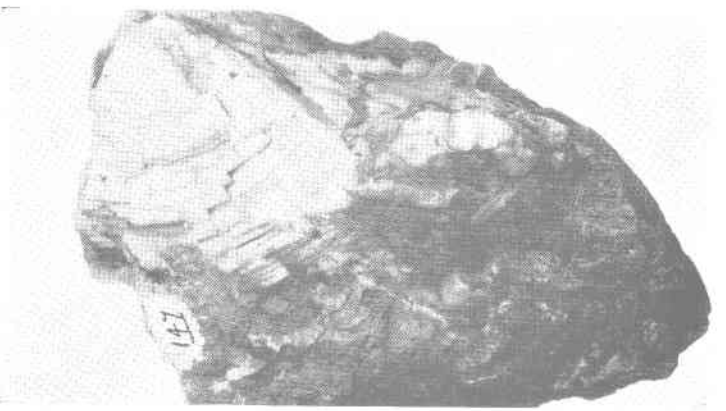
C. Radiating structure of coarsely crystalline barite; from the Myers-L. Copenhaver mines, Smyth County, Virginia.



A. Radiating structure common in replacement masses of barite; the Henderlite mine, Smyth County, Virginia.



B. Barite cleavage fragments united parallel to the crystallographic "b" axis; from the Myers-L. Copenhaver mines, Smyth County, Virginia.



C. Radiating structure of coarsely crystalline barite; from the Myers-L. Copenhaver mines, Smyth County, Virginia.

cleavage fragments 3 to 4 inches in width. The barite is associated with calcite and fluorite and near the northeastern end of the cut is badly stained with iron oxide. Since the residual barite is largely exhausted, it is most probable that the remaining bedrock occurrences are not of commercial value.

There is another opening on the Counts estate, along State Highway No. 80 and approximately one-fourth of a mile southwest of the principal open cut. It contains a few small veins and replacement masses of barite from which a few tons of high-grade barite are reported to have been recovered.

Stump mine.—The Stump mine is near the crest of a prominent ridge about one mile northwest of Blackford and one mile northeast of Hubbard Junction. The workings range from shallow pits a few feet in diameter to open cuts averaging about 100 feet long, 30 feet wide, and 20 feet deep. Approximately two acres are honeycombed with old openings, and it is reported that large quantities of high-grade barite were recovered from the thick residual soil mantle in these workings. Bedrock was not exposed at the time of the writer's visit but surface wash and slump could easily have covered exposures in the deeper openings.

The extensive mining and prospecting of this property and the present scarcity of barite on the surface would indicate that commercial quantities of barite do not now exist at this locality.

Honaker mine.—The Honaker mine is one-fourth of a mile northeast of Hubbard Junction and about 1,000 feet north of Clinch River. It was originally worked by Joseph Harrison about 50 years ago and reworked by Lias Honaker in 1906. The workings include several open cuts, the largest of which is about 100 feet long, 20 feet wide, and 20 feet deep. The barite recovered during the last operation was milled at the plant of the Clinch Valley Barytes Company along Clinch River near Blackford.

No bedrock is exposed in the openings, but the location is stratigraphically about 300 feet below the red shale and dolomite of the Murfreesboro limestone. A few fragments of barite occur in the residual clay, but there are probably no commercial reserves.

Hubbard mine.—The Hubbard mine operated by the Clinch Valley Barytes Company, is on the west side of Clinch River about half a mile southwest of Hubbard Junction. It was one of the largest producers in Russell County and in order to facilitate transportation of the crude barite a tramway was constructed from the Norfolk & Western Railway spur-line along Lewis Creek to the mine.

The mine consists of an open cut about 200 feet long, 100 feet wide and from 10 to 50 feet deep. Along the northwest wall is an inclined shaft about 40 feet deep. In addition to the principal workings there are several shallow trenches about 500 feet to the southwest.

Most of the bedrock is fine-grained Beekmantown limestone and dolomite with a few beds of coarsely crystalline limestone. The rocks strike N. 70° E., dip 20° to 30° SE., and are intersected by joints dipping steeply to the northwest. All of the deeper parts of the workings are in bedrock, but a residual soil layer, about 20 feet thick, is exposed along the southwest wall of the main open cut.

The barite occurs as veins and replacement masses with a maximum width of two feet. Some of these bodies parallel the bedding, with others filling open fractures and having random orientation. Much of the barite is white and coarsely crystalline, but near the northeastern end the barite is encrusted with thin layers of limonite (Pl. 14, C).

It is most probable that the locality contains small reserves of barite but it is doubtful if such occurrences in bedrock can be profitably recovered.

Meade mine.—The Meade mine includes openings on the east and west sides of Clinch River about three-fourths of a mile north of Miller View School and 1 mile southeast of Barretts School. The most easterly open cut begins 10 feet above the river and extends northeastward 30 feet through bedrock into the side of the hill. Barite occurs as thin intersecting veins in dolomite that strikes N. 60° E., and dips 30° SE. The larger opening on the hill 400 feet west of the river is in residual soil. The barite appears to be of good quality, but there are no indications of commercial reserves in any of the old workings on this property.

Blumer mine.—The Blumer mine now owned by A. Jackson, is on the southwest side of Clinch River about one-fourth of a mile southwest of the Meade mine. The largest of the four open cuts is 100 feet long, 60 feet wide and 20 feet deep. There are a few pinnacles of limestone and dolomite in all of the openings, but most of the mining was restricted to the residual material. The bedrock strikes N. 45° E., and dips 25° SE. There are no indications of a fracture zone, and the few thin barite seams noted occur chiefly along bedding surfaces.

Although this property is reported to have been an important producer, the present showings are meager and do not indicate commercial reserves of barite here. Considerable limonite and pyrite were associated with the barite fragments found in these workings by the writer.

Ward prospect.—The Ward prospect is one-fourth of a mile south of Clinch River and 500 feet west of Dilly Branch. The workings comprise several open cuts and trenches, each averaging about 20 feet in length. Limestone containing thin seams of barite crops out in the walls of the largest cut. Although there have been no shipments from this property, dumps contain about 25 tons of barite of good quality.

Buckles mine.—The Buckles mine is one-fourth of a mile east of Cedar Creek and about half a mile north of Corner Church. The principal working is an open cut 75 feet long, 25 feet wide and 30 feet deep. Dolomite striking N. 50° E., and dipping 25° SE., crops out in each wall. A few replacement masses of barite ranging from an inch to a foot in thickness, were noted in the dolomite but their apparent scarcity indicates that the deposit has been largely exhausted. This property was operated by the Clinch Valley Barytes Company between 1902 and 1905, and the crude barite was shipped to the milling plant southwest of Blackford.

Leonard mine.—The Leonard mine is on Cedar Creek about 1½ miles south of its junction with Clinch River and 3 miles northeast of Lebanon. It was operated between 1902 and 1905 by the Clinch Valley Barytes Company. The crude barite was elevated about 150 feet to the top of the hill south of the mine, hauled by wagons to Cleveland, and then shipped by the Norfolk & Western Railway to the company's milling plant southwest of Blackford. The principal working is an open cut about 100 feet long, 50 feet wide and 30 feet deep. In addition there are several smaller openings which form a bench about 30 feet above Cedar Creek and extend west of the main open cut.

Bedrock is fine-grained Beekmantown dolomite striking N. 55° E., and dipping about 30° SE. The barite occurs as veins and replacement masses with a maximum thickness of 2 feet. Most of the barite is restricted to a fracture zone about 20 feet wide in the dolomite which, on one wall is exposed the full depth of the open cut. Except for the admixed wall rock (Pl. 10, A), the barite is remarkably free from visible impurities such as fluorite and iron compounds. It is estimated that barite constitutes about 20 per cent of the mineralized fracture zone.

According to some residents the Leonard mine was the largest producer in the Russell-Tazewell counties area; others state that it ranked favorably with the Hubbard and Counts mines. Under present market conditions mining of this property is not recommended, but it is the writer's opinion that the Leonard mine has the largest barite reserve in Russell and Tazewell counties.

Hughes-Cowan mines.—The Hughes mine one-fourth of a mile south of Copper Ridge School and the Cowan mine, in the same barite

belt, about 1 mile northeast of Spring City, represent extensively worked deposits in the extreme southwestern part of the Russell County barite area. The mines consist of open cuts, chiefly in the residual soil mantle, which were worked between 1902 and 1905. Other openings are reported west of Spring City near by.

Groseclose prospect.—The Groseclose prospect is along Arney Creek about one-fourth of a mile south of the Lee Highway and three-fourths of a mile east of Mt. Carmel Church. It represents the northeastern end of the known barite belt in Smyth County. The original workings are partly filled with rock debris, but in the bedrock along the stream, just east of the open cut, are thin irregular veins and replacement masses of coarsely crystalline barite. None of these occurrences are thought to be of commercial value.

Henderlite mine.—The Henderlite mine is on the hill west of the Groseclose prospect and extends S. 70° W., for 1,500 feet. It comprises a number of open cuts ranging from a few feet to 100 feet in length and averaging about 20 feet in depth. They are closely spaced over an area of about 10 acres.

Fine-grained Beekmantown dolomite striking N. 80° E., and dipping 30° SE., crops out as pinnacles in many of the workings, but most of the mining has been in the residual material. The bedrock associated with these deposits is broken by many intersecting fractures which are filled with barite and associated minerals. Evidence of faulting is lacking in the openings, but it is thought that these fractures may be genetically associated with the thrust fault[67] mapped southeast of the deposits.

The barite occurs as veins and replacement bodies (Pl. 15, A), in bedrock and as irregular fragments in the residual clay. The associated minerals include abundant fluorite and calcite, and smaller amounts of chalcopyrite, pyrite and malachite. One car of copper ore is reported to have been mined from a shaft near the northeastern end of the Henderlite estate. Irregular grains and well-defined cubes of colorless and purple fluorite comprise at least 20 per cent of some veins.

The extensive mining of the property probably has exhausted all of the commercial occurrences of barite.

McDonald mine.—The McDonald mine, one-fourth of a mile southeast of Mt. Carmel Church and half a mile southwest of the Henderlite estate, consists of three open cuts, each about 50 feet long, 15 feet wide and 10 feet deep. Bedrock is not exposed in the workings and no barite was found in the open cuts, but fragments of barite

[67] Butts, Charles, Geologic map of the Appalachian Valley of Virginia with explanatory text: Virginia Geol. Survey Bull. 42, 1933.

were scattered over the surface for several hundred feet southwest of the workings.

Eller mine.—The Eller mine is about one-fourth of a mile southwest of the McDonald mine and about the same distance south of the Middle Fork of Holston River and the Lee Highway. The largest of the five open cuts is 50 feet long, 25 feet wide and 12 feet deep. The bedrock is a compact limestone (typical vaughanite) that strikes N. 80° E., and dips 30° SE. There are a few replacement masses of coarsely crystalline barite and associated colorless and purple fluorite, some more than a foot in thickness, but the barite probably does not occur in sufficient quantity to be considered a future reserve.

Cornett-Hull mines.—The adjoining Cornett-Hull mines are on a ridge about 1 mile southwest of Marion. The old workings extend along the ridge, about 1,500 feet southwest of the Lee Highway, for about 1 mile, and comprise one of the most extensive barite operations in Smyth County. The entire area of these two properties is honeycombed by open cuts, shafts and trenches. The larger openings are about 100 feet long, 75 feet wide and 40 feet deep.

The barite occurs in Beekmantown dolomite near the thrust fault[68] that brings this formation in contact with the Athens shale on the northwest and the Stones River group on the southwest. The largest workings are about 100 to 200 feet southeast of the trace of the fault.

The barite occurs as veins and replacement masses in a highly fractured belt of dolomite (Pl. 9, A). Definite vein systems were not identified and it is most probable that the mineralization occupies an irregular fracture zone.

It is thought that a considerable quantity of barite remains in the bedrock, but that the expense involved in its recovery will probably make future mining of these properties unprofitable. The residual barite is largely exhausted.

Shanklin mine.—The Shanklin mine is 1½ miles southwest of Marion and one-fourth of a mile north of the Middle Fork of Holston River. It consists of an open cut 60 feet long, 40 feet wide and 30 feet deep, and several shallow trenches some as much as 300 feet long. In the main open cut, Beekmantown limestone and dolomite containing replacement masses of barite, strike N. 55° E., and dip 45° SE.

H. P. Copenhaver mine.—The H. P. Copenhaver mine is about half a mile southwest of the Shanklin mine, and the workings extend S. 70° W., for about one-half a mile. This property was one of the largest producers of high-grade barite in Smyth County. Speci-

[68] Cooper, Byron N., Stratigraphy and structure of the Marion area, Virginia: Virginia Geol. Survey Bull. 46-L, Plate 14, 1936.

mens submitted by Mr. Copenhaver won first prize at the Chicago Exposition in 1893.

The largest of the open cuts is about 100 feet long, 50 feet wide and 50 feet deep. Most of the barite was recovered from the residual soil, although in all of the larger openings mining extended into bedrock. The enclosing rocks are fine-grained limestone and dolomite that vary locally in strike and dip. The apparent local variation from the regional structure is probably due to the minor cross faults[69] on the northwest side of the McMullin syncline.

Coarsely crystalline barite occurs as veins and replacement masses in bedrock and as irregular fragments in the overlying unconsolidated material, but the occurrences noted are not sufficiently extensive to be considered of commercial value. However, since the Copenhaver workings are conveniently located with respect to the old milling plant on the Middle Fork of Holston River about 2½ miles southwest of Marion, and convenient to the Norfolk & Western Railway, additional prospecting between the old workings may discover deposits not now known.

Miles-Gardner mines.—The Miles-Gardner mines are three-fourths of a mile northeast of McMullin and about 800 feet south of the Middle Fork of Holston River. The Miles workings consist of several shallow open cuts about 50 feet long and two shafts that are reported to have been 50 feet deep. The more extensive workings are on the adjoining Gardner farm. These include several trenches with a total length of 400 feet and an average depth of about 10 feet. The Miles-Gardner deposits are in the same mineralized zone as the H. P. Copenhaver and Shanklin mines, but they have been relatively unimportant producers.

Myers-L. Copenhaver mines.—The Myers-L. Copenhaver mines in Wassum Valley, about 4 miles west of Marion and half a mile north of Mt. Zion Church, were the most extensively worked barite deposits in Smyth County. The developments began 100 feet east of the Wassum Valley road and extended S. 70° E., for approximately 1,500 feet. It is estimated that the trenches, pits and open cuts cover an area of at least 5 acres. Some of the larger open cuts are 400 feet long, 100 feet wide and 40 feet deep.

Beekmantown limestone and dolomite, striking N. 30° W., and dipping 30° SW., crop out in many of the cuts. The barite occurs as small veins and replacement masses in fractured bedrock, and as irregular fragments in the residual soil mantle. Near the southeastern end of the workings, on the L. Copenhaver farm, a few cleavage frag-

[69] Cooper, Byron N., Stratigraphy and structure of the Marion area, Virginia: Virginia Geol. Survey Bull. 46-L, p. 165, 1936.

ments of barite having a width of 10 inches were noted (Pls. 1, B, 15, B, and 15, C).

Although extensive mining here has probably exhausted all of the large deposit, it is thought that small quantities of high-grade residual barite could be recovered from the old workings by hand methods.

Faris mine.—The Faris mine is one-fourth of a mile north of Mt. Zion School along Wassum Creek. It consists of several open cuts about 30 feet in diameter and one inclined shaft. This property was actively mined at the same time as the Myers-L. Copenhaver deposit.

Orr mine.—The Orr mine is in Rich Valley, about half a mile northeast of Longhollow and 2 miles southwest of Ellendale School. Here barite occurs as small replacement masses in Beekmantown dolomite. Large crystals of calcite and small amounts of pyrite, chalcopyrite, malachite and limonite are associated with the barite. It is reported that barite from this property was hauled by wagon to the mill in Marion about 40 years ago.

OTHER DEPOSITS

GENERAL STATEMENT

Barite has been reported from many counties in the State, but production has been confined mainly to the deposits in the ten counties included in the six areas already described. In addition to these areas the writer has visited prospects in Augusta, Louisa, Rockbridge and Wythe counties. These are briefly discussed below.

PRINCIPAL PROSPECTS

Johnson prospect.—The Johnson prospect is in southern Rockbridge County three-fourths of a mile north of the Botetourt-Rockbridge county line and about one-fourth of a mile west of the Lee Highway, U. S. Route 11. This property has not been developed, but a few fragments of barite more than a foot in thickness were uncovered while repairing the local farm road. Smaller pieces of white and dark barite float were noted on the surface. (See Fig. 14.)

The discovery of the few large pieces of apparently high-grade barite should encourage systematic prospecting of this property.

Becktel prospect.—The Becktel prospect is about 4 miles south of Lexington and half a mile west of the Lee Highway, in Rockbridge County. No work has been undertaken here, but a few small fragments of barite were noted in association with abundant chert float. The largest pieces are probably not more than 6 inches in width.

Shorter prospect.—The Shorter prospect, half a mile northwest of Rapps Mill in Rockbridge County, contains a few shallow test pits. Barite occurs sparingly in these holes, but nothing is known about the size of the deposit. (See Fig. 14.)

Earhart prospect.—The Earhart prospect is on the southeast side of the Baltimore & Ohio Railroad about 1 mile northeast of Spottswood in Augusta County. It was prospected by J. N., and N. S. Hotinger of Lexington, Va., in 1934 and mined on a small scale during the summer of 1936. About one truck load of barite was recovered from the residual soil mantle, but at present the deposit is largely exhausted.

J. C. Groseclose prospect.—The Groseclose prospect, 6 miles southwest of Wytheville and 1½ miles northeast of Crocketts, is in the southwestern part of Wythe County. This property contains abundant fragments of float barite, but it has not been systematically prospected to determine the extent of the deposit.

Walker prospect.—The Walker prospect is three-fourths of a mile south of Mechanicsville and 3 miles southeast of Lindsay in Louisa County. According to Watson,[70] who described the property in 1907, the workings comprised several test pits and shafts, the deepest one between 70 and 80 feet. None of the workings were accessible at the time of the writer's visit in 1933, but residents of the area state that a vein of solid barite 3 feet thick was mined in the deepest shaft.

The enclosing rocks are fine-grained mica schists that strike N. 35° E., and dip steeply to the southeast. A few fragments of coarsely crystalline barite associated with quartz were noted on the dumps, but there are no surface indications of commercial reserves.

[70] Watson, T. L., Geology of the Virginia barite deposits: Am. Inst. Min. Eng. Trans., vol. 38, pp. 968-969, 1907.

INDEX

A **Page**

Abstract ---1
Acknowledgments ---3
Adams, G. I., cited---17
Alkaline bicarbonate ---21
Altavista ---35, 36, 42
Alteration of wall rock--18, 19, 43-44
Altizer prospects ---70
Analyses ---20
Anhydrite ---11
Appalachian deformation ---24
Arthur mine ---36
Associated minerals---9-13, 18, 19
Associated rocks--20, 28-30, 43-44, 46-47, 52, 57, 66-67
Athens shale---57, 60, 67
Augusta County---79, 80

B

Ball property ---71
Ball, S. H., and Smith, A. F., cited 17
Banded vein---14, Pl. 1C
Barite
associated minerals ---9-13
Bedford County area---42-44
Campbell-Pittsylvania counties area 27-42
cleavage fragment--9, 78-79, Pls. 1B, 15B, 15C
commercial development ---25-26
crystals---4, Pl. 1A
deposits, types of ---14-16
distinguishing characteristics ---4
distribution ---9
Fauquier County area---51-55
general features ---4-8
Grayson County area---45-50
history ---4-5
in fossils and concretions 18, Pl. 10B
in pegmatites ---24, 30, Pl. 6B
mining and washing---25-26
origin ---16-24
other deposits ---79-80

Page

paragenesis of minerals---14
properties ---4, 9-11
prospecting ---25
relation to fracture zones---23
Roanoke-Botetourt counties area 56-63
Russell-Tazewell-Smyth counties area ---63-79
time of mineralization---24
uses ---6-8
Barium
chemicals ---8
content of wall rock---20-21
salts, solution and deposition---21
source of ---20
sulphate, solubility of---21-22
Barium Mining Corporation 33, 38, 39, 40, 42
Barns property ---71
Bärtling, R., cited---4
Barytes, see barite ---4
Bayley, W. S., cited---6
Becktel prospect ---79
Bedford County-9, 13, 19, 23, 42, 43, 44
Bedford County area---42-44
associated rock ---43-44
geology ---43
history ---43
location ---42
mines and prospects---44
Beekmantown limestone---20, 57, 59, 60, 63, 66, 69, 71, 72, 74, 75, 78
Bennett mine ---39
Berger mine ---38
Biotite ---13, 14, 19, 29, 43, Pl. 3
Blue Ridge plateau---45
Blumer mine ---74
Botetourt County (see also Roanoke County) ---11, 56-63
Botts prospect ---54-55
Bragg mine ---35
Breccia matrix---23, Pls. 10A, 11A
Breccia zones---14, 15, Pls. 10A, 11A
Buckles mine ---75

Page

Bull Run shale 52, 55, Pl. 2A
Butler, B. S., cited 22, 23
Butts, Charles, cited 57, 66

C

Calcite 4, 9, 12, 14, Pl. 6A
Caldwell prospect 60
Campbell-Pittsylvania counties area 9, 13, 23, 24, 27-42
  associated rocks 28-30
  geology 28
  history 27-28
  location 27
  mines and prospects 30-42
Carbonates 12
Carroll County 30
Carson mine 30
Catoctin-Blue Ridge anticlinorium 28
Cedar Run mine 54, Pl. 2A
Chalcopyrite 9, 11, 14, 29
Chemicals, barium 8
Chlorite 9, 13, 14, 19, 29, 43, Pls. 4A, 5A, 6A
Circulating waters 16, 18-24
Clarke, F. W., cited 20, 21
Clifton mines 71
Clinchfield Sand and Feldspar Co. 56
Clinch Valley Barytes Co. 65, 73, 75
Cockeysville marble 20, 28, 29
Commercial factors 26
Concentration, mechanical 16
Concretions, barite in 18, Pl. 10B
Conococheague limestone 57, 59, 62, 67
Cooper, B. N., cited 67, 77, 78
Copenhaver, H. P., mine 77-78
Copenhaver, L., mine 78-79
Cornett-Hull mines 77, Pl. 9A
Counts mine 72-73
Cox prospect 50
Crabill, C. B., cited 45
Cross faulting 33, 78
Crush mine and prospect 58-59
Cundiff prospect 35, Pls. 2B, 3

D

Page

Dana, E. S., cited 4
Deposition, barium salts 21
  depth of 15
Deposits
  location of 9, 27, 42, 51, 56, 63-64
  minerals of 9-13
  types of 14-16
Development
  commercial 25-26
  suggestions for 25-26
Diabase 20, 52, 53
Dikes 24, 30, 47, 52, 53, Pl. 6B
Disseminations 15

E

Earhart prospect 80
Earl mine 69-70
Edmundson, R. S., cited 19
Elbrook dolomite 57, 63
Eller mine 77
Emmons, W. H., cited 17
Epidote 9, 13, 14, 19, 43, Pls. 4A, 5
Evington 27, 33, 34

F

Faris mine 79
Faults 23, 33, 76
Fauquier County 4, 9, 23, 51, 54
Fauquier County area 51-55
  associated rocks 52
  geology 51
  history 51
  location 51
  mines and prospects 52-55
Feldspars 38, 43, Pls. 4B, 6B
Fenneman, N. M., cited 56
Fissure veins 11, 14-15, 72, Pls. 1C, 7B
Fletcher mine 71
Flow sheet, barite 27
Fluorite 9, 12, 14, 19
Fossils, barite in 18, Pl. 10B
Fracture zones, relation of barite 23, 54, 57, 63, Pls. 7A, 11A
Fudge mine and prospect 68
Furcron, A. S., cited 28

G Page

Galax 45
Gangue minerals 18, 19
Gear mine 55, Pl. 7A
Geology of deposits 28, 43, 45, 56-57, 66
Goodell-Copenhaver barite mill 64, 78, Pl. 12C
Gordon, C. H., cited 17
Glenarm series 28
Granite gneiss 38, 46-47
Grasty, J. S., cited 17
Grayson County area 45-50
  associated rocks 46-47
  geology 45-46
  history 45
  location 45
  mines and prospects 47-50
Grayson granite gneiss 46-47
Griffitts property 71
Groseclose prospect 76
Groseclose, J. C., prospect 80
Ground barite 7
Gusler-Austin mine 57, 60-61, Pl. 12B
Gypsum 9, 11

H

Haden mine 34
Haloids 12
Hamner mine 36-37
Hardy, C., cited 6
Harman mine 72
Hayes, C. W., cited 17
Henderlite mine 76, Pl. 15A
Herschenz, O., cited 4
Hewitt mine 29, 33, Pls. 10C, 12A
History
  barite industry 4-5
  Virginia areas 27-28, 43, 45, 51, 56, 64-66
Honaker mine 73
Hopkins mines 69
Hornblende 9, 13, 14, 19, 29, 43, Pls. 3, 4A
Hotinger, N. S. and J. N., cited 56, 59
Hubbard mine 73-74, Pl. 14C
Hubble mine 68

Page

Huffman prospect 57, 62
Hughes-Cowan mines 75-76
Hurt prospects 42
Hydrothermal alteration 13, 18, 19-20, 43-44, 49, Pls. 2B, 3, 4A, 5, 6A

I

Industry, history of barite 4-5
Iron oxide 9, Pl. 14C

J

Johnson prospect 57, 79
Jonas, A. I., cited 23, 28, 46

K

Kaolinized feldspar 38
Kemper mine 55-56
Knopf, E. B., cited 28

L

Ladoo, R. B., cited 6
Lenticular bodies 15, Pl. 9A
Leonard mine 75, Pl. 10A
Lewis, J. V., cited 23, 54
Lilley, E. R., cited 6
Limonite 11, 12, Pl. 14C
Lithopone 7
Looney farm 62
Lynchburg 30

M

Magmatic origin 18-24
Malachite 11
Marion 64, 67, 77, 78
Marion Barytes Works 64
Marshall granite 43-44
Martin prospect 48-49
Mattox mine 35
McDonald mine 76-77
McGraw mine 72, Pls. 1C, 14B
McLean prospect 45
Meade mine 74
Mease mine 41
Metallic barium 6

Page

Meteoric origin 18
Mica 9, 13, 14, 19, 29, 30, 43, Pls. 3, 6B, 9C
Miles-Gardner mines 78
Mineralization, time of 24
Minerals of deposits 9-13
Mines (see individual mines)
Mining methods 25-26
Moore prospect 50, Pl. 9C
Mount Athos formation 28
Murfreesboro limestone 66, 69
Muscovite 30, Pl. 6B
Mutter, W. E., cited 65
Myers-L. Copenhaver mines 78-79, Pls. 1B, 15B, 15C

N

Nipper prospect 70
North Tazewell 63, 64, 68

O

Origin of barite 16-24
conclusions 24
general statement 16
magmatic theory 18-24
meteoric theory 18
Orr mine 79
Osborne, O. C., cited 45, 50
Oxides 12, 20

P

Paragenesis of minerals 14
Parker mine 39-41
Peery, K., mine 68
Peery, M. L., mine 68
Pegau, A. A., cited 28, 30
Pegmatite 24, 30, 41, 47, Pl. 6B
Phillips mine and prospect 29, 32-33
Phipps prospect 50
Piedmont province 9, 13, 19, 24
Pittsburgh Baryta and Milling Corp. 65
Pittsylvania County 9, 13, 20, 23, 27, 30, 36, 42

Page

Poole prospect 45, 49-50, Pls. 5B, 7B, 9B
Porter prospect 48
Production, principal states 5
Propylitization 19-20, 24
Prospecting 25
Prospects (see individual prospects)
Prince William County 51, 54
Pyrite 9, 11, 20, 29, Pl. 1C, 10B, 14C

Q

Quartz 9, 12, 14, 19, 43, Pls. 2B, 3, 4, 5, 6, 7A
Quartzite 28, 29, 32, 33, Pl. 12A

R

Ramsay mine 39
Ransome, F. L., cited 17
Reed mine 57, 63
Relation of barite to fracture zones 23
Replacement masses 15, 49, 50, 71, 77, Pls. 7C, 9B and C, 15A
Residual deposits 16
Reynold mine 57, 62
Rhudy prospect 48
Ringstaff mine 70
Roanoke and Botetourt counties area 9, 56-63
associated rocks 57
geology 56-57
history 56
location 56
mines and prospects 58-63
Roberts, J. K., cited 51
Rucker mine 57, 62-63
Russell, Tazewell, and Smyth counties area 9, 63-79
associated rocks 66-67
geology 66
history 64-66
location 63-64
mines and prospects 68-79

S

St. Stephens mine 52-54
Sandy Level 41

Page

Santmyers, R. M., cited 5
Saunders mine 31-32
Saxton-McMillan mines 44
Shanklin mine 77
Shorter prospect 80
Silicates 13, 43
Silicification 19, 52, Pl. 2A
Slickensides 44
Smith, W. S. T., cited 17
Smyth County (see also Russell-Tazewell counties area) 9, 63-79
Solution and deposition of barium salts 21-23
Source of barium 18, 20-21
Spheroidal weathering 53
Statistics, barite production 5
Steele mine 70
Stose, G. W., cited 17
Stuckey, J. L., cited 17
Stump mine 73
Sulphate radical, source of 22
Sulphates 9, 11, 21-23, Pls. 1B, 15B, 15C
Sulphides 11, Pls. 1C, 14C

T

Tarr, W. A., cited 5, 6, 17, 20, 21
Taylor mine 69
Tazewell County (see also Russell-Smyth counties area) 9, 63-70
Teets, M., cited 51, 54
Texture of barite 9
Thomas mine 71, Pls. 7C, 14A
Thompson mine 41, Pl. 6B
Time of mineralization 24
Tourmaline 9, 13, 14, 19, 35, Pls. 2B, 3A, 4A
Triassic area 51
Triassic igneous activity 24
Tri-State Mining and Mfg. Co. 65, 69

Page

Tuck mine 37
Types of deposits 14-16

U

Umber 29, 38

V

Valley and Ridge province 9, 23, 56, 66
Vaught, F., prospect 47-48, Pls. 4B, 11B
Vaught, S., prospect 48
Veins, fissure 14-15, 49-50, 55, 72, Pls. 1C, 7A, 7B
Virginia barite deposits (see barite)

W

Walker prospect 80
Ward prospect 75
Washing methods 25-26
Watson, T. L., cited 4, 17, 28, 29, 39, 43, 45, 51, 64, 65, 80
Weathering 16, 17, 53
Weigel, W. M., cited 5, 6
Williams, J. T., and Son plant 65
Williamson mine 57, 59
Winslow, A., cited 20
Wissahickon formation 20, 29-30
Witcher mine 41
Wood prospect 36
Woodward, H. P., cited 56, 57
Wyman Baryta Company 65

Y

Yoe, J. H., analyses by 20

Z

Zone, fracture 14, 15, 23, Pls. 10A, 11A