GEOLOGICAL SURVEY OF GEORGIA
S. W. McCALLIE, State Geologist

BULLETIN NO. 36

REPORT

ON THE

BARYTES DEPOSITS

OF

GEORGIA

BY

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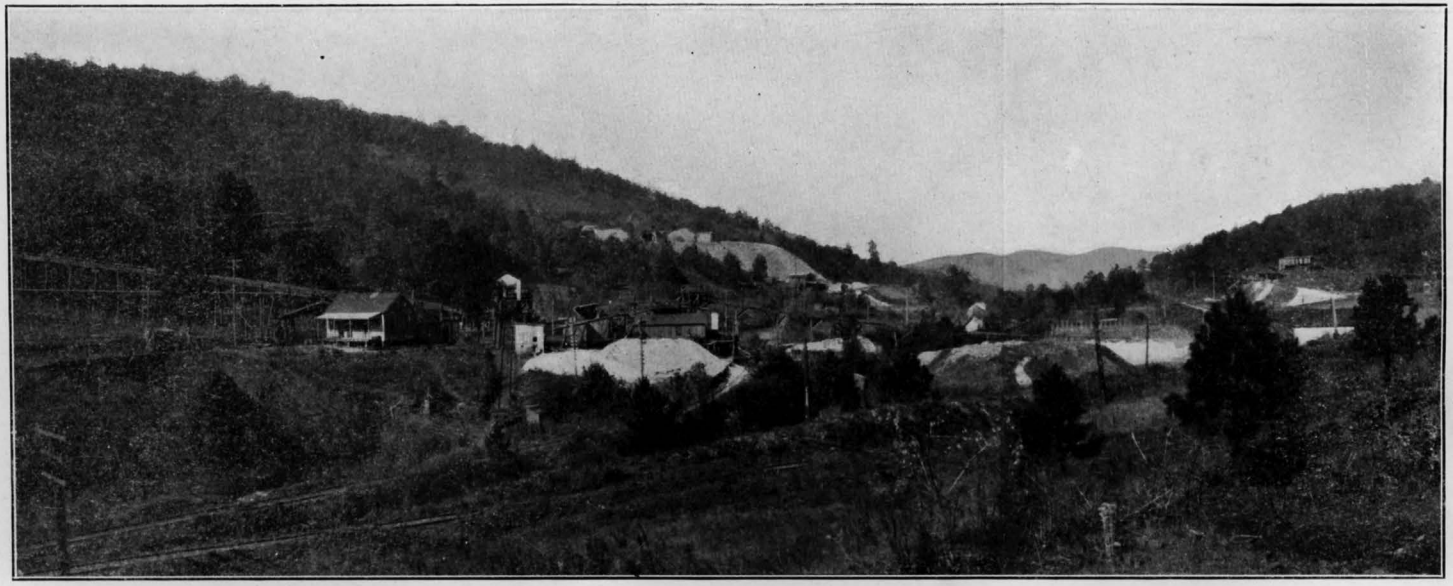
Assistant State Geologist

1920
BYRD PRINTING COMPANY,
ATLANTA, GA.



DUPONT, NULSEN, AND SECTION HOUSE BARYTES MINES IN EMERSON GAP NEAR CARTERSVILLE, BARTOW COUNTY.

THE ADVISORY BOARD

OF THE

Geological Survey of Georgia

IN THE YEAR 1919

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LETTER OF TRANSMITTAL

GEOLOGICAL SURVEY OF GEORGIA,
ATLANTA, Dec. 20, 1919.

To His Excellency, HUGH M. DORSEY, *Governor, and President of the Advisory Board of the Geological Survey of Georgia.*

SIR: I have the honor to transmit herewith the report of Mr. J. P. D. Hull, Assistant State Geologist, on the Barytes Deposits of Georgia, to be published as Bulletin No. 36 of this Survey.

Very respectfully,
S. W. MCCALLIE,
State Geologist.

PREFACE

The barytes deposits of the Cartersville district of Georgia are the most productive in the United States and their mining development likewise has been the most elaborate and efficient, but because they have become really valuable only in the few years since 1914, they have been described in a rather limited number of publications. The principal reports heretofore published on Georgia barytes are the following:

1907. Hayes, C. W., and Phalen, W. C., A commercial occurrence of barite near Cartersville, Ga.: U. S. Geol. Survey Bull. 340 M., pp. 458-462, 1907.

1910. Watson, T. L., and Grasty, J. S., The geology and barite deposits of the Cartersville district, Ga.: The Tradesman, pp. 35-37, May 22, 1910.

1915. Watson, T. L., and Grasty, J. S., Barite of the Appalachian states: Am. Inst. Min. Eng., Bull. 98, pp. 345-390, February, 1915.

1916. Vivian, Arthur C., Barytes mining in Georgia: Eng. & Min. Jour., Vol. 102, No. 26, pp. 1083-1085, Dec. 23, 1916.

The field work for this report was done in nine weeks of the summer and fall of 1917, but because of the sudden demand for detailed information about the more important war minerals of Georgia and the urgent need for stimulating a greater production of those minerals for war purposes, the preparation and publication of the report was necessarily delayed. The steady development of the industry has been noted, however, from time to time since 1917, and in the fall of 1919 the whole situation was reviewed in ten days of field work in the Cartersville district. Georgia continues to lead the states in the production of crude barytes.

Unless otherwise stated, all chemical analyses in this report were made in the laboratory of the State Geological Survey by Dr. Edgar Everhart, Acting Chemist.

Acknowledgment of information and assistance is specifically made in footnotes to the text. To the managers, superintendents, and foremen of mines and to the citizens of Cartersville who have shown me many courtesies, I wish to express my gratitude and indebtedness. I appreciate especially the advice and direction of Mr. S. W. McCallie, State Geologist.

J. P. D. HULL.

December 24, 1919.

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BARYTES

THE MINERAL

Barytes is the common commercial name for the mineral barite whose chemical composition is barium sulphate ($BaSO_4$) containing when pure, sulphur trioxide (SO_3) and barium oxide or baryta (BaO) in the proportion by weight 34.3 to 65.7.

The element barium which is the principal consistuent of the compound barium sulphate is widely distributed in the oxide form throughout the earth's crust. It occurs in small quantities in the rocks, particularly the igneous rocks rich in the feldspars and micas[1] high in potash[2]; in soils[3]; in plants[4]; in spring water[5]; in mine water[6]; and in sea water[7]. In his computation of the average composition of known terrestrial matter, Clarke[8] finds that barium constitutes 0.08 per cent, or in other words, ranks with manganese in holding sixteenth place in relative abundance of the chemical elements. The name barium, meaning heavy, is derived from the Greek.

Barytes, or according to the correct terminology of mineral species, barite, is also known as heavy spar in recognition of its high specific gravity, 4.3 to 4.6, one of its characteristic properties. Among the

[1] Clarke, F. W., The data of geochemistry: U. S. Geol. Survey Bull. 616, p. 14, 1916.
[2] Hillebrand , W. F., The analysis of silicate and carbonate rocks: U. S. Geol. Survey Bull. 422, p. 25, 1910.
[3] Failyer, G. H., Barium in soils: U. S. Bureau of Soils Bull. 72, 1910.
[4] Idem, p. 20.
[5] McCallie, S. W., A preliminary report on the mineral springs of Georgia: Geol. Survey of Ga. Bull. 20, pp. 40 and 104, 1918.
Clarke, op. cit., pp. 579, 580, quoting sources, 1916.
Emmons, W. H., The enrichment of ore deposits: U. S. Geol. Survey Bull. 625, pp. 488-490, quoting sources, 1917.
[6] Clarke, op. cit.
Emmons, op. cit.
[7] Clarke, op. cit., p. 121.
[8] Op. cit., p. 34.

local terms used for the mineral are "tiff" in Missouri and "cawk" in Derbyshire. Barytes may be briefly described as a heavy white mineral easily scratched with a knife, crystallizing in the orthorhombic system commonly with both tabular and prismatic habit. Its hardness ranges from 2.5 to 3.5, it does not effervesce in acid, it colors the blowpipe flame green. Besides forming in transparent and translucent cleavage prisms and rhombohedral plates that commonly grow in parallel, radiate, curved, and crested groups, barytes ordinarily occurs in opaque massive crystalline, concretionary, banded, granular, and earthy forms. The mineral is rarely pure in nature, but generally contains compounds of silicon, aluminum, iron, calcium, manganese, strontium, and other elements in small quantities.

THE DEPOSITS

The source of barium, the origin of barytes, and the different modes of occurrence have been discussed and the literature bearing on these subjects has been reviewed by Hillebrand[1], Clarke[2], Emmons[3], Failyer,[4] and others.

It is generally agreed that barytes is deposited from solutions, both hot and cold, that have derived their barium content from the rocks through which they passed, both igneous and sedimentary, though the original source is in the barium feldspars and micas of the crystalline rocks.

In regard to the origin of barytes, Clarke[5] says in part: "It may form as a direct deposit from waters, or as a precipitate when different waters commingle, or, as C. W. Dickson[6] has shown, by a reaction between solutions of barium bicarbonate and gypsum. Barium sulphate is also produced according to Dickson, when the bicarbonate solution is brought into contact with oxidizing pyrite; and its presence in limestones is attributed to a possible coincidence of the two reactions."

From the authorities previously referred to it may be seen that barytes has formed at the surface of the earth and at depth; that

[1] Op. cit., pp. 25, 26, 1910.
[2] Op. cit., pp. 579-581, 1916.
[3] Op. cit., pp. 488-490, 1917.
[4] Op. cit., 1910.
[5] Op. cit., p. 581, 1916.
[6] School of Mines Quart., vol. 23, p. 366, 1902.

it has been deposited as a gangue mineral in the unoxidized and the oxidized zones of ore lodes; that it occurs as a primary and a secondary mineral; and that it is deposited from cold descending waters and from hot ascending waters.

Barytes deposits may be classified according to their modes of occurrence. In hard rock they occur as veins, filling fractures and fault fissures; they constitute the cementing material for mineral grains and brecciated masses; and they form replacement beds and lenses. In unconsolidated formations they have accumulated as residual, colluvial, and alluvial bodies composed largely of fragments weathered from the original deposits. The rock in which barytes most generally occurs as an ore deposit is limestone or the soil product of limestone decay. Other rocks with which the ore is associated are sandstone, quartzite, shale, slate, schist, marl, and even granite, porphyry, pyroxenic gneiss, augite diorite, and basalt. Barytes deposits have been found in rocks ranging in age from pre-Cambrian to Recent, though the formations containing the most productive ore bodies are Cambrian and Ordovician.

GEOGRAPHIC DISTRIBUTION

The world's principal commercial deposits of barytes are in the United States, Great Britain, and Germany. Canada and Austria also have important deposits. Among other places where barytes occurs, India, Australia, and Tasmania may be mentioned to show the wide geographic distribution of the ore.

In Germany, whose output just previous to the world war equalled about half of the world's production, the ore is largely of the vein type. There are mines in the Thuringian and Harz mountains and the Rhine district.

In Great Britain[1] most of the barytes is a vein mineral occurring in England, Wales, and Ireland. In 1916 only one mine was worked in Scotland. The chief centers are North of England, particularly Durham and Westmoreland; Shropshire and Welsh Border, and County Cork. North of England veins traverse upper strata of Car-

[1] Carruthers et al., Barytes and witherite, 2d edit.. Special reports on the mineral resources of Great Britain, vol. II., Memoirs of the Geological Survey, 1916.

boniferous limestone series and the Coal Measures. In Shropshire and Welsh Border districts the country rock is Lower Paleozoic.

In 1916 the only barytes deposit being worked in Canada[1] was at Lake Ainslie, Inverness County, Nova Scotia, where veins cut pre-Cambrian felsites. Other places in northeastern Nova Scotia where barytes occurs in commercial quantities are North Cheticamp, Inverness County, Five Islands and Steurake, Colchester County, and near River John, Pictou County. Other localities are in the southern part of the provinces of Quebec and Ontario.

In the United States,[2] commercial deposits of barytes occur in nineteen states including Alaska. Almost all of the ore is produced in two regions in the eastern part of the country, namely, in the states of Alabama, Georgia, Tennessee, and Kentucky in the Appalachian region and in Missouri in the Mississippi Valley region. In a general review of the deposits, Hill[3] says in part: "The distribution of the barite in the original rocks seems to have been influenced largely by the presence of openings through which solutions carrying barium could penetrate. Thus, in Alabama, Georgia, Tennessee, central Kentucky, and Virginia the barytes deposits are located along or near zones of folding and faulting of the late Cambrian and early Ordovician rocks. In Missouri, fracturing of the Cambrian rocks is conspicuous, and in western Kentucky the Carboniferous strata, in which the fluorite-barite veins are found, are faulted to a considerable degree."

Besides the principal producing states just mentioned, the other eastern states having commercial deposits of barytes are Connecticut, Illinois, Maryland, North Carolina, Pennsylvania, and South Carolina. The western states, with which is included Alaska, are California, Colorado, Idaho, Montana, Nevada, and Utah. There are barytes-bearing veins in basalt and sandstone in Arizona, but these occurrences are generally associated with metallic ore deposits and the barytes is not considered to have commercial value.

[1] McLeish, John, Annual report on the mineral production of Canada during the calendar year 1916, Dept. of Mines, Mines Branch, No. 474, p. 176, 1918.
McLeish, John, et al., Economic minerals and mining industries of Canada, Dept. of Mines, Mines Branch, No. 322, p. 47, 1914.

[2] Hill, James M., Barytes and barium products in 1916: U. S. Geol. Survey Mineral Resources, 1916, pt. II, 1917.
——— ———., Barytes and strontium in 1915: U. S. Geol. Survey Mineral Resources, 1915, pt. II, 1916.

[3] Op. cit., p. 167, 1916.

USES

Aside from the characteristics of barium compounds that make barytes of importance in chemical uses, the principal properties of the mineral are whiteness, weight, inertness, and softness. On these distinctive properties its uses depend. The chief use is in the manufacture of paint. For this purpose barytes should not be considered as an adulterant for it has the qualities of a good pigment, possessing a lasting white color that does not blacken from the effects of weather and gases so quickly as does white lead. A somewhat detailed discussion of the uses of barytes and barium compounds is given by Fohs[1] in connection with his study of Kentucky barytes deposits.

The barium products in whose manufacture barytes is used may be classed as (1) ground barytes, (2) lithopone, and (3) barium chemicals.[2] Two-fifths of the barytes produced in the United States in 1917 was roasted for use in making lithopone and less than a third was used for ground barytes. These products are used principally in the preparation of ready-mixed interior paints and in the rubber industry. A comparatively small quantity of barytes is used in the manufacture of barium chemicals but the industry has developed rapidly since the beginning of the world war.

Under these three heads, the uses of barytes may be classified as given in the following table. Ground barytes and lithopone are frequently the source of material for the same use.

Tabulation of Uses of Barytes

I. Ground barytes
   1. Base, body, substance, load, dressing, filler in white mixed paints, colored pigments, rubber, rope, putty, fabrics, paper, cardboard, wood preservatives, imitation marble, white figures, jasper ware, asphalt, pavement surfacing
   2. Enamel for paper, cardboard, metal work, porcelain, pottery
   3. Adulterant in powdered sugar, candy, flour, Paris green, fertilizer

II. Lithopone
   1. Pigment in "flat" wall paints
   2. Filler in oil cloth, linoleum, fabrics, rubber, soap, calcimine
   3. Enamel for oil cloth, linoleum, paper, paper collars, playing cards, bristol board

[1] Fohs, F. J., Barytes deposits of Kentucky: Kentucky Geol. Survey, 4th ser., vol. 1, pt. 1, pp. 551-572, 1913.
[2] Hill, James M., op. cit., pp. 179-185, 1916.

III. Barium chemicals
1. Barium binoxide or peroxide (BaO_2) in preparation of hydrogen peroxide and oxygen
2. Barium hydroxide as chemical agent
3. Barium monoxide in preparation of the binoxide and hydroxide and manufacture of special glasses
4. Barium carbonate in manufacture of cyanides, lithopone, bricks, barium chemicals, green fire, luster in glass, rat poisons, water softener, flat wall paints, ceramic and rubber industries, case carbonizing steel
5. Barium chloride in lithopone, blanc-fixe, barium salts, water softener, chemical reagent, purification of table salt, ceramic arts, rat poison
6. Barium chlorate in pyrotechnics
7. Barium nitrate in green fire, signal lights, explosive "saxifragin"
8. Barium sulphate (blanc-fixe or permanent white) in paint industry, glazed paper, putty, fabrication of rubber and of lake colors, glass making, manufacture of alumina from bauxite, stiffening and printing calicos, air- and germ-proofing canvas casings for meat
9. Barium hydrate in lithopone, blanc-fixe, clarifying sugar and recovering sugar from molasses, purifying and softening water, glass making, preparing hides for tanning, mercerizing cotton goods, reducing agent in aniline industry
10. Barium sulphide in lithopone, blanc-fixe, barium compounds, depilatory, insecticide, luminous paint
11. Barium carbide in fixation of atmospheric nitrogen

MANUFACTURED BARIUM PRODUCTS

The following quotations on the manufacture of ground barytes, lithopone, and barium chemicals are taken from the Mineral Resources of the United States published by the United States Geological Survey, in order to present a brief description of the three classes of barium products.[1]

Ground barytes.—"The treatment of crude barytes to make ground barytes varies in different plants. The general practice, however, seems to be to crush to about 1 inch and log-wash and jig to remove clay, calcite, fluorite, silica, and part of the iron oxide. This cleaned material is next crushed to one-fourth to one-eighth inch at some plants, and at others ground fine and subjected to a bleaching process. The bleaching, largely to remove iron oxide, is accomplished by

[1] Hill, James M., Barytes and strontium in 1915: U. S. Geol. Survey Mineral Resources, 1915, pt. II., pp. 181, 182, and 183, 1916.

treating the material with sulphuric acid from 8 to 12 hours in lead-lined wooden tanks. The bleached product is washed several times and ground in burr mills or pulverizers to pass 200 to 300 mesh and in some plants is water floated to insure a uniformly fine product, and is then dried, pulverized, and packed. Much care is required not only in the bleaching, but also in the drying operation to insure a uniformly perfect color."

Lithopone.—"Lithopone is a mixture of approximately 70 per cent barium sulphate, 25 to 29 per cent zinc sulphide, and 1 to 5 per cent zinc oxide, which is made by mixing hot solutions of barium sulphide and zinc sulphate. In the preparation of high-grade lithopone the solutions of barium and zinc compounds must be essentially pure. The precipitate from the tanks is filter-pressed, dried, subjected to considerable heat, quenched in water, ground to pulp, filter-pressed, dried, and packed for shipment. A recent paper by O'Brien[1] brings out the important points in the preparation of lithopone and indicates some of the features necessary to produce a light-proof product. Lithopone is sold under a great variety of trade names, such as Beckton White, Green Seal, Blue Seal, Sterling White, Fulton White, Phonolith."

Barium chemicals.—"The principal barium chemicals made in the United States are the binoxide, carbonate, chloride, hydroxide, nitrate and sulphate or blanc-fixe.

"The manufacturers of barium chemicals prefer to use washed, high-grade barytes of the soft variety; nevertheless they can, and some do, use barytes which could not be used for the highest grades of ground floated barytes. The first step in the barium chemical plants is the reduction of the barium sulphate to the sulphide, which is soluble in water. The barytes is finely crushed and mixed with a certain proportion of pulverized coal and common salt. The mix varies in different plants, but is generally stated to be about one-fourth coal by volume. This material is fed to rotating furnaces, where it is roasted from three to four hours. The charge is next leached in most plants, first, with a boiling, weak solution of barium sulphide,

[1] O'Brien, W. S., A Study of lithopone: Jour. Phys. Chemistry, vol. 19, pp. 113-144, 1915.

which is obtained by washing the leached material with hot water. The ash, after the leaching and washing, is waste, though it may contain some undissolved barium compounds. The extraction of barium sulphide is ordinarily stated to be 70 per cent, though it is known that a higher extraction can be made. The liquid from the barium sulphide leach is stored in large heated tanks, from which it is drawn into the different vats for the preparation of the various salts. Barium sulphide can be precipitated by allowing the solution to cool below 150°."

Other barium compounds may be prepared from barium sulphide.

The following table[1] shows the quantity of barytes used in the manufacture of barium products.

Crude barytes used in the manufacture of barium products, 1915-1917, *in short tons*

Year	For barium chemicals	For ground barytes	For lithopone	Total
1915	10,216	53,903	44,503	108,622
1916	38,283	75,507	71,893	185,688
1917	49,842	60,132	86,065	196,039

PRODUCTION

The first production of crude barytes in the United States, as recorded in the Mineral Resources by the United States Geological Survey,[2] was 22,400 short tons in 1880. During the period of 20 years from 1880 to 1899 inclusive, the yearly production ranged from a minimum of 11,200 tons in 1886 to a maximum of 41,894 tons in 1899, and the average was 25,090 tons. For the 14 years from 1900 to 1913 inclusive, the average was 53,378 tons a year. In 1914, the year in which the world war began, the United States produced 52,747 tons. In 1915 the production was 108,547 tons or more than twice that of the previous year, and in 1916 it was 221,952 tons or more than four

[1] Hill, James M., Barytes and barium products in 1917: U. S. Geol. Survey Mineral Resources, 1917, pt. II., p. 287, 1918.

[2] Hill, James M., Barytes and barium products in 1916: U. S. Geol. Survey Mineral Resources, p. 244, 1917.

times the output in 1914. This remarkably rapid increase was due to the curtailment of imports from Germany and the consequent development of the domestic mining industry. In 1917 the production increased to 206,888 tons and in 1918 it was 155,241 tons. The total amount of crude barytes produced and sold in the United States from 1880 to 1918 inclusive was 1,982,004 short tons.

The following table from the Mineral Resources of the United States shows the productions by states for 1917 and 1918, together with the value of the ore and the average price per ton.[1]

Crude barytes produced and marketed in the United States, by states, 1917-1918

State	1917			1918		
	Quantity (short tons)	Value	Average price per ton	Quantity (short tons)	Value	Average price per ton
Alabama	1,976	$ 8,868	$4.49	1,667	$ 9,408	$5.64
Georgia	111,300	601,895	5.41	69,318	418,178	6.03
Kentucky	6,720	36,084	5.37	(a)	(a)	(a)
Missouri	59,046	391,363	6.63	49,094	393,738	8.02
N. Carolina	1,019	5,080	4.99	(a)	(a)	(a)
Tennessee	16,972	79,058	4.66	22,542	141,844	6.29
Other States[b]	9,855	48,836	4.96	12,620	81,169	6.43
	206,888	$1,171,184	$5.66	155,241	$1,044,337	$6.73

a. Included in "Other States."

b. Includes, 1917: California, Nevada, South Carolina, and Virginia; 1918: Kentucky, Nevada, New Mexico, North Carolina, South Carolina, Virginia, and Wisconsin.

IMPORTS

According to the records of the Mineral Resources of the United States Geological Survey, importations of manufactured barytes began about 1867 and crude ore in 1884. From 1867 to 1913 inclusive, or during a period of 47 years, approximately 118,000 short tons of manufactured barytes were imported. From 1884 to 1917 inclus-

[1] Division of Mineral Resources, U. S. Geol. Survey, Preliminary report on the mineral resources of the United States in 1918, p. 27, 1919.

ive, approximately 270,000 short tons of crude barytes were imported. The effect of the world war on decreasing crude barytes imports is strikingly shown in the figures for the period from 1913 to 1918. From 1913 to 1917 inclusive, the importations dropped from 35,840 tons to 6 tons, and in 1918 no ore was imported.

CONSUMPTION

The following table[1] indicates the quick growth of the domestic barytes industry, beginning with the war and the consequent curtailment of the foreign product. The figures for domestic production combined with those for importations show the apparent consumption of crude barytes in the United States.

Apparent consumption of crude barytes in the United States, 1913-1918, *in short tons*

Year	Domestic Barytes produced		Barytes imported for consumption		Apparent consumption[a]	
	Quantity (short tons)	Value	Quantity (short tons)	Value	Quantity (short tons)	Value
1913	45,298	$ 156,275	35,840	$ 61,409	81,138	$ 217,684
1914	52,747	155,647	24,423	46,782	77,170	202,429
1915	108,547	381,032	2,504	4,877	111,051	385,909
1916	221,952	1,011,232	17	245	221,969	1,011,477
1917	206,888	1,171,184	6	63	206,894	1,171,247
1918	155,241	1,044,337	0	0	155,241	1,044,337

a. No exports reported. Stocks at plants included, but those at mines excluded.

[1] Op. cit., p. 26.

BARYTES IN GEORGIA

GENERAL LOCATION

The barytes deposits of Georgia are situated in the northwestern part of the State, the most important mines being about 40 miles Plateau on the west and the Piedmont Plateau and the Appalachian division known as the Appalachian Valley, though a few occurrences are in the Piedmont Plateau. These physiographic divisions are here briefly described.

APPALACHIAN VALLEY

The Appalachian Valley division lies between the Cumberland Plateau on the west and the Piedmont Plateau and the Appalachian Mountains on the east. It extends south-southwest across the State from Tennessee into Alabama and is generally co-extensive with the valley of Coosa River. The Appalachian Valley in Georgia is drained southwestward by the Coosa system whose northeastern sources are Conasauga and Coosawattee rivers which unite to form Oostanaula River. The Oostanaula is joined by Etowah River to form the Coosa in the southwestern part of the Great Valley.

The Appalachian Valley comprises for the most part a broad valley with a rolling floor from which a few hills and ridges rise to local altitudes of 400 and 500 feet, but on the northwest side of the valley proper, sharp northeasterly ridges rise 700 and 800 feet higher than the valley. Elevations in the whole division range from 600 feet almost to 1700 feet above sea level. The greatest length of the Appalachian Valley in Georgia is about 80 miles from northeast to southwest and the greatest width is about 50 miles from northwest to southeast.

PIEDMONT PLATEAU

The Piedmont Plateau, next to the Coastal Plain, is the largest physiographic division in Georgia. It forms a belt about 100 miles wide between the Appalachian Mountains and the Appalachian Valley on the northwest and the Coastal Plain on the southeast, extending from South Carolina about 150 miles southwest across the State

to Alabama. The general character of the Piedmont Plateau is that of an undulating plain sloping gradually from north and northwest to southeast with elevations decreasing from approximately 1600 feet to 400 and 500 feet. Some mountains rise above the plain, however, to elevations of 3000 feet above sea level and some of the river trenches entering the Coastal Plain division are less than 300 feet above sea level. Although the northwestern part of the plateau is drained by streams of the Coosa system and by Chattahoochee River flowing into the Gulf of Mexico, the distinctive Piedmont drainage is southeastward through the Savannah and Altamaha systems to the Atlantic Ocean.

GEOLOGIC ASSOCIATIONS

The physiographic boundary between the Appalachian Valley and the Piedmont Plateau is the escarpment of the Cartersville fault, and the fault itself is likewise the line of separation between the Paleozoic sediments of the Valley and the Paleozoic and pre-Paleozoic metamorphosed rocks of the Plateau.

In the Piedmont Plateau, the rocks in which deposits of barytes occur are named beginning with the oldest as follows: Corbin granite, Pinelog conglomerate, and Wilhite slate. In the Appalachian Valley, the rocks with which barytes is associated are in ascending order: Weisner quartzite, Shady limestone, Cartersville shale, Conasauga shale and limestone, and Knox dolomite. These formations, ranging in age from igneous Archean types to sedimentary Paleozoic types, will be described in the districts where they occur.

TYPES OF DEPOSITS

The barytes deposits of Georgia may be classified into six types according to their mode of occurrence, namely: (1) vein, (2) replacement, (3) breccia, (4) residual, (5) colluvial, and (6) alluvial. The first three occur in hard rock, or consolidated formations; the last three occur in unconsolidated material. It may be said that only the residual and colluvial deposits are of commercial importance, although a few deposits of the vein type have been worked on a small scale.

VEIN DEPOSITS

With deposits of the vein type may be grouped fracture-fillings. Much of the breccia ore is also a fractured phase of vein-filling. Veins and fractures filled with barytes are not common in the known rocks of Georgia, but there are several occurrences sufficient to indicate that the large fragmental ore deposits have accumulated by the weathering of veins. The veins occur for the most part in limestone. The exposures are generally ill-defined as regards attitude and extent of the ore body, and it is not always clear whether they represent true veins or replacements in the rock. Veins in limestone have been observed to be from a few inches to three feet thick and fractures in quartzite contain barytes an inch or two thick.

A shattered vein of crystalline barytes occurs in the Shady limestone exposed in the right bank of Etowah River, at the Thompson-Weinman grinding mill, 1½ miles southeast of Cartersville station, Bartow County. Another vein of similar character occurs in limestone of the Conasauga formation on the S. J. Whatley property about 10 miles northeast of Rome, Floyd County.

REPLACEMENT DEPOSITS

Many of the ore bodies of the residual type have accumulated from fragments weathered out of deposits that formed in veins and as replacements in limestone. Ore fragments are found showing barytes occupying portions of finely granular but somewhat porous siliceous material from which the calcium carbonate particles have apparently been removed. The barytes replaced the more calcareous portions of the rock. One of the best evidences of metasomatic replacement is that of the complete replacement by barytes of a Cambrian coral-sponge found in the residuum of the Shady limestone at the Bertha mine of the New Jersey Zinc Company, 1½ miles east of Cartersville. An illustration of a bedded-vein deposit probably representing replacement of a limestone lens or layer in the Wilhite formation may be seen on the White property about 4 miles southwest of Waleska, Cherokee County.

BRECCIA DEPOSITS

The breccia type of deposit forms a part of a large number of the barytes ore bodies. While ore was being deposited in fissures and

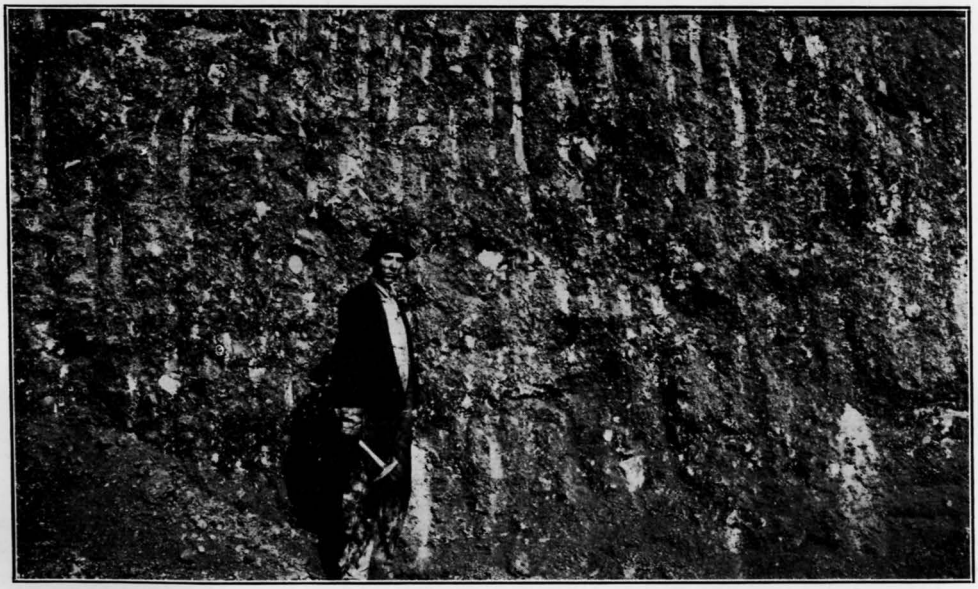
fractures, the broken and shattered adjacent portions of the rock were being cemented together with barytes. As there were doubtless more than one period of fracturing and deposition, the quantity of brecciated ore increased. Much of the brecciated ore is found in the residual deposits also, where some of the breccia masses consist of angular limestone fragments held together by a barytes cement, and others consist of barytes fragments cemented by ferruginous material of both ocherous and limonitic character. Among the many places where breccia ore may be seen are the Clayton mine, ¾ mile southeast of Cartersville, Bartow County, where it occurs in the ferruginous form, and the Love property at Eton, Murray County, where it occurs in the form of limestone breccia.

RESIDUAL DEPOSITS

Residual deposits as here defined form at present the only profitably workable barytes deposits in Georgia. By the term "residual," it is not intended to restrict the definition of these deposits to ore bodies that have been left behind, *in place,* by the wearing away of the mother rock, but it is intended also to embrace those other fragmental accumulations that have been added to the strictly residual deposits and have thus been concentrated in unconsolidated material by long continued weathering agencies such as frost action, hillside creep, and gully wash. Thus it is seen that the residual deposits contain some colluvial, or hillside, accumulation and in places where ancient stream channels and beaches have been cut into by hillside erosion may contain some alluvial, or water-borne, accumulation. All of these are fragmental and secondary in nature. The term "residual" seems most applicable in that these accumulations are generally in the red and yellow soil mass that overlies or represents the ore-bearing rock which is as a rule limestone. Residual deposits may have been formed from any of the three consolidated types—vein, replacement, or breccia—or from all of them.

As all of the commercial deposits are in part residual it is unnecessary to give illustrations. One of the important mines that might be mentioned, however, where the unconsolidated ore body overlies, and continues down to the unaltered Shady limestone, is the Paga No. 1 mine, 1¼ miles west of Emerson, Bartow County.

A. BARYTES VEIN IN SHADY LIMESTONE AT THOMPSON-WEINMAN MILL ON ETOWAH RIVER, CARTERSVILLE, BARTOW COUNTY



B. WORKING FACE OF RICH UNCONSOLIDATED HILLSIDE ACCUMULATION OF BARYTES AT BERTHA MINE. CARTERSVILLE, BARTOW COUNTY.

COLLUVIAL DEPOSITS

All of the large barytes deposits of Georgia may be described as colluvial deposits, that is, they are unconsolidated accumulations formed by the wearing away of hillsides and they still occupy hillside positions. The ore-bearing beds that were tilted and folded in the formation of the hills gradually disappeared in disintegration and decay and the heavy ore, released from the hard rock, slowly fell down the hillside in loose deposits that increased as the rocks wore away. Since the colluvial deposit, however, is a gradual accumulation from strictly residual ore, the ore *in place* slowly passing by means of hillside creep into a strictly secondary position, it can not, therefore, be definitely separated from the residual deposit. Since the principal deposits are both residual and colluvial in nature, they may rightly be termed *secondary-residual* or *residual-hillside* deposits.

The colluvial character of the deposit is shown at the DuPont mine, a quarter of a mile west of Emerson, as well as in many other open-cuts where the ore occurs on the east hillslope mixed with soil and rock debris and covered with an overburden of similar material that increases in thickness down the slope.

ALLUVIAL DEPOSITS

Although alluvial, or water-borne, accumulations of barytes are not recognized as distinct and separate ore bodies, they do form a part of several important deposits. The close and common association of stream and beach gravel with the ore deposits, the rounded pebbly appearance of some of the barytes itself, and in places the distinct and almost horizontal stratification of the unconsolidated material, are good evidence that water transportation has contributed in a small way to the secondary deposition of the ore.

Water-worn quartz gravel probably of Tertiary age is particularly noticeable at the Bertha mine, 1½ miles east of Cartersville, where the entrance to the open-cut passes through an old stream channel in which gravel and barytes are intimately mixed. Rounded barytes pebbles were found, among other places, between the Tucker Hollow mine and the New Riverside Ochre Company's mine. A bed of barytes and rock fragments 1½ feet thick, observed in cut No. 4

at Paga No. 2, a mile west of Emerson, suggests an origin similar to that of an alluvial fan.

TYPES OF ORE

Aside from the minor forms in which barytes occurs in Georgia, such as crystals, concretions, nodules, pebbles, stalactites, stalagmites, fossils, and structures of banded and mammillary nature, the principal types of ore may be classified as (1) crystalline and (2) granular. The crystalline ore is both coarse and fine in texture, translucent in thin fragments, and generally slightly bluish-white in color. The granular ore is finely granular, opaque, and dull white. Different phases of these two types are caused by iron, manganese, quartz, limestone, and other impurities. There seems to be little, if any, difference in the chemical composition between the two types, although the opaque granular ore is the weathered and thus the somewhat altered and softer product. Both types occur as irregularly shaped fragments, some angular, some with smoothly worn surfaces, ranging in size from mere grains to unwieldy masses several feet thick.

ORIGIN OF DEPOSITS

The source of the barium together with the origin of the barytes deposits in Georgia may be generally and somewhat hypothetically stated as follows: barium originally in the feldspars and micas of the crystalline rocks was removed in solution by circulating meteoric and thermal waters, and carried from uncertain depths upward through channels made by faulting and fracturing in the earth's crust to limestone formations where favorable precipitating reactions caused the deposition of the barium sulphate, barytes. It is not thought that the sulphate was formed by the reaction between barium carbonate, or wiherite, and calcium sulphate, or gypsum, as has been suggested for the origin of some deposits, because neither of these minerals has been found associated with any of the deposits studied .

Local conditions regarding the source of barium and the origin of the deposits will be given in more detail in the description of the Cartersville district which is at present (1919) the only producing area in the State.

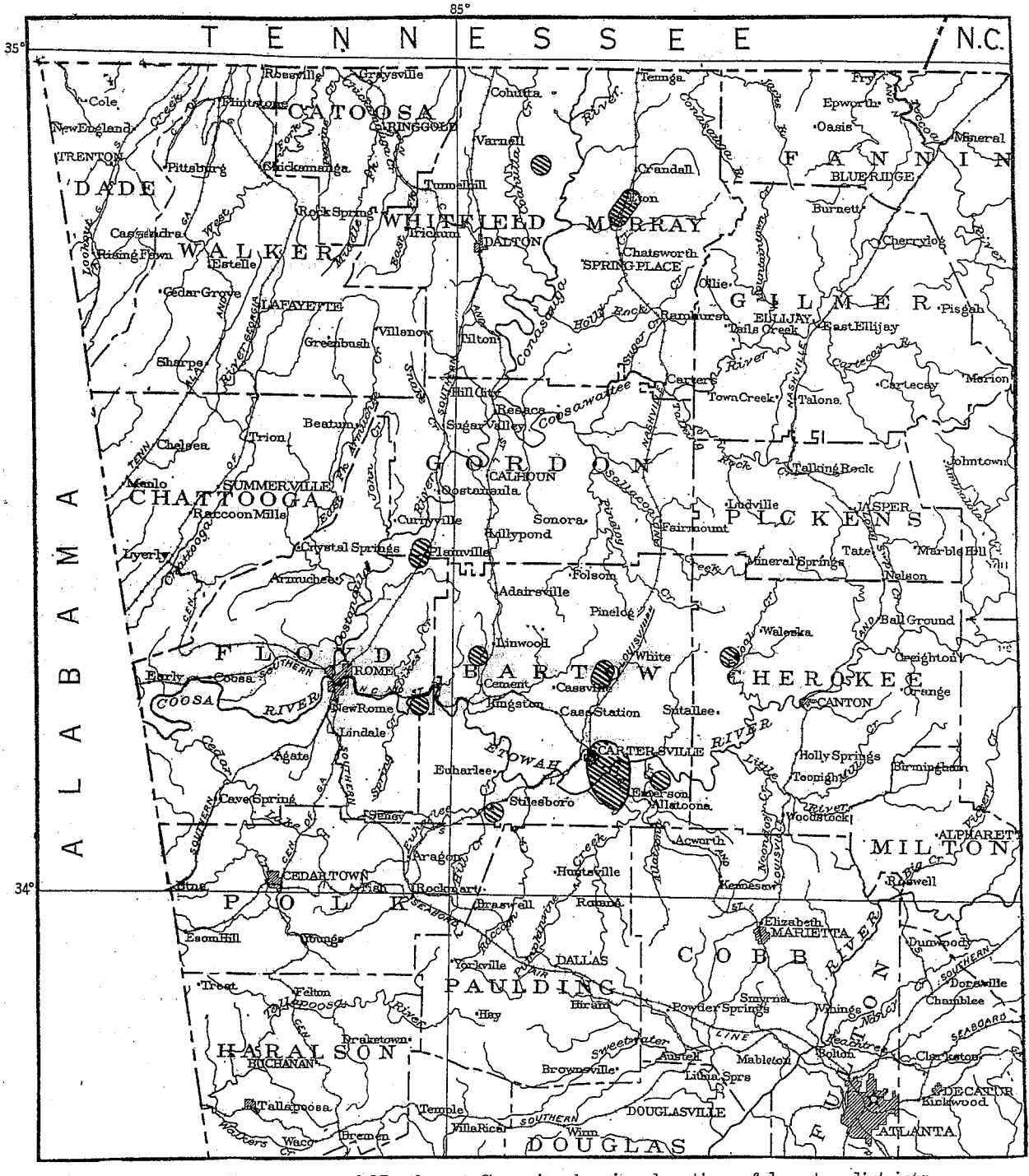
Considering the deposits in the State as a whole it is seen that the larger ore bodies are near the great Cartersville fault, and that the small deposits are near minor faults or near the contact of one formation with another. Almost all of the occurrences are in zones of shattering or structural disturbances where openings in the rock have afforded conditions favorable for the passage of solutions and the depositions of minerals.

Although the original vein and replacement ore bodies occur in the Archean and early Paleozoic rocks, they were probably not deposited in those formations until the end of the Paleozoic time, when the Appalachian deformation was in progress and the structure of the Piedmont Plateau and the Appalachian Valley was complicated in a most confusing manner by folding, fracturing, and faulting. Faults and fissures formed by this shattering became the channels for many different mineral-bearing solutions from which barytes was one of the important ores deposited. During subsequent periods of weathering and degradation of the mountains formed at that time, the original deposits of barytes have been exposed and the enclosing rocks have been greatly worn away, leaving the more resistant and less changeable ore behind as residual hillside accumulations.

DISTRIBUTION OF DEPOSITS

The barytes deposits are almost wholly in the Appalachian Valley division of the northwestern part of Georgia, occurring principally in vicinity of Cartersville, Bartow County, about 40 miles northwest of Atlanta, and in minor quantities and isolated localities from the Alabama line near Esom Hill northeastward to the deposits near Ruralvale, 6 miles south of the Tennessee line. The area including these scattered deposits is 75 miles long and the greatest width near its center is 25 miles. The following 7 counties named in order from the Alabama line northeast to the Tennessee line contain deposits: Polk (?), Floyd, Bartow, Cherokee, Gordon, Murray, Whitfield.

All of the large deposits and all that were being worked in 1919 are in the Cartersville mining district in the southeastern part of Bartow County. A smaller and inactive district includes the old mines



Map 1. Index map of Northwest Georgia showing location of barytes districts and deposits. Scale: 1 *inch approximately* 16 *miles. Base map by the U. S. Geological Survey.*

near Eton in central Murray County. Seven other localities are described in this report, namely: (1) near Bass Ferry, eastern Floyd County, (2) south of Plainville, northeastern Floyd County, (3) southwest of Stilesboro, southwestern Bartow County, (4) north of Kingston, western Bartow County, (5) southwest of Waleska, western Cherokee County, (6) north of Plainville, southwestern Gordon County, and (7) near Ruralvale, eastern Whitfield County. The occurrence reported near Esom Hill, Polk County, is doubtfully in Georgia.

CARTERSVILLE DISTRICT[1]

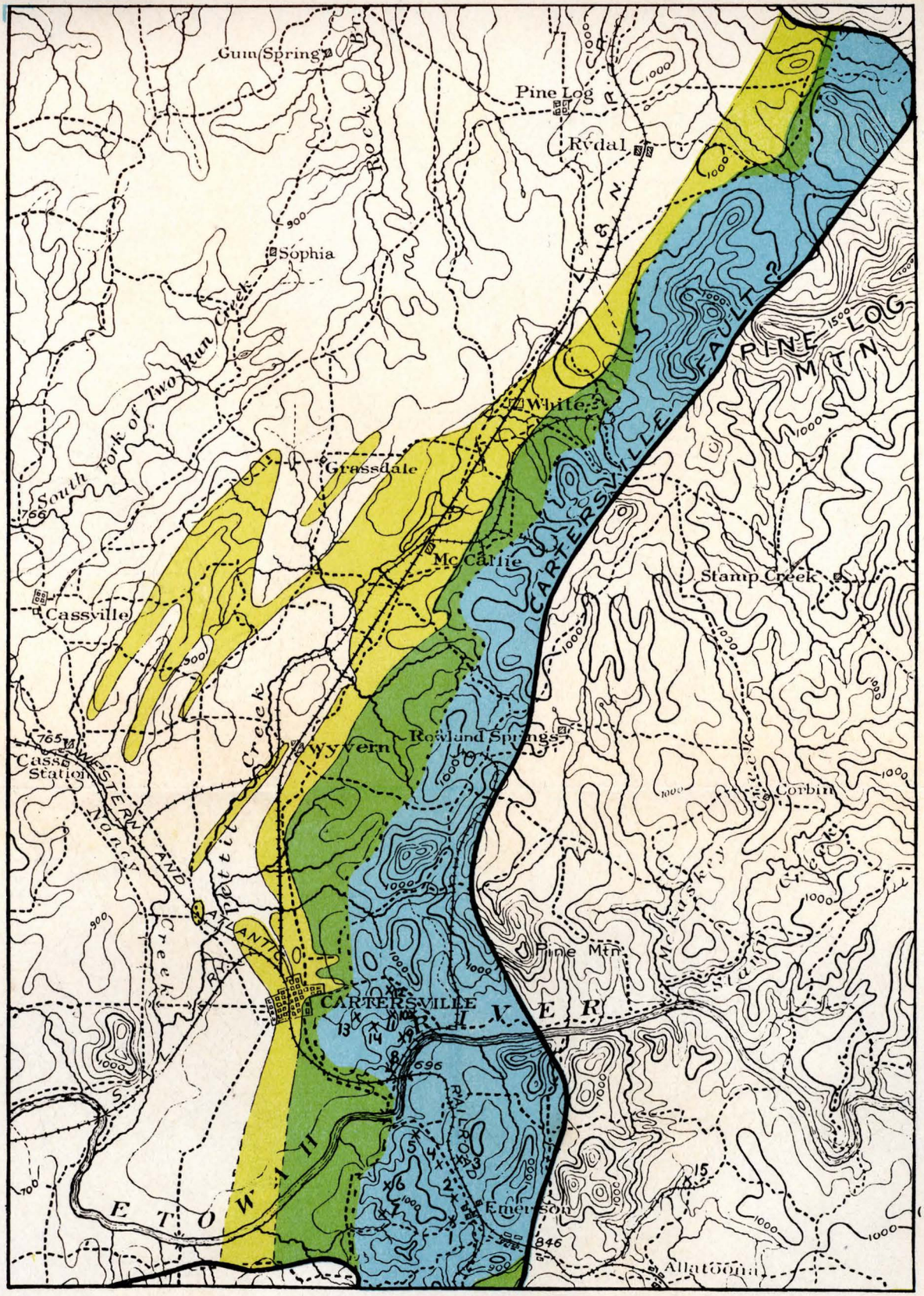
GEOGRAPHY

The Cartersville mining district in which are included ore deposits other than barytes is in the southeastern part of Bartow County. It is 18 miles long from the vicinity of Emerson at the south end to the vicinity of Pinelog and Martins Mill at the north end. Its greatest width through the middle part from the vicinity of Cassville on the west to Rowland Spring on the east is about 7 miles. Thus limited, it lies wholly within the Appalachian Valley just west of the Cartersville fault.

The principal barytes deposits of the Cartersville district are confined to the southern part, comprising an area about 6 miles long and 3 miles wide extending northward from Pumpkinvine Creek on the south side of Etowah River to the mines northwest of Pine Mountain on the north side of the river. The minor deposits near Grassdale and north of Allatoona, though outside of the group at Cartersville, will, nevertheless, be described with the Cartersville district deposits.

Cartersville, a city of about 5000 people, on the northwest side of the Etowah and the village of Emerson on the southwest side, are situated on the Western & Atlantic Railroad 48 miles and 43 miles, respectively, northwest of Atlanta, and 89 and 94 miles southeast of Chattanooga, Tenn. The power transmission line of the Georgia Railway & Power Company crosses the district.

[1] For a more comprehensive treatment of the general geography and geology of the Cartersville district than is here given, the reader is referred to LaForge's description in Hull, LaForge, and Crane, Report on the manganese deposits of Georgia: Geol. Survey of Ga. Bull. 35, pp. 25-67, 1919.



Map II.

MAP OF THE CARTERSVILLE MINING DISTRICT

Topography from the Cartersville Topographic Map of the U. S. Geological Survey

Scale 1:125,000 Contour Interval 100 feet

Barytes mines: 1. Big Tom. 2. DuPont. 3. Section house. 4. Nulsen. 5. Paga No. 3. 6. Georgia Peruvian. 7. Paga Nos. 1 and 2. 8. Krebs. 9. New Riverside. 10. Bertha. 11. Tucker Hollow. 12 Parrott Springs and Munford lot. 13. Clayton. 14. Thompson-Weinman. 15. Iron Hill.

PHYSIOGRAPHY

The district is in the eastern part of the Appalachian Valley division, in the broken hills and ridges that form the western and lower part of the Cartersville fault escarpment. East of the supposed major fault the higher ridges, represented by Pine Mountain north of Etowah River and by Signal Mountain south of the river, form the eastern boundary of the barytes district proper.

The barytes district which lies between Cartersville and Emerson may be described as the hilly, or foothills, section between the rolling plain of Nancy and Pettit creeks on the west and the rugged ridges of Pine and Signal mountains on the east. The hills trend in a generally northward direction, but north of the river they swerve northwestward. Etowah River flows through the middle of the district from northeast to southwest at right angles to the trend of the hills. Where the river leaves the Piedmont Plateau and enters the district it occupies a narrow rocky trench from which the hills rise precipitously, particularly on the left bank, to summits several hundred feet above the river; where it leaves the district it flows through cultivated bottom land half a mile wide. The river is about 700 feet above sea level and Cartersville, situated on the rolling plain a mile and a half to the northwest is 787 feet above sea. The ore-bearing hills have an average elevation between 900 and 1000 feet and the ridges bounding the district on the east range from 1200 feet to 1552 feet (Pine Mountain) above sea level.

Pumpkinvine Creek flowing generally westward in this area through a bottom land half a mile wide, bounds the barytes district on the south and joins Etowah River. It here follows approximately the boundary between the Piedmont Plateau and the Appalachian Valley.

GEOLOGY

Including in the Cartersville barytes district the isolated deposit at Iron Hill in the Piedmont Plateau, 6 miles east of Cartersville, we find that the stratigraphic sequence of the rocks begins with Archean and ends with Upper Cambrian formations. The ancient crystalline rocks of the Piedmont Plateau east of the great fault are included in the discussion of the geology of the district because some of them

contain feldspars and percentages of barium that are probably significant as the source of the barium and the origin of the barytes deposits. The following formations are those with which barytes is more or less closely associated in the Cartersville district.

Geologic formations in the Cartersville district

III. Cambrian
- 7. Conasauga shale and limestone
- 6. Cartersville shale, slate, and sandstone
- 5. Shady limestone
- 4. Weisner quartzite

II. Ocoee. Cambrian ? or Algonkian ?
- 3. Wilhite slate and limestone lentils
- 2. Pinelog conglomerate

I. Archean
- 1. Corbin granite

CORBIN GRANITE

The Corbin granite as mapped by C. W. Hayes of the U. S. Geological Survey in his manuscript map of the Cartersville quadrangle extends 18 miles northwestward from a point between Bartow and Allatoona, rapidly widening to its greatest breadth of 6 miles through the settlement of Corbin and narrowing again to its northernmost exposures midway between Martins Mill and Waleska in Cherokee County.

This formation constitutes the hills of the Piedmont Plateau east of Pinelog, Brushy Knob, Pine, and Signal mountains. The largest part of the area is drained by McKasky and Stamp creeks flowing south to Etowah River, which crosses the southern part of the granite area from east to west. The general elevation of the hills is about 1000 feet above sea level. The altitude at the river is approximately 700 feet and some of the highest hills approach 1200 feet.

Hayes[1] described the granite as being, "for the most part, a massive coarse-grained rock, containing large porphyritic crystals of feldspar (microcline) in a groundmass of plagioclase feldspar, muscovite-mica, and blue quartz. Some portions of the rock have undergone considerable alteration, being converted into an augengneiss."

[1] Hayes, C. W., Geological relations of the iron ore in the Cartersville district, Ga., Trans. Am. Inst. Min. Eng., vol. XXX., p. 406, 1901.

As the largest barytes deposits of the State occur in sedimentary rocks near this ancient granite mass whose silicate minerals contain barium, it seems probable that they owe their origin in part at least to the granite. A chemical analysis[1] of Corbin granite by H. N. Stokes shows 0.20 per cent of barium oxide.

It is also of interest to note from the same authority that a "quartz gabbro, 2 miles southeast of Waleska, Cherokee County," contained 0.17 per cent of barium oxide.

PINELOG CONGLOMERATE

The Pinelog conglomerate borders the granite area on all sides but the southeast. It forms Pinelog, Pine, and the eastern part of Brushy Knob and Signal mountains. This formation constitutes the highest peaks of the mountains forming the eastern boundary of the larger Cartersville mining district. Pine Mountain in Bartow County is 1552 feet and Bear Mountain in Cherokee County is 2276 feet above sea level. The conglomerate was recognized by Hayes as an altered phase of the granite and this border or peripheral character is shown in its areal distribution.

LaForge[2] described the formation in part as follows: "This is a rather heterogeneous formation composed of conglomerate, arkose, quartzite, siliceous phyllite, and graphitic slate, all much sheared and largely altered to sericitic schist and gneiss."

WILHITE SLATE

The Wilhite slate overlies the Pinelog conglomerate and likewise surrounds the Corbin granite area by narrow borders ranging from 1/8 to 1 mile wide. The Wilhite slate formation, according to Hayes, belongs to the Ocoee series and Algonkian age, is the youngest of the pre-Cambrian rocks, and is separated from the oldest Cambrian, the Weisner quartzite, by the great Cartersville thrust fault.

The age of the Wilhite, however, and the position, or even presence, of a definite major fault is not altogether certain, for as has been pointed out by LaForge,[3] "It now seems not improbable . . . . that

[1] Clarke, F. W., Analyses of rocks and minerals from the laboratory of the U. S. Geol. Survey, 1880 to 1914: U. S. Geol. Survey Bull. 591. p. 53, 1915.
[2] Hull, J. P. D., LaForge, Laurence, and Crane, W. R., Report on the manganese deposits of Georgia: Geol. Survey of Ga. Bull. 35, p. 40, 1919.
[3] Op. cit., pp. 40-41, 1919.

the slate [Wilhite] and conglomerate [Pinelog] conformably underlie the quartzite [Weisner] and constitute the base of the Cambrian strata and that the whole section from the basal arkose to the top of the quartzite is equivalent to Safford's Chilhowee group of Tennessee."

The Wilhite contains graphite mines 2 miles south of Emerson and near Bartow, and from these localities extends northeastward on the east side of the granite and conglomerate mass and northward on the west side, forming the western part of Signal and Pine mountains, Brushy Knob, and the western flanks of Pinelog Mountain.

Besides being characterized by carbonaceous or graphitic material, the slate and schist contain limestone lentils that have probably afforded favorable conditions for the deposition of barytes by replacement. This may be the mode of occurrence on the Munford property north of Allatoona and on the White property southwest of Waleska.

WEISNER QUARTZITE

The Weisner quartzite in its association with the overlying Shady limestone is one of the most important formations in the barytes district in its relation to the occurrence of the barytes deposits. It extends along the western side of the Cartersville fault from Pumpkinvine Creek north-northeastward about 18 miles, the length of the whole Cartersville district, to Pinelog Creek. In the barytes district, proper, it occupies the foothills, or the ore-bearing area, 2 or 3 miles wide on both sides of Etowah River west of Pine and Signal mountains. The village of Emerson is in this area.

Although the area thus described has been mapped as Weisner and although the exposures are almost all quartzite, or at least siliceous rock, no small part of the area is underlain by Shady limestone. The evidence of the limestone is seen in the characteristic red residual soil, in the scattered exposures here and there in valley bottoms and mine openings, in the occurrence of ferrugmous chert-like masses that are recognized as remnants of the limestone, and in the ridge-valley type of topography that has resulted from the resistance of the quartzite and the weathering away of the limestone. Many of the valleys, therefore, in the Weisner quartzite area represent limestone.

The rugged ore-bearing hills of the quartzite formation in the barytes district have a northerly trend and range from 900 to 1300 feet above sea level. The rock has been highly folded and repeatedly fractured so that the hills and valleys represent in some places overthrust anticlinal and synclinal structure, and in other places represent a series of thrust fault blocks overlapping each other. Disregarding the many different attitudes due to a complicated structure, it may be said that the Weisner quartzite as associated with the barytes deposits strikes from north-northeast to north-northwest and dips 45°-50°SE. to NE.

Hayes[1] described the rock as follows: "It consists chiefly of vitreous quartzite, although it also contains some beds of fine conglomerate, and probably, considerable beds of siliceous shales. The latter, however, are usually concealed by the abundant debris from the quartzite beds, which tend to break up into angular fragments when exposed to atmospheric conditions. . . . The thickness of the formation is probably 2000 or 3000 feet, and may be considerably more. . . ."

The Weisner is correlated with the Erwin quartzite of Tennessee and Virginia and with a part of the Chilhowee series of Tennessee. Lower Cambrian fossils have been found by McCallie[2] who collected a few Brachiopods and Corals near Emerson, and by LaForge[3] who found some Scolithus tubes near Cartersville.

Typical outcrops of the quartzite showing both a peculiar pitted or pocketed weathering feature and a vitreous pyritiferous phase may be seen at the Bertha mine 1½ miles east of Cartersville.

One of the most significant features of the quartzite as it is related to the barytes deposits is its content of barium. All the analyses of the rock in which the barium determination was made showed an average content higher than that so far known in any other formation associated with the barytes deposits. The surprisingly high

[1] Hayes, C. W., Geological relations of the iron-ores of the Cartersville district, Ga., Trans. Am. Inst. Min. Eng., vol. XXX., p. 404, 1901.

[2] McCallie, S. W., A preliminary report on a part of the iron ores of Georgia: Geol. Survey of Ga. Bull. 10-A., p. 124, 1900.

———— ————, Notes on the geology of Georgia: Jour. of Geology, vol. XXVII., No. 3, p. 171, Apr.-May, 1919.

[3] Hull, J. P. D., LaForge, Laurence, and Crane, W. R., Report on the manganese deposits of Georgia: Geol. Survey of Ga. Bull. 35, p. 42, 1919.

percentage of barium sulphate in the samples collected by T. L. Watson does not harmonize with the comparatively low percentage in the samples collected by the writer, but the higher percentage may be explained by the presence of the mineral barytes.

Analyses of Weisner quartzite

Constituents	*Watson*	*Hu-349*	*Hu-339*
Silica (SiO_2)	90.36	95.56	89.80
Alumina (Al_2O_3)	1.52	0.35	----
Ferric oxide (Fe_2O_3)	0.57	1.52	2.64
Ferrous oxide (FeO)	----	1.36	----
Magnesia (MgO)	0.27	0.03	----
Lime (CaO)	0.27	0.00	----
Soda (Na_2O)	0.43	trace	----
Potash (K_2O)	0.16	0.07	----
Moisture at 100°C	0.00	0.02	----
Moisture above 100°C	0.31	0.06	----
Titanium dioxide (TiO_2)	0.07	0.05	----
Sulphur trioxide (SO_3)	----	0.20	0.10
Manganous oxide (MnO)	0.00	0.17	0.91
Barium oxide (BaO)	----	0.40	0.15
Barium sulphate ($BaSO_4$)	4.46	----	----
Total	99.92	99.79	93.60

Watson.—"Specimens of the Weisner quartzite, carefully collected by writer from the different localities covering the entire area exposed in Georgia, were thoroughly mixed and prepared as one sample, which yielded on analysis by the N. P. Pratt Laboratory, Atlanta, for the Geological Survey, the following results:" (*see* table) From Watson, T. L., A preliminary report on the manganese deposits of Georgia: Geol. Survey of Ga. Bull. 14, p. 37, 1908.

Hu-349.—Fresh somewhat vitreous fragment from foot wall of an old ocher open-cut of the New Riverside Ochre Company, lot 533, 4th district, 3d section, 1½ miles east of Cartersville, Bartow County.

Hu-339.—Fresh vitreous fragment, containing a few specks of pyrite, from outcrops west of the Bertha barytes mine, lot 476, 4th district, 3d section, 1½ miles east of Cartersville, Bartow County.

SHADY LIMESTONE

The Shady limestone, including the unconsolidated products of its decomposition, is the formation that contains the barytes deposits of the Cartersville district. It overlies the Weisner quartzite and occupies an area, as mapped, paralleling that formation on the west.

Its width ranges from ⅛ mile to 1¼ miles. The formation occupies the gently rolling area on the lower slopes of the quartzite hills and parts of the level area in the valleys of Pettit Creek and Etowah River. Some of the hills in the barytes district of the Shady limestone are 900 feet above sea level or 200 feet higher than the river. The eastern part of the city of Cartersville is on this formation.

The attitude of the Shady is difficult of determination because of the scarcity of definite outcrops, but it corresponds to the strike and dip of the underlying Weisner formation.

The formation was named Beaver limestone by Hayes but as it is now known not to occur at Beaver Ridge, Tenn., the old name has been abandoned.[1] The Lower Cambrian age of the formation and its correlation with the Shady limestone in Tennessee and Virginia are determined by Ulrich's[2] identification of a coral-sponge—*Ethmophyllum profundum* (Billings) Walcott—found by the writer at a barytes mine in the decomposed remnants of the formation east of Cartersville.

The Shady formation consists of gray dolomitic limestone, generally rather sandy, and in places clayey. The principal characteristics of the weathered formation are the chert-like masses of siliceous and ferruginous rock and the residuum of red clay soil. The thickness of the formation as estimated by Hayes ranges from 800 to 1200 feet.

Good exposures of the fresh rock together with veins of barytes occur at the Paga mines west of Emerson and at the Cartersville city pumping station on Etowah River. Exposures of the weathered ferruginous siliceous remnants are the more common representatives of the formation. Such a typical bouldery outcrop containing barytes occurs at the city reservoir on the ridge east of Cartersville.

Outside of the barytes deposits themselves, the content of barium in the limestone is evidently neither large nor widespread, if the analyses of the few samples collected from the formation south of Etowah River may be taken as a criterion. Only one of the five analyses showed a content of barium and that was of a sample (*Hu-55*) taken near a surface deposit of barytes on the Paga Mining Company's property west of Emerson.

[1] Hull, LaForge, and Crane, op. cit., p. 44, 1919.
[2] Ulrich, E. O., manuscript special report to Philip S. Smith, Acting Director U. S. Geol. Survey, Dec. 7, 1917.

A. SILICEOUS AND FERRUGINOUS REMNANTS OF SHADY LIMESTONE CONTAINING BARYTES. RESERVOIR HILL EAST OF CARTERSVILLE, BARTOW COUNTY.

B. WEISNER QUARTZITE SHOWING DIP AND CHARACTERISTIC WEATHERING PITS AND CAVERNS, BERTHA MINE, CARTERSVILLE, BARTOW COUNTY.

Analyses of Shady Limestone

Constituents	*Hu-40*	*Hu-414*	*Hu-16A*	*Hu-45*	*Hu-47*
Insoluble	------	0.40	0.27	0.50	0.21
Silica (SiO)	2.32	1.95	2.80	2.30	1.35
Alumina (Al_2O_3)	2.35	0.05	0.20	0.16	0.24
Ferric oxide (Fe_2O_3)	1.40	1.04	0.60	0.11	0.47
Ferrous oxide (FeO)	------	0.70	0.70	1.73	5.76
Magnesia (MgO)	19.78	20.65	20.46	19.65	17.57
Lime (CaO)	28.86	29.32	29.54	29.60	28.78
Moisture at 100°C	0.25	0.02	0.01	0.04	0.80
Loss on ignition	44.67	45.70	45.43	44.83	43.46
Sulphur trioxide (SO_3)	0.07	------	------	------	------
Phosphorus pentoxide (P_2O_5)	------	0.05	trace	0.02	0.03
Manganous oxide (MnO)	0.00	0.21	0.42	0.52	1.60
Barium sulphate ($BaSO_4$)	------	------	------	0.55	------
Barium (Ba)	0.00	0.00	0.00	------	0.00
Total	99.70	100.09	100.43	100.01	100.26

Hu-40.—City pumping station, 1½ miles south-southeast of Cartersville.
Hu-414.—Tennessee Coal, Iron & Railroad Company, lot 902, 4th district, 3d section, Bartow.
Hu-16A.—Old limestone quarry north of Pumpkinvine Creek, 1½ miles southwest of Emerson.
Hu-45.—Paga Mining Company, lot 838, 4th district, 3d section, 1¼ miles west of Emerson.
Hu-47.—Old limestone quarry near Paga barytes mines, lot 838, 4th district, 3d section, 1½ miles west of Emerson.

CARTERSVILLE FORMATION

The Cartersville formation occupies a narrow belt just west of, and parallel to, the Shady limestone, extending about 17 miles from Etowah River on the south to Pinelog Creek on the north. The name, taken from the city of Cartersville which is situated on the formation, was given by Shearer[1] as applying to the potash-bearing slate, shale, and feldspathic sandstone of the district. The formation is 600 to 700 feet thick.

The physiographic expression is seen in the low land and roll-

[1] Shearer, H. K., Report on the slate deposits of Georgia: Geol. Survey of Ga. Bull. 34, p. 48, 1918.

ing ridges of Pettit Creek and south of Cartersville to Etowah River. The elevations range from 700 to 800 feet above sea level.

Barium is not known in this high-potash rock, although no determinations have as yet been made for it. The barytes deposit west of McCallie is one of the few closely associated with the Cartersville formation, and it is near the contact of the Cartersville and the Conasauga formations.

CONASAUGA FORMATION

The Conasauga shales and limestones form only a small part of the barytes district proper. The formation underlies a broad area west of the Cartersville formation. Its dolomitic limestones, with which the barytes is associated when present at all, outcrop typically in the lowland of Pettit Creek. The strike and dip are generally north-northeast and east-southeast, respectively. Hayes estimates the thickness as between 1500 and 2000 feet. Some parts of the Conasauga contain an abundant Cambrian fauna.

Barytes is not definitely known to occur in this formation as represented in the immediate Cartersville district, unless the minor occurrence on the Tedder property in the city of Cartersville be included. At Grassdale fragmental barytes occurs near the contact of the Conasauga and the Cartersville formations.

STRUCTURE

The geologic structure of the Cartersville barytes district is complex and in many places so obscure that it defies explanation. These complications and obscurities are the result of intense folding, faulting, and metamorphism of the formations. In general, however, the structure may be simply expressed in terms of the attitude of the beds. As commonly shown in outcrops and exposures the rocks strike from north-northeast through north to northwest forming a crescent bending around the east side of Cartersville; they dip in corresponding easterly directions. This local expression of the northeast strike and southeast dip of the Cartersville district and Appalachian rocks in general was brought about by enormous regional tension that forced the rocks of the whole area northwestward and when the strain became too great for further folding, thrust the older

metamorphosed rocks over the younger sediments along the line of the Cartersville overthrust fault. This wrinkling and shortening of the earth's crust was not only accompanied by complicated folding, shattering, and metamorphism by physical deformation, but it must have generated enough heat to assist materially in the alteration of the rock minerals.

Omitting the complicated and confusing array of local and minute folds that are common throughout the district and are almost impossible of interpretation and mapping except as minor and unimportant recurrences in the larger scheme of structure, it may be said that most commonly observed folds such as affect topography are closed, overturned, and anticlinal. There is evidence in the dips of the outcrops on both the east and west slopes that the northern part of the ridge extending southward from the covered bridge over the Etowah northwest of Emerson is in the main an anticline of Weisner quartzite, from which the overlying blanket of Shady limestone has been eroded except at the foot of the western limb.

Faults together with their relation to the structure and topography of the district are described in part by LaForge[1] as follows: "The dominant structural characteristic of the district, especially of the portion in the Appalachian Valley, is the abundance of thrust faults. In a very few places is evidence of faulting seen in outcrops but the distribution and relative position of the formation, considered in the light of their known sequence and normal relations, can hardly be explained in any other way than by the occurrence of extensive faulting. As in other parts of the southern Appalachians, the faults are of the overthrust type and the traces of most of the fault planes are nearly parallel to the strike. Where they cut across formations they do so very obliquely. As the fault planes are rarely seen in outcrops little is known of their attitude. From general structural considerations, the dip of the faulted strata, and the relation to the topography, it is concluded that they have as a rule a moderate dip to the southeast and that the overthrusting was toward the northwest as in neighboring areas.

[1] Hull, J. P .D., LaForge, Laurence, and Crane, W. R., Report on the manganese deposits of Georgia: Geol. Survey of Ga. Bull. 35, pp. 51-52, 1919.

"The width of the belts occupied by the Cambrian formations as compared with their thickness is accounted for chiefly by repeated thrust faulting along planes oblique to the bedding, which has cut the rocks into a series of slices and has brought up the same beds several times. The Weisner quartzite, in particular, seems to be cut by a bewildering series of faults into a patchwork of blocks that almost defy interpretation."

Although it has generally been considered that the structure of the district is characterized by folds and that the topography is largely the expression of folds of different kinds, there is a considerable amount of evidence as already suggested by LaForge that much of the ridge-valley topography is the result of the differential erosion of Weisner quartzite and Shady limestone which are repeated in series from east to west by overthrust fault blocks, each overlapping block being made up of only the two formations. This ridge-valley topography probably resulting from repeated fault block structure may be observed in the series of hills east of Cartersville, extending from the Clayton mine on Reservoir Hill through the Bertha mine north of Etowah River. Within this distance of a mile, there are three quartzite ridges with intervening valleys representing limestone that has been eroded. All of the determinable dips are to the east. All of the larger ore deposits, which are principally barytes, are on the

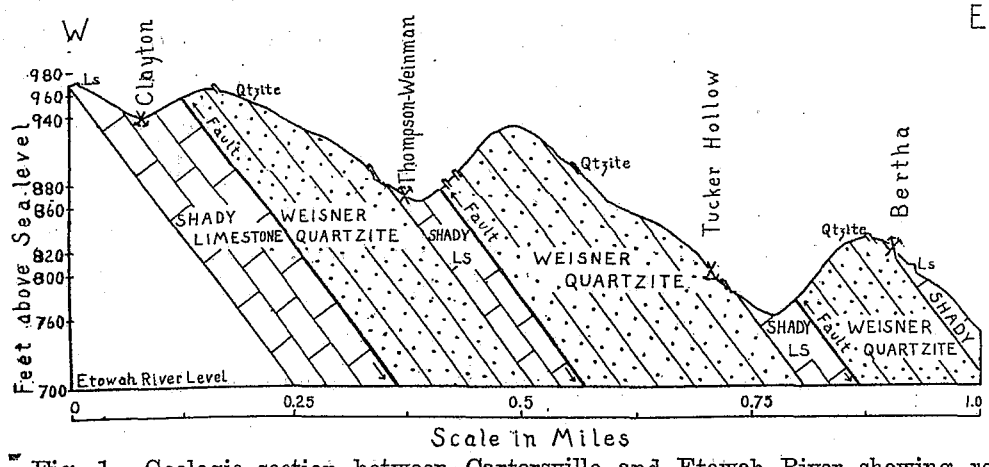


Fig. 1. Geologic section between Cartersville and Etowah River showing repeated thrust-faulted structure as indicated by topography, barytes deposits and rock outcrops. *Topography from Cartersville Special topographic sheet, U. S. Geological Survey.*

eastern slopes at the base of the decomposed limestone overlying the quartzite. The fault traces necessary for the explanation of this structure must be on the east side of each valley and at the western base of each hill. Fig. 1 shows these structural relations.

ORE DEPOSITS

The Cartersville barytes deposits are so closely associated with ocher, brown iron, and manganese ores that a discussion of their origin and occurrence almost of necessity involves a discussion of all these ores. All the commercial deposits are residual-colluvial, wholly or in part, although the ocher deposits belong more strictly to the replacement type. They occur in the unconsolidated residual and colluvial clayey accumulations decomposed from the Shady limestone and to some extent from the Weisner quartzite. Their stratigraphic and topographic relations in typical hillside deposits have been described in part as follows:[1]

"Observation of all the ore deposits in the district shows the following typical stratigraphic sequence: steeply dipping Weisner quartzite foot wall overlain by yellow ocher and limonite, manganese, and barite. Each of the four minerals commonly occurs in the same open-cut, but only one generally forms an ore deposit. Furthermore, the same sequence holds in a general way topographically. First below the quartzite outcrop, down the hillslope, occur limonite and ocher mixed in the clay; farther down the slope, manganese nodules appear with the limonite; and next appear barite fragments mixed with the manganese.

"It is thus seen that the hillside is marked by zones of ores down the slope from the quartzite outcrop, each lower zone occupied by an ore having a successively higher average specific gravity, that is, yellow ocher and limonite (3.8); wad, psilomelane, manganite, and pyrolusite (4.03); barite (4.8). An ideal section showing these relations is given in fig. 2. The position of the ore as shown in fig. 2 is the result in large measure of the tilting of the ore-bearing beds and the gradual selective concentration of the ores by gravity."

As this zoning of the ores is not everywhere definite nor clearly

[1] Hull, J. P. D., LaForge, Laurence, and Crane, W. R., Report on the manganese deposits of Georgia: Geol. Survey of Ga. Bull. 35, pp. 69 and 70, 1919.

marked it is not easily recognized at every mine, but a study of the whole district shows there is a decided tendency of the ores to accumulate in this mechanical manner.

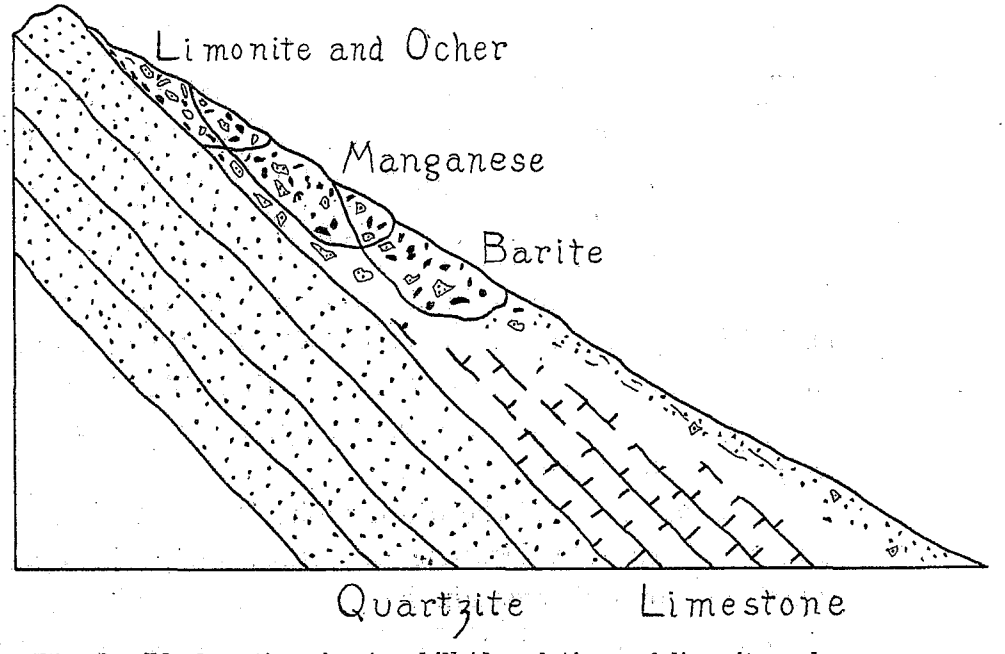


Fig. 2. Ideal section showing hillside relations of limonite, ocher, manganese, and barytes accumulations according to specific gravity, as brought about by tilting of the ore-bearing beds.

The more general relation of the barytes ore deposits to the topography of the district is controlled by the range in elevation of the parent ore-producing formation, the Shady limestone. Barytes veins doubtless occur in the limestone at considerable depths below the lowest part of the surface of the district, which is about 680 feet above sea level at Etowah River. Loose fragments of the ore were found several feet below river level in a well dug near the Krebs mine.[1] Barytes occurs in the siliceous cherty remnants of Shady limestone about 970 feet above sea level at Reservoir Hill east of Cartersville and in loose fragments about 980 feet above sea level on the ridge west of Emerson. The workable deposits, however, are at elevations between 700 and 960 feet above sea level or not more than 280 feet higher than the river. Water-worn gravel from 1 to 4 inches in diameter

[1] Information from the late J. L. Waite, Cartersville, 1917.

which may be in part Tertiary in age is associated with the ore deposits as high as 910 feet above sea level or 230 feet higher than Etowah River.

The commercial bodies of barytes belong to the residual and colluvial types that have accumulated from veins and replacements occurring principally in limestone but partly in quartzite. The original deposition of barytes as well as the associated minerals was favored by the widespread shattering of the rocks thus affording free passage for both surface and deep-seated ore-bearing solutions. The action of thermal springs which Hayes and Phalen[1] suggest once characterized the region was probably instrumental in the deposition of barytes.

In describing the barytes at the ocher mine of the Georgia Peruvian Ocher Company, Hayes[2] says: "Numerous open passages and cavities penetrating the quartzite and the bodies of ocher are met in mining. The smaller cavities are generally lined with a crust of small crystals of barite, which were probably deposited after the conditions favorable for the solution of silica and the deposition of ocher had passed. Groups of acicular crystals of this mineral, several inches in length, are not uncommon. It also occurs in white granular veins. The barite is called 'flowers of ocher' by the miners."

The order of deposition of the barytes and its associated minerals evidently differed with different periods of fracturing and attendant introduction of solutions, for the sequence observed is not always the same. It is probable that the barytes was more or less contemporaneous with the other secondary deposits of iron and manganese.

The source of barium in the Cartersville deposits as well as in barytes deposits in general is sought in the barium silicates (certain feldspars and micas) of the igneous rocks. As the mass of Corbin granite just east of the district is characterized by feldspars and contains a marked percentage of barium, it is at least suggestive that this igneous formation was a contributing source of the barium.

Aside from the unconsolidated and decidedly secondary deposits barytes occurs rather sparingly in the district. It occurs in veins and

[1] Hayes, C. W., and Phalen, W. C., A commercial deposit of barite near Cartersville, Ga., Contributions to economic geology, 1907: U. S. Geol. Survey Bull. 340, pt. 1, p. 5, 1908.

[2] Hayes, C. W., Geological relations of the iron ores in the Cartersville district, Georgia: Trans. Am. Inst. Min. Eng., vol. 30, pp. 403-419, 1900.

fractures in the Shady limestone and the Weisner quartzite, but more noticeably in the limestone. Since the underlying quartzite, however, has been shown upon a number of analyses to contain much more widespread barium and higher percentages of it, and since the limestone in several places shows no barium whatever, it is concluded that the source of the barium was from rocks below the limestone and that the barium was carried by solutions ascending through the shattered quartzite to the equally disturbed limestone where barytes was deposited under conditions more favorable for its chemical precipitation than those encountered in the siliceous rock. The presence of pyrite, oxidizing and producing alkaline sulphates in the rocks passed through, may have aided in the deposition of barium sulphate. If barium sulphate (barytes) were formed from the alteration of barium carbonate (witherite) through the action of calcium sulphate (gypsum) waters, such an origin is not indicated by the presence of any witherite or gypsum. Pyrite, however, is present in the barytes ore, together with limonitic pseudomorphs after pyrite.

MINING AND MILLING METHODS[1]

MINING

The simple signs to be followed in locating a barytes deposit in the Cartersville district are generally in the following combination: a *"blossom"* or surface showing of ore fragments in *red clayey soil* on a *hillside* down the slope from an outcrop of *ferruginous chert or quartzite,* less than 300 feet higher than Etowah River. The deposit probably extends parallel to the ridge. Exposures of yellow ocher and brown iron may indicate associated barytes. Circular test-pits less than 3 feet in diameter are dug to depths ranging from 10 to 40 feet in order ascertain the depth at which the ore occurs or the thickness of the ore-bearing material. The ore generally lies deeper farther down the slope. The holes are dug by means of short-handled pick and shovel, and the dirt is raised to the surface by hand-windlass.

The following quotation regarding the mining of barytes at Car-

[1] For a more or less exhaustive description of the machinery and methods used in working Cartersville manganese ores, which require a treatment almost the same as that used for barytes ores, see Crane's discussion in Hull, LaForge, and Crane, Report on the manganese deposits of Georgia: Geol. Survey of Ga. Bull. 35, pp. 215-286, 1919.

tersville is taken from the United States Geological Survey Mineral Resources:[1]

"The Cartersville deposits are of sufficient size to warrant operations on a large scale, which is not the case with some of the other deposits in the United States. Operators have been quick to recognize this and as a consequence probably the most efficient equipment for barytes mining to be seen in the country is at Cartersville."

All of the mining is done by open-cut methods, as these are best suited to the working of unconsolidated hillside deposits. Very little hand mining is now carried on unless a new deposit of doubtful extent is being opened and it is not considered advisable to install equipment until the size of the ore body justifies it. The hillside is opened by a steam shovel and as it advances into the open-cut the working face is loosened by occasional shots of powder. The shovel follows the ore along the side of the hill, skirting clay horses when possible, and, when the horizontal extent of the original ore level has been exhausted, opening a lower level, or second lift, in the deposit. When the deposit is opened, it may have an almost negligible overburden, but farther down the hillside it may lie beneath a barren blanket 15 or 20 feet deep. The largest open-cuts are several hundred feet long and considerably less than a hundred feet deep. They are drained by natural slope through the entrance, by tunnelling through the down-slope wall, or by pumping, but as they are generally above ground-water level, they encounter little mine water.

Transportation from mine to washer is by narrow-gage steel rail tram line, laid from steam shovel at the working face out of the cut to the bull-pen, or grizzly. In case the bottom of the mine pit is much lower than the entrance, a steam or an electric hoist is used to haul the tram cars up the incline out of the mine. Mules are sometimes used to pull the cars, but as a rule small steam or crude oil-burning locomotives do the hauling. Some of these ore railroads are almost half a mile long.

WASHING

Essentially, the cleaning of the barytes ore is as simple in operation as the actual mining of it, since the principal part of the concentrat-

[1] Hill, James M., Barytes and barium products in 1916: U. S. Geol. Survey Mineral Resources, 1916, pt. II., p. 247, 1917.

ing plant is the log washer which removes the bulk of the impurities by washing in water. This washer consists of one or two logs about 30 feet long, armed with short stout cast-iron lugs, or teeth, bolted to each log in a spiral row like the thread of a screw so that when the log revolves in its sloping box or casing, it forces the ore upward against a stream of water which washes the dirt from the barytes and carries the slimes away to the mud pond. The barytes and the rock fragments that come out of the lower end of the log washer are separated by hand picking as the material is carried on a long picking belt or conveyor to shipping bins. A more thorough cleaning, however, is generally required for an efficient recovery of barytes and the ore as it comes from the log washer passes through a revolving screen which separates the fragments according to sizes, the larger going to the picking belt as before, but the smaller going to jigs which may be simply described as a series of compartments or boxes, with perforated bottoms through which water pulsates and agitates the material in the box, separating the ore by specific gravity, so that the lighter impurities are carried off at the top and the heavier barytes sinks to the bottom.

The concentrating plants are operated by steam and electric power but electricity is more generally used for this purpose. A line of the Georgia Railway & Power Company crosses the district. Water for the washing process is pumped from Etowah River, which is scarcely more than a mile from many of the principal washing plants, to reservoirs on the hillside above the mine. Some mines in the vicinity of the Cartersville city reservoir use the city supply and do no pumping. At several of the properties the mines are so favorably situated that the ore is transported by gravity through a large number of the different steps of its handling from open-cuts on the hillside to shipping bins on spurs from the Western & Atlantic Railroad. Aerial tram lines are also used to reach the railroad.

The ore dirt or run-of-mine material as it is received at the washing plant may contain from 10 to 60 per cent of barytes. The finished product of the plant as loaded on the cars contains from 90 to 96 per cent of barytes. A deposit containing less than 15 per cent of barytes

is not considered profitable to work. Washed ore containing less than 92 per cent of barytes is not wanted by the manufacturers.

A flow-sheet representing the practice of washing barytes ore in the Cartersville district is here given. Variations of this plant may be found at each mine.

Wash dirt (ore) from mine by tram line to 1.

1. Grizzly (local term, bull-pen), 7 steel rails, spaced 3 to 4 inches, 12 feet long: oversize rock by hand to 2; oversize rock broken by hand sledge to undersize to 3.
2. Rock dump.
3. Log washer (double), 30 feet long: overflow (slimes) by flume to 4; discharge (rock and ore) to 5.
4. Mud or settling pond: clear water reclaimed or to river.
5. Revolving screen, cylindrical, 5 feet long, 2 to 3 feet diameter, perforations ½-and ¾-inch: oversize to 6; undersize by chute or cup elevator to 7.
6. Picking belt, 30 feet long, 2 feet wide: rock by hand to 2; barytes to 9.
7. Jig (4-cell Harz step), ⅛-inch mesh: overflow by flume to 4; hutch (flushings or screenings), under ⅛-inch, by chute to 8; discharge, ⅛-to ¾-inch, by chute or elevator to 9.
8. Hutch dump, more than 60 per cent barytes: sometimes rejigged; sometimes used to surface roads.
9. Storage bin, finished product, more than 92 per cent barytes.

GRINDING

A large part of the washed barytes is used in the manufacture of ground barytes at the mill of Thompson-Weinman & Co., situated on Etowah River, 1½ miles southeast of Cartersville. This is the only grinding and bleaching plant in the district and since 1917 when the fine-bleach process was put in operation to replace the coarse-bleach, the only crude ore used has been that from the Cartersville mines. The company leases, or controls the operation of, several mines and is the largest buyer or consumer of Cartersville ore.

The capacity output of the mill is 60 tons of white barytes a day. This high-grade product is sold to paint and rubber manufacturers. The company expects to have in operation in 1920 a new plant which will be one of the largest grinding mills in the United States, having a daily capacity of 70 tons of ground and bleached barytes. The water-grinding and water-floating process will be used.

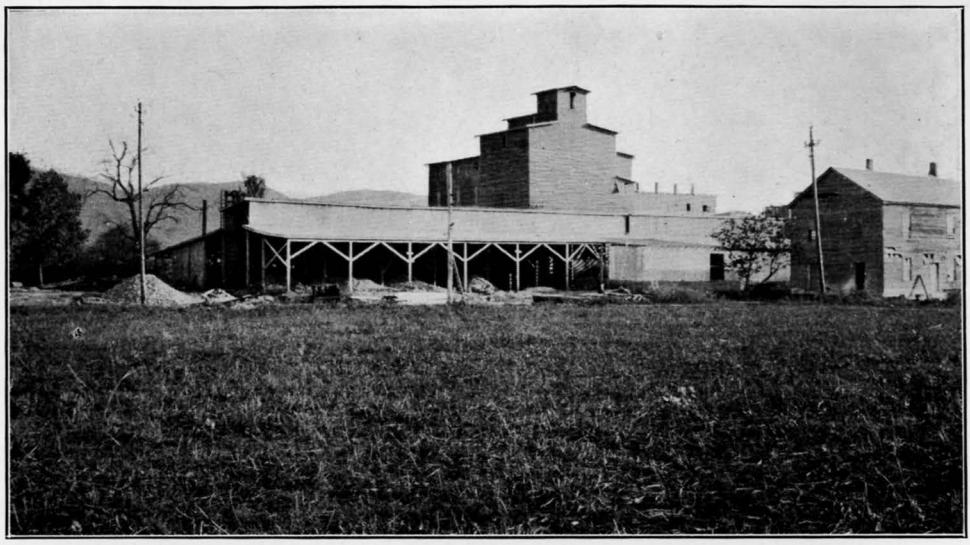
The mill is on a short spur of the Western & Atlantic Railroad. Both water and electric power are used, and about 30 men are employed at the plant. The flow sheet showing the treatment of the ore in the fine-bleach process now used is here given.

Washed ore from the mines to 1.
1. Elevator (cup or bucket belt).
2. Rotary screen, 1-inch mesh: oversize to 10; undersize to 3.
3. Elevator.
4. Rotary screen, ⅜-inch mesh; oversize to 6; undersize to 5.
5. Jig (4-cell): discharge to 8; overflow and tailings to 7.
6. Picking belt: ore to 8; rock to 7.
7. Mud, tailings, and rock dump.
8. Elevator.
9. Storage bin: clean, crude ore to 14.
10. Picking belt: rock to 7; ore to 11.
11. Blake jaw crusher, 1-inch and less.
12. Single log washer: slimes to 7; ore to 13.
13. Elevator.
14. Heavy set breaker rolls, ½-inch and less.
15. Single log washer: slimes to 7; ore to 16.
16. Rotary drying kiln.
17. Elevator.
18. Raymond mill (impact pulverizer), fineness 200-mesh.
19. Spiral conveyor.
20. Bleach tanks (4), lead and brick lined, 7 feet diameter, 7 feet deep: barytes boiled with sulphuric acid, mechanically stirred.
21. Wash tanks, 10 feet diameter, 17 feet high.
22. Storage tanks.
23. Live shell steam dryers, 4 feet diameter, 10 feet long.
24. Elevator and spiral conveyor.
25. Storage shed and sacks.

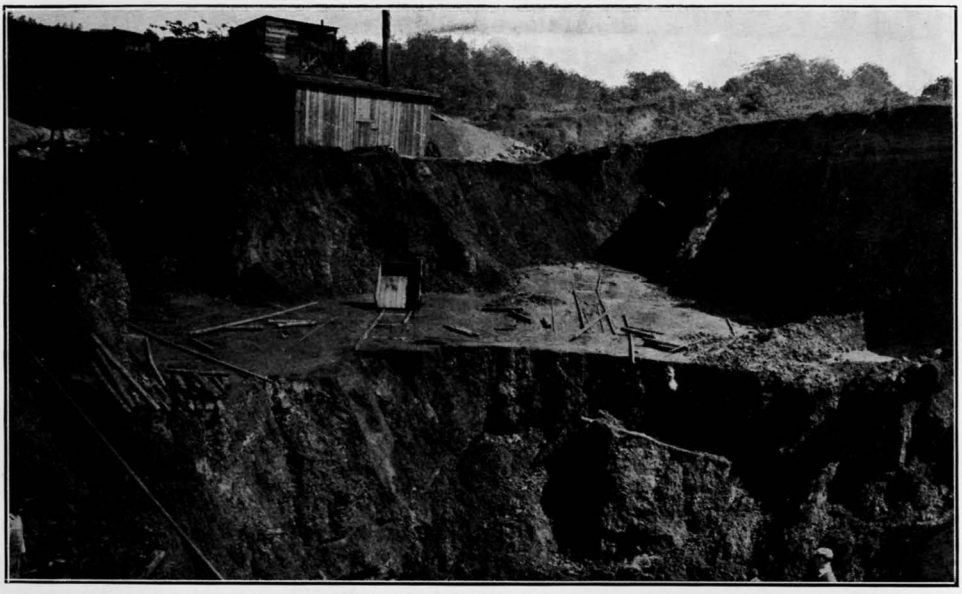
VALUE OF DEPOSITS AND PRICE OF ORE

The value of barytes ore in the ground is said to range from $1.50 to $2.00 a ton, that is, if a property has been prospected by test holes so that it is possible to estimate the tonnage of the deposit, and if it is favorably situated for mining and transportation, it may be valued at that price. Not all of the deposits are thoroughly known as yet and some of them have been very little prospected. A relatively small amount of prospecting work, if it shows the presence of the ore deposit, greatly increases the value of the property. The ownership of ore properties has changed many times since the increasing value of the deposits was realized, particularly since 1914 when the foreign supply was affected by the world war, and properties are still in the market.

A 40-acre lot of land that might have sold, at the beginning of the war, for several hundred dollars based on its agricultural value and small iron ore rights, probably brought several thousand dollars in 1914 or 1915 after a little prospecting proved the presence of a barytes deposit, and subsequently, upon thorough testing and discovery of a



A. BARYTES BLEACHING AND GRINDING MILL OF THOMPSON-WEINMAN & COMPANY, CARTERSVILLE, BARTOW COUNTY.



B. OPEN-CUT, BIG TOM MINE WEST OF EMERSON, BARTOW COUNTY.

rich deposit, was doubtless resold for tens of thousands of dollars. Some properties have thus increased in value, through the proving of their barytes deposits, from a few hundred dollars to a few hundred thousand dollars within 6 or 7 years.

If the owner of the property retains the agricultural or surface rights and leases the mineral (barytes) rights, he is usually paid a royalty ranging from $0.30 to $1.50 for each ton of ore shipped, the rate depending on several factors such as situation of mine, richness of ore, and date of contract. So long as the contracting operator does not work the property, he may be required to pay the owner a minimum of $200 a month for each lot of 40 acres, although some lots have been leased as low as $25.

The price obtained for washed ore as shipped from the mine in 1919 ranged from $6.25 to $10.00, depending on such conditions as quality of ore, terms of contract, and urgency of demand. When a quick shipment of a few cars of special high-grade ore is wanted, the price given may be $9.00 or $10.00, and as high as $12.00 is sometimes asked. The average price of Cartersville washed ore containing about 95 per cent of barium sulphate is probably $7.50.

According to the United States Geological Survey Mineral Resources for 1917 domestic ground barytes of fine white grade was quoted at prices ranging from $25 to $36 a ton, and off-color barytes from $22 to $24 a ton. The prices during the first three months of 1919 were about the same.

COST OF EQUIPMENT AND LABOR

The estimated cost in 1919 of building and equipping a barytes washing plant, consisting of a double log washer, a revolving screen, a 4-cell jig, a picking belt, and a 40-horsepower engine or motor, was $5000. If the mining machinery included a steam shovel, two 4-yard side-dump cars, and the necessary steel rails, $9000 should be added to the mill cost. If a 12-ton locomotive were used and a pump were needed to supply water for washing purposes, about $5000 additional would be necessary.

Electric current cost as follows: a service charge of $1.11 per K. W. of maximum demand per month, plus an energy charge based on a

sliding scale ranging from $1.33 per K. W. H. for the first 1000 K. W. H. per month, to $0.44 per K. W. H. for all over 100,000 K. W. H. per month. Run-of-mine coal cost from $4.50 to $5.00 per ton, F. O. B. cars. The wage for unskilled labor was $2.50 to $3.00 per 10-hour day.

PRODUCTION

Before barytes was known to occur in large deposits in the Cartersville district, it was commonly found in the brown iron ore mines and considered an objectionable impurity. Even after its more extensive occurrence was discovered and its value as an ore was recognized, it was not very generally mined. It was overshadowed by the mining of iron, manganese, and ocher. Not until the world war began to cut off the German importations in the latter part of 1914 and the early part of 1915, was it realized that the large size and favorable situation of the Cartersville barytes deposits made them the most important in the country.

In 1887 the United States Geological Survey Mineral Resources mentioned barytes as a useful mineral mined at Cartersville and at Stegall (now Emerson). A small amount of ore is recorded as being produced in 1901, and beginning with 1907 some ore was recorded each year but the yearly production was not made public until 1915 because it would have disclosed the individual outputs of the one or two operators then active. From 1914 to 1916, however, the number of operators increased from 2 to 9, and the State rose from third to first place in the rank of producers, a position it still holds, although the maximum of 111,300 tons, or more than half of the country's production, was reached in 1917.

As the Cartersville district is the only producing area in the State, all figures of production apply to district and State alike.

The following table, compiled in part from statistics collected by the United States Geological Survey, shows the yearly production and value of ore produced in Georgia from 1914 to 1919 inclusive. The figures for 1919 are estimated from information obtained by the Geological Survey of Georgia.

Crude barytes produced and marketed in Georgia, 1914-19, in short tons

Year	Operators	Rank in production of States	Propotion of U. S. production	Quantity	Value	Average price per ton
1914	2	3d	9%	5,000+		$2.91[a]
1915	6	2d	29%	31,027	$102,825	3.31
1916	9	1st	47%	104,784	401,295	3.83
1917	9	1st	53%	111,300	601,895	5.41
1918	7	1st	44%	69,318	418,178	6.03
1919	9			90,000[b]		7.50[b]

[a] Average for Alabama, California, Georgia, Kentucky, North Carolina, South Carolina, and Virginia.
[b] Estimated by the writer, November, 1919.

The quantity of reserve ore in the district is somewhat difficult of estimation, but the frequently voiced fears that the deposits are rapidly nearing exhaustion may be allayed with the statement that two-thirds of the ore has not yet been mined. The chief cause for alarm is the probable re-entrance of the German product into the field of competition.

RECENT PRODUCERS OF CRUDE BARYTES IN GEORGIA

1. Bertha Mineral Co., L. B. Womelsdorf, superintendent, Cartersville, Ga.

2. Big Tom Barytes Co., care of W. C. Satterfield, Cartersville, Ga.

3. E. I. DuPont de Nemours & Co., Wilmington, Del., or care of H. S. Hebble, superintendent, Cartersville, Ga.

4. Krebs Pigment & Chemical Co., Newport, Del. (Property sold to New Jersey Zinc Co.)

5. New Jersey Zinc Co., 55 Wall St., New York City, and Palmerton, Pa. (Mines operated by Bertha Mineral Co.)

6. New Riverside Ochre Co., W. C. Satterfield, agent, Cartersville, Ga.

7. The Nulsen Corporation (formerly Nulsen, Klein & Krausse Manufacturing Co.), Levee and Sidney Sts., St. Louis, Mo., or care of G. Miltenberger, manager, Cartersville, Ga.

8. Paga Mining Co., W. S. Peebles, general manager, Cartersville, Ga.

9. Peebles & Sloan, Cartersville, Ga.

10. P. F. Renfroe, Cartersville, Ga.

11. Thompson-Weinman & Co.,[1] 101 Park Ave., New York City, or care of W. J. Weinman, Cartersville, Ga.

SOME RECENT CONSUMERS OF GEORGIA CRUDE BARYTES

(*a*) *Used ore in manufacture of ground barytes*

(*b*) *Used ore in manufacture of lithopone*

(*c*) *Used ore in manufacture of barium chemicals*

1. (*c*) Ault & Wiborg Co., Cincinnati, Ohio.

2. (*b*) Beckton Chemical Co., 3500 Grays Ferry Road, Philadelphia, Pa., or Newark, N. J.

3. (*b, c*) Chemical Pigments Corporation, 825 Stock Exchange Building, Philadelphia, Pa., or St. Helena, Md.

4. (*b, c*) E. I. DuPont de Nemours & Co., Wilmington, Del.

5. (*a, c*) Elkhorn Chemical Co., Elsinore and Gilbert Avenues, Cincinnati, Ohio.

6. (*c*) Globe Chemical Co., 1205 Regent Ave., Cincinnati, Ohio.

7. (*b, c*) Grasselli Chemical Co., Cleveland, Ohio, or Grasselli, N. J.

8. (*c*) Harrison Bros Co. (Inc.), 3500 Grays Ferry Road, Philadelphia, Pa., or Pittsburg, Pa.

9. (*b*) Krebs Pigment & Chemical Co., Newport, Del.

10. (*b*) Midland Chemical Co., 1531 Railway Exchange Building, Chicago, Ill., or Argo, Ill.

11. (*b*) New Jersey Zinc Co., 55 Wall St., New York City, or Palmerton, Pa.

12. (*a*) The Nulsen Corporation (formerly Nulsen, Klein & Krausse Manufacturing Co.), Levee and Sidney Sts., St. Louis, Mo., or Lynchburg, Va.

13. (*c*) Rollin Chemical Co., Charleston, W. Va.

14. (*b*) Sherwin-Williams Co., 601 Canal Road, Cleveland, Ohio, or Kensington, Ill.

15. (*a*) Thompson-Weinman & Co., 101 Park Ave., New York City, or care of W. J. Weinman, Cartersville, Ga.

[1] Also produce ground barytes.

ETON DISTRICT

The Eton barytes district is a small district in the northern part of the State that produced several carloads of ore about 1907, but has since become inactive. It is 3½ miles long and about half a mile wide, extending in its greatest length from the vicinity of Eton, south-southwestward to Oran, about 2 miles north of Chatsworth, the county seat. The district is in the central part of Murray County and is traversed by the Louisville & Nashville Railroad. It occupies the valley of Mill Creek at the western edge of the foothills of the Cohutta Mountains. The general elevation is 800 feet, or less, above sea level and the drainage is southwestward to Conasauga River.

The rock formations represented in the district include Rome shale and sandstone and Conasauga shale and limestone (Cambrian) and Knox dolomite (Cambro-Ordovician). The general strike of these formations is northeast and the dip is southeast. Barytes occurs in veins in the limestone members and in loose fragments in the residual soil.

Two mines were once in operation, one at Eton and one near Oran, but the equipment at both has been dismantled several years.

OTHER LOCALITIES

Outside of the Cartersville and Eton districts there are six localities of small isolated deposits of barytes—five in the Appalachian Valley and one in the Piedmont Plateau. All of these are relatively unimportant as commercial deposits and only two have been worked.

Near Ruralvale, eastern Whitfield County, barytes occurs in the residual soil overlying Knox dolomite (Cambro-Ordovician). Small deposits are indicated by surface fragments of high quality and by several shallow prospect pits extending about 3 miles north from Ruralvale.

Near Plainville in southwestern Gordon County and northeastern Floyd County, small deposits of good ore have been worked at a few places for a distance of 4 miles along the Southern Railway. The barytes occurs in brecciated and fractured vein material in Conasauga limestone near its contact with Rome shale (both Cambrian). The workable ore occurred in the residual soil.

At Bass Ferry, in the eastern part of Floyd County, a small unprospected deposit is exposed in the red and yellow soil of the Knox dolomite.

Three miles north of Kingston, western Bartow County, there is a commercially unimportant deposit near the contact of the Conasauga formation and Knox dolomite.

Near McGinnis, 2 miles southwest of Stilesboro, southwestern Bartow County, deposits of somewhat impure barytes have been prospected in the Knox dolomite residuum, but only small accumulations have been found.

Near Moore Mill in the Piedmont Plateau region of western Cherokee County is the only occurrence that definitely appears to be a bedded replacement deposit. The ore, *in place,* occurs as a sharply defined layer or lens (originally limestone?) in quartzite of Ocoee or possibly early Cambrian time. Loose fragments occur in the talus material of the hillside.

DESCRIPTION OF INDIVIDUAL DEPOSITS

BARTOW COUNTY

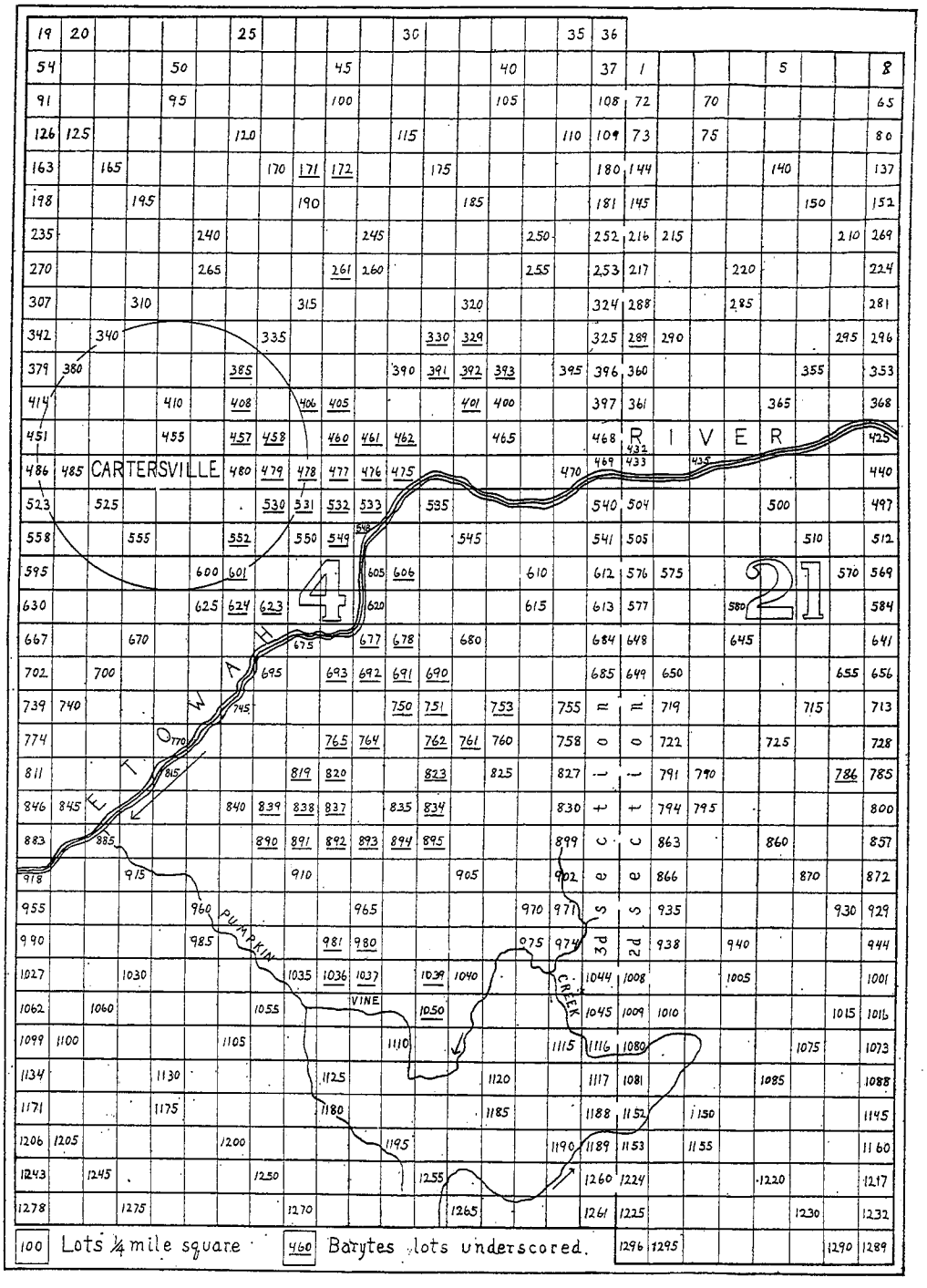
CARTERSVILLE DISTRICT

BIG TOM MINE

The Big Tom barytes mine is on lot 895, 4th district, 3d section, less than half a mile southwest of Emerson. Lot 895 is a 40-acre lot that is part of a tract of 424 acres owned by J. E. Satterfield of Macon, and his brother, W. C. Satterfield of Cartersville. The mine was worked by the Satterfield brothers under the name of the Big Tom Barytes Company.

It is said that barytes was mined at this place in the eighties by the Pyrolusite Manganese Mining Company under the direction of E. H. Woodward.[1] The ore was dug by hand, crushed in two 8-stamp mills, and ground at a flour mill near the old Tennessee Hotel in the northern part of Cartersville. In 1915, the Satterfield brothers bought the property and began open-cut mining by hand. The follow-

[1] Information about the early history of the Big Tom property was furnished by G. W .Wheeler, superintendent at the mine in 1917.



Map III. Lot map of a part of the 4th and 21st land districts of Bartow County showing lots containing barytes.

ing year, a steam shovel was purchased and the open-cut enlarged. A well-equipped washing plant was operated until 1918, when the machinery was sold and removed to a barytes mine near Sweetwater, Tenn.

The elevation at the Big Tom mine is approximately 850 feet above sea level. Lot 895 is on a low hill between two forks of a small branch that flows south to Pumpkinvine Creek. The mine is 150 feet higher than the pumping station on the creek which is 1¼ miles to the south. The washer was only 30 or 40 feet higher than the loading point on a spur track half a mile south of Emerson on the Western & Atlantic Railroad.

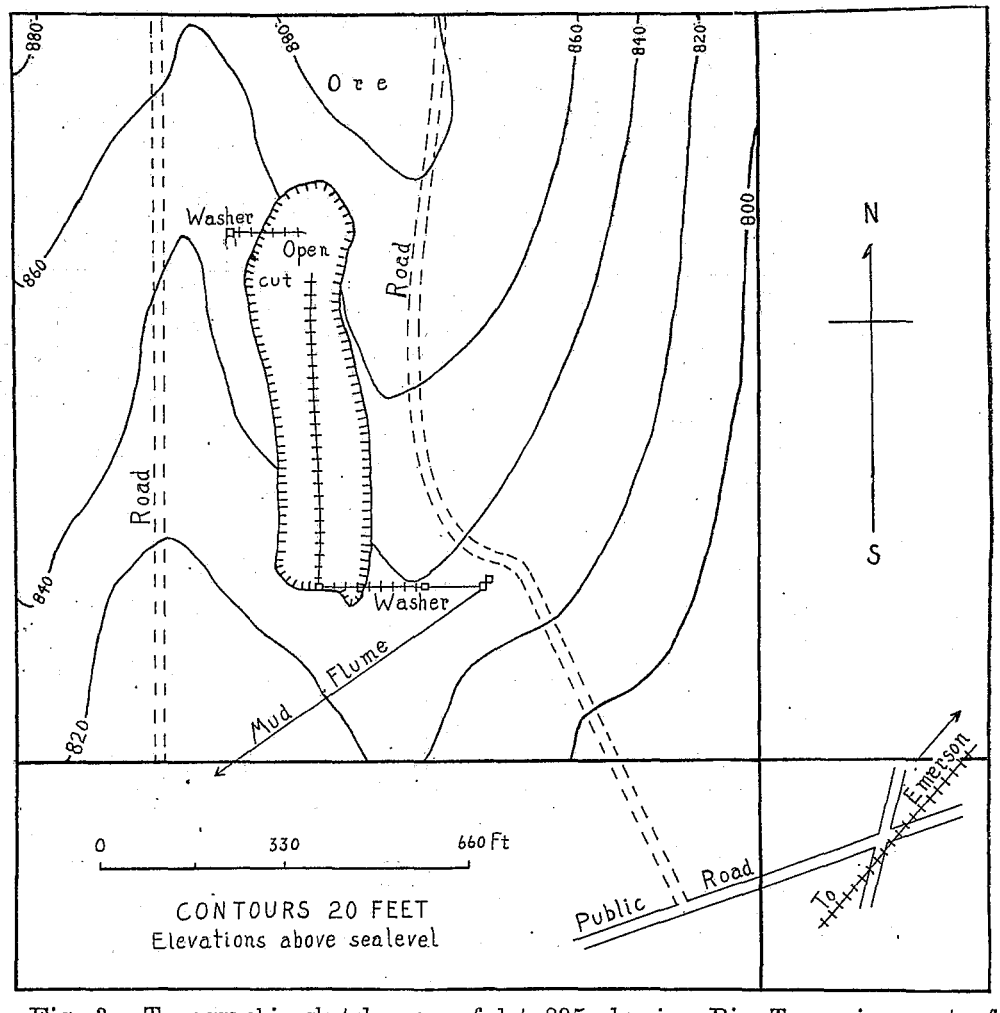


Fig. 3. Topographic sketch map of lot 895 showing Big Tom mine west of Emerson.

The character and attitude of the underlying rocks at the Big Tom mine are obscured by a thick unconsolidated mantle of reworked ore-bearing clay that is the result of ancient hillside accumulation and alluvial wash. No solid rock has been uncovered in mining and no outcrops occur within several hundred yards of the open-cut. The loose ore-bearing material as exposed in vertical section in the open-cut is largely clay. Its color, grain, and plasticity are widely different throughout the formation, though there appears to be no regularity in the change. The surface soil is red clay loam ranging in depth from 2 to 6 feet. Beneath this the change to yellow clay is marked but not abrupt. Within the yellow clay are more or less definite streaks, or "horses," of sticky reddish-yellow clay called "gumbo" that may be either ore-bearing or barren. These gumbo masses are generally 10 to 15 feet thick. All the formations contain quartzite fragments of different sizes and in all stages of decay; some are several feet thick and only slightly weathered. Small fragments of ferruginous quartzite and chert, vein quartz, slate, brown iron ore (limonite) and manganese (pyrolusite) are commonly but irregularly associated with the barytes fragments. The presence of river gravel (quartz pebbles) and rounded fragments of barytes proves the secondary character of this heterogenous deposit.

The ore deposit as shown by the open-cut is about 700 feet long, 200 feet wide, and 50 feet deep. Prospect pits in the bottom of the mine prove the ore to an additional depth of 30 feet and surface prospects indicate a total workable area of about 6 acres, although some float ore is much more widely scattered. The deposit has its maximum extent north and south, parallel to the general trend of the nearby quartzite hills. A little more than a quarter of a mile north of the Big Tom mine, barytes is being extensively worked by E. I. DuPont de Nemours & Company.

The ore is in the form of small particles and irregular lumps or masses mixed with the clay and other unconsolidated material. The fragments range in size from tiny particles that are lost in the mining and milling operations to heavy masses more than a foot thick. Generally, however, they are 2, 3, and 4 inches thick. The ore fragments are white crystalline barytes with an uneven, pitted

surface, not uncommonly coated with a thin brown layer of limonite or stained by spots of pyrolusite. Small ill-formed crystals of barytes cover the surface of some of the crystalline or massive lumps and occupy pocket-like openings and cracks in the ore.

The richness of the deposit is not the same throughout the open-cut, but a large part of the run-of-the-mine ore taken to the washer in 1917 required not more than a 4 to 1 concentration to produce high-grade barytes. Much of the deposit required less than a 3 to 1 concentration. In June, 1917, a day's run of 177 tram cars (about 177 tons) dumped at the tipple, yielded 63 tons of shipping product, or about 35 per cent of the material washed. In September and October, 1917, approximately a third of the material washed at the mill was high-grade shipping ore. This shipping product, however, represented a fifth of all the material taken out of the open-cut, as a large part of the steam shovel work was in barren dirt. But not all of the barytes was recovered, for the screenings that were sluiced to the dump frequently contained more than 50 per cent of barytes. This rejected material was not saved because the jigs were not in operation.

The grade of the ore is shown in the following analyses.

Analyses of clay lump and barytes ore. Big Tom mine

Constituents.	*Hu-10*	*Hu-13*	*1*	*2*
Silica (SiO_2)	50.34	0.57		
Alumina (Al_2O_3)	9.28	0.45		
Ferric oxide (Fe_2O_3)	12.32			
Magnesia (MgO)	tr	------		
Lime (CaO)	0.00	------		
Soda (Na_2O)	0.04	------		
Potash (K_2O)	0.08	------		
Moisture at 100°C	0.30	0.00		
Loss on ignition	8.51	0.14		
Titanium dioxide (TiO_2)	0.48	------		
Sulphur trioxide (SO_3)	3.01	33.82		
Manganous oxide (MnO)	7.61	tr		
Barium oxide (BaO)	8.01	64.68		
Total	99.98	99.66		
Barium sulphate ($BaSO_4$)	----	97.94	94.65	94.23

Hu-13.—Clay lump containing barytes particles. This material is rejected because of difficulty in disintegrating it in the concentrating process. Sample from the dump.

Hu-10.—Clean crystalline barytes fragment from bottom of open-cut.

1.—Average analysis of 6 carloads shipped Oct., 1916. Analyses from Big Tom Barytes Co.

2.—Average analysis of 6 carloads shipped Jan., 1917. Analyses from Big Tom Barytes Co.

In 1918 the equipment of the Big Tom Barytes Company included a 30-ton steam shovel with a ¾-yard dipper, several wooden tram cars, four electric motors ranging from 15 to 50-horsepower, a 14-foot rotary screen, a 28-foot double log washer, a 6-foot rotary sand screen, a 42-foot picking belt, a set of jigs (not in operation), a centrifugal pump, several thousand feet of 6-inch iron pipe, and several hundred feet of light narrow gage steel track.

The method of mining was the same as that generally used throughout the district. Mining and milling practice is described elsewhere in this report. The steam shovel loaded the ore into tram cars which were hauled by mules to the incline where motors elevated the cars to the bull pen. The ore was then sluiced to the screens and log washer. Mining was done by steam, supplemented by man and mule power. All of the milling and pumping machinery was run by electricity furnished by the Georgia Railway and Power Company. Altogether about thirty men were employed at the mine and mill.

Many thousands of tons of barytes have been mined from the Big Tom open-cut. A day's production of 40 to 50 tons of high-grade ore was not uncommon and under favorable conditions, much more was produced.

In February, 1919, J. A. Morgan leased lot 895 and together with W. S. Peebles extended the north end of the open-cut and operated a single log washer several months during the year.

DU PONT MINE

The DuPont mine and mill are on lots 823 and 762, respectively, 4th district, 3d section, about half a mile north-northwest of Emerson. This property, operated in 1917, by Thompson-Weinman & Company, and known as their No. 2 plant, was acquired in 1918 by E. I. DuPont de Nemours & Company, Wilmington, Del., who leased the greatest part of the ore from the owner, the Nulsen Corporation. W. R. Sat-

terfield did a large part of the first prospecting and proving of this property, and for some time it was owned by John T. Williams & Son. H. S. Hebble is superintendent for the DuPont Company.

The property is on the east slope of a partially cleared north-south ridge whose elevation is 1000 feet above sea level. The north end of the ridge slopes gradually downward 200 feet to the little valley whose drainage is northwestward to Etowah River, a mile distant. The Dixie Highway and the Western & Atlantic Railroad follow this valley-pass through the hills northwest of Emerson. The topographical situation is admirable for hillside mining by open-cut and for transportation by gravity to the concentrating plant at the railroad. Etowah River, which furnishes water for all mining and milling purposes, is 250 feet lower than the mine and more than 100 feet lower than the washer.

The rocks with which the ore is associated at the DuPont mine are Weisner quartzite and remnants of the overlying Shady limestone. Their structural relation is simple and typical of the two formations in the whole Cartersville district. The stratigraphic sequence from fresh quartzite foot wall to unconsolidated ore deposit is also well shown at this mine. Gray weathered quartzite in spine-like and broken outcrops forms the top of the ridge. The strike is generally N.13°-20°E. with the trend of the ridge and the dip is 40°-55° SE., considerably steeper than the slope of the hill. On the east slope of the hill and overlying the quartzite, all of the material as shown on the surface and exposed in the cut is the unconsolidated hillside accumulation of clay containing many fragments of quartzite and decayed dolomite. Although no Shady limestone has been observed in place overlying the quartzite, the evidence that it once occupied this position is found in the scattered fragments of porous siliceous rock with the characteristic dolomitic structure that has been recognized in other parts of the district; furthermore, limestone has been found in a fragmental state in the bottom of the open-cut.[1] Water-worn quartz pebbles were observed on the hillside at an elevation 910 feet above sea level or 220 feet above the river. At least one specimen of barytes has been found at this mine preserving on its ferruginous sur-

[1] Information from W. S. Peebles, manager for Thompson-Weinman & Company, Cartersville, 1917.

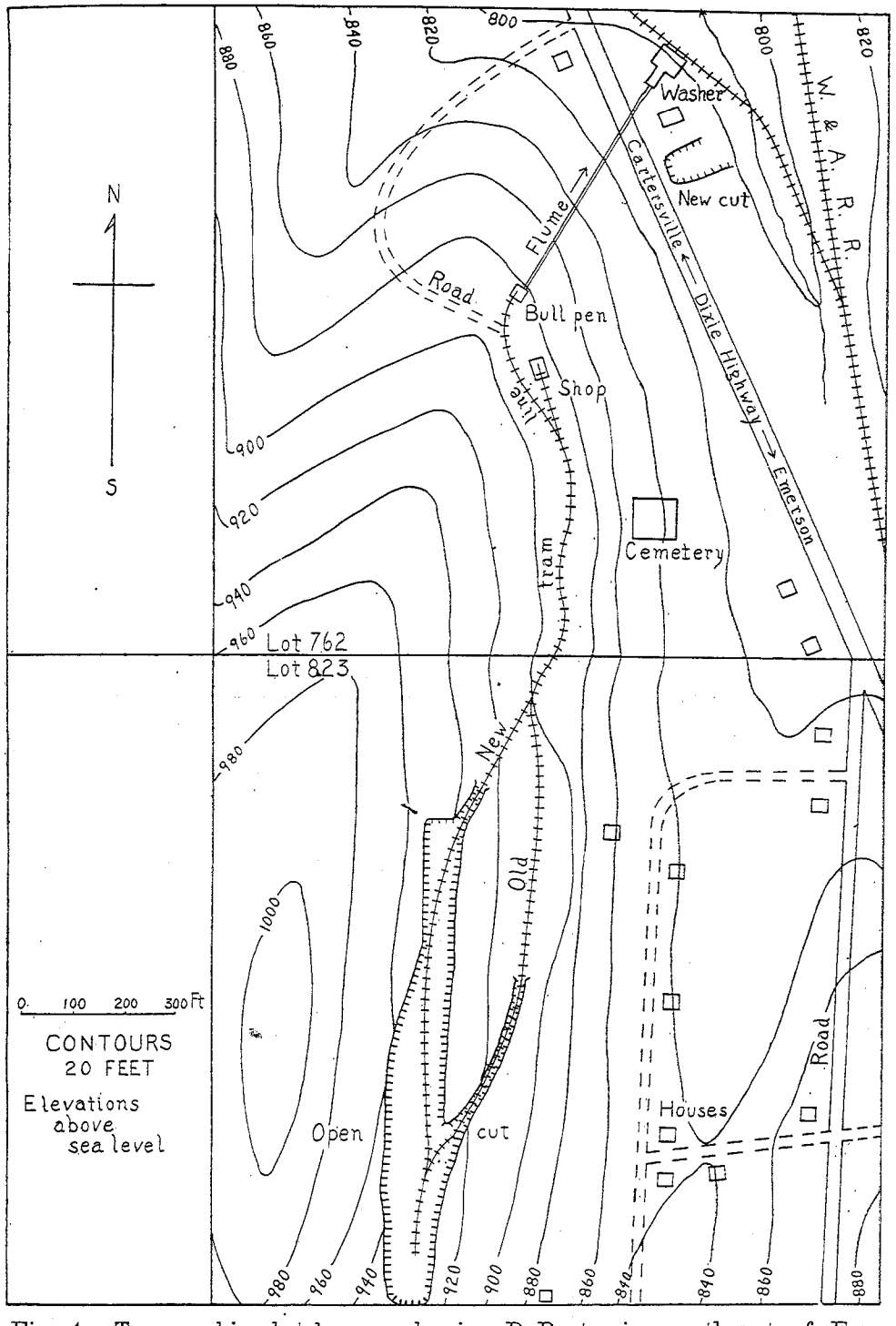


Fig. 4. Topographic sketch map showing DuPont mine northwest of Emerson.

face a design that strongly suggests that organic structure of early Cambrian sponges or corals.

The barytes deposit is in a rather well-defined zone on the east slope of the hill less than 100 feet east of the quartzite outcrops on the ridge and parallel to them. In places this zone is 100 feet wide. It extends through various degrees of richness from the southwest quarter of lot 823 to the north part of lot 762, a distance of half a mile. In some places, the ore extends to a depth of 50 feet below the surface. The overburden increases down the slope of the hill. The immediate foot wall of the ore deposit is dark brown clayey material of manganiferous composition, commonly known in the district as the manganese clay foot wall. This soft foot wall may not be continuous. Stratigraphically it is about 30 feet above the quartzite. It contains no iron nor manganese in minable quantities.

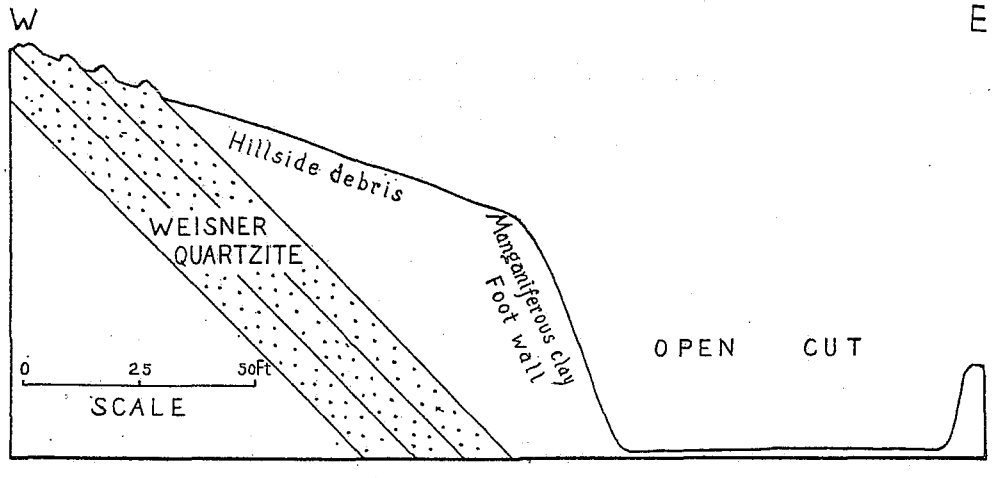


Fig. 5. Section through hill at DuPont mine showing position of quartzite foot wall.

In the open-cut the ore occurs in the usual irregular masses and fragments embedded in the clay together with quartzite and chert fragments. A few nodules of limonite and pyrolusite are mixed with the detritus, but the barytes is generally clean and solid except for some thin limonitic and manganiferous coatings or linings in small pockets in the ore masses. Several working faces in the cut have shown good ore constituting 50 per cent or more of the area exposed.

In 1917, it was reported that the percentage of barytes won from the open-cut ranged from 10 to 60 per cent of the ore dirt.

The chemical analyses here given indicate the high quality of the ore.

Analyses of barytes ore. DuPont mine

Constituents	*1*	*2*	*Hu-23*	*Hu-24*	*Hu-33*
Silica (SiO_2)	4.28	4.49	0.36	0.57	10.48
Alumina (Al_2O_3)	------	------	0.30	0.43	4.24
Ferric oxide (Fe_2O_3)	1.65	1.39			8.32
Moisture at 100°C	------	1.10	0.00	0.08	0.28
Loss on ignition	------	------	0.14	0.28	4.32
Titanium dioxide (TiO_2)	------	------	------	------	0.10
Sulphur trioxide (SO_3)	------	------	34.00	33.87	23.58
Manganous oxide (MnO)	------	------	0.00	tr	2.49
Barium oxide (BaO)	------	------	65.07	64.72	44.96
Total			99.87	99.95	98.77
Barium sulphate ($BaSO_4$)	92.15	93.13	99.04	98.50	68.43

1, 2.—Average analyses, each of one carload of ore. Analyses by Sherwin-Williams Co., Cleveland, Ohio, 1917.

Hu-23.—Clean specimen of crystalline bluish barytes from shipping platform, 1917.

Hu-24.—Specimen of crystalline-granular brownish barytes from shipping platform, 1917.

Hu-33.—Screenings from 12-mesh screen. Washing plant, 1917.

The ore is rather uniformly clean. It occurs loose in the clay ranging in size from grain-like particles to irregular fragments more than 100 pounds in weight. The barytes masses as a rule carry a very thin limonitic or manganiferous coating, but commonly they are either bluish-white crystalline fragments of high grade as shown by the analysis of sample *Hu-23*, or somewhat granular brownish-white fragments of almost equal purity as shown by the analysis of sample *Hu-24*. These specimens were specially selected clean fragments.

All of the ore at the DuPont mine is worked by open-cut methods. In 1919 the cut is more than 60 feet deep in places and had been extended 970 feet northward from the south side of lot 823. Many thousand cubic yards of material have been removed. The ore dirt is dug by steam shovel and loaded directly into tram cars which are

hauled over a narrow-gage steam railroad about 600 yards along the hillside to the grizzly. The ore is then washed down a 600-foot wooden flume across the highway to the log washer about 85 feet lower than the grizzly. In 1917 the washing plant was equipped according to the general custom in the district, including a coarse screen receiving the ore from the flume, a double log washer, a sand screen, and a picking belt. Much good barytes was lost in tailings, or screenings, from the sand screen, though a considerable quantity of this low-grade fine material (see analysis of sample *Hu-33*) was used in making an inferior, or "off-color," ground barytes at the Thompson-Weinman grinding mill on Etowah River.

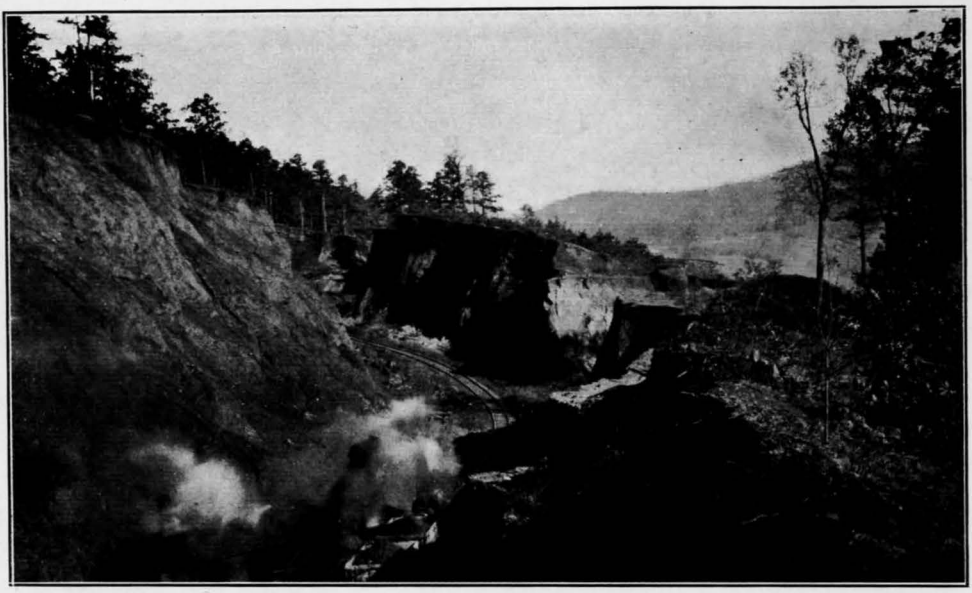
In 1918, the DuPont Company greatly enlarged the plant, so that the equipment now (1919) includes two double logs, two sand screens, and a 4-cell jig. The tailings, or sand dump is remarkably free from barytes. Electric power is used at the washing plant and at the pumping station on Etowah River, which is a mile northwest of the mine and 250 feet lower. Steam power is used in the open-cut and on the tram line. Slimes and water from the washer are conducted by ditches and flumes along the valley to the mud pond almost three-quarters of a mile northwest of the washer.

The company has leased the barytes on lot 834 from the Big Tom Barytes Company and is extending the large open-cut to the south. A new and smaller cut is also being opened near the washer on the north side of the Dixie Highway, with the intention of extending it under the public road and into the hill on the opposite side.

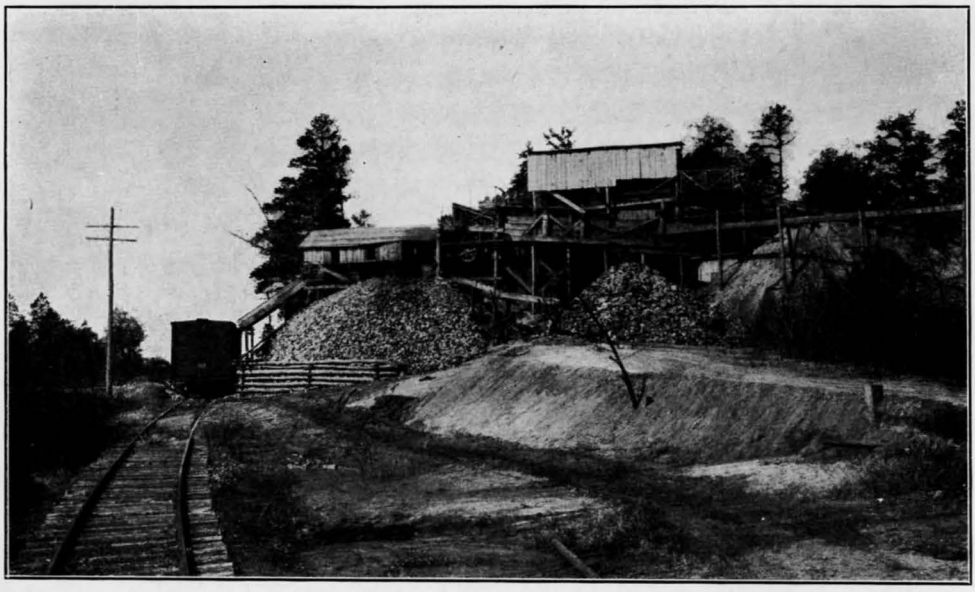
The DuPont mine is on one of the largest producing barytes deposits in the Cartersville district and the reserve ore on the property amounts to many thousands of tons, though high-grade ore has been produced at the rate of several carloads a day since the deposit was first systematically worked in 1917. About 80 men are employed in two shifts, this mine being the only one in the district which now (1919) works night and day.

SECTION HOUSE MINE

The Section house barytes mine is on lot 751, 4th district, 3d section, three-quarters of a mile north-northwest of Emerson. The



A. OPEN-CUT, DUPONT MINE NORTHWEST OF EMERSON, BARTOW COUNTY.



B. CONCENTRATING MILL, SECTION HOUSE MINE, EMERSON GAP, BARTOW COUNTY.

washer is situated on a siding of the Nashville, Chattanooga & St. Louis Railway and the open-cut is 130 yards northeast of the railroad. The land forms a part of the railroad property near the section house, hence the name of the mine. In April, 1917, W. S. Peebles and B. C. Sloan of Cartersville leased the property and began working the deposit.

The mine is at an elevation of 830 feet above sea level or about 55 feet higher than Etowah River which is three-quarters of a mile to the northwest. It is on a gentle southerly slope near the bottom of the northwest-trending valley that leads from Emerson to Etowah River. Directly opposite the mine, on the southwest side of the valley, is the Nulsen mine and a few hundred yards south is the DuPont mine.

The geological structure at the Section house mine is somewhat obscured by the unconsolidated and heterogeneous mass of ore-bearing clays. No outcrops of rocks occur at the mine and no solid rock was exposed by the open-cut, but about 100 yards southwest and less than 100 yards north and northeast of the cut there are outcrops of Weisner quartzite that show strikes ranging from N.22°E. to N.25°E. and dips from 55° to 70°SE. This general attitude of the formation is typical and the position of the rock corresponds to that of the quartzite foot wall of other mines in the vicinity. The open-cut extends northeastward, approximately parallel to the strike of the rocks. It is in the clayey material down the dip from, or overlying, the quartzite.

The ore deposit on lot 751 is about 200 yards long, extending northeastward from the open-cut into the northeast corner of the lot. Barytes fragments are found throughout this distance both on the surface and in test pits. As exposed in the open-cut, the width of the deposit ranges from 40 to 100 and its depth is more than 50 feet. Barren clay masses, or horses, are encountered in places and irregular streaks of the sticky clay known as "gumbo" are present, but neither of these obstacles is especially troublesome.

All of the ore is in the form of loose fragments that weathered out of the ancient limestone or dolomite. The residual rock decayed and disappeared long ago and left the resistant veins and pockets of

barytes to accumulate in the detrital and reworked clay by long-continued and varied processes of erosion. Quartzite fragments are abundant and a few water-worn quartz pebbles have been found in the ore dirt.

The barytes fragments that occur on the surface have a gray weathered appearance and irregular outline, not unlike the quartzite fragments with which they are associated. In the open-cut, the ore masses are stained with red and yellow clay, and some are encrusted with a thin layer of limonite or manganiferous iron. Freshly broken ore, however, discloses the white barytes. The purest ore is somewhat bluish and distinctly crystalline with cleavage surfaces clearly showing. Other specimens are snow-white, opaque, and granular. Some fragments of barytes are discolored by fine grains of pyrite and chalcopyrite that alter to limonite and impart a brown color to the ore. These impurities, however, are hardly of an importance to affect the generally high quality of the ore.

The analysis here shown is of a fragment of ore taken from the stock pile in June, 1917.

Analysis of barytes ore. Section house mine (Hu-20)

Silica (SiO_2)	0.56
Ferric oxide (FeO_2)	0.75
Moisture at 100°C	0.04
Loss on ignition	0.12
Sulphur trioxide (SO_3)	33.71
Manganous oxide (MnO)	0.00
Barium oxide (BaO)	64.46
Total	99.64
Barium sulphate ($BaSO_4$)	98.11

Peebles and Sloan operated the barytes deposit with an open-cut following the lead of the ore into the hillside. The cut is now (1919) almost 400 feet long, 40 to 100 feet wide, and 48 feet deep at the working face. Ore dirt is removed by a 30-ton Vulcan steam shovel with a 1¼-yard dipper loading a wooden tram car that runs by gravity about 100 yards to the incline, where a hoisting motor raises it to the bull pen. The washer is equipped with the usual type of double log

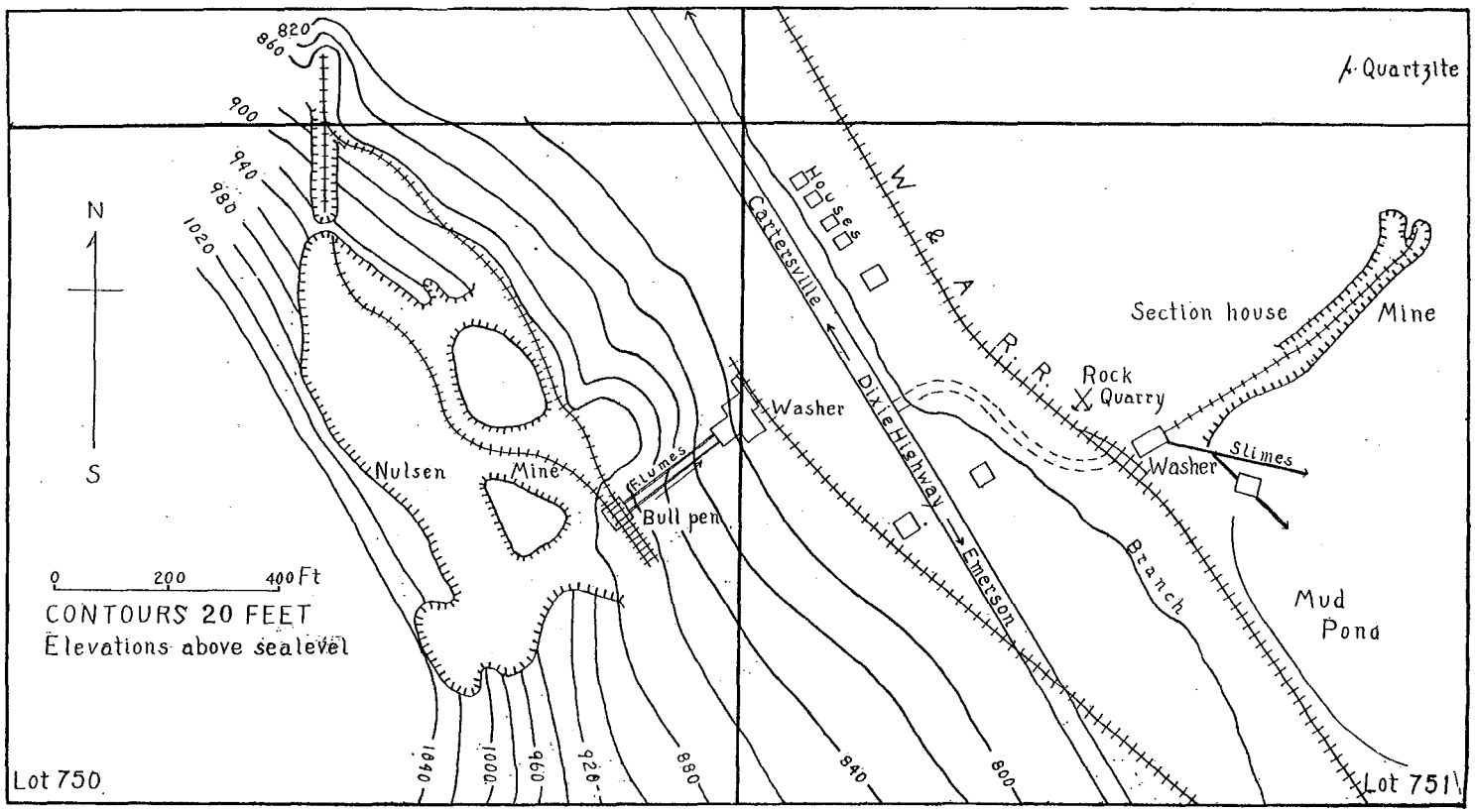


Fig. 6. Sketch map showing Section house and Nulsen mines in Emerson Gap southeast of Cartersville.

washer, sand screen, and picking belt. Finished ore from the picking belt may be fed directly into railroad cars on the track below, or diverted to a storage platform. All mill machinery is operated by electricity. Water for the washer is delivered through a 6-inch pipe by a steam pump at Etowah River, three-quarters of a mile away. A 30-horsepower motor reclaims the cleared water from the mud pond outlet and returns it to be used again in the washer.

NULSEN MINE

The Nulsen Corporation (formerly Nulsen, Klein & Krausse Manufacturing Company), Levee and Sidney Sts., St. Louis, Mo., owns barytes rights on lots 691, 692, and 750, and in fee simple parts of 678, 691, 693, and 751, 4th district, 3d section, three-quarters of a mile northwest of Emerson. This property is in addition to the barytes rights on lots 762 and 823 which are leased to the DuPont de Nemours Company. The mine is on lot 750, just west of the Western & Atlantic Railroad. G. Miltenberger, Jr., is manager. It was first opened about 1905 as a brown iron ore mine, but so much barytes was encountered that the limonite was abandoned. The next year W. R. Satterfield sold his option on the barytes ore to Nulsen, Klein & Krausse. The Nulsen Corporation still owns the rights and produces thousands of tons of high-grade ore each year. When the mine was first opened, the ore was hauled in wagons to Emerson, but about 1908 or 1909, a spur track was laid connecting the mine and washer with the Western & Atlantic Railroad. The Nulsen mine is the oldest operating barytes mine in the State.

The property is for the most part on the northeastern slope of a northwest-trending ridge about half way between Emerson and Etowah River. This ridge rises from 760 feet in the valley to 1160 feet above sea level directly southwest of the mine. The difference in elevation from the railroad siding to the top of the open-cut is about 240 feet, and the bottom of the cut is 70 feet higher than the log washers. The bull pen at the top of the flume is approximately 200 feet higher than Etowah River, or 880 feet above sea level.

The geologic structure at this mine is not complicated and on the whole is similar to that shown at almost all of the barytes mines in

the district. The strike of the formations, however, is at variance with the general northeast trend of the rocks in the region. The only rocks exposed *in place* are outcrops of Weisner quartzite occurring in scattered broken ledges from the top of the open-cut southwestward across the strike up to the top of the ridge. The rocks strike north and dip 45°E., forming the foot wall of the ore deposits.

The stratigraphic relations, or sequence of formations, are so clearly shown at the mine and in the vicinity that the geologic section here exposed may well serve as the type for the whole mining district.

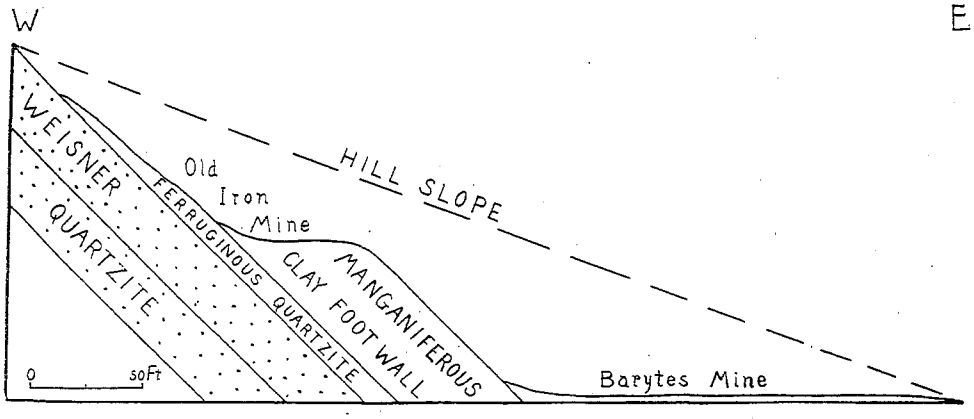


Fig. 7. Section through Nulsen mine showing geological relations and typical sequence of ore overlying quartzite.

The Shady limestone is absent, but it is represented by the several ore deposits which, in a much less concentrated state, were once a part of it. Furthermore, ocher does not occur as a separately recognizable body, but it is present in small and impure masses associated with the manganese clay foot wall and the ferruginous quartzite foot wall. The sequence of formations and deposits as shown in the open-cut is here given, with approximate thicknesses in feet. The strike is north and the dip is 45°E.

Geologic section at Nulsen mine

			Feet
Top.	5.	Red clay loam and subsoil	6
	4.	Barytes ore deposit in red and yellow clay. Contains quartzite fragments and a few iron and manganese nodules. Contains in places as much as 50 per cent of barytes	50
	3.	Manganese clay foot wall. Ferruginous, manganiferous clayey material, generally unworkable for any ore. (See analysis of sample *Hu-26*)	30-40+
	2.	Iron ore. Nodular deposits in clay and concentrated crusts on quartzite. Limonite, once worked as an ore	10-15 ?
Bottom.	1.	Weisner quartzite, conglomeratic and and iron-stained on top. Contains thin gray and yellow schist layers, but grades downward into hard, fine-grained quartzite, jointed and fractured. Constitutes the ridge	several 100

The ore deposit is similar in almost all respects to the other barytes deposits of the district. The workable body is in unconsolidated clayey and gritty material containing many quartzite fragments or boulders overlying the soft dark manganiferous clay foot wall, though the hard rock foot wall is the quartzite still farther back of, or below, the barren clay. Fragments and nodules of barytes occur irregularly throughout the whole clayey mass overlying the quartzite, but the deposit that has slowly accumulated by erosion through geological ages, is in a definite body comparatively near the surface and stratigraphically above all the other ores occurring above the quartzite. The greater part of the ore, however, occupies the lower part of the hillside farthest down the slope from the quartzite outcrops. A few quartz pebbles occur in the ore deposit.

As proved by the open-cut, test pits, and float ore on the surface, the deposit is more than a quarter of a mile long in a northerly and northwesterly direction parallel to the quartzite ridge. South and southeast of the south end of the open-cut, the ore body is difficult to trace. Surface and topographic indications suggest that the ore does not extend very far in that direction and that there is no connection with the DuPont mine from which it is probably separated by a fault a quarter of a mile to the southeast. The thickness of the ore is probably 50 feet in places and the depth, as measured from the top of the old brown iron ore cut to the bottom of the barytes cut, is 160 feet, with every probability of a workable deposit extending to the bottom of the valley, or to a total depth of 270 feet. Barytes frag-

ments have been found near the top of the cut immediately overlying iron-stained quartzite and far below the cut along the Dixie Highway in the valley. Some barytes undoubtedly extends from the Nulsen mine a quarter of a mile northwestward along the hillside to the Paga No. 3 mine just east of Etowah River, but the presence of workable deposits between the two properties has not yet been proved.

Clays and sands of different colors and grades occur in the open-cut. The most noticeable colors are red, yellow, dark brown, and white. Irregular streaks of "gumbo," or very sticky clay, cut across the ore-bearing mass and in places, barren lenses, or "horses," separate good bodies of ore parallel to the strike.

The ratio of barytes to run-of-mine material is by no means uniform throughout the deposit. In some parts it is 1 to 3; in limited rich places it is 1 to 2; and in exceptionally good pockets, considerably higher.

The ore possesses the general high quality of the district, requires the usual washing treatment, and contains relatively little objectionable impurity.

Analyses of barytes ore and foot wall. Nulsen mine

Constituents	*Hu-26*	*Hu-32*	*Hu-25*
Silica (SiO_2)	53.90	20.44	0.80
Alumina (Al_2O_3)	7.50	3.00	0.42
Ferric oxide (Fe_2O_3)	15.28	5.12	
Magnesia (MgO)	0.60	------	------
Lime (CaO)	0.37	------	------
Soda (Na_2O)	0.08	------	------
Potash (K_2O)	0.04	------	------
Moisture at 100°C	0.28	0.10	0.00
Loss on ignition	9.33	1.65	0.01
Titanium dioxide (TiO_2)	0.10	tr.	------
Sulphur trioxide (SO_3)	1.60	23.40	33.94
Manganous oxide (MnO)	8.25	1.20	tr.
Barium oxide (BaO)	3.05	44.74	64.90
Total	100.38	99.65	100.07
Barium sulphate ($BaSO_4$)	4.64	68.09	98.78

Hu-26.—Soft manganiferous clay foot wall.
Hu-32.—Tailings from jigs. Collected June, 1917.
Hu-25.—Barytes. Selected specimens from stock pile, June, 1917.

Like the majority of barytes deposits in the Cartersville district, the Nulsen ore deposit is almost ideally situated for mining, washing, and transportation of ore. Hillside open-cut methods are used. The combined length of the workings which really form one large open-cut is almost a quarter of a mile. The maximum width of the area that has been worked is 400 feet and the depth, 160 feet. Until recent years the mining was done by hand. The face of the cut was extended by occasional blasting and the ore dirt was broken and thrown into small tram cars by means of pick and shovel. Sticky "gumbo" and dirt were removed by "slacking off" over night, after a small stream of water had been sprayed over the ore mass.

In 1915 two Osgood, model 18, steam shovels with ¾-yard dippers were installed at the mine. In 1917 one shovel was used for stripping and the other for ore. Four 2-yard wooden tram cars ran by gravity 140 yards to the bull pen, where the ore dirt was dumped into the flume. Empty trams were hauled back to the working face by mules. In 1919 a new cut was made on the north side of lot 750 and is being extended 175 feet southward to meet the old cut. This new opening is connected with the bull pen by a narrow gage steam railroad. One of the most noticeable features of the property as viewed from the Dixie Highway is the huge dirt and boulder dump that occupies the hillside between mine and washer and beneath which are large reserves of barytes ore.

All water used for the washing plant is pumped about three-quarters of a mile from Etowah River. The pumping station has a Worthington 2-stage pump of 100-horsepower, which delivers 75 gallons per minute through an 8-inch pipe to water tanks at the mine. Electric power replaced steam about 1916.

Ore from the double bull pen is washed down two parallel wooden flumes that drop about 70 feet in 200 feet to the two double log washers. The washer equipment also includes 2 sand screens, 2 sets of jigs with 4 cells each, and 2 picking belts. The washing machinery is driven by a 75-horsepower motor which was installed in 1917. Equipment for steam power was retained for emergency or auxiliary use. About 35 men are employed.

In 1917 tailings from the jigs contained as much as 68 per cent

of barytes (see analysis of sample *Hu-32*). This is largely waste product as regards its use as barytes, though it may be used for inferior grades of ground barytes. It is locally used for road repair work. The mud and slimes from the logs are flumed about a quarter of a mile northwest to a mud pond of a few acres between the Dixie Highway and the Western & Atlantic Railroad. Ore from jigs and picking belts is stored in stock piles alongside the railroad spur or loaded by wheelbarrows directly into waiting cars. It frequently happens that several thousand tons of barytes have to be held at the storage platforms because of shortage of freight cars.

Although this mine is the oldest in the district, it still ranks as one of the heavy producers. In 1917 the maximum daily output was said to have been 150 tons of shipping product; the average, of course, is much less. Future development work on this property will continue northward and northwestward along the strike of the ore body parallel to the ridge and also down the dip of the ore body at right angles to the trend of the ridge. This latter extension of the mining devolopment will necessitate the removal of the large waste dumps, unless underground methods are used to win the barytes now covered by the dumps. It is probable that a large reserve of ore still remains unexplored.

PAGA NO. 3 MINE[1]

The Paga No. 3 mine is on lots 677 and 692, 4th district, 3d section, 1¼ miles north-northwest of Emerson, and a quarter of a mile east of Etowah River. The washer is in the southeast corner of lot 677 and the open-cut is in the northeast corner of lot 692. Both are on the south side of the Dixie Highway. The property belongs to the Georgia Peruvian Ocher Company, R. C. May, agent, Cartersville, except a little more than 4 acres comprising the extreme northeast corner of lot 692, which belongs to Mrs. Kittie P. Larey. Although the deposit had been prospected some time previously, it was not opened and worked until July, 1917. P. C. Renfroe, of Cartersville, leased and operated the mine from 1917 to the first part of

[1] This mine was first known as the Renfroe mine. As it is distinct from the other mines of the Paga Mining Company, it is here described separately.

1919. In 1919 the Paga Mining Company acquired Renfroe's interest in the property and the mine became known as Paga No. 3.

The mine is at the foot of a northeastern hill slope about 720 feet above sea level and 35 feet higher than Etowah River. It is near the northwest end of the prominent ridge that extends northwest from Emerson to Etowah River. Three-eighths of a mile south of the mine, the top of the ridge is 1060 above sea level.

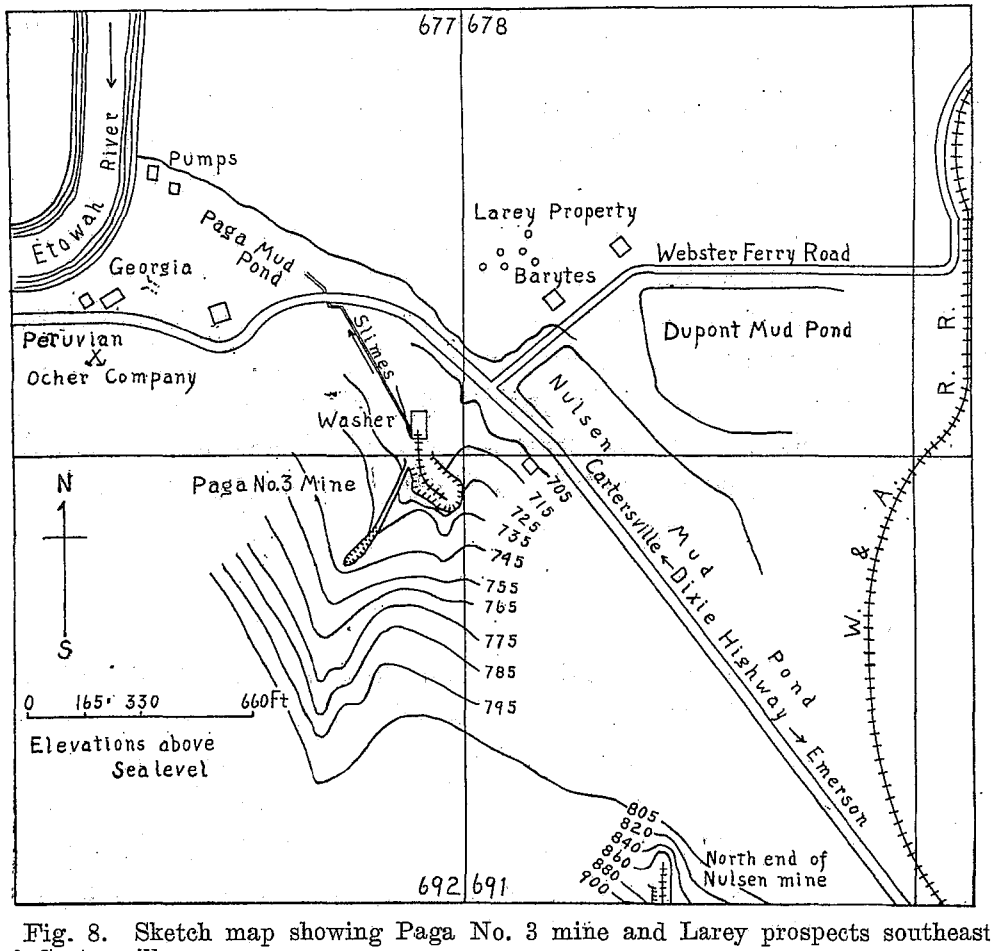


Fig. 8. Sketch map showing Paga No. 3 mine and Larey prospects southeast of Cartersville.

The barytes ore deposit is in the reworked and detrital reddish-yellow clays peculiar to the Shady limestone and Weisner quartzite areas. Cherty and quartzitic fragments are mixed with the nodules and masses of barytes. There are no outcrops of rock at the open-cut,

but farther south up the steep quartzite ridge, ledges and broken exposures of Weisner quartzite show strikes of N. 40°-45°W. and dips of 60°-70°NE. The quartzite forms the foot wall of the unconsolidated ore bodies.

Barytes particles and fragments ranging in thickness from a fraction of an inch to more than a foot have been found on the surface and in test pits throughout a distance of approximately 300 yards south of the Dixie Highway, up to an elevation of about 780 feet above sea level. Nodules also occur 150 yards southeast of the cut in the direction of the Nulsen mine. Water-worn quartz pebbles are abundant in places on the hillside up to an elevation of 860 feet above sea level or about 175 feet higher than the river. Small open-cuts and entries have been made in brown iron ore at elevations of 900 and 960 feet on the hillside.

Test pits show the barytes ore is concentrated at the foot of the hill and in a little ravine leading up the slope south of the washer. The ore is generally abundant and high-grade. When the mine was opened in 1917, some impure ferruginous ore masses a few feet thick were found with the good ore. These fragments showed the association of different minerals with barytes and their sequence of deposition.

The sequence here given was observed in a small geodal specimen composed largely of brown iron ore. The different layers and crystals of the minerals occurred as linings in a shallow cavity 3 inches long and 2½ inches wide.

Sequence of formation of minerals in an ore specimen from the Paga No. 3 mine (Hu-331B)

1. Quartzite, fine-grained.
2. Limonite, massive. In some specimens, partially altered pyrite remains in the limonitic layer.
3. Quartz. A mat of tiny crystals less than 1 mm. thick. Some are stained blood-red by a coating of hematite.
4. Barytes. Scattered tabular crystals a fraction of an inch long, covered by a thin film of iridescent hematite.
5. Hematite. Blood-red stain on quartz crystals. Iridescent finely mammillary layer on limonite, quartz, and barytes. In places, fibrous and crystallized.
6. Barytes. A few clean clear crystals on the iridescent hematite.

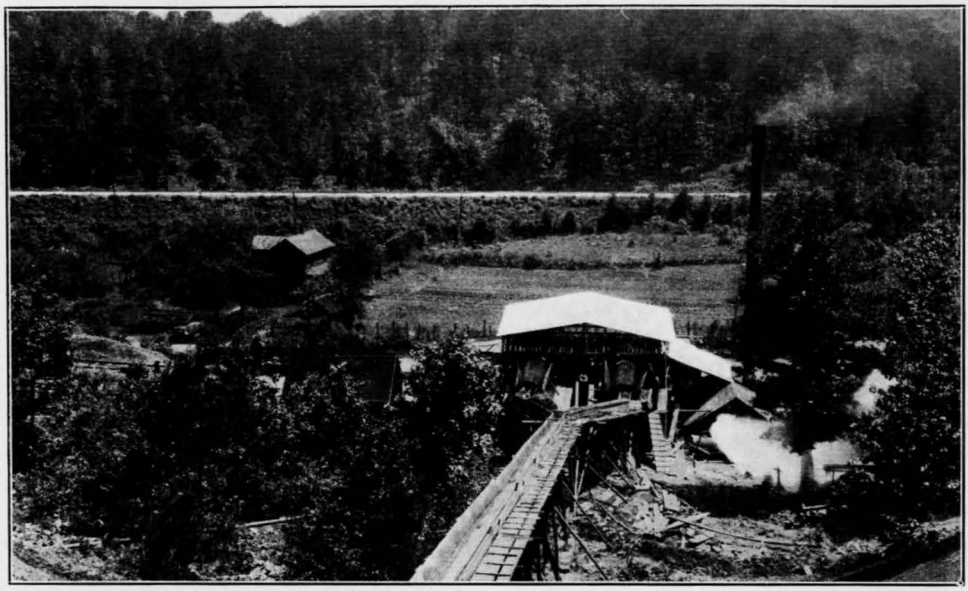
In some specimens the sequence is limonite, fibrous goethite, and barytes. The fragments and nodules of barytes ore, which are not in crystal form, are generally crusted with a thin layer of limonite, as is common in all the barytes deposits. Though the ferruginous layer appears to be a coating deposited after the barytes was formed it may have been in many instances, the original lining of a pocket or cavity in the limestone or quartzite formation. The iron-lined cavity was then filled with barytes and subsequently the limestone matrix decomposed, leaving an iron-coated barytes nodule in the soil.

The principal open-cut is 200 feet long, 100 feet wide, and about 50 feet deep. A shallower open-cut extends 100 yards to the southwest up a narrow ravine. The ore is mined by steam shovel and hauled up an incline to the double log washer by steam hoist. Besides the logs, the mill equipment includes a coarse screen, a 4-cell jig, and a picking belt. The plant is run by steam power. About 20 men were employed. Water for the washer is pumped from Etowah River.

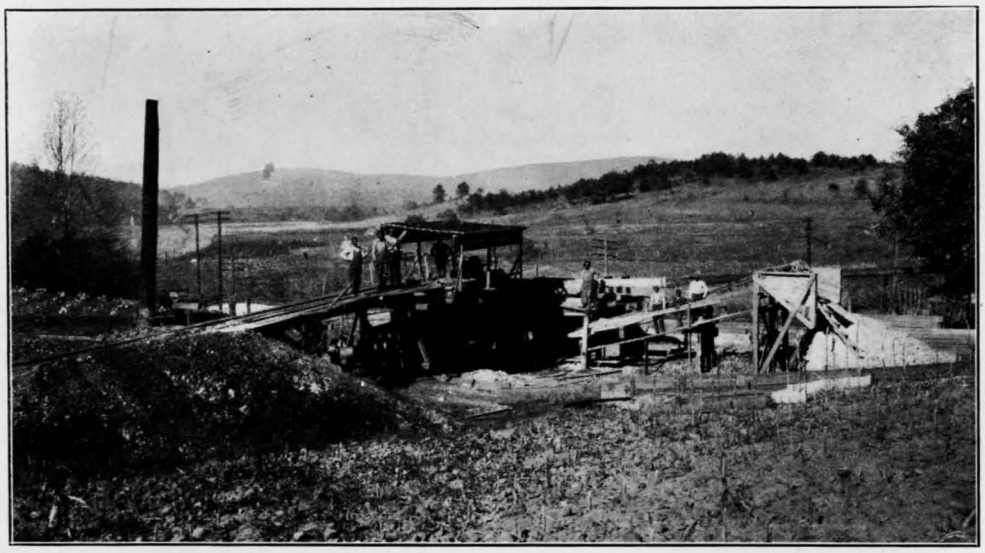
The shipping point is Etowah Siding on the Western & Atlantic Railroad on the north side of the river, about a mile from the mine. Hauling is in wagons by contract work.

GEORGIA PERUVIAN OCHER COMPANY

The Georgia Peruvian Ocher Company, R. C. May, agent, Cartersville, owns several hundred acres of mineral land along Etowah River between Cartersville and Emerson. The company mines ocher and operates a large ocher mill at the wooden bridge on the south side of the river. Important barytes deposits have been worked on several of the company's lots. The Paga No. 3 mine on lot 692 has already been described. Barytes ore also occurs on lot 677, adjoining the Paga No. 3 deposit on the north and northwest. It is exposed in the road cut of the Dixie Highway west of the wooden bridge and it has been found in underground development work at th ocher mine. Beautiful crystals of barytes are commonly associated with the ocher and ocherous quartzite on lots 676, 677, and 693 and abundantly in the big old open-cut just south of the Dixie Highway and the log washer on lot 677. A complete analysis of a crystal (sample *Hu-416*) collect-



A. WASHING PLANT, NULSEN MINE, EMERSON GAP, BARTOW COUNTY.



B. WASHER, PAGA NO. 3 (RENFROE) MINE, SOUTHEAST OF CARTERSVILLE, BARTOW COUNTY.

ed from this locality, about 60 yards east of the covered bridge, is here given.

Analysis of barytes crystal. Georgia Peruvian Ocher Co. (Hu-416)

Silica (SiO_2)	0.18
Alumina (Al_2O_3)	0.00
Ferric oxide (Fe_2O_3)	0.04
Ferrous oxide (FeO)	0.00
Magnesia (MgO)	0.00
Lime (CaO)	0.00
Soda (Na_2O)	0.00
Potash (K_2O)	0.00
Moisture at 100°C	0.01
Loss on ignition	0.07
Carbon dioxide (CO_2)	0.00
Titanium dioxide (TiO_2)	0.00
Sulphur trioxide (SO_3)	34.09
Chlorine (Cl)	0.00
Fluorine (Fl)	0.00
Manganous oxide (MnO)	0.02
Strontium oxide (SrO)	0.14
Barium oxide (BaO)	65.03
Lead (Pb)	0.00
Zinc (Zn)	0.00
Total	99.58
Barium sulphate ($BaSO_4$)	98.98

The company owns deposits of barytes on lots 531 and 532 east of the Cartersville city reservoir and north of Etowah Siding, and on lots 692, 764, 765, and 820 on the south side of Etowah River and west of Emerson. The ore on all of these lots has been leased by Thompson-Weinman & Company, who are now working a mine on lot 531 which is described elsewhere in this report.

The deposit known as the Georgia Peruvian Ocher Company's barytes mine is on the west part of lot 764, 4th district, 3d section, a mile northwest of Emerson. The company opened the mine in January, 1915, and stopped work in November, 1915.[1] Since that time only a little dry mining has been done.

[1] Much information about this mine was given by R. C. May, superintendent at the ocher mill.

The mine is situated at an elevation of 900 feet, more or less, above sea level on the west side of the principal ridge of hills that extends in a general northerly direction from Pumpkinvine Creek to Etowah River. Just east of the mine the ridge rises to an elevation of 1140 feet. The ore deposit is near the head of a ravine whose drainage is southwest, then northwest to Etowah River. The mine is less than half a mile southeast of the public road.

Several outcrops of Weisner quartzite on the hillsides near the mine and on the top of the ridge east of the deposit show strikes and dips indicating that the ore has accumulated at the base of the western limb of the anticline that forms the prominent north-south quartzite ridge. On the ridge top the strikes are north and the dips east, but farther down the western slope just east of the mine, westerly dips are shown. The superintendent of the ocher mill reports that the barytes ore body dips west. Up the hill slope east of the mine, several prospect pits show brown iron and ocher in the somewhat decomposed quartzite.

It is probable that the ore deposit extends several hundred yards north and south along the hillside. As proved by the open-cut its width is more than 100 feet and its depth 30 feet. These latter dimensions, however, do not represent the maximum. That the deposit continues southward along the western hill slope to the Paga mines a quarter of a mile distant is indicated by float ore and prospect pits.

When visited in 1919 the open-cut was partly under water. The walls of the pit showed fragments of barytes associated with loose quartzite and clay. The dump contained both massive and crystallized mineral. The ore is of good quality and readily mined, but the exposures indicate a rather lean deposit. It is reported that carload shipments of the ore contained on the average 93 per cent of barium sulphate (barytes).

The principal open-cut is 330 feet long heading northeast, about 100 feet wide, and 30 feet deep. In places the overburden is 10 to 20 feet deep and clay "horses" cut the deposit at right angles. About 120 yards S.25°E. from the large cut is a smaller opening that

was formerly connected by tramway. It is 40 feet wide, 25 feet deep, and heads northeast.

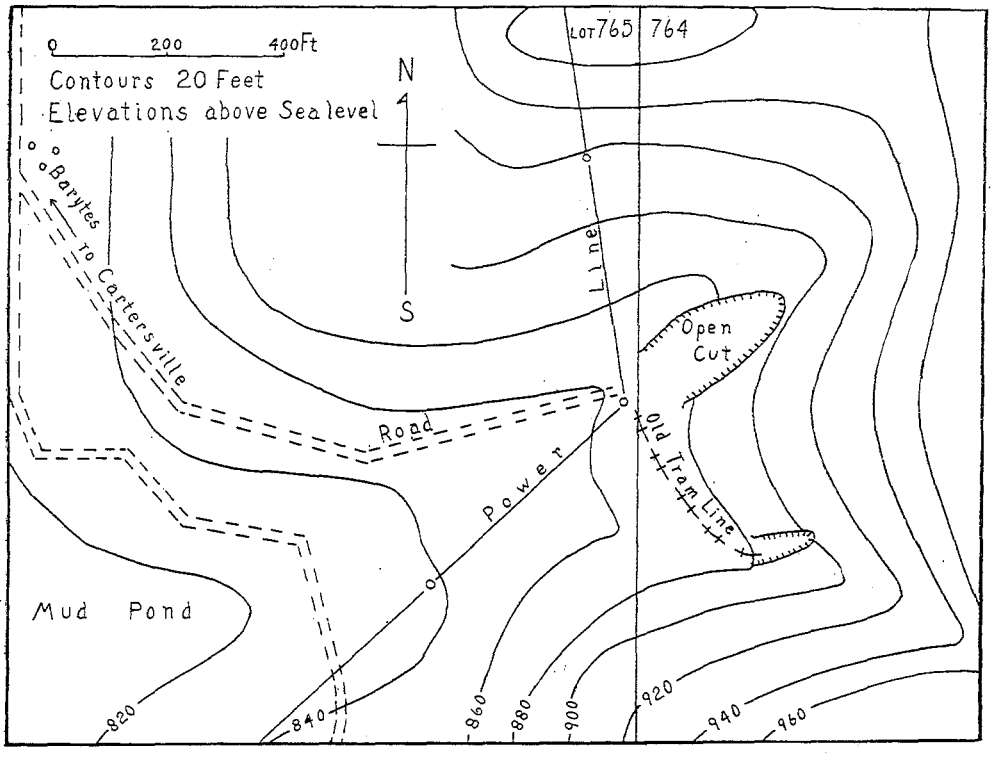


Fig. 9. Topographic sketch map showing Georgia Peruvian mine west of Emerson. *Contours from map by Hall Bros., June,* 1896.

Since the mining stopped in 1915 the washing plant that stood at the large open-cut has been dismantled. When in operation it was equipped with a double log washer and sand screen. Both steam and electricity were used at the plant. Water was delivered to the washer by the same pump at Etowah River that serves the company's ocher mill. The ore was mined by hand and hoisted by inclined tram to the washer. The shipping point was Etowah Siding on the Western & Atlantic Railroad, where the ore was hauled in wagons over a mile and a half of ordinary dirt road. About 25 men were employed at the mine and washer.

Compared with the amount of material moved, the output of barytes ore was very favorable, more than 1500 tons of barytes having been shipped. Steam shovel mining would probably be an

economical method of opening up the remaining deposit which is rather extensive.

PAGA MINING COMPANY

The Paga Mining Company of Cartersville leases and operates barytes mines on lots 819, 838, 891, 892, and 692, 4th district, 3d section, one mile west of Emerson. The two largest mining plants are on lots 819 and 891, the former being known as No. 1 and the latter as No. 2. Paga No. 3, originally known as the Renfroe mine, has already been described. Paga No. 1 was opened in August, 1916, under the direction of Wilbur A. Nelson who managed the mining operations of the company at that time. Shortly afterward two openings were made at Paga No. 2 on lot 891, and in 1917 a third cut was begun. In 1918 James Torbert, Wilbur A. Nelson, and W. L. Torbert, who were the original owners of the Paga Mining Company, sold their interests to W. J. Weinman, B. C. Sloan, and W. S. Peebles, of Cartersville, who are, respectively, president, vice-president, and general manager and treasurer of the reorganized company. In 1919 the mine being worked at Paga No. 2 is the fourth open-cut at that plant. It is on lot 892.

The land and mineral rights at the No. 1 and No. 2 plants belong in part to the company and in part to several owners of which the principal ones are the E. M. Field estate, A. W. Fite, Tom Townsend, Maxwell Bros., and Mrs. L. F. Tumlin, of Cartersville, and J. R. Moore, of Birmingham, Ala.

The Paga barytes deposits are on the west side of the principal range of hills east of Etowah River and west of Emerson. These hills form a broken but generally well-defined ridge extending northward from Pumpkinvine Creek. At the highest point of the ridge which is east of Paga No. 1 the elevation is 1160 feet above sea level Both of the principal open-cuts are about 800 feet above sea level and are at the base of the steepest part of the western hillslope near the heads of small streams that flow west to Etowah River which is a mile away and approximately 100 feet lower than the mines.

The rock formations with which the barytes is associated at the Paga mines are Weisner quartzite and Shady limestone. East of the

mines the whole ridge is made up of quartzite as shown by many outcrops and exposures of both fresh and altered rock. It is impossible in many places to determine the strike and dip but the attitude of outcrops on adjoining properties and the uniformity of the trend of the ridge make it appear that the rock constituting the ridge east of the mines is quartzite in the general form of a fold with a north-south axis and overturned somewhat toward the west. Limestone overlies the quartzite. As a rule the limestone has been removed and is not found in hard rock condition except where uncovered in the bottom of deep open-cuts, or encountered in drill holes on the hillsides or in the valleys. On the Paga property, however, it outcrops at several places within an area of several acres between the No. 1 and No. 2 mines. In November, 1917, the steam shovel at Paga No. 1 exposed unaltered limestone at a depth of 50 feet in the bottom of the cut. It was also found, according to local miners, in digging a well a few hundred yards north-northeast of Paga No. 1.

A few hundred yards north of the No. 2 washer there are two small limestone quarries that were worked in the sixties and as late as 1875.[1] The rock was used as a flux in the iron furnaces at Bartow. Though the quarries have been abandoned many years, the character of the fresh rock is still shown. It is bluish-gray finely granular dolomite, in places very hard and cherty. It has been irregularly shattered, so that no reliable strikes and dips could be observed. An exposure on the north side of lot 891 strikes N.45°E. and dips 20°NW. The weathered surfaces just beneath the red soil mantle are unequally furrowed and roughened as a result of differential decay around the cherty impurities.

Above the limestone, the unconsolidated red and yellow clay and loam mantles the hillsides and valley bottoms. In some places this material is more than 100 feet deep. It is largely detrital and fragmental waste that has gradually accumulated from the long weathering of the quartzite and dolomite. In working faces made by the shovel where a clean vertical section may be studied from unaltered dolomite in the bottom of the cut to clay loam at the surface, it is difficult to distinguish between residual and secondary, or detrital

[1] Information from J. M. Field, Cartersville, 1917.

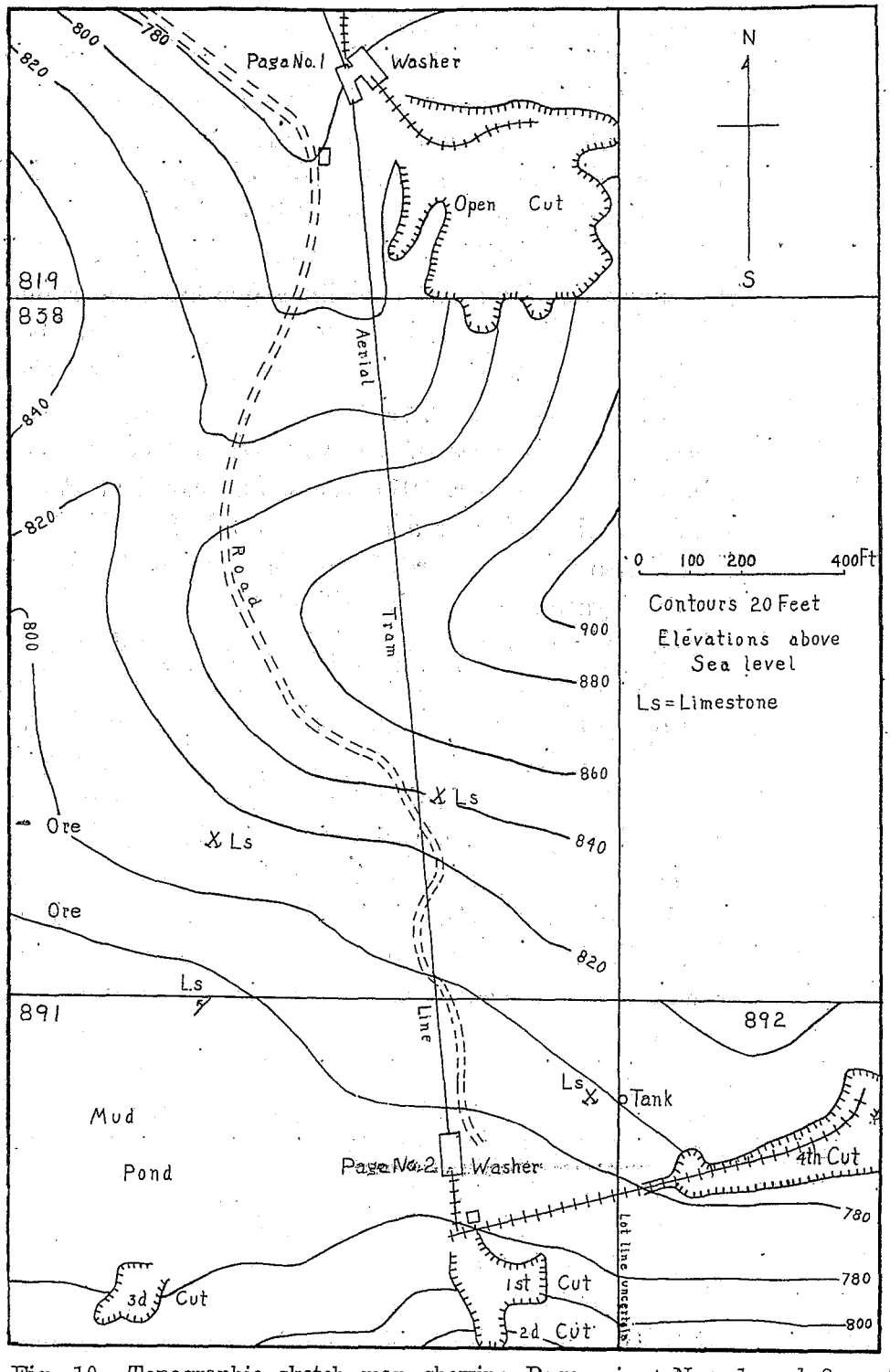


Fig. 10. Topographic sketch map showing Paga mines Nos. 1 and 2 west of Emerson.

formations. Within the small area of limestone outcrops between the open-cuts some of the exposures have a soft, decayed surface representing a stage in the alteration from hard rock to soil. In most of the openings, however, where both limestone and unconsolidated clayey material occur in the same section, no gradation from one to the other can be detected. Furthermore, the loose soil mantle contains angular quartzite fragments and rounded water worn quartz and quartzite pebbles, neither of which are residual from the weathering of limestone. Quartz pebbles occur commonly but irregularly throughout the soil and detrital matter. The highest point at which they are observed is about 910 feet above sea level, on the hillside a few hundred yards southeast of Paga No. 1. This is 230 feet higher than the Etowah.

Barytes is widely but not uniformly scattered throughout the clayey mantle on lots 766, 767, 819, 820, 837, 838, 839, 890, 891, 892, and 893, all 40-acre lots comprising the Paga Mining Company's property and adjoining property. The ore is found on the surface and at all depths to 110 feet. It was found at this depth in a well dug for drinking water at the No. 1 machine shop in 1917.[1] In some parts of the open-cuts, it is necessary to remove a few feet of reddish-yellow overburden and in other places there are barren lenses or "horses" of clay and rock fragments. Red "gumbo" clay showing uneven slicken-sided faces is an objectional feature in parts of the deposit and narrow streaks of yellowish-brown manganiferous clay also reduce the richness of the ore-bearing material. In the deposits being worked the abundance of the ore is typical of the Cartersville district; both lean and rich bodies are encountered. During a large part of the time since the mine was opened in 1916 the concentration ratios have been 3 and 4 to 1.

Barytes occurs in the heterogeneous clay and soil accumulation as subangular, pitted, and irregular fragments ranging in size from grains to boulders more than 100 pounds in weight. Its texture is both crystalline and granular, the former being bluish-white, and translucent, the latter white and opaque. The granular opaque phase is commonly the exterior or more weathered part of a frag-

[1] Information from Wilbur A. Nelson, Cartersville, 1917.

ment whose center is fresh and crystalline. The ore is generally clean and white excepting the red clay and ferruginous coating that is characteristic of all the ore in the district. Breccia ore is present but it represents only a small part of the deposit. It is an intimate mixture of small angular barytes fragments in ferruginous cherty or quartzitic matrix and is as a rule too impure to mine. Very few crystals of barytes have been observed at the Paga mines. Although the workable ore is in the form of loose fragments in the soil, some barytes occurs as small vein- and fracture-filling in both limestone and quartzite. None was observed, however, in quartzite that was *in place;* only in quartzite fragments.

During the period from Oct. 31, 1916, to Nov. 22, 1916, the average analysis of 14 cars of ore shipped showed 95.96 per cent of barium sulphate and the average of another lot of 14 cars during the same time showed 91.12 per cent of barium sulphate. The lowest carload lot contained 88.92 per cent and the highest 96.78 per cent of barium sulphate (barytes).[1] The following analyses show the high grade of selected samples of barytes taken from the second open-cut at the No. 2 plant and from several prospect pits in good ore on lot 893. Sample *Hu-493* is the only sample of Cartersville barytes in which barium carbonate has been determined. No witherite was recognized in the hand specimen.

[1] Analyses furnished by the Paga Mining Company, Cartersville, 1917.

Analyses of barytes. Paga Mining Company

Constituents	*Hu-53*	*Hu-54*	*Hu-493*
Silica (SiO_2)	1.16	0.43	1.28
Alumina (Al_2O_3)	0.00	1.33	2.37
Ferric oxide (Fe_2O_3)	0.35		1.88
Lime (CaO)	------	------	0.00
Moisture at 100°C	0.06	0.00	0.03
Loss on ignition	------	0.12	0.30
Carbon dioxide (CO_2)	------	------	0.28
Titanium dioxide (TiO_2)	------	------	trace
Sulphur trioxide (SO_3)	33.32	34.04	31.88
Manganous oxide (MnO)	trace	0.00	0.16
Strontium oxide (SrO)	1.16	------	0.14
Barium oxide (BaO)	63.80	63.86	60.63
Barium carbonate ($BaCO_3$)	------	------	0.70
Total	99.85	99.78	99.65
Barium sulphate ($BaSO_4$)	97.12	97.19	92.28

Hu-53.—Barytes. White granular opaque weathered exterior of selected clean specimen from Paga No. 2 open-cut, 1917.
Hu-54.—Barytes. Bluish-white crystalline translucent interior of selected clean specimen from Paga No. 2 open-cut, 1917.
Hu-493.—Barytes. Fragments from test pits on lot 893, 1919.

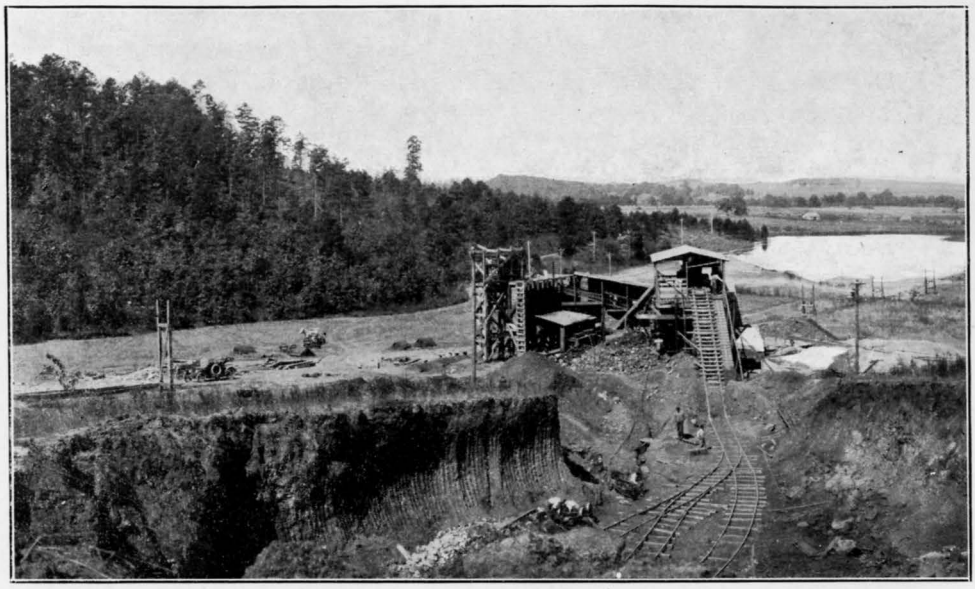
Development work on the Paga Mining Company's property has centered at the No. 1 plant in the southeastern part of lot 819 and at the No. 2 plant in the northern part of lot 891. The No. 1 open-cut is the largest opening on the property. It is a combination of several main cuts radiating south, southeast, and east from the washer. The greatest length of the whole mine, or the distance from the washer southeast to the farthest working face, is more than 200 yards. The maximum width of the combined workings is more than 150 yards and the greatest depth is more than 90 feet. A 27-ton steam shovel with a ½-yard dipper is used in the cut. It loads side dump cars of 2 yards capacity, which are hauled out of the cut up an incline to the washer by a steam hoisting engine. The concentrating mill at No. 1 contains a 30-foot double log washer, a 5-foot sand screen with ½-inch perforations, a 6-cell set of independent

jigs, and a 30-foot picking belt. Electricity from the Georgia Railway and Power Company is used to operate the mills. The No. 1 plant has an 150-horsepower motor at the washer and an 80-horsepower motor at the mud dike to reclaim the cleared water for use again at the washer. In 1917 about 30 men were employed on each shift, night and day, but only one shift is now (1919) used.

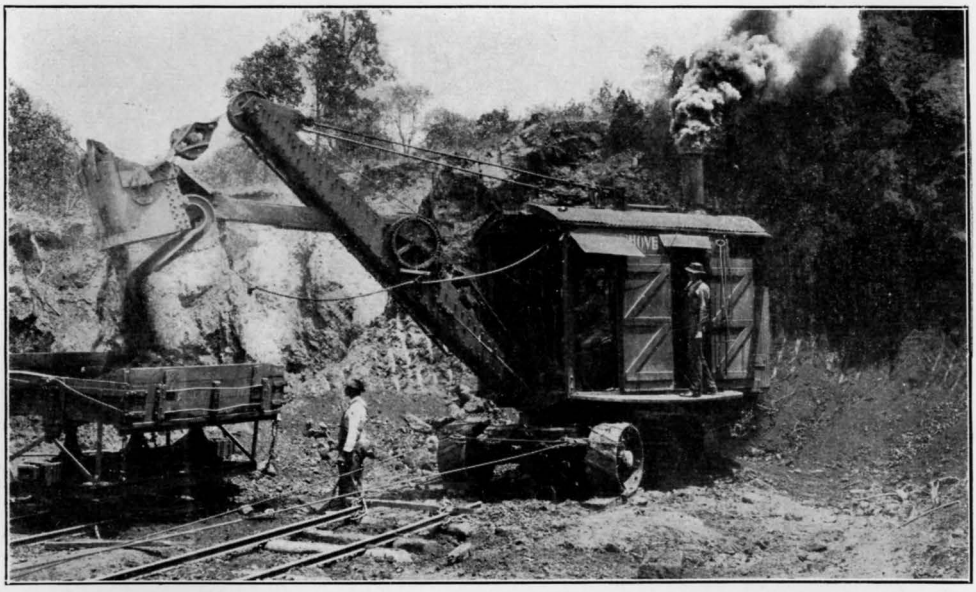
At the No. 2 plant, the original open-cut 100 feet south of the washer is 250 feet long heading south-southeast, 150 feet in greatest width, and about 20 feet deep. In the latter part of 1917 another opening was made about 200 yards west of the washer. In 1919 the fourth and largest open-cut to be operated at No. 2 is 150 yards east of the washer on lot 892. It is 150 yards long, headed east in a promising deposit. The ore is hauled out of the mine on a narrow gage steam railroad. The same method of steam shovel mining has been used at the No. 2 mines as was described for the No. 1 mine, and the milling equipment is similar. A 40-horsepower motor runs the washer and one of 45-horsepower is used to hoist the tram cars to the bull pen. Twenty men are employed at the No. 2 plant.

Water for milling purposes is pumped through a mile of 8-inch pipe from Etowah River. An 150-horsepower electric motor is used. About 1000 gallons of water per minute are used by both plants.

After the ore is washed and concentrated it is conveyed by aerial tram to a spur of the Western & Atlantic Railroad at Thompson-Weinman & Company's grinding mill on the west side of Etowah River, 1½ miles southeast of Cartersville. The aerial line was built by the Amberson Company of New York. The line from Paga No. 1 to the railroad is a mile long and carries 80 cars, each of which has a capacity of 600 pounds. The line between Paga No. 1 and Paga No. 2 is five-eighths of a mile long and carries 20 cars. A 15-horsepower motor operates the No. 1 line and one of 10-horsepower the No. 2 line. The cars are 4-wheeled, run on a steel cable track, and are hauled by means of a ¾-inch steel cable to which they are attached at regular distances. It is claimed that the aerial method of transportation is generally more satisfactory, as employed at these



A. WASHING PLANT AND MUD POND, PAGA NO. 1 MINE, WEST OF EMERSON, BARTOW COUNTY.



B. STEAM-SHOVEL MINING, PAGA NO. 2 MINE, WEST OF EMERSON, BARTOW COUNTY.

mines, than any other means of delivering the ore to the railroad. The haul by wagon is more than 2 miles and the road is unimproved.

In 1917 the Paga Mining Company produced a tonnage of barytes ore next to the largest in the State and the output from the No. 1 mine alone ranked second in quantity. Many thousands of tons of high-grade ore have been shipped since the deposits were opened in 1916. A daily production of 100 tons is not at all uncommon and as many as 150 tons a day have been produced at Paga No. 1 and 80 tons at Paga No. 2.

Indications for a large reserve body of barytes are as favorable on the Paga property as anywhere else in the district. Float ore and prospect pits show good deposits still unworked in the vicinity of each of the large open-cuts and much good ore is still untouched on adjoining lots.

KREBS PIGMENT AND CHEMICAL COMPANY

The Krebs Pigment & Chemical Company of Newport, Del., owned[1] lot 548 and 25 acres in lots 533 and 605, joining 548 on the north and south, respectively, 4th district, 3d section, 1½ miles southeast of Cartersville. The barytes deposit which is on lot 548 was worked as early as 1900 by J. T. Williams. In 1914 the company began work and in 1917 installed a steam shovel. Work was stopped in 1918.

The mine is on the river road on the west side of the Etowah, 250 yards north of the Western & Atlantic Railroad bridge. The open-cut is on the west side of the public road and extends into the eastern slope of a quartzite hill approximately 40 feet higher than the river and 740 feet above sea level. Just west of the mine, the hill rises to an altitude of 820 feet forming the south end of a higher ridge that trends generally northward between Cartersville and Etowah River. The washing plant and mud ponds occupied the flood plain east of the road. The river flows southwest at this place.

The geological conditions at the Krebs mine in a general way are similar to those already described in connection with other barytes deposits, except the difference in strike of the rock. The only rock outcropping at the open-cut is Weisner quartzite which strikes

[1] The land, ore, and equipment were sold in 1919 to the Bertha Mineral Company. The plant is completely dismantled.

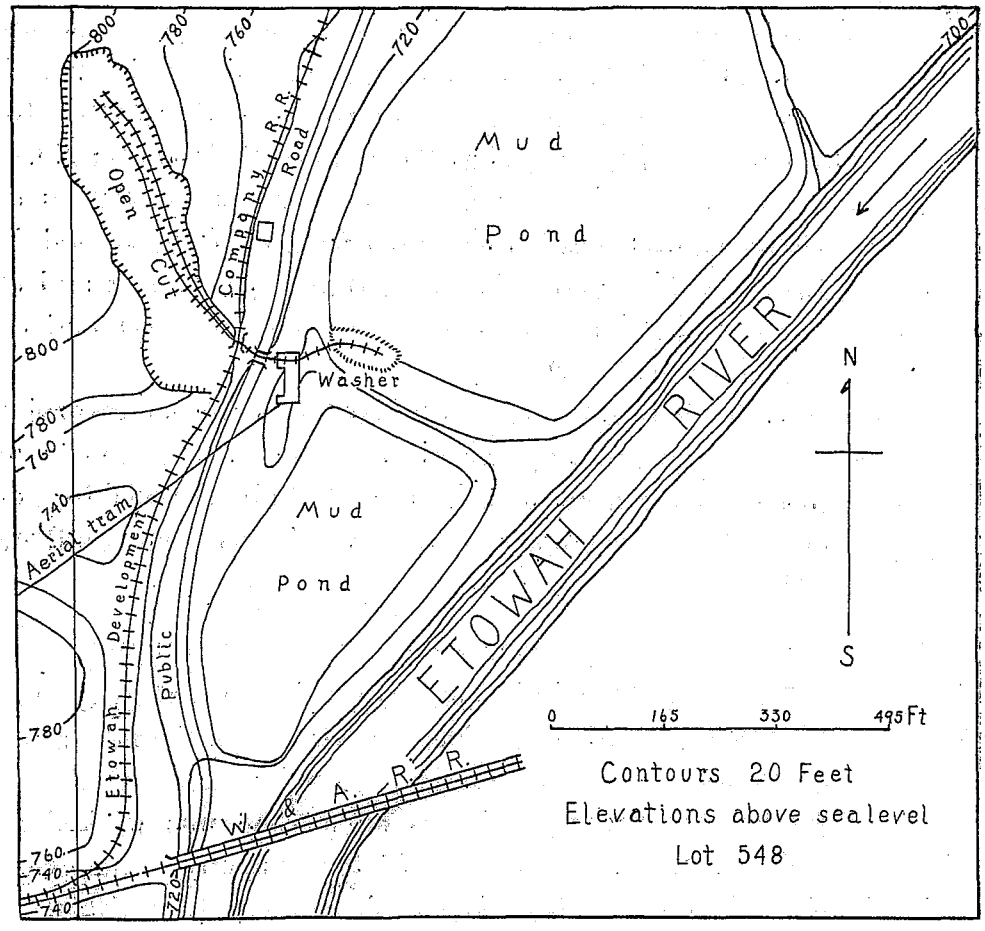


Fig. 11. Topographic sketch map showing Krebs mine east of Cartersville.

N.15°-20°W. and dips steeply northeast. This is shown in an outcrop and exposure at the surface and in the west wall of the cut. The quartzite foot wall is covered in most places by the dark soft manganiferous and ocherous clayey formation against which lies the red and yellow ore-bearing clay carrying quartzite fragments and a few water-worn quartz pebbles.

Barytes occurs as an erosional and detrital accumulation of fragmental ore in a soft clay formation that strikes N.15°-20°W. parallel to the underlying rock. No limestone has been found in the mining operations, but it once probably occupied a large part of the Etowah valley east of the mine and it now presumably forms the valley floor at a depth to which decomposition and disintegration have not penetrated. The ore undoubtedly weathered out of the limestone where it

filled veins and pockets in the hard rock. The size of the deposit on this property is about 500 feet long, more than 100 feet wide, and 80 feet deep. These dimensions are proved by the open-cut work, but the deposit continues northwest from lot 548 to the adjoining property of the New Riverside Ochre Company, and its width extends more than twice that of the open-cut, as shown by prospect pits down the eastern hillside. A well dug for drinking water just west of the public road contained barytes fragments in the bottom, at a depth of 47 feet which is several feet lower than the bed of Etowah River.[1]

In abundance and quality of ore the deposit compares favorably with the best deposits of the Cartersville district. The ore fragments have both crystalline and granular texture, and are generally clean and white under a thin ferruginous surface stain. It is not unusual, however, to find some of the fragments permeated with a brown stain as the result of the alteration of pyrite that occurs as small irregular grains in the mass of barytes. Manganese is another impurity of the ore, generally as pyrolusite or wad, coating the ore fragments or filling fractures.

Although no fossils have been found at the Krebs mine, there do occur certain unusual forms of barytes that strongly suggest organic structure. These forms are pod- or bud-like generally about 2½ inches long and 1½ inches in greatest diameter. They are thickest in the middle and taper convexly to a point at either end much like the fruit pods of the milk weed. The surface is rough with parallel longitudinal furrows. As the interior of the forms is uniformly crystalline and as there is no positive evidence of organic structure, it seems probable that the "pods" are merely aggregates of parallel tabular crystals arranged in columnar form, radiating outward from a common long axis and tapering at either end.

A rarer form of occurrence is the mammillary structure. Only a few specimens of this type were found at the Krebs mine, but these are almost pure and exhibit an intimate combination of concentric films and radiate fibers, beautifully intergrown in cauliflower clusters less than an inch long and terminated by smooth mamillary surfaces. The specimens tend to break as thin white concentric

[1] Information from the late J. L. Waite, superintendent, Cartersville, 1917.

shells whose curved surfaces show here and there the delicate black tracing of dendritic manganese. Mammillary and stalactitic forms occur in combination and are somewhat similar.

The mineral impurities just described are not peculiar to the ore at the Krebs mine and they are by no means so abundant as to detract from the richness of the deposit and the generally high grade of the ore.

A chemical analysis of the washed and jigged ore made by the Krebs Pigment and Chemical Company, January, 1917, showed 95.80 per cent of barium sulphate and 0.04 per cent of manganese. The following analysis represents a hand specimen collected from the company's stock piles at Etowah Siding, Nov. 14, 1917. It contained small grains of pyrite whose decompositoin gave the fragment of ore a brownish color.

Analysis of barytes ore. Krebs mine. (Hu-335)

Silica (SiO_2)	0.39
Alumina (Al_2O_3)	0.06
Ferric oxide (Fe_2O_3)	0.48
Manganous oxide (MnO)	0.08
Carbon dioxide (CO_2)	0.00
Strontium oxide (SrO)	1.34
Chlorine (Cl)	0.02
Sulphur trioxide (SO_3)	34.10
Barium oxide (BaO)	63.47
Total	99.94
Barium sulphate ($BaSO_4$)	96.60

In 1917 and 1918 development work on the ore deposit was being done by means of open-cutting in the hillside west of the public road and the Etowah Development Company's railroad. The open-cut is about 500 feet long, 80 to 100 feet wide, and 80 feet deep. The entrance to the first lift, or level, of the workings was made a few feet higher than the Etowah railroad. The second lift is about 20 feet lower than the first ,and the entrance is through a concrete pass under the railroad. The ore from the working faces was loaded by steam shovel into tram cars which ran by gravity out of the cut,

under the railroad, and by trestle over the public wagon road to the washer. The empty cars were hauled back by mules.

The ore dirt passed from bull pen to double log washers, thence to a rotary screen with ¾ and 1-inch holes. Oversize fragments from the coarse screen went to the picking belt; undersize passed to a sand screen which fed a set of 4-cell jigs. Ore from picking belt and jigs went to two storage bins made of lattice or crib work so as to let the ore dry before being loaded into the aerial trams. One bin held 40 tons; the other 50 tons.

The aerial tram line was 1680 feet long. It carried the washed ore over a hill 133 feet high to shipping bins at Etowah Siding on the Western & Atlantic Railroad. The line carried 15 cars, each with a capacity of 750 pounds, but because of the steep grade only 550 pounds were loaded. Though the original cost of an aerial line is relatively high, the cost of operating is very low as compared with transportation by wagon, and in many places the aerial is much more satisfactory than a railroad, as is illustrated at the Paga mines where a river had to be spanned and at the Krebs mine where a high hill had to be crossed to reach the railroad. The Krebs washer was situated on the Etowah Development Company's steam railroad which connects with the Western & Atlantic, but the distance from washer to main line was so short that a privately owned aerial tram was probably considered more satisfactory as a means of transportation. Electric current from the Georgia Railway & Power Company furnished the power.

The several motors used were as follows: tram, 15-horsepower; washer, 50-horsepower; pump, 15 and 35-horsepower. The pump was at the river 200 yards southeast of the plant. Water was delivered through 4-inch and 6-inch pipes. The mud ponds covered several acres of bottom land between the public road and the river. Barren dirt and rock from the open-cut were also dumped on this low land.

The whole output of the mine was shipped to the owners, the Krebs Pigment & Chemical Company at Newport, Del. The ore was used in the manufacture of lithopone, sold under the company's trade name, "Ponolith—the best of lithopone." The mine and washer produced as much as 1980 tons of barytes in two weeks, but the ordi-

nary output during the period of greatest mining activity from 1914 through 1918 was probably between 80 and 100 tons a day. Several thousand tons of workable ore remain in the deposit, but steep walls and the narrow bottom of the open-cut make deeper working difficult by steam shovel methods, unless an expensive removal of overburden be undertaken further down the hill to the east. It is doubtful if the quantity of ore is large enough to be worked profitably by underground methods.

NEW RIVERSIDE OCHRE COMPANY

The New Riverside Ochre Company, W. C. Satterfield, agent, Cartersville, owns 39 acres of lot 533, 4th district, 3d section, 1½ miles east-southeast of Cartersville. Although the principal mining operations of this company have been in the ocher deposits, the mining of barytes was carried on rather extensively in 1914 and 1915. Since that time, however, the only barytes produced has been that encountered in the mining of ocher.

The chief topographic feature of lot 533 is the little valley extending approximately through the middle of the lot from north to south and opening into the trench of Etowah River. The river flows southwest near the southern boundary of the property. On either side of the valley the hills rise 100 feet higher than the river or about 800 feet above sea level. They have a northerly trend corresponding to the general strike of the rocks. The timber on this lot is largely second growth pine and scrub oak. Ample space for mud ponds is afforded by the gently sloping valley floor, and the situation of the ore deposits higher up on the hillsides is likewise favorable, as gravity can be used to facilitate handling of ore and disposal of waste material.

The only rock exposed *in place* on the lot is Weisner quartzite which strikes generally north and dips steeply east. Weathered outcrops may be seen on the tops of the ridges and exposures of the unaltered rock are made by the open-cut mines. Where fresh the quartzite is medium- to fine-grained and somewhat vitreous. In most places it is deeply covered by red soil and hillside accumulations that contain the ore deposits.

The deposit of barytes that was worked in 1914 and 1915 is closely associated with ocher in the southwest corner of lot 533. It forms the northern extension of the Krebs barytes deposit and the two open-cuts are separated only by a few feet of unworked material along the boundary of the two lots. The ore occurs in the common form of irregular and angular fragments scattered through the clay. Both barytes and ocher occur together, but the large bodies of ocher lie just above the quartzite foot wall and the concentrated barytes deposits that were worked lay stratigraphically above the ocher.

In 1917 prospecting on the ridge in the northwest corner of the property about 150 yards south of the Bertha mine revealed a good deposit of barytes estimated at several thousand tons. This is in a slight gap in the ridge at an elevation about 790 feet above sea level and forms the southern continuation of the edposit being worked by the Bertha Mineral Company. In 1919 the Bertha Mineral Company leased this deposit.

The deposits on the New Riverside Ochre Company's property have not been worked exclusively for barytes in several years ,but the concentrating plant is used (1919) in washing ore mined on lot 478 under contract with Thompson-Weinman & Company. The mine is connected with the washer by half a mile of narrow gage steam railroad. The plant includes a double log washer, a rotary screen, one 4-cell jig, one 3-cell jig, and a picking belt. The machinery is run by electricity.

The quantity of ore produced from the old barytes cut and from various parts of the ocher deposits has amounted to several thousand tons. The ore in reserve on the hill south of the Bertha mine is also promising in quantity and quality. The deposits share the natural advantages of those on nearby properties in being well situated for hillside open-cut mining, convenient to rail transportation, and near an unlimited supply of water from Etowah River.

BERTHA MINE

The Bertha barytes mine is on lots 475 and 476, 4th district, 3d section, 1½ miles in an air line east of Cartersville. The whole

property including the mine comprises lots 461, 475, east half of 476, and 534 west of Etowah River. It is owned by the New Jersey Zinc Company and operated by the Bertha Mineral Company of Cartersville. L. B. Womelsdorf is the local superintendent. About 1900 this property was first worked for ocher and iron by the American Ocher Company, which continued to produce ocher for several years. Soon after the beginning of the world war in 1914, W. S. Peebles and B. C. Sloan of Cartersville worked the barytes deposit by hand methods. In 1916 the Bertha Mineral Company opened the deposit on a larger scale and is still producing ore of a grade that is on the whole unsurpassed by any in the district. This company also works the associated ocher deposits and operates a mill for washing and drying the ocher. The company has recently (1919) leased from the New Riverside Ochre Company the barytes on two acres of land in the northeast corner of lot 533 adjoining the Bertha mine, from the Etowah Development Company all the barytes deposits owned by that company subsequently described as such in this report, and from the estate of L. S. Munford the Iron Hill barytes mine also separately described. In addition the company has bought the Krebs Pigment & Chemical Company's property at Cartersville, previously described as the Krebs mine.

The property of the New Jersey Zinc Company lies on the right bank of Etowah River. Its principal topographic feature is a wooded ridge extending north-northwest from the river and rising from about 700 feet to an elevation of 880 feet above sea level at the northern extremity of the property on lot 461. The ore deposits occupy the east slope of the ridge, extending half a mile in length. Water is pumped a quarter of a mile from Etowah River to a tank near the open-cut about 110 feet above the river level. The Etowah Development Company's railroad which follows the right bank of the river connects the property with the Western & Atlantic Railroad three-quarters of a mile southwest.

Weisner quartzite forms the hills and ridges giving them their northerly trend in conformity to the strike of the rock. Both hillsides and valleys have a thick covering of red and yellow soil that has slowly accumulated as the rocks decayed and as the debris moved down

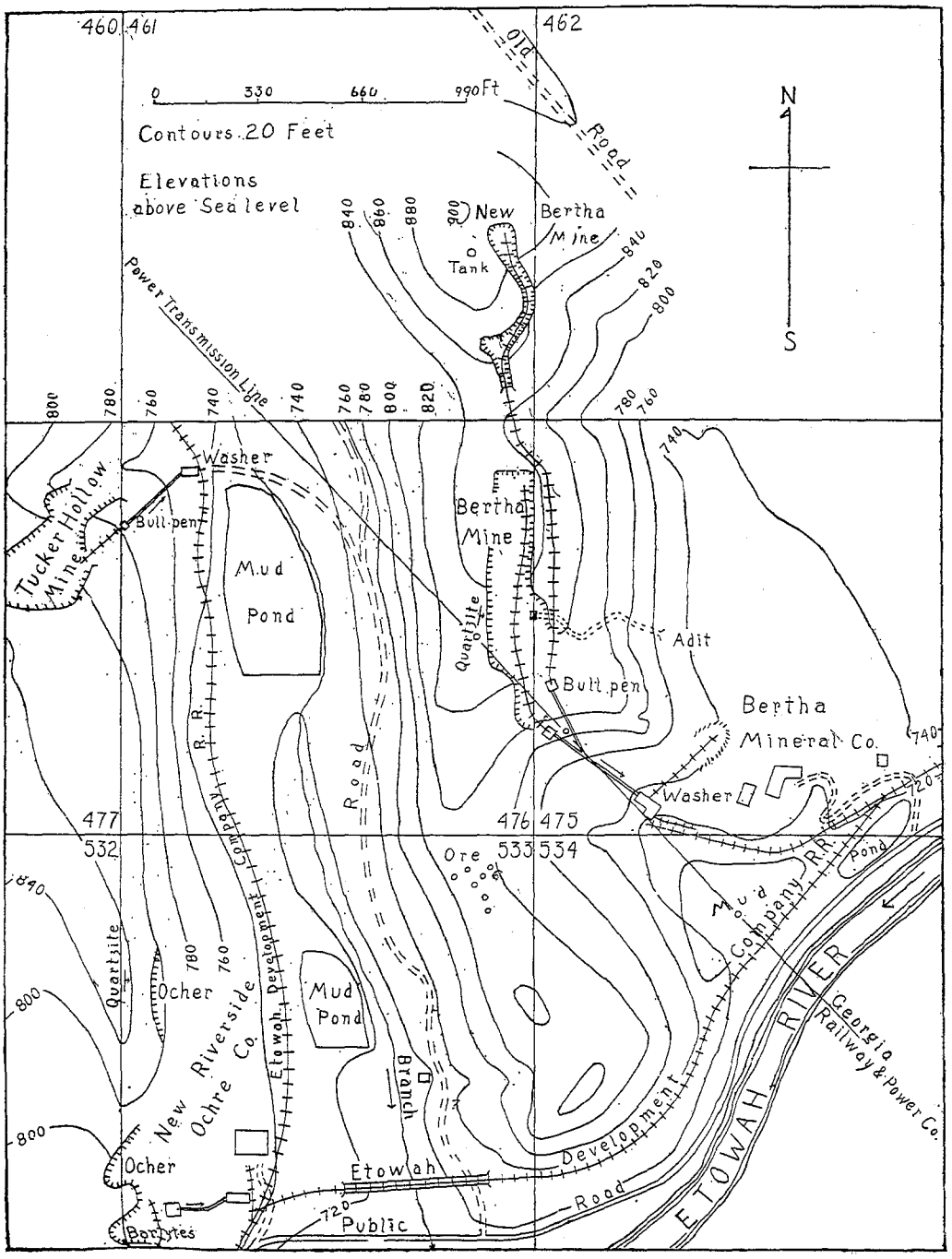


Fig. 12. Topographic sketch map showing New Riverside, Bertha, and Tucker Hollow mines east of Cartersville.

the slopes, but underneath this soft detrital material it is probable that Shady limestone forms the valley floors. The quartzite outcrops at many places along the top of the ridge and shows strikes ranging from N.10°E. to N.10°W., and dips generally 50°SE. and NE. It is exposed especially well near one of the steel towers of the high-power transmission line on top of the ridge just west of the barytes open-cut. The rock has a gray weathered appearance and outcrops both as fractured ledges and as rather massive exposures that show a tendency to exfoliation.

Its weathered faces are markedly pitted by small irregular cavities, or pockets, many of which have an oval outline and are 2 or 3 inches long and 1 or 2 inches deep. On one fragment of rock 125 pits were counted in an area of 12 square feet. There is no apparent regularity in the arrangement of the pits, though in places they seem to be elongated parallel to the strike of the rock, or at right angles to the direction of pressure that altered all the formations. Their oval form suggests some organic structure, but it is improbable. Their explanation may be found in the weathering of small spots or portions of rock that contained an abundance of iron minerals as accessories in the quartzite. Grains of pyrite occur in the fresh rock more concentrated in some spots than in others. When the rock is exposed to weathering influences, the tiny sulphide grains decompose to limonite leaving the quartz grains so loosely bound together that the mass soon disintegrates and a cavity is formed where the iron accessories or cementing minerals were more abundant.

The Shady limestone is represented at the Bertha mine by ferruginous siliceous remnants exposed *in place* in the bottom of the large cut extending north from the power transmission line. This finely granular, leached material, to which the name "Shady chert" has sometimes been applied, overlies the quartzite and conforms to it in strike and dip. So far as known, the only fossil yet found representing the Shady limestone in Georgia is the one collected at this mine in 1917—the lower Cambrian coral-like sponge, *Ethmophyllum profundum* (Billings) Walcott.[1] Ulrich described it in part as follows: "The fossil has been preserved through metasomatic replacement by

[1] Identified by E. O. Ulrich, U. S. Geological Survey, Washington, D. C., 1917.

barytes, which, though completely obliterating its minute internal structure, has yet reproduced the outer and inner surfaces of the wall of its obconical cup with sufficient exactness and detail to warrant a considerable degree of confidence in its biological determination." The specimen has a height of 8 inches and a diameter of 5¼ inches. At least 130 septa can be distinguished. Pod-like forms of barytes, already described as occurring at the Krebs mine have also been found in the red soil at the Bertha mine, but although they suggest organic structure, they can not be certainly recognized as possessing it.

The loose heterogeneous soil mass overlying the barytes ore body contains, besides the ordinary fragments of quartzite in various sizes and conditions of decay, an unusual quantity of water-worn quartz gravel. In some parts of the open-cut there are distinct bodies or pockets of unstratified gravel. Pebbles ranging in diameter from 2 inches to 8 inches are scattered over the hillside and a few were found on top of the ridge among the quartzite outcrops at an elevation of 830 feet above sea level or about 130 feet higher than Etowah River. In the open-cut gravel has been observed to a depth of 15 feet and doubtless occurs throughout the unconsolidated material.

It is seen then, that the typical geological relations of the Cartersville district hold at the Bertha barytes mine, namely, Weisner quartzite foot wall dipping generally east, overlain by Shady limestone, represented in part by leached, siliceous remnants and in part by the following unconsolidated masses: 20 to 30 feet of soft clay foot wall that is manganiferous and in places sufficiently ferruginous and ocherous to be worked for iron and ocher, and lastly the barytes ore body itself, a residual-hillside accumulation of yellow and reddish-yellow gritty clay containing rock fragments, pebbles, and barytes, all mantled by 5 to 15 feet of red loam and clay loam.

The Bertha barytes ore deposit has proved to be one of the largest and richest in the State. Actual mining of the ore has shown it to continue more than a quarter of a mile along the east slope of the ridge, and prospect pits north of the open-cut indicate a further extension of the ore body. Ore has been mined at a depth approximat-

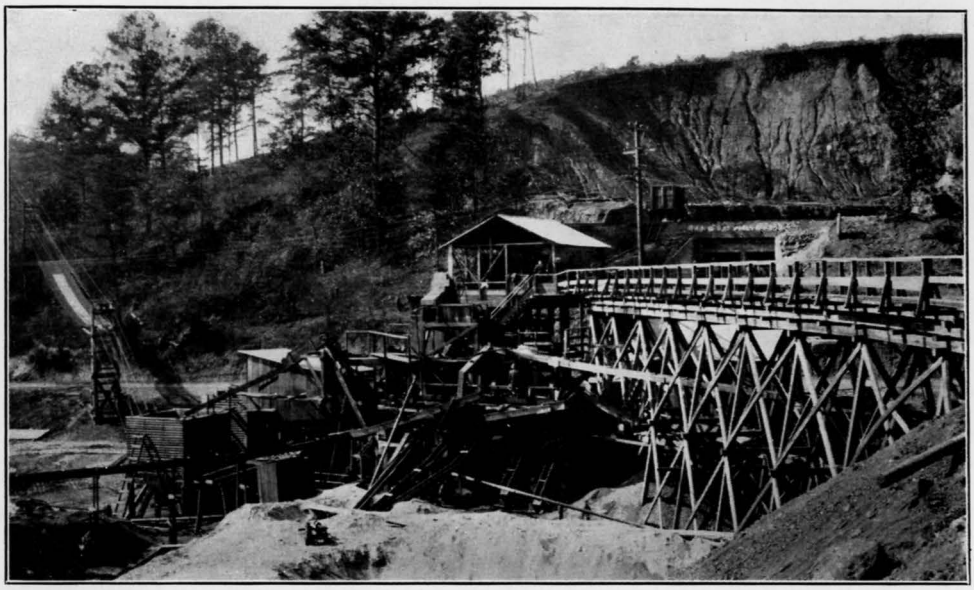
ing 50 feet but it is probable that workable barytes continues to more than twice that depth.

In 1916 an adit was driven into the eastern slope of the hill on the west half of lot 475. Its entrance is about 660 feet northwest of the ocher mill and 50 feet higher than the river. It was driven west 300 feet to a point beneath the present (1919) large barytes cut.[1] The last 15 feet of the adit showed barytes. An almost vertical shaft, opened from the end of the adit to the surface, passed through about 100 feet of barytes and a few feet of red clay overburden. The shaft was recently encountered in the lowest level of the big open-cut, near the line between lots 475 and 476 about 185 feet north of the old barytes ore tipple.

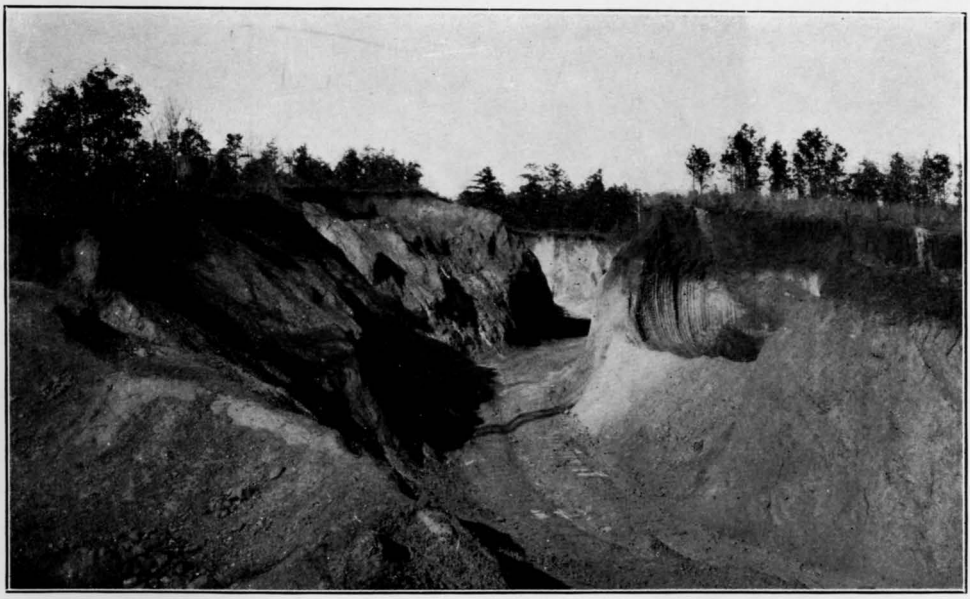
In several parts of the open-cut the working faces have been remarkably free from quartzite fragments, manganese, and iron, and have yielded run-of-the-mine material containing more than 50 per cent of barytes. During the period from Oct. 6, 1917, to Nov. 3, 1917, 5,929 tons of dirt and ore as mined by steam shovel gave 2,753 tons of barytes washed and ready for shipment. The only concentrating treatment this ore received was rough sorting at the bull pen, fluming to the washer, coarse screening in the rotary screen, log washing, and sorting by hand at the picking belt. No jigs were used. At times this simple washing method has produced ore containing 96 per cent of barytes.

The following analyses made by the New Jersey Zinc Company, Palmerton, Pa., represent shipments from the Bertha mine in the summer and fall of 1917, and a hutch sample from the jigs in 1919.

[1] Information about this underground prospecting was given by L. B. Womelsdorf, superintendent for the Bertha Mineral Company, and by the late J. L. Waite, who was formerly superintendent for the American Ocher Company.



A. OPEN-CUT, WASHER, AND AERIAL TRAM, KREBS MINE, CARTERSVILLE, BARTOW COUNTY.



B. OPEN-CUT, BERTHA MINE, EAST OF CARTERSVILLE, BARTOW COUNTY.

Analyses of barytes ore. Bertha mine

Constituents	1	2	3	4	5	6
Silica (SiO_2)	2.82	2.80	2.55	------	------	19.0
Alumina (Al_2O_3)-	------	2.28	2.69	------	------	------
Ferric oxide (Fe_2O_3)	3.43					
Magnesia (MgO)	------	------	0.07	------	------	Fe,7.6
Lime (CaO)	0.54	0.56	0.33	------	------	------
Loss on ignition	0.58	0.65	0.64	------	------	------
Carbon dioxide (CO_2)	0.05	0.03	0.04	------	------	H_2O,3.9
Sulphur trioxide (SO_3)	31.86	32.79	32.38	------	------	------
Fluorine (F)	------	------	0.00	------	------	------
Manganous oxide (MnO)	------	------	0.17	------	------	Mn,1.5
Barium oxide (BaO)	60.84	61.34	60.76	------	------	------
Total	100.12	99.95	99.63	------	------	------
Barium sulphate ($BaSO_4$)	92.59	93.36	92.48	95.45	96.1	64.2

1, 2.—Average of several carloads.
3.—Average of 23 cars shipped in August and September, 1917.
4.—Average of 10 cars.
5.—Analysis of one carload.
6.—Sample of hutch material from cells 1 and 2 of cleaner jig. *See* flow sheet.

All mining of barytes at the Bertha mine is done by steam shovel methods. The open-cut follows the ore deposit northward along the strike of the formations and the trend of the ridge. By the end of 1916 the first lift or upper level of the cut had been extended through a length of 600 feet or more. It was 75 to 100 feet wide and about 30 feet deep. In 1917 a second lift was begun to win the ore in the bottom of the first working. The second or lowest lift has now (1919) been extended northward the full length of the open-cut, about 275 yards, and a second mine has been opened on lot 461, which is connected with the washing plant by a quarter of a mile of narrow gage steam railroad and 150 yards of flume line. The ore cars from the original cut are hauled by a small locomotive burning crude oil. The

equipment at the mines includes the following: 2 steam shovels, 10 steel side dump cars with a capacity of 2 cubic yards or about 1½ tons each, 6 wooden cars, and 2 small locomotives, one oil-burning. Twenty men are employed at mine and washer.

The ore passes through the grizzly, or bull pen, and is flumed through a distance of 100 yards or more to the washer 40 feet lower than the grizzly. Two double log washers, two sand screens, 2 sets of jigs, and a picking belt comprise the concentrating machinery at the washer.

The flow sheet at the Bertha concentrating mill is here given.

Ore dirt from mines to 1.

1. Grizzly: ore broken by hand sledge to 3 or 4 inches; rock boulders by hand to 2; undersize to 3.
2. Rock dump.
3. Flume.
4. Double log washer (2); slimes to 5; ore to 6.
5. Mud pond.
6. Revolving screens, 2 perforated cylinders, ¾-inch mesh, 5 feet long; undersize to 7; oversize to 13.
7. Bin.
8. Chute with flat inclined screen, ¼ to ⅜-inch mesh: oversize to 10; undersize to 9.
9. Jig (3-cell rougher), each cell 23 by 29 inches, $\frac{3}{16}$-inch mesh; overflow to 5; hutch (screenings) to 10; discharge from 1st and 2d cells by car to 12; discharge from 3d cell, if clean to 12, if dirty, by elevator to 10.
10. Jig (3-cell cleaner), each cell 23 by 29 inches, ⅛-inch mesh: overflow to 5; hutch from 1st cell rejigged; hutch from 2d and 3d cells to 11; discharge from 1st and 2d cells by car to 12; discharge from 3d cell rejigged.
11. Tailings dump (hutch or screenings).
12. Stock pile (jigged ore).
13. Picking belt. Rock picked out by hand.
14. Storage crib (coarse ore).

Electric current for the four motors at washer and pumps is taken from the Georgia Railway & Power Company's power line which crosses the property at the south end of the open-cut. The pumps are at the river about a quarter of a mile from the mine and 110 feet lower than the reservoir-tanks. Ore from the picking belt falls into storage bins whence it is loaded directly into cars on the spur of the Etowah Development Company's standard gage railroad which connects with the Western & Atlantic Railroad at Etowah Siding.

The total quantity of barytes shipped from the Bertha mine may be reckoned in tens of thousands of tons. The daily production has

sometimes amounted to considerably more than 100 tons. As regards the future of this deposit it may be said that the ore reserve is still large. Although it is not probable that the ore is so uniformly plentiful in the northern extension of the deposit on lot 461 as in the southern part of the deposit on lots 475 and 476, it is nevertheless doubtful whether the whole ore body has been as yet half worked out.

TUCKER HOLLOW MINE

The Tucker Hollow mine is in the northeast quarter of lot 477 and the washer is in the northwest quarter of lot 476, 4th district, 3d section, 1½ miles east of the Cartersville courthouse and less than three-quarters of a mile north of Etowah River. Thompson-Weinman & Company operated this property under lease from the Cherokee Ochre Company from 1916 to 1918. The work was carried on under the supervision of W. S. Peebles and B. C. Sloan, of Cartersville.

Topographically and geologically this deposit has a situation so similar to the majority of barytes deposits in the Cartersville district that it would be mere repetition to describe it except in a few details. An open-cut was made in the ore-bearing dirt overlying Weisner quartzite that has a northerly strike and a dip that is generally to the east, though it differs in accordance with minor folds in the rock. The elevation at the washer is about 750 feet above sea level or 50 feet higher than Etowah River. At the mine the elevation is 800 feet, more or less, and still farther west up the northerly trending quartzite ridge the altitude approximates 1000 feet. The mud pond occupies part of the little valley east of the mine, only 20 feet lower than the washer. Drainage is southward past the New Riverside Ochre Company's mill to Etowah River. Water from the river for use at the mine and mill has to be pumped half a mile with a difference in elevation of 90 feet. The Etowah Development Company Railroad connects the property with the main railroad and the Georgia Railway & Power Company power line passes within 100 yards of the washer.

The Tucker Hollow mine cuts into the eastern slope of the same

ridge that bears the New Riverside deposit at the south and the Munford lot deposit at the north. As it is midway between these two ore bodies it indicates the connected relation of these mines as parts of the same general deposit of barytes along the eastern slope of this ridge.

At an elevation of 910 feet, 100 yards west of the open-cut, quartzite outcrops with a north strike and a steep east dip. Its exposed dipping surface is crusted with limonite. On top of the ridge in the western part of the same lot (No. 477) the rock is extensively exposed, but in places the soil mantle is heavy and contains small deposits of barytes that have been dry-mined by W. D. Gravley and Harold Howard. It is evident from observations on outcrops and from the study of cross sections in the cut that the Weisner quartzite forming the ridge has buckled, or billowed, in several places on the east slope. The crests of the folds form outcrops separating several ore-bearing basins. (See fig. 13.)

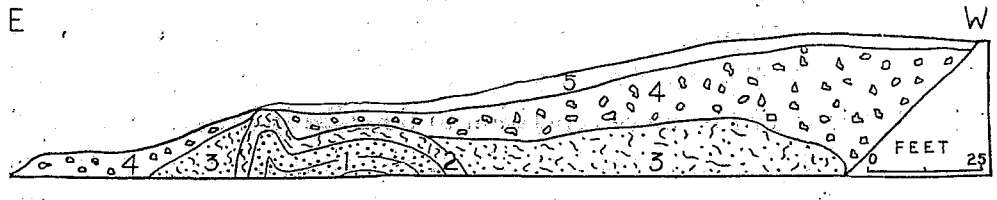
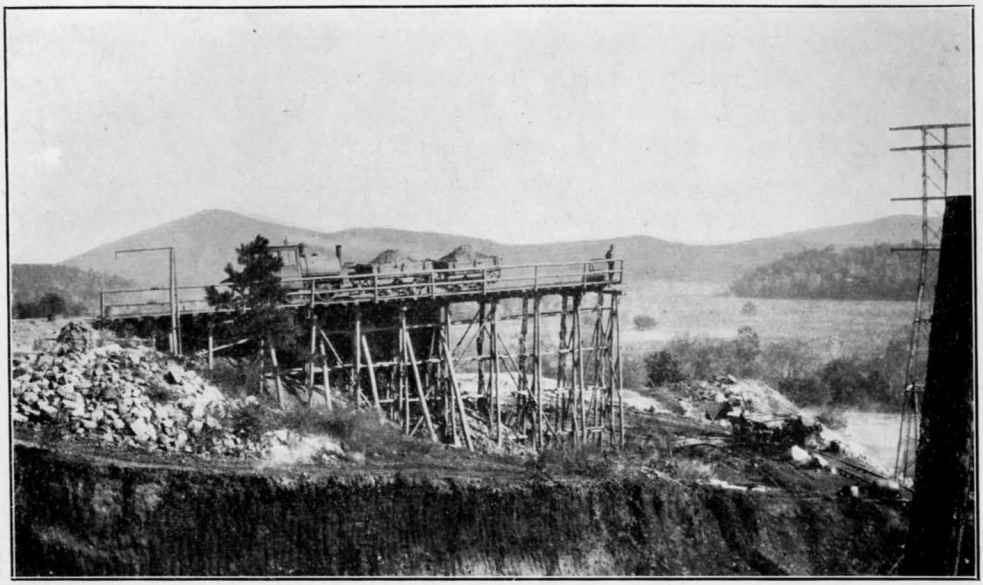


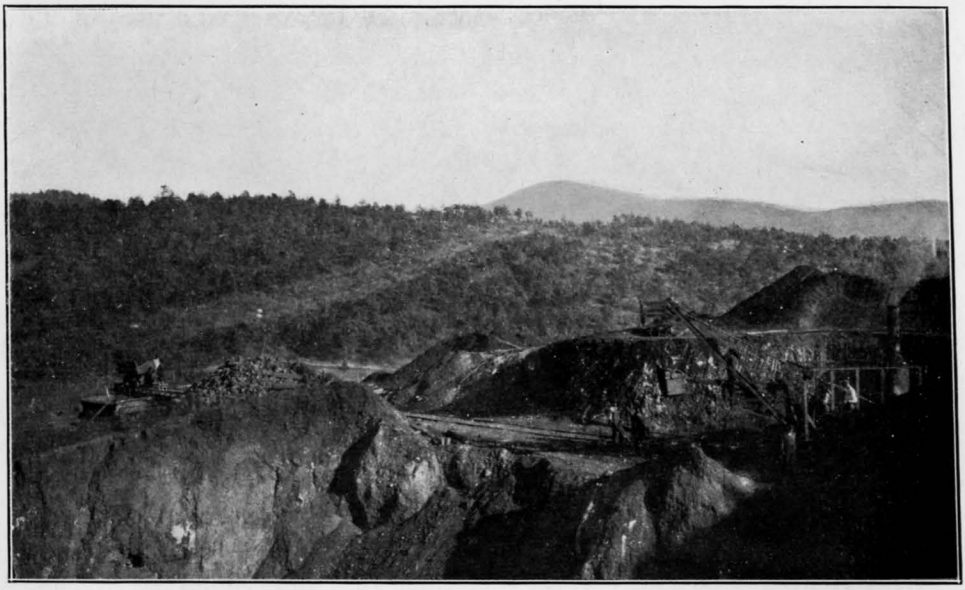
Fig. 13. Section through south face of Tucker Hollow mine showing typical sequence of (1) quartzite, (2) ocher, (3) manganiferous-ocher clay foot wall, (4) barytes, and (5) red soil.

Quartz pebbles occur irregularly in the soft manganiferous clay loam along the ore railroad 40 feet above the river. These elevations are not definite gravel horizons, however, for water-worn pebbles are scattered throughout the unconsolidated mass. Smoothed and partially rounded barytes occurs sparingly in association with the quartz pebbles.

Weathered rock fragments or boulders 1 to 4 feet thick make up no small part of the ore deposit. Many of these are angular porous masses of friable gray grit. One of the features of the open-cut walls exposed in 1917 was the variety of striking and contrasting colors that are so frequently observed in the long-weathered formations of the district. Among the most noticeable were red ferruginous top



A. ORE TIPPLE AT GRIZZLY, BERTHA MINE. PINE MOUNTAIN IN BACKGROUND, CARTERSVILLE, BARTOW COUNTY.



B. OPEN-CUT, TUCKER HOLLOW MINE, EAST OF CARTERSVILLE, BARTOW COUNTY.

soil, salmon-colored clay, brown umber, many dark tones of manganiferous clay, black graphitic or carbonaceous material, and white quartz flour.

No samples of the Tucker Hollow barytes were collected for chemical analysis, but the ore is high-grade and in all respects desirable in common with the Cartersville ore in general. The average concentration ratio during the whole period of operation is said to have been about 6 to 1.

In 1916 the deposit was first worked by an open-cut in a ravine heading westward into the hill. The total length of the opening as worked by steam shovel at two or three different levels is approximately 175 yards, its maximum width more than 80 yards, and its depth about 50 feet. A 14-ton Thew shovel with a 5/8-yard dipper was used in the cut. The ore was flumed down the hillside to a 28-foot double log washer 40 feet lower than the tipple at the mine. The rotary sand screen was of the flaring type with an average diameter of 3 feet. It had 8 perforations per inch. A 28-foot picking belt discharged to the storage platform alongside the railroad.

All machinery at the washer was operated by a 40-horsepower electric motor. Electricity was also used for the 75-horsepower pump at the river. About 18 men were employed on the property and one mule hauled the tram car in the open-cut.

It was reported in 1917 that 60 tons of barytes were sometimes shipped in one day. The total production amounted to several thousand tons. Although many small deposits and pockets of workable ore still remain in the vicinity of the open-cut, it is probable that the largest part of the ore has been mined. Some walls and possibly the bottom of the opening might produce profitable quantities by dry-mining methods, as would small accumulations in other parts of lots 476 and 477.

MUNFORD LOT MINE

Lot 460, 4th district, 3d section, locally known as the Munford lot, is 1¼ miles east of the center of Cartersville. The property is owned by the Etowah Development Company but was leased to Thompson-Weinman & Company who began mining barytes on

this lot after abandoning the Parrott Springs mine in October, 1917. The mine was sometimes called the New Parrott Springs mine.

This 40-acre lot is on the east slope of the same quartzite ridge on which the Krebs, New Riverside, and Tucker Hollow mines are situated. From the western part of the lot where the top of the ridge is about 960 feet above sea level, the hillside slopes gradually east and northeast to the head of the south-southeast trending valley which is approximately 750 feet above sea level or 50 feet higher than Etowah River. Pine timber covers a large part of the lot and has been used in rough construction work at the mine and washer. Convenient power and transportation are afforded by the Georgia Railway & Power Company's transmission line and the Etowah Development Company's railroad, both of which cross the northeast quarter of the lot.

Weisner quartzite constitutes the hard rock mass of the ridge. It is exposed in a number of places on the hillside and though its attitude is rather indefinite on account of the several agencies of folding, fracturing, and weathering, the general strike is north-northeast and the dip east-southeast. Outcrops are more numerous along the top of the ridge and high on the hillside than they are on the lower slopes.

The barytes deposit first worked on this property was in the loose red and yellow hillside accumulation half way up the slope at an elevation about 840 feet above sea level. Fifty feet higher toward the west may be seen old openings in ferruginous and manganiferous deposits whose foot wall is exposed as outcrops of massive and fractured quartzite. Still father west near the top of the hill, occurs the deposit of barytes that was worked in 1918 after the lower ore body had become too lean for profitable mining.

Both of the barytes deposits were small as compared with the adjoining mines on the same ridge and in neither did the ore occur in more than ordinary richness. They were good deposits, however, and contained barytes of high quality. The lower deposit showed the usual characteristic occurrence, such as irregularly shaped fragments of rather clean crystalline and granular ore in a reddish yellow clayey ore body that extended lengthwise parallel to the trend

of the ridge and the strike of the rock. In 1917 the concentration ratio was about 8 or 9 to 1.

Open-cut methods were used in mining the ore. Before the mine was abandoned, steam shovel work had extended 100 yards northwest from the washing plant. The mining and concentrating equipment used on the Munford lot was the same as that used at the Parrott Springs mine. It included the following: one 20-ton Thew steam shovel with a ⅝-yard dipper, 4 tram cars, a 30-foot double log washer, a flaring 8-foot cylindrical screen 3 feet in diameter at intake and 4 feet at discharge, with ¾-inch perforations, a 5-cell jig, and a picking belt 24 inches wide and 30 feet long. Electric power was used throughout, except in the open-cut. The motor at the washing plant had a capacity of 40-horsepower and that for the pump at the river three-quarters of a mile away, 100-horsepower. Altogether, 28 men were employed on the property.

When the ore body on top of the ridge was opened after the lower deposit had been practically worked out, the ore was delivered from the open-cut to the washer by a flume line more than 220 yards long with a difference in elevation of 100 feet. The mud pond receiving slimes from the washer was near the head of the ravine in the southeast corner of lot 405, about 100 yards northeast of the plant.

Thompson-Weinman & Company shipped several thousand tons of high-grade barytes from the Munford lot. The few pockets of ore known to remain on the property in 1919 might be profitably worked only on a small scale.

PARROTT SPRINGS MINE

The open-cut of the Parrott Springs barytes mine, abandoned since 1917, occupies parts of lots 459 and 406, 4th district, 3d section, one mile due east of Cartersville. These lots belong to the Cherokee Ochre Company, Cartersville. In 1916 Thompson-Weinman & Company leased the property and mined barytes until the latter part of 1917. At that time the ore deposit profitably workable by steam shovel was practically exhausted and the open-cut was abandoned to occasional dry-mining some or which was carried on by W. D. Gravley and

Harold Howard of Cartersville. The Thompson-Weinman mining and milling equipment was removed and set up on lot 460, known as the Munford lot or New Parrott Springs.

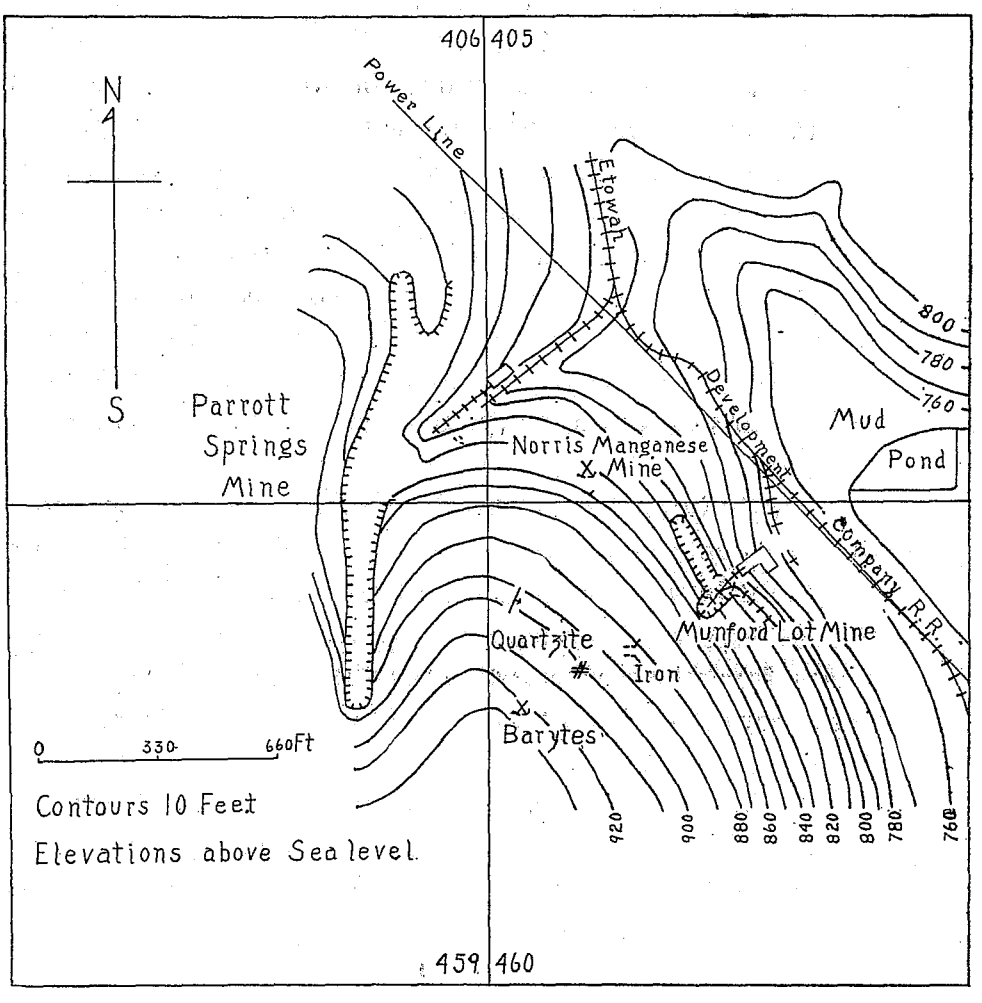


Fig. 14. Topographic sketch map showing Munford lot and Parrott Springs mines east of Cartersville.

Local relief on the Parrott Springs property is approximately 100 feet. The washer which stood beside a spur of the Etowah Development Company's railroad on the extreme east side of lot 406 was about 820 feet above sea level or 120 feet higher than Etowah River. Just west of the washer site lies the large open-cut whose average altitude is 850 feet. It was cut in the eastern slope of the ridge and extended southward into a narrow ravine from which the slopes of the

adjacent hills rise 50 feet or more. Rock outcrops are rare except on the upper hillsides and on top of the ridges. Reddish-yellow clayey soil and weathered talus material mantle the hills and fill the ravines to a depth not yet penetrated by mining operations and a fair stand of second-growth pine and oak tends to cover the rugged features of the quartzite hills. Drainage from the vicinity of the mine goes north and northeast into the head of the small valley that opens south-southeast toward Etowah River. The Parrott Springs mine was at the northern end of the Etowah Railroad which followed the side-valley up from the river.

Geologic relations of the ore body and the hard rock formations are not clearly shown in the open-cut, but the conditions so commonly observed at other barytes deposits in the district doubtless hold in a general way at this mine. The hills have maintained their prominence because they are formed of Weisner quartzite which has resisted the erosional forces that have so generally removed the overlying Shady limestone. The trend of the ridges corresponds to the strike of the rocks, ranging from north-northwest to north-northeast. What few dips that are determinable from outcrops are easterly.

The ore deposit lay in unconsolidated hillside wash and talus concentrated near the base of an eastern slope and in a narrow north-south ravine. The soft foot wall of ocherous, ferruginous, and manganiferous clays is noticeable on both sides of the cut that extends southward into the ravine. The dark generally barren foot wall shows many irregularly slicken-sided faces sloping at various angles toward the bottom of the cut, as evidence of hillside slumping. It contains quartz pebbles. Barytes ore fragments occurred in both red surface soil and underlying clays, from the top of the open-cut to a depth of 30 or 40 feet. It is reported[1] that the concentration ratio varied from 12 to 1 in some parts of the mine to 2 to 1 in other parts. There was a large part that concentrated 3 to 1. Little difficulty was experienced with sticky clay horses or gumbo masses and the ore was free-washing and of high quality.

When abandoned in October, 1917, the open-cut was 330 yards long from north to south, very irregular in width, ranging from 40

[1] Information from P. M. Broyles, foreman, 1917.

to 175 feet, and 30 or 40 feet deep. The washer and all mining equipment was removed to the Munford lot less than half a mile southeast of the old Parrott Springs mine, and the northern part of the ore railroad that served the mine was also taken up. During the period of operation from March, 1916, through October, 1917, almost 20,000 tons of barytes ore were shipped from the Parrott Springs mine, making it one of the most productive and valuable mines worked by Thompson-Weinman & Company. Remnants of the principal deposit and isolated pockets of ore have since been worked on a small scale by dry mining.

CLAYTON MINE

On Reservoir Hill three-quarters of a mile east-southeast of the railroad station at Cartersville, is the open-cut formerly worked as the Clayton mine. It is on land lot 479, 4th district, 3d section, a part of the property of S. P. Clayton for whom G. H. Aubrey of Cartersville is trustee. Thompson-Weinman & Company leased the property in 1917 and re-leased to H. G. Cope of Cartersville, who began mining barytes Apr. 1, 1917. In October, 1917, the Clayton mine was abandoned and the mining and milling machinery was moved to the Cope mine which was about to be opened less than half a mile southeast on lot 531.

The Clayton open-cut occupies a shallow notch in the middle of a short ridge 960 feet above sea level or approximately 260 feet higher than Etowah River. The ridge forms a prominent feature of the southeastern horizon when viewed from the center of Cartersville. On its southwest end 200 yards from the barytes mine, is the city reservoir which receives water from the pumping station at Etowah River 1¼ miles to the south. The length of wagon-haul from the mine to the Western & Atlantic Railroad at Cartersville is only three-quarters of a mile and the railroad is 200 feet lower than the washer.

Rock outcrops in the vicinity of the Clayton mine do not indicate a clear and simple relation between the ore deposit and its associated formations. In the open-cut itself no rock was found *in place*, but along the ridge 250 feet northeast and east of the cut, Weisner

quartzite occurs in both fresh and altered condition, and a few hundred feet southwest of the cut are large exposures of ferruginous ore-breccia and iron-stained masses of both porous and cherty sili-

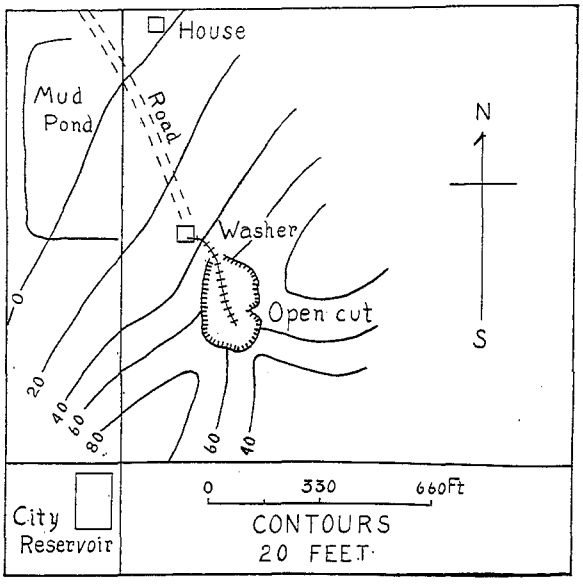


Fig. 15. Sketch map showing Clayton mine on lot 479, Reservoir Hill, east of Cartersville.

ceous material that are recognized as leached and fragmental portions of Shady limestone. The ridge trends northeast corresponding to the direction shown in quartzite outcrops which strike N.45°E. and dip 55°SE. The open-cut, however, following the ore body through the notch or gap, extends southeast approximately at right angles to the trend of the ridge. The position of the ore body, cutting across the ridge instead of following it, and the difference in character of the rocks on either side of the cut, suggest a local zone faulting or fracturing in which the ore was deposited. Southwest of the open-cut, all rock exposures are deeply weathered and show much brecciation and fracturing. A few water-worn quartz pebbles occur in the red and yellow surface soil on either side of the open-cut.

The workable ore body was proved by open-cut mining to be generally V-shaped, about 100 yards long as worked S.20°E. through the gap in the hills, 165 feet wide at the top, and in places 50 feet

deep. Prospect pits and surface fragments showed good barytes a number of yards eastward along the ridge and southeastward down the slope of the hill. Outside the limits of the open-cut, however, the brecciated and ferruginous condition of the ore made it quite undesirable. As a rule the barytes as mined occurred in typical nodular or fragmental form buried in the soft reddish-yellow clayey mass that lay between hard rock formations to the northeast and southwest. Aside from the barytes ore proper, there is a considerable quantity of barytes breccia, but as this did not occur as a rule within the workable ore body, it caused little trouble in the concentrating process. The brecciated fragments are sharply angular and range in thickness from a small fraction of an inch to several inches. The matrix, or cementing material, is ferruginous—good limonite, in some fragments, and a gritty ocherous mass in others.

All actual mining of ore on the Clayton property was carried on by open-cut methods and hand labor. Fourteen men were employed in the cut and 10 at the washer, mud pond, and in hauling ore to Cartersville. As the bottom of the mine was 25 feet lower than the first opening made near the washer, pumps had to be used occasionally to free the pit from water. Ore was shovelled from the working face into tram cars that were hauled up the incline out of the pit to the tipple by a 30-horsepower Samson hoisting engine. The trams dumped directly into a 24-foot double log washer. When the run-of-mine ore was fairly clean, only a fine sand screen finished the concentrating process after the log washing, but if mechanical impurities such as ferruginous and siliceous fragments were present in objectionable quantity, a coarse sand screen was used and in addition the ore was further treated in a 2-cell jig. The capacity production of the plant was from 35 to 40 tons a day. Steam power was used and water was taken from the city reservoir; also some water was reclaimed at the mud pond by a Worthington pump.

During the 7 months of operation at the Clayton mine, several thousand tons of barytes were shipped. When the deposit was abandoned in the latter part of 1917, the quantity of good ore remaining in the walls and bottom of the open-cut was small. The brecciated barytes requires careful crushing and concentrating and could

not be profitably worked at this time, even if it were found in larger quantity than the relatively small deposit on the Clayton property.

THOMPSON-WEINMAN & COMPANY

Through its actual operation of, and controlling interest in, mines and through its manufacturing activity, Thompson-Weinman & Company is one of the most important factors in the barytes industry of the State. Besides manufacturing ground barytes at its mill on Etowah River, the company either controls the output of, or operates, the following mines: Paga No. 1, Paga No. 2, Paga No. 3, and the mines on lots 478 and 531. It is also a buyer of barytes ore from other mines. Through its activity, the following mines have been worked: Parrott Springs, Munford Lot, Tucker Hollow, Clayton, and prior to 1918 the DuPont mine. Among other holdings the company leases the following lots of land containing barytes deposits: from the Cherokee Ochre Company, lots 406, 459, 477, 478, and half of 476; from the Georgia Peruvian Ocher Company, lots 531, 532, 692, 764, 765, and 820; and from the Etowah Development Company, lot 460. All these properties are in the 4th district and 3d section of Bartow County.

Because of certain individual features of importance, these mines have been described separately, except those on lots 531 and 478 which, because of their more recent development, proximity, and similarity of deposit may now be described together.

The mine on lot 531, about a mile southeast of Cartersville, was originally known as the Cope mine. The barytes rights on lots 531 and 532 belong to the Georgia Peruvian Ocher Company and are leased to Thompson-Weinman & Company. H. G. Cope moved the mining and milling equipment from the Clayton mine and began work at the mine on lot 531 in November, 1917. Ore on the south part of the lot was dry-mined on a small scale by H. M. Hebble and W. L. Torbert who shipped a few hundred tons of barytes in July, August, and September, 1917. In December of that year a log washer was set up near the Hebble & Torbert opening by Harold Howard but very little barytes was actually mined. J. A. Morgan is now (1919) in charge of the mining operation on lot 531.

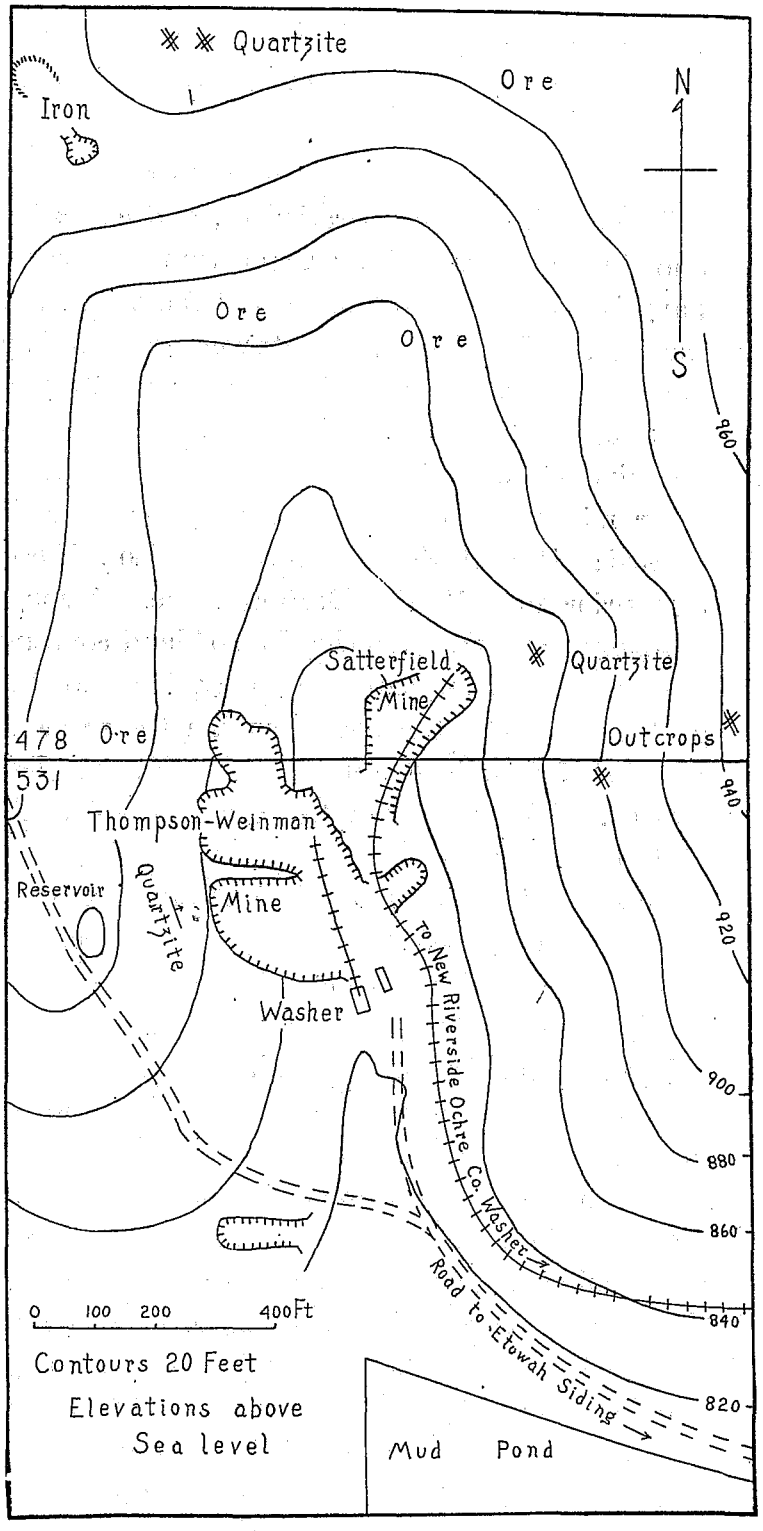


Fig. 16. Topographic sketch map showing Thompson-Weinman and Satterfield mines on lots 531 and 478 near Cartersville.

The mine on lot 478 is immediately northeast of the opening on lot 531. Lot 478 is owned by the Cherokee Ochre Company and is leased by Thompson-Weinman & Company who contracted with W. C. Satterfield for mining and washing the ore. The ore is hauled about half a mile by narrow gage steam railroad to the barytes washing plant on lot 533 of the New Riverside Ochre Company, which has already been described.

Lots 531 and 478 occupy a southward sloping ravine in the hills southeast of Cartersville, between the city and Etowah River. The ravine includes both wooded ridges and cultivated fields of the bottom land. Local relief of the topography is 200 feet or more, and the elevation at the washer is approximately 820 feet above sea level. The principal surface feature is the ravine that opens southward through the middle of the property. Etowah Siding on the Western & Atlantic Railroad is half a mile to the southeast.

Red soil and reddish-yellow subsoil formation mantle the lower slopes of the hills on either side of the ravine and form the unconsolidated barytes ore body. Just west of the open-cuts and 40 feet higher than the ravine, fresh finely textured quartzite outcrops with a strike N.15-20°W. and a dip 75-80°NE. On the east side of the ravine iron-stained quartzite is exposed in several places. Between these hard rock limits, there is a large deposit of high-grade barytes ore. The loose clayey deposit contains the impurities and waste material usually found elsewhere in the district, such as ferruginous nodules, quartzite fragments, and quartz pebbles.

The ravine extends northward more than a quarter of a mile and heads in a gap between two hills just south of the Parrott Springs mine. Throughout its length this little valley is marked by good barytes prospects. It has been formed along a north-south line of structural weakness and has received erosional accumulations of ore from the hills on either side. At one place on the east side of the ravine a few hundred yards northeast of the mines, a 4-foot pit exposed a rich gravel deposit of quartz and barytes pebbles. The barytes pebbles ranged from a fraction of an inch to 3 inches in diameter and constituted 50 per cent of the ore pocket exposed.

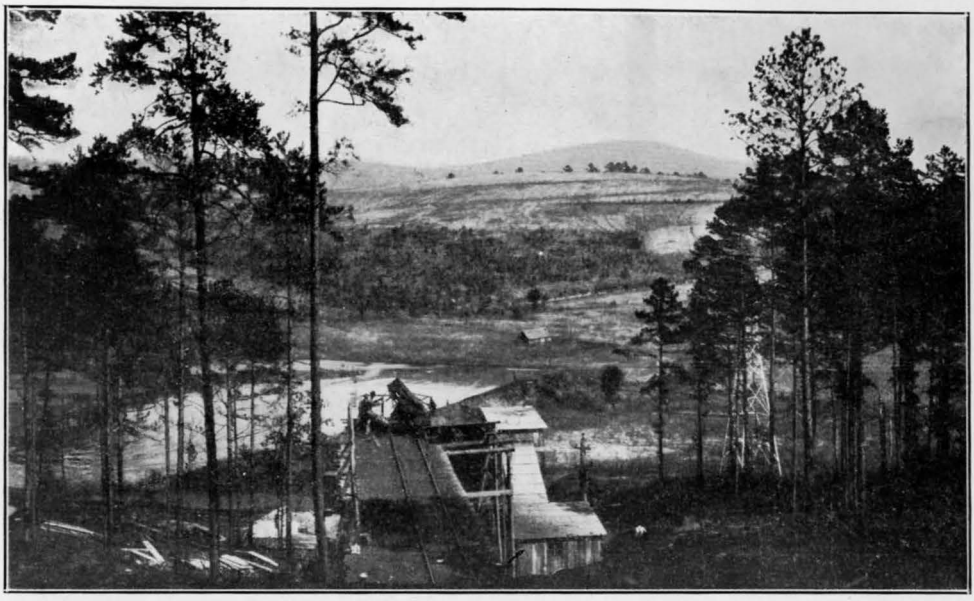
The ore is being mined from open-cuts by two steam shovels and

is cleaned by the ordinary log-washing treatment. The equipment used on lot 531 is the same as that formerly in operation at the Clayton mine, although a second log washer is now (1919) installed and further development is in progress. Water is piped from the city reservoir less than half a mile west of the washer. It may be stated that this ravine northwest of Etowah Siding contains the most promising, if not the largest, prospected but as yet little worked, barytes deposits in the State. The reserve ore may be estimated as being much more than 100,000 tons.

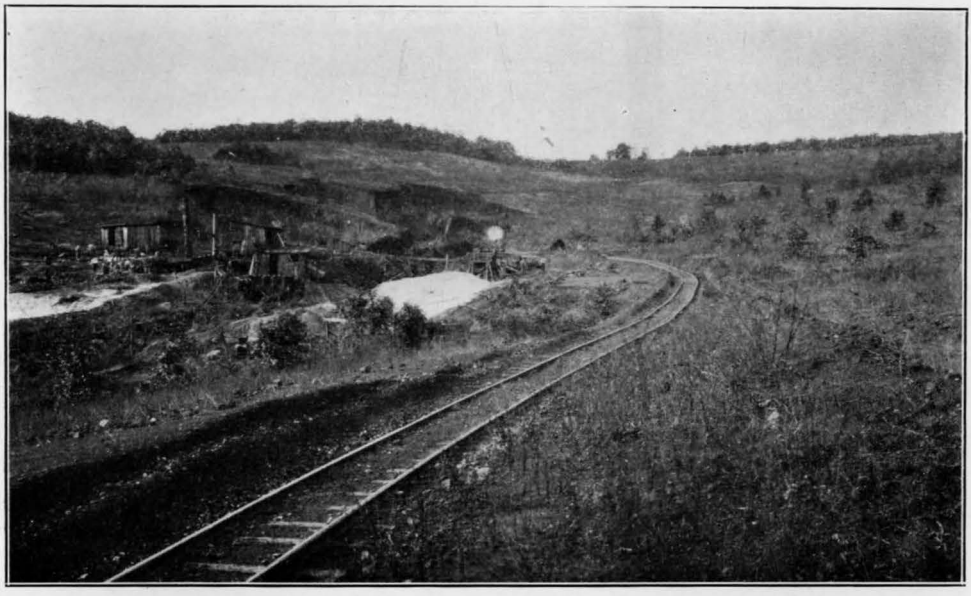
BIG CREEK MINE

The Big Creek mine is on lot 385, 4th district, 3d section, half a mile northeast of the Western & Atlantic Railroad station at Cartersville. This property is a part of what was formerly the Ford estate, but the land now belongs to O. L. Tomlinson of Cartersville. In 1915 the Big Creek Mining Company, organized by several Atlanta business men, secured a lease on the mineral rights, erected a washing plant, and shipped a few hundred tons of barytes. Work was not continued, however, and the plant was idle until 1917. At that time H. G. Cope and B. C. Sloan of Cartersville leased the barytes rights and prepared for steady operation of the mine, but scarcity of labor and the government embargo on shipments of barytes caused them to stop work before any ore was shipped.

Lot 385 occupies almost level land sloping gently northward to a small intermittent branch flowing westward to Pettit Creek. Elevations above sea level range from 760 to 780 feet. It is part of a distinct, undulating embayment plain that extends from Cartersville into the quartzite hills on the north, east, and south. No outcrops of rock break through the deep unconsolidated material that extends in places to a depth of more than 100 feet. The red clay loam mantle that marks the surface of the land is as a rule 5 to 12 feet deep. It contains pellets and nodules of limonite and manganiferous iron together with a few hematite particles. Beneath the red soil lies the yellow ore-bearing formation that may be considered the decomposed representative of the Shady limestone formation. Exposures in the gut or bed of the intermittent stream just north



A. ORE TIPPLE AT GRIZZLY, MUNFORD LOT MINE, EAST OF CARTERSVILLE, BARTOW COUNTY.



B. RAVINE NORTH OF ETOWAH SIDING SHOWING THOMPSON-WEINMAN AND SATTERFIELD MINES, CARTERSVILLE, BARTOW COUNTY.

of the washer indicate, however, that this yellow substratum is not wholly residual and that in part it represents the Cartersville slate.

The barytes ore is fragmental and occurs at depths ranging from 10 to 25 feet as shown in test wells and in the open-cut. The grade of the ore is excellent and mechanical impurities such as quartz, iron, and manganese are not particularly troublesome. Furthermore, being some distance from the rocky talus of the quartzite hills, this deposit is comparatively free from boulders. The overburden, which in places is rather heavy, and the generally level surface of the property combine to make this a less favorably situated deposit than those occupying hillsides where gravity may be used to dispose of waste and to transport ore.

The open-cut is about 100 feet south of the washer and a few hundred yards east of the old Tennessee road. It is 100 feet in diameter and 20 feet deep. All mining was done by pick and shovel work. Electricity from the Georgia Railway & Power Company furnished power for the hoist and washing machinery and Cartersville city water was used. The equipment included 2 tram cars running on an incline about 100 feet from pit to bull pen, a double log washer, a sand screen, a picking belt, and two 2-cell jigs that were not in use.

The total production of the mine has amounted to a few hundred tons of ore, which were almost all mined and shipped in 1915 by the Big Creek Mining Company. Though the deposit is not considered more than ordinarily rich and though the overburden and level topography are objectionable conditions, there are several features that may be used to advantage in the operation of the Big Creek mine. The haul to the Western & Atlantic Railroad is short, only half a mile, over a level road. Overburden and ore material are relatively free from barren rock boulders, and the ore is readily concentrated by simple washing methods. In addition there are several 40-acre lots joining this property on the south and southeast that have been prospected by test wells ranging in depth from 10 to 65 feet. These lots contain at least promising barytes deposits, showing the presence of an extensive, though probably deep and lean, ore body that might be worked as a whole by steam shovel methods.

R. B. SATTERFIELD PROPERTY

R. B. Satterfield owns 87 acres in lots 245, 259, and 318, 4th district, 3d section, 2 miles northeast of Cartersville. George H. Woodrow of Cartersville leased the property in 1917 and mined both barytes and manganese ore. At the end of 1917, however, he removed his washing equipment to the R. R. Rhea manganese mine south of Etowah River. The Satterfield property was worked for manganese ore many years ago and it is reported that several hundred tons were shipped.

The ore deposit lies at the base of a steep eastern slope about 900 feet above sea level. It is somewhat more than half a mile northwest of the large brown iron ore mines of the Etowah Development Company. West of the mine the quartzite hill rises to an altitude of 1060 feet. The general trend of the ridge is north-northwest. On the east side of the openings and only a few feet below them, a small stream flows southeastward to Etowah River about 1¼ miles distant. Geologically the barytes ore body occupies the blanket-hillside position so commonly found in the Cartersville deposits. The foot wall is Weisner quartzite which outcrops a short distance up the slope from the openings and shows a north-northwest strike and a northeast dip.

As shown in the open pits and test wells near the base of the hill, barytes ore of good quality occurs in moderate quantity as the ordinary white fragments slightly stained by red soil and ferruginous crusts. The opening worked in 1917 is in the hillside west of the branch and about 15 feet higher. It is 50 feet in diameter and 10 to 15 feet deep. Mining was carried on by hand and the ore was concentrated in a single log washer run by steam.

Possibly 100 tons of high-grade barytes have been produced. The deposit is not large but could doubtless be worked in a small way in connection with the manganiferous iron ore on the property.

ETOWAH DEVELOPMENT COMPANY

The Etowah Development Company, Cartersville, of which O. T. Peeples is president and R. S. Munford is general manager, owns several thousand acres in the southeastern part of Bartow Coun-

ty. The general situation of the land possesses all the natural and industrial advantages for the development of mineral properties that are so favorably peculiar to the Cartersville district. Many of the lots are separated from the main part of the property, but the tract as a whole occupies the partially cleared hills and narrow valleys that are drained by Etowah River and its tributaries east of the city of Cartersville. Standing timber for mine and mill construction work is still available, the Etowah furnishes an unfailing and convenient supply of water for steam and milling purposes, the electric transmission line of the Georgia Railway & Power Company crosses the property, and the Western & Atlantic Railroad with its many sidings for the loading of ore is easily reached by wagon roads and tram lines.

The company owns and operates approximately 4 miles of standard gage steam railroad connecting its own washers and those of other operators with the Western & Atlantic Railroad. Two miles of the Etowah Railroad serve the Iron Hill mines north of Allatoona, south of Etowah River, and 2 miles form a system reaching out from Etowah Siding on the north side of the river to the many different mines between Cartersville and Pine Mountain. The standard gage lines are supplemented by various narrow gage tram lines leading from mines to ore washers. Since the beginning of the general activity in barytes mining in 1915, the company's road leading north from Etowah Siding has served 6 barytes mines besides as many ocher, iron, and manganese mines.

The property includes many mineral deposits of considerable importance, but the most extensive are the brown iron ores and the manganese ores. The iron ores have been worked more or less continuously since the early forties. Barytes in association with limonite, ocher, and pyrolusite is of common occurrence on the property. Definite deposits of this ore have been prospected by test pits on about a dozen 40-acre lots, although the ore has been mined at only a few places, and the total production by the company has amounted to only a few hundred tons. Lot 460 is a part of this property, but the ore deposit was leased and worked by Thompson-Weinman & Company. This mine has been described as the Munford Lot mine.

Aside from this, the principal lots that are known to contain barytes ore bodies owned by the Etowah Development Company are as follows: lots 171, 261, 329, 330, 391, 392, 401, 753, and 761, 4th district, 3d section; and lot 289, 21st district, 2d section. These deposits are here briefly described. In 1919 the Bertha Mineral Company leased almost all of the Etowah Development Company's property that contained barytes deposits.

Lot 171.—Lot 171 is on the west slope of a quartzite hill five-eighths of a mile northwest of the Rowland Spring road and 2½ miles north-northeast of Cartersville. The elevation is approximaetly 1000 feet above sea level. Three-quarters of a mile west of the lot and 200 feet lower is a small steam flowing southwest to Pettit Creek. The lot is sparsely wooded.

High-grade barytes fragments occur in the loose soil in an area of 2 or 3 acres. In places they are plentifully exposed in shallow openings made for brown iron and manganiferous iron ore, but as a rule the showings of barytes are scattered and not especially promising for a distinct ore deposit. The barytes is in close association with manganese, manganiferous iron, and quartzite breccia. It is probable that fair-sized bodies of the ore could be dry-mined, though all the ores are intimately mixed and would require careful separation.

Several carloads of ferruginous manganese ore have been shipped from this lot and in 1917 and 1918 the Ingram and Evans lot (No. 172) joining lot 171 on the east, was being dry-mined for manganiferous iron ore. The ore was hauled 3 miles to Cartersville.

Lot 261.—Lot 261 is 1½ miles northeast of Cartersville. It is in the rolling red farm land that slopes generally westward to an intermittent branch of Pettit Creek. The average elevation is about 900 feet above sea level. About a quarter of a mile east of the Rowland Spring road, several test pits, 5 to 15 feet deep in the reddish-yellow soil on the north slope of a hill, show fragments of high-grade barytes ore in somewhat indefinite quantity scattered over an area of 2 or 3 acres. Fragments have also been noticed on lot 260.

Lots 329, 330, 392, and 393.—These four 40-acre lots are 2 miles east-northeast of Cartersville. On them are the large ore banks that

were first opened and worked for brown iron ore many years ago. They occupy the steep wooded hillsides and gaps west of Pine Mountain and about a mile north of the Etowah Development Company's Riverside washer that is situated at the eastern end of the company's railroad on the right bank of Etowah River. Mines and washer are connected by a narrow gage steam tram line.

The principal drainage is south and southwest following the trend of the quartzite ridges and the strike of the rock. Elevations range approximately from 800 to 1200 feet above sea level or 100 to 500 feet higher than the river.

Barytes deposits have been prospected on all these lots. The ore occurs in many places but seems most promising near the west end of the area worked for iron ore. It is exposed at several places in the old open-cuts. Both east and west of the new opening being worked for brown ore in 1917 and 1918, test pits showed high-grade barytes to a depth of 10 feet.

The ore pockets were isolated, however, and the quantity was doubtful as a workable deposit, although it is said a few carloads had been mined by small scale dry-mining methods. It is improbable that the deposits will be found sufficiently concentrated to be worked independently for barytes, but rich pockets may be encountered in the process of mining the brown iron ore that will merit being separated from the iron and saved from the dump.

Lot 391.—Lot 391 is south and west of the lots just described and contains similar prospects of barytes ore bodies. Several test pits in the hillside east of the Blue Ridge Ocher Company's drying sheds and west of the manganese mine worked in 1917 and 1918 by Hebble Brothers, show a desirable quality of barytes to a depth of 15 feet. There is little evidence of anything but a small deposit here. R. S. Munford erected a single log washer on this lot but no barytes ore was ever shipped.

Lot 401.—A small open-cut on lot 401 half a mile north of the Riverside washer of the Etowah Development Company was worked about 1915 and a few carloads of barytes were shipped. The opening is near the head of a ravine that is drained southward to Etowah River. It is a few yards east of the narrow gage railroad that

serves the brown iron ore mines half a mile to the north. While the deposit was being worked it was connected by tram line with the washing plant at the river.

The barytes forms a small fragmental blanket deposit in the yellow soil overlying manganese and manganiferous iron ore. Some manganese ore was being mined on this lot in 1918. The open-cut is about 70 feet long, 30 to 40 feet wide, and 5 to 15 feet deep. The barytes seems to extend no deeper than the bottom of the cut. In quality the ore is quite satisfactory; the best part of this deposit, however, has apparently been worked out, and the only ore showing is in scattered fragments near the mine.

Lot 753.—Lot 753 is on the east slope of a north-trending quartzite ridge three-quarters of a mile north of Emerson. Several test pits have been dug in the reddish-yellow soil at elevations about 920 to 940 feet above sea level or 60 to 80 feet higher than the valley that is drained north to Etowah River 1¼ miles away. On the east side of the valley, opposite the prospect pits, is the roadbed of the old tram line that connected the Wheeler brown ore bank and several other iron mines with the Western & Atlantic Railroad at Emerson, when those mines were in operation a number of years ago.

No rock outcrops were seen near the prospect pits as the soil mantle is rather deep, but on top of the ridge west of the pits and 180 feet higher, Weisner quartzite forms distinct massive ledges striking north and dipping east. The south nose of this red soil-covered quartzite ridge is locally known as Abromsons' peach orchard.

Prospecting shows the barytes to extend to depths of 12 and 15 feet in the unconsolidated hillside accumulation. The pits have proved the ore on 2 or 3 acres in excellent quality and promising quantity. The ore is generally clean, crystalline, and fragmental. Brown iron ore has been dry-mined in a small way near the barytes prospects.

Lot 289.—Lot 289 is in the 21st district, 2d section; the lots previously described are in the 4th district, 3d section. No. 289 is on the east side of Pine Mountain near its base, 3½ miles in an air line east of Cartersville. It is reached by wood-road and trail that follow a wooded gorge-like valley 1¼ miles north-northwest from Eto-

wah River. The trail leaves the river road at one of the old furnace stacks of the Mark A. Cooper Iron Works which was the pioneer iron industry along Etowah River.

J. M. Knight of Cartersville prospected the barytes deposit on the east slope of the mountain a few hundred yards west of the house occupied in 1917 by D. J. Bohannon. There are four test pits 7 to 9 feet deep, 40 to 50 feet higher than the little stream. The elevation is approximately 880 feet above sea level. Up the slope 100 feet west of the pits, quartzite outcrops with a strike N.5-10°E. and a dip 75°SE., thus forming the typical foot wall of the ore-bearing talus material. Fragments of chloritic schist, foliated, quartz-eyed and pyritiferous, are scattered on the surface between the rock outcrops and the barytes prospects.

The barytes occurs in good quality but moderate quantity. Some fragments are bluish-white, crystalline, show cleavage faces, and are remarkably free from impurities; others are associated with chloritic schistose material and contain quartz grains and small pyrite cubes.

Surface indications of an ore deposit are almost lacking, float ore being unusually scarce. The test pits proved ore from a depth of 3 feet to 10 feet and undoubtedly the deposit was not penetrated. The soil is gray and drab in color and none of the red and reddish-yellow clay is seen that is so common in the ore areas of the Weisner and Shady formations west of Pine Mountain. The rocks on lot 289 probably belong to the pre-Cambrian crystalline formation that was described[1] and mapped[2] by Hayes as Pinelog conglomerate of the Ocoee series (Algonkian?)

JONES PROPERTY

Mrs. Laura A. Jones owns lots 624, 4th district, 3d section, a mile southeast of Cartersville. In the northeastern part of the lot is a small gravel and barytes deposit that was worked to some extent prior to 1917 by B. C. Sloan of Cartersville.

The property is in the broad cultivated bottom land bordering the right bank of Etowah River. The deposit forms a knoll about 10

[1] Hayes, C. W., Geological relations of the iron ore deposits in the Cartersville district, Georgia: Trans. Am. Inst. Min. Eng., Vol. 30, pp. 405-408, 1901.
[2] Hayes, C. W., Manuscript map of the Cartersville folio: U. S. Geol. Survey.

feet higher than the surrounding plain at an elevation 700 feet above sea level or less than 20 feet above river level. It is a few hundred yards south of the Dixie Highway, on the east side of the wagon road and the railroad spur leading to the barytes grinding mill of Thompson-Weinman & Company. Etowah River is a quarter of a mile south of the ore pit.

This was primarily worked as a gravel bank to provide material for roads in the vicinity of Cartersville. Water-worn pebbles of quartz and quartzite are still plentiful in the pit and gravel occurs generally on the knolls and "swells" that rise a few feet above the lines of drainage. The deposit as opened by the cut is 150 feet in diameter and ranges from 5 to 20 feet deep. In the north and northwest walls, barytes is richly deposited in small fragments, ½ inch to 2 inches in greatest dimension, but much of the mineral is cement or breccia-filling in quartzitic rock and siliceous remnants probably representing Shady limestone. It also occurs as small grains and occupies pockets or cavities in siliceous boulders, altogether too intimately mixed to make good ore. In the bottom of the cut, however, large angular fragments of bluish-white barytes, as large as 12 feet in greatest dimension represent an ore high in barium sulphate but rather unfavorably high in alumina, ferric oxide, and silica. A chemical analysis of this ore is here given.

Analysis of barytes ore. Jones property (Hu-355)

Silica (SiO_2)	1.50
Alumina (Al_2O_3)	1.48
Ferric oxide (Fe_2O_3)	0.64
Lime (CaO)	0.00
Moisture at 100°C	0.01
Loss on ignition	0.20
Carbon dioxide (CO_2)	0.00
Sulphur trioxide (SO_3)	33.41
Barium oxide (BaO)	63.15
Total	100.39
Barium sulphate ($BaSO_4$)	96.11

The deposit has not been worked recently. The principal objection to the ore seems to be the high percentage of silica. Pyrite

is a minor impurity occurring as partially oxidized particles 1/16 to 1/8 inch thick.

In 1919 a few tons of ore remained in the stock piles at the open-cut. Surface indications in the form of float ore scattered through the red clayey soil and mixed with gravel were observed north and northwest of the Jones property leading to the deposits in the hills east of Cartersville.

IRON HILL MINE

The Iron Hill barytes mine is on lot 786, 21st district, 2d section, 1½ miles north of Allatoona. The property contains 40 acres and belongs to the estate of the late L. S. Munford of Cartersville. The ore deposit is leased to the Bertha Mineral Company, a subsidiary of the New Jersey Zinc Company. It lies on the west side of the Allatoona-Webster Ferry public road, a few hundred yards west of the Iron Hill brown ore mines that are owned and operated by the Etowah Development Company.

The Iron Hill mines were formerly known as the Allatoona and the Crow ore banks which were first worked before the Civil War. Not long after the war the mines were connected with the Western & Atlantic Railroad by a narrow gage line from a point near Allatoona station. This spur was later taken up, but in 1917 a standard gage branch road was built by the Etowah Development Company from milepost 41, a mile northwest of Allatoona, to the iron mines, 2 miles northeast of the Western & Atlantic Railroad. The Iron Hill barytes deposit was first worked in the eighties, when it was known as the Keys property. Two pits were opened and the ore was freed from mechanical impurities by hand-cobbing, or chipping with hammers and chisels. Some high-grade barytes produced by this simple preparation was shipped from Allatoona. A few tons of ore remain in piles near the open-cuts, and some rather extensive prospecting done in 1919 gives promise of an excellent ore deposit.

The barytes deposit on lot 786 occupies the west end of the long narrow ridge that extends west-southwest from the hill containing the Iron Hill brown ore deposits. A small branch rises in a ravine just west of the open-cuts and flows south a quarter of a mile to Allatoona

Creek, a tributary of Etowah River. The major trend of the hills and ridges in the vicinity is northeast, or southwest, so that the valley of Allatoona Creek, extending in a straight line from the Iron Hill mines 1¾ miles southwest almost to the Western & Atlantic Railroad, forms the most distinctive feature of the topography. This remarkable southwest direction of hills and valley appears especially pronounced because of the abrupt change in the course of Allatoona Creek a quarter of a mile north of the Western & Atlantic Railroad where the stream turns sharply through a deep narrow trench east of Signal Mountain northward to Etowah River.

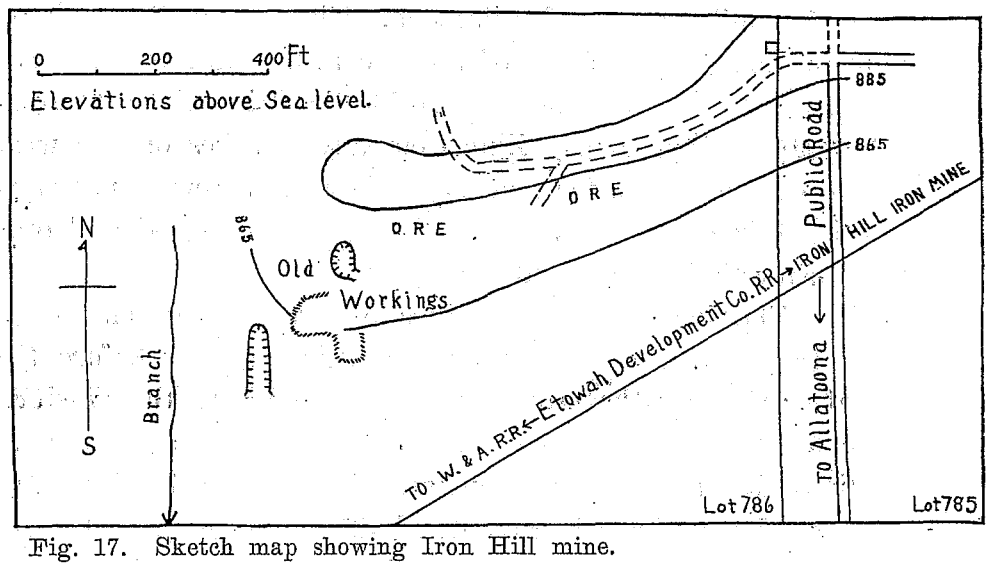


Fig. 17. Sketch map showing Iron Hill mine.

The maximum elevation on lot 786 is 890 feet and the minimum is about 800 feet above sea level. The surface is drained southward to the creek which affords a plentiful supply of water. Some standing timber still remained on the property in 1917 and was being used in the construction of the ore railroad to the iron mines.

Rock exposures near the barytes deposit show that the country rock forming the foot wall of the ore body is dark gray granite gneiss striking N.50-80°E. and dipping 55-85°SE. The rock contains the blue quartz grains characteristic of the mass of granite and gneiss that was described and mapped by Hayes[1] as Corbin granite of Arch-

[1] Hayes, C. W., Geological relations of the iron ore deposits in the Cartersville district Georgia: Trans. Am. Inst. Min. Eng., Vol. 30, pp. 405-406, 1901.
———— ————., Manuscript map of the Cartersville quadrangle: U. S. Geol. Survey.
Watson, T. L., Preliminary report on the manganese deposits of Georgia: Geol. Survey of Ga. Bull. 14, pp. 41-46, 1908.

ean age. The principal rock minerals are orthoclase and plagioclase feldspars, muscovite, and quartz. The bluish quartz grains, because of their prominence in size, being 1/16 to 1/8 inch in diameter, and in color, showing various shades from amethystine to dark smoky, tend to give the rock a porphyritic appearance. The structure of the gneiss is banded, however, and shows the effect of shearing.

On the southeast side of the Iron Hill barytes and iron deposits is a comparatively narrow strip of dark slaty formation which was mapped by Hayes as Wilhite slate of the Ocoee series. Whether the Wilhite belongs to Algonkian time or to Cambrian time has not been definitely determined. In its graphitic or carbonaceous character it is similar to the Nantahala state (Lower Cambrian) which has been mapped in the Ellijay quadrangle by LaForge[1] and others, and has also been traced southward across the Suwanee quadrangle into the Cartersville quadrangle. The graphitic character of the Wilhite is shown in the exposures along the Dixie Highway about a mile west of Allatoona.

The ore deposits occur at, or near, the contact of the Corbin granite and the Wilhite slate. Since the Wilhite formation contains lentils of limestone at other localities in the Cartersville quadrangle, it does not seem improbable that the Iron Hill barytes deposit has accumulated from the weathering of one of these lentils. Furthermore the former presence of limestone is not only suggested by the very presence of the barytes which is generally associated with limestone, and by the unusually distinct and open valley such as would result from the erosion of an easily weathered rock, but it is indicated by the red clayey soil and the leached porous masses of ferruginous siliceous material that are similar to the remnants of limestone found so closely related to the ore deposits west of the Cartersville fault.

The Iron Hill barytes deposit is in general similar to those nearer Cartersville. The ore occurs as angular and partially rounded fragments embedded at irregular intervals in the loose red and yellow

[1] LaForge, Laurence, and Phalen, W. C., U. S. Geol. Survey Geol. Atlas, Ellijay folio (No. 187), 1913.

clay lying against a steeply dipping foot wall of granitic gneiss. A few of the ore fragments have a rounded pebbly appearance but the most of them are irregular and angular in shape. Some fragments are as large as 2 feet in greatest dimension. Mechanical impurities, such as quartz, brown iron, manganiferous iron, pyrite, and stain from ocher and red clay are present but not in large amounts. As a rule, the ore is free from both mechanical and chemical impurities.

The following analysis was made of a clean piece of barytes taken in 1917 from an old stock pile at the open-cuts.

Analysis of barytes ore. Iron Hill mine (Hu-369)

Silica (SiO_2)	0.43
Ferric oxide (Fe_2O_3)	0.30
Lime (CaO)	0.00
Carbon dioxide (CO_2)	0.00
Sulphur trioxide (SO_3)	33.92
Manganous oxide (MnO)	trace
Strontium oxide (SrO)	1.40
Barium oxide (BaO)	64.04
Total	100.09
Barium sulphate ($BaSO_4$)	97.47

Fragments on the old stock piles that have been exposed many years show alteration rims that are dull white and granular, grading into a center of bluish-white crystalline barytes. This alteration goes on, however, before the mineral has been removed from the deposit, for the weathered exterior of the fragments is noticed throughout the district.

The two principal mine openings are on the southwest slope of the hill on the east side of the small branch, north of the Etowah Development Company's railroad. Both cuts are about 20 feet deep and 40 to 50 feet wide. One is 50 feet long, the other, 100 feet long. Barytes fragments occur in the clayey walls of the cuts from top to bottom and in a test pit 10 feet deep in the bottom of the smaller cut. The property has been prospected by many test pits which reveal the length of the ore body several hundred yards from east to west across the center of lot 786. A large part of the area is

probably workable, as almost all of the pits show high-grade ore plentifully to depths ranging from 6 to 15 feet, and deeper workings show it to 30-foot depths.

The deposit has not been worked in many years and relatively little ore was ever shipped. The situation is favorable for steam shovel methods. An ample supply of water flows within a few hundred yards and the branch railroad passes within a few hundred feet of the open-cuts.

PUMPKINVINE CREEK LOCALITIES

Barytes occurs at several places in the hills just north of Pumpkinvine Creek, 1½ miles south and southwest of Emerson. It has not been found as an ore, however, but as crystals embedded in a ferruginous siliceous matrix and filling small fractures in the rock. Three of these occurrences are here briefly described. All lots are in the 4th district, 3d section.

Jones property.—Crystals of barytes occur rather plentifully at places on lots 1039 and 1050, known as part of the Col. C. M. Jones property. At one locality less than 100 yards up the slope northwest of a sharp turn in the Emerson public road, clear tabular crystals may be seen as large as 2 inches in length. The matrix is porous siliceous material deeply stained with limonite and ocher. It is finely granular and possesses the appearance of leached magnesian limestone. In places the barytes crystals have been eroded or broken out of the matrix, leaving cavities still retaining the crystal form.

Puckett property.—S. F. Puckett of Emerson owns land north of the Pumpkinvine on lots 1037, 1038, and 1051, 1½ miles south-southwest of Emerson. This property is on the steep south slopes of the partially wooded hills west of an old limestone quarry that was once worked near the line of the branch railroad that connected the brown iron mines with the Western & Atlantic Railroad at Emerson. In 1917 and 1918, some iron and manganiferous iron ore were dry-mined on lot 1037.

Barytes occurs in crystal form in quartzite and ferruginous matrix less than a hundred yards east of Puckett's open-cuts on lot 1037.

At this locality there is a lime sink 175 feet in diameter and more than 10 feet deep. It is in the steep south slope about 85 feet higher than the wagon road and the grade of the old branch railroad at the foot of the hill. In it are outcrops of cavernous granular rock composed principally of ferruginous siliceous material, whose generally leached and altered appearance suggests its previous condition as limestone. There are also outcrops of dark pure quartzite, so dense in texture as to resemble chert. Both of these types of rock contain many small pockets and fractures that are lined and filled with barytes crystals, evidently deposited from solutions passing through the porous and broken rock. The crystals are white and pale straw-colored, short, stout, tabular, and less than ¼-inch in greatest dimension. After the formation of the barytes crystals, a thin layer of crystalline and crystallized quartz, a small fraction of a millimeter thick, was deposited, completely covering the barytes.

The walls of the sink are covered with talus material and vegetation. A few water-worn quartz pebbles are mixed with the reddish-yellow soil and quartzite fragments, both in the sink and nearer the top of the hill at an elevation 860 feet above sea level or 120 feet above Pumpkinvine Creek. Barytes crystals similar to those just described occur at several places on the property, particularly on top of the ridge north of the sink and in the gully north of S. F. Puckett's house. No barytes ore has been found on the property.

Stephens property.—Lots 981 and 1036, 1½ miles southwest of Emerson, are part of the property of Mrs. Maggie M. Stephens, of Cartersville. There is a large open-cut on the southeast part of lot 981, which was formerly worked for brown iron ore. Small flat tabular crystals of barytes occur in a ferruginous and siliceous matrix at the south entrance of the cut. The crystals appear to have been formed in cavities and fractures in the quartzite and later to have been cemented more closely together and encased by deposits from ferruginous and siliceous solutions. No massive barytes ore occurs here.

Lot 892, a mile west of Emerson, is in part Mrs. Stephens' property. It contains deposits that are being worked by the Paga Mining Company.

PITTSBURG-GEORGIA MINING COMPANY

The Pittsburg-Georgia Mining Company owns a number of acres of barytes property half a mile west of Emerson. B. C. Sloan of the Southern Leasing Company, Cartersville, has prospected the east slope of the wooded hill a quarter of a mile west of the Big Tom mine. The test pits show a small deposit of ore in the unconsolidated ocherous material overlying Weisner quartzite, but it is doubtful that a profitably workable body of ore occurs here.

ABROMSON PROPERTY

Lot 690, 4th district, 3d section, a mile north-northwest of Emerson, belongs to A. Abromson of Adairsville. In 1918 the mineral rights were leased by P. C. Renfroe but in 1919 were transferred to the Paga Mining Company.

The chief topographic feature is a roughly conical hill rising to an elevation 940 feet above sea level or about 250 feet higher than Etowah River which flows southwest half a mile northwest of the property. The hill covers almost the whole lot. The Western & Atlantic Railroad passes around its south and west sides, and a small tributary of Etowah River flows northwest about 40 feet lower than the railroad. A few hundred yards southeast of the Abromson deposit is the Section House mine and across the valley south of the railroad is the Nulsen mine.

Weisner qhartzite is exposed in an old railroad stone quarry in a little ravine at the foot of the south slope on the northeast side of the tracks. The rock is fractured, massive, and almost indeterminable as regards its attitude, though the strike seems to be northeast. Farther north up the hill, more distinct outcrops show strikes of N. 33°-53°E. and dips of 65°-70°SE. Barytes occurs as loose fragments in the yellow soil overlying the quartzite. Many prospect pits have proved its plentiful occurrence on the steep hillside from the level of the railroad tracks at 800 feet to an elevation approximately 860 feet above sea level.

In the railroad cut on the west side of the lot a small deposit of nodular and soft manganese together with limonite occurs in the

red soil of the hillside. Water-worn quartz pebbles were observed about 110 feet above river level.

Lot 690 has a good workable deposit of high-grade barytes ore, admirably situated for economical mining, being on a hillside sloping down to the railroad and near an ample supply of water from Etowah River.

LAREY PROPERTY

Mrs. Kittie P. Larey of Cartersville owns 212 acres in several 40-acre lots on both sides of Etowah River 1½ to 2 miles southeast of Cartersville. Barytes has been prospected for on lot 678, 4th district, 3d section.

This locality is on the west side of the lot, north of the Dixie Highway and west of the Webster Ferry road three-eighths of a mile directly east of the covered wagon bridge over Etowah River. It is on the opposite side of the road from the Paga No. 3 mine, which is also owned in part by Mrs. Larey. Barytes fragments occur in the red soil in an open field and along the Webster Ferry road west of the house, at elevations ranging from 20 to 40 feet above the river. Several test pits a few feet deep in red topsoil and yellow subsoil show a good quality of ore in moderate quantity. Small brown iron nodules are abundant in the red soil.

Quartzite exposures are numerous with strikes N.25°-55°E. and dips 45° ?85°SE. The trend of the low ridge, however, is northwest and one outcrop of rock was observed conforming in general to this direction, having a strike N.35°W. and a dip 45°S.W.

McCLATCHEY PROPERTY

Lots 552, 553, and 601, 4th district, 3d section, are owned by Hardendorf & McClatchey, 210-211 Candler Building, Atlanta. The barytes rights belong to M. R. McClatchey. The lots occupy the southwest slope of the hill northeast of the Dixie Highway and the Western & Atlantic Railroad less than a mile southeast of Cartersville. No barytes has been worked on this property, but some prospecting has been done. Ore of high grade is exposed rather plentifully in the road cut a few hundred feet northwest of the under-

pass of the wagon road, and float ore occurs in many places in the red and yellow soil up the slope from the road, from an elevation of 720 feet to 840 feet above sea level. Rock exposures on the ridge show greatly weathered iron-stained siliceous masses that contain irregular cavities lined with limonite and crystals of barytes and quartz. The formation is much the same as that at the Cartersville city reservoir on lot 529, a quarter of a mile north along the ridge. This ferruginous rock containing fragments and veins of barytes is doubtless an altered remnant of the Shady limestone formation. No limestone, however, is exposed.

HARRISON-CHILES PROPERTY

A. B. Harrison and Nettie G. Chiles of Cartersville own 130 acres in lots 407, 457, 388, and 389, 4th district, 3d section.

Lot 457 is in the corporate limits of Cartersville, half a mile east of the Western & Atlantic Railroad station. The lot has been rather extensively prospected for barytes by means of test holes some of which are as deep as 65 feet. The south half of the lot, south of East Main Street, appears to be the more promising for a body of workable ore. Ten holes and a well ranging in depth from about 15 to 110 feet showed barytes at different depths in the loose red and yellow formation. The red surface soil contains little barytes, though some float ore occurs. At a depth of 5 feet or less the red clay is underlain by a yellow clayey formation more or less residual in character and containing thin fragments, or chips, of yellowish gray shale, similar to that overlying the Shady limestone on the Paga Mining property south of Etowah River. The yellow clay begins to be ore-bearing at depths ranging from 10 to 30 feet. As a rule the overburden is deep over the whole deposit.

The ore is high grade and evidently forms an extensive deposit in the unconsolidated clays, but the heavy overburden delays the working of this ore body until the more readily mined hillside deposits in other parts of the Cartersville district are exhausted. The lot occupies an almost level or very gently rolling area mapped as part of the Shady limestone formation, though no rock outcrops occur.

Lots 388 and 389 are 1½ miles east-northeast of Cartersville station. The barytes deposit occupies the south slope of a hill and the head of a ravine a few hundred yards northwest of the old pest house. The locality is near the east side of lot 388 and the west side of 389 at an elevation about 920 feet above sea level. In the latter part of 1917, J. E. Wikle of Cartersville dry-mined 100 tons, more or less, of high-grade barytes from small open-cuts 10-12 feet deep. A good ore body was proved by test pits 15-20 feet deep within an area of less than an acre.

TUMLIN LOT

Lot 408, 4th district, 3d section, half a mile northeast of Cartersville station, is the property of Mrs. L. F. Tumlin. This 40-acre lot is south of the Big Creek plant and north of the Harrison-Chiles deposit on lot 457. The topographical and geological conditions are the same as those of adjacent properties. The surface is generally level. Barytes ore, as proved by about 25 test pits 20 feet deep, occurs as rather clean fragments in the yellow clayey formation underlying several feet of red soil overburden in the northern part of the lot within 200 yards of the Big Creek washer. Some pits show ore in plentiful quantity; others show only clay and small fragments of yellowish-gray shale. No mining has been done on the property. Thousands of tons of high-grade barytes underlie the red soil blanket on the Big Creek, Tumlin, and Harrison-Chiles properties.

CHEROKEE OCHRE COMPANY

The Cherokee Ochre Company of which J. T. Norris, Cartersville, is secretary and treasurer, owns 170 acres in lots 406, 459, 476, 477, and 478, 4th district, 3d section, about a mile east of Cartersville. There are barytes deposits on each of these lots, but the company has confined its principal mining activity to the working of ocher on the west side of lot 406. The barytes deposits of the Cherokee Ochre Company have been leased by Thompson-Weinman & Company of Cartersville.

The Tucker Hollow barytes mine and washer on lots 477 and 476

have already been described; also in that connection, the small deposits on the west side of 477.

Lot 478, one mile east of Cartersville, is at the head of the little valley that opens southward and contains the deposits described as the Thompson-Weinman mine on lot 478. This lot has been rather thoroughly prospected by means of test pits. On both sides of the valley and at its head are ore bodies of high quality and promising quantity. The ore occurs in rather clean fragments as commonly found in the red and yellow unconsolidated hillside accumulations overlying Weisner quartzite.

Lot 459 joins the north side of lot 478. The Parrott Springs mine on lot 406 extends into the north side of the lot.

On lot 406 within a few hundred feet west and southwest of the Cherokee Ochre Company's plant, a good barytes ore deposit is indicated by fragments of "float" and by a few test pits in the reddish-yellow soil. Though the size of this ore body is probably small, an excellent quality of barytes is exposed at the surface.

NORRIS-HALL PROPERTY

Lot 405, 4th district, 3d section, 1¼ miles east of Cartersville, belongs to J. T. Norris of Cartersville and Mrs. L. C. Hall of Milledgeville. This lot is part of the Parrott Springs tract and lies just east of the Parrott Springs mine and north of the Munford Lot mine, both recently worked for barytes.

Lot 405 has on it the Norris manganese mine that was worked in 1917 and 1918 by the Republic Iron & Steel Company of Birmingham, Ala. The mine was connected with the Western & Atlantic Railroad 1¼ miles to the south by the Etowah Development Company's railroad. Water was pumped from Etowah River about a mile distant, and 100 feet lower than the mine. The general elevation of the property is 900 feet above sea level.

Barytes is associated with the manganese ore at the Norris mine in the relation typical of the ores in the Cartersville district. In places it is plentiful from the surface to depths of 15 and 20 feet in the red and yellow soil overlying the manganese ore body. The sequence of deposits from the bottom of the open-cut to the surface

is as follows: quartzite foot wall, limonite and ocher, manganese, and barytes—all except the quartzite forming a loose clayey hillside accumulation, partly residual and partly colluvial.

Manganese and manganiferous iron are the only ores, that have been worked, but as good barytes is exposed to some extent in proximity to the northwest extension of the barytes open-cut on the Munford lot, it is probable that a small quantity could be profitably dry-mined. During the recent work for manganese, an attempt was made to save the barytes ore but none was shipped.

TEDDER PROPERTY

A small quantity of barytes was found in front of the residence of T. P. Tedder, Konodle St., Cartersville. About a wheelbarrow load of good ore was dug out of the reddish-yellow soil where a concrete walk was being laid. No prospecting was ever done and it is improbable that a workable deposit occurs here. A few hundred yards east of the Tedder residence, several tons of brown iron ore were once mined.

CARSON PROPERTY

Jesse C. Carson (colored) owns 90 acres in lot 230, 5th district, 3d section. The property is part of a lot of 160 acres, 6 miles north of Cartersville and 1½ miles southwest of McCallie, a station on the Louisville & Nashville Railroad.

Carson's home is a few hundred feet east of the Cartersville-Grassdale road and on the east side of a branch flowing south to Pettit Creek. The north side of the property is bounded by a road leading east to McCallie. A quarter of a mile east of the house and the same distance north of Pettit Creek, a barytes deposit has been prospected on the west side of the hill. Several pits have been dug within 20 feet of the hilltop or at an elevation about 840 feet above sea level.

Barytes fragments as large as a foot thick lie in reddish-yellow soil at a depth of 5 feet. The ore is generally clean, some of it being bluish-white and crystalline. Some fragments possess a worn or smoothed appearance and contain small cavities, or pockets, filled with

dirt. The deposit rests on grayish-colored shale, though the rock does not seem to form a solid foot wall. The ore is evidently all near the surface forming a shallow body in an area of a few hundred square yards. A gully 8 feet deep between two nearby prospect openings shows on barytes and no shale.

The property is in an area of the Cartersville shale and slate formation which strikes from N.80°E. to east and dips 45°-50°SE. to 50°S.

SAXON PROPERTY

C. H. Saxon, Cartersville, owns 120 acres comprising the western part of lot 227, 5th district, 3d section, at Grassdale, 7 miles north of Cartersville, and 2½ miles southwest of White, a station on the Louisville & Nashville Railroad.

The barytes prospects are a quarter of a mile east of the Saxon residence, in a level cultivated field south of the public road. A dozen test holes, the deepest of which is 8 feet deep, have encountered barytes ore scattered over an area of a third of an acre. The soil in which the fragments occur is reddish-yellow and is probably the residual representative of the Cartersville shale and slate formation, though for the most part the rocks in the vicinity of Grassdale belong to the Conasauga shales and limestones. The generally level surface near Grassdale is a little more than 800 feet above sea level.

The ore forms a small deposit of high quality. About one carload of ore was taken from the property of B. C. Sloan of Cartersville.

RICHEY PROPERTY

The heirs of Anthony and Antoinette Richey (colored) own 40 acres in the eastern part of lot 227, 5th district, 3d section, at Grassdale, 2½ miles southwest of the Louisville & Nashville Railroad at White. The property adjoins the Saxon property just described. A few test pits 150 feet east of those on the Saxon property showed little evidence of a workable barytes deposit, although it is said that ore of a similarly high grade was found in the prospecting.

OTHER LOCALITIES IN BARTOW COUNTY

Besides the mines and prospects that have already been described and included in the Cartersville district, there are a few isolated barytes deposits in Bartow County which deserve mention, although they are not commercially important. The three properties to be described include two near Stilesboro in the southern part of the county and one near Kingston in the western part of the county.

BRANDON PROPERTY

Lot 1200, 17th district, 3d section, near the south boundary of Bartow County, 2 miles southwest of Stilesboro and half a mile southeast of McGinnis, stations on the Seaboard Air Line Railway, is owned by the Misses Mary and Cordelia Brandon for whom J. D. Brandon is agent.

The property lies at an elevation of 700 feet above sea level in the rolling land drained northward by Floyd Creek. It is in an area underlain by Ordovician limestone of the Chickamauga formation, about 2 miles north of the prominent Cartersville fault scarp which forms the northern boundary of the ancient crystalline rocks.

A shallow pit in the northeast corner of the lot a few hundred yards west of Floyd Creek shows some fragments of moderately clean barytes in reddish-yellow soil. Nearby exposures of limestone come within 4 or 5 feet of the surface indicating that the barytes deposit occupies irregularities or erosional cavities in the rock. Surface indications do not suggest anything but a small deposit. More extensive prospecting has been done on the adjoining McCormick property but the combined properties show ore of only doubtful commercial importance.

MCCORMICK PROPERTY

Lot 1177, 17th district, 3d section, half a mile southeast of McGinnis on the Seaboard Air Line Railway, is just north of the Brandon property previously described. The property belongs to Miss Annie McCormick, for whom J. H. D. McCormick of Stilesboro is agent.

Barytes ore fragments have been found in an area comprising a small fraction of an acre a few hundred yards south of the Taylors-

ville-Stilesboro road and west of Floyd Creek. The ore forms part of the same deposit that was described as the Brandon property. A prospect pit 8 to 12 feet deep has exposed fragmental ore overlying limestone of the Chickamauga formation. The surface of the limestone is roughened and furrowed and is in sharp contact with the loose reddish-yellow soil overburden. So far as could be observed the barytes is confined to the unconsolidated material. The locality is only a few feet higher than the creek bottom.

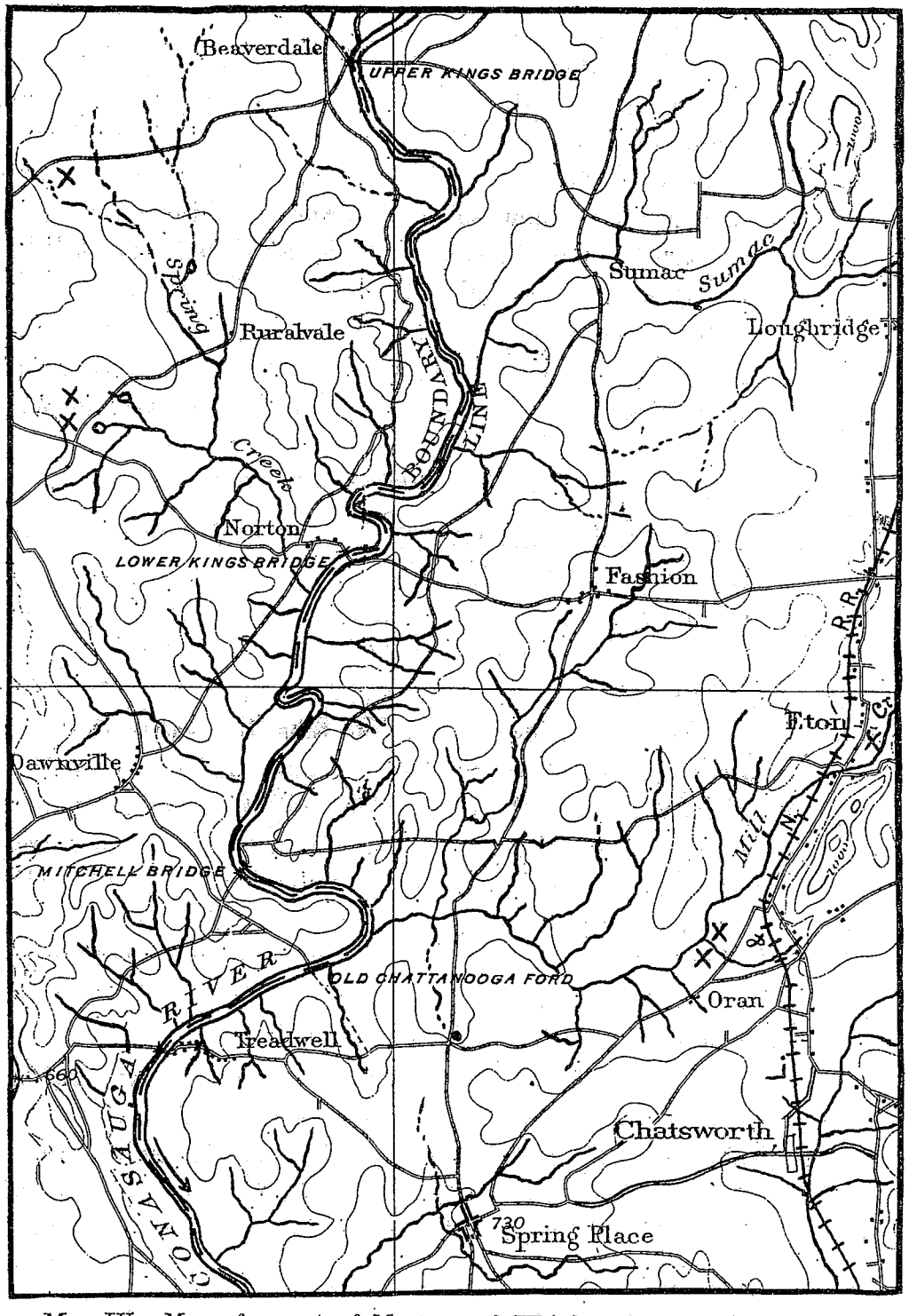
The barytes fragments exposed on the McCormick property are generally porous, dirty, and so intimately mixed with iron oxide impurities that the presence of a workable deposit seems improbable.

HOLCOMBE PROPERTY

Lot 158, 16th district, 3d section, western part of Bartow County, belongs to Mrs. R. E. Holcombe of Kingston. The property is west of the Western & Atlantic Railroad about half way between Hall's and Cement or 2½ miles north of Kingston.

Barytes has been prospected for at a place a few hundred yards south of the Holcombe residence and less than 100 yards west of Connesena Creek. The stream flows south to Etowah River about 1½ miles west of Kingston. Both wagon road and railroad follow the valley just east of the stream. A few test pits not more than 6 feet deep have been dug at the foot of the east slope of a ridge made up of Cambro-Orvodician rocks of the Knox dolomite formation. The locality is 10 feet higher than the stream, at an elevation approximately 800 feet above sea level. The north-south ridge west and northwest of the prospects rises to an altitude of 1200 feet.

The deposit as prospected occupies a space of 150 square yards between two outcrops of Knox dolomite. The rock on the northeast side strikes N.60°W. and dips 15°NE., but on the other side the attitude is indeterminate. The ore is fragmental, mixed with the yellow soil, and of limited extent. Besides massive crystalline fragments, there are crystal groups of thin curving plates arranged with vertical axes parallel, but radiating from a common vertical center, or hinge, like leaves from the back of a book, except that the outer edges of the



Map IV. Map of a part of Murray and Whitfield Counties showing location of barytes in the Eton district and near Ruralvale. *From the Dalton topographic sheet, U. S. Geological Survey.* 1 *inch equals* 2 *miles. Contour interval* 100 *feet.*

leaves are curved so as to form a round bud-shaped mass, or ball, made up of radiate plates.

Manganese and brown iron ore also occur in small quantities as shown by prospect pits on other parts of the same lot. The barytes deposit is unpromising as a workable or profitable ore body.

MURRAY COUNTY[1]

ETON DISTRICT

C. C. KEITH PROPERTY

C. C. Keith of Eton owns 135 acres in lot 157, 9th district, 3d section, 2¾ miles south-southwest of Eton (formerly Dunn), and 2 miles north-northwest of Chatsworth, both on the Louisville & Nashville Railroad. Barytes was mined on this property in 1907, or soon thereafter, by the Georgia Barytes Company. Some time later the mine was again worked by Colvin & Davis of Asheville, N. C., whose representative is J. G. Adams of Asheville.[2]

The property lies at an elevation about 750 feet above sea level, in the rolling topography of the Appalachian Valley 2 miles west of the base of Fort Mountain which rises to an elevation 2835 feet above sea level and forms a part of the prominent westward-facing fault-scarp marking the boundary between the Appalachian Valley and the Appalachian Mountain physiographic provinces. The lot is just east of, and a few feet higher than. Mill Creek which flows westward to Conasauga River approximately 3 miles distant.

The rock exposed at the mine belongs to the Knox dolomite formation of Cambro-Ordovician time. This formation underlies a large area of the county extending north and south between Conasauga River on the west and the Cartersville fault on the east. The dolomite is represented in the open-cut by a chert "horse" 25-30 feet long and 15 feet wide overlain by yellow residual clay which is the characteristic substratum in the dolomite area. The top soil and surface formation to a depth of 18 to 20 feet in places are red clay

[1] In connection with the description of the individual deposits of Murray County, the writer wishes to express his appreciation of the field assistance and the hospitality of J. A. Coffey, Eton, and of W. M. Graham, Chatsworth.

[2] Information from George W. Bruce of Cartersville, who had charge of the work on the Keith property.

loam and unconsolidated clayey material containing scattering pebbles of water-worn quartz 1 to 3 inches in diameter. One smooth, rounded pebble of barytes, distinctly water-worn, was found on the surface. This red and pebbly surface is believed to represent reworked deposits of Tertiary time.

The ore deposit has been opened to a depth of 18-20 feet by an open-cut about 250 yards west of the Eton-Spring Place road. The walls of the opening show fragmental barytes in the red clay throughout a length of 200 feet and a width of 85 feet. Several of the working faces show as much as 50 per cent of barytes; at other places the walls are almost barren. Much of the ore still remaining in sight has a porous, iron-stained character that makes it rather low-grade and that was probably the principal reason for stopping the work after the ore of higher grade had been mined. Barytes of excellent quality occurs at this mine and at openings on the Love property at Eton, as is shown by the following chemical analyses which represent ore from both of these localities.[1]

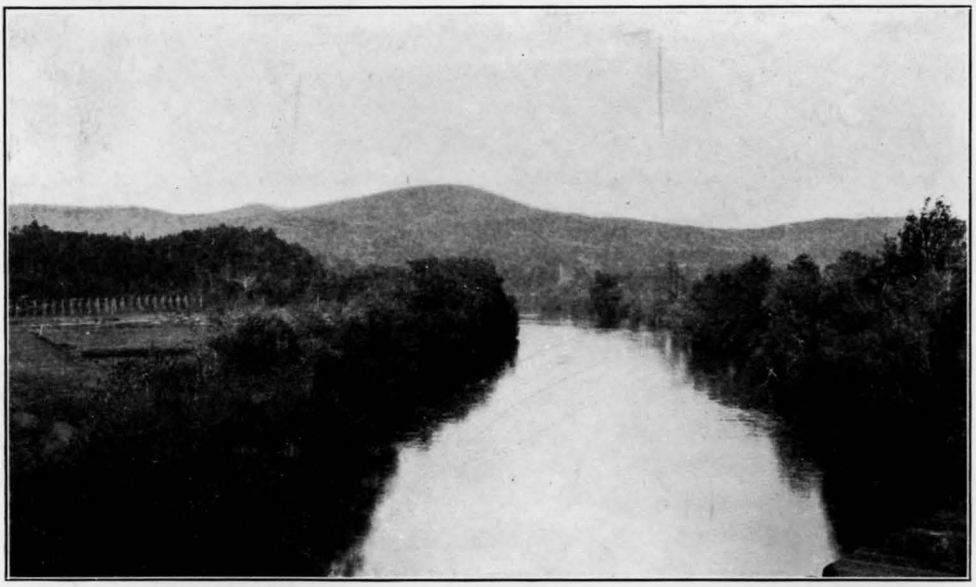
Analyses of barytes ore. Murray County

Constituents	1	2
Silica (SiO_2)	0.27	0.34
Alumina (Al_2O_3)	0.20	0.35
Ferric oxide (Fe_2O_3)	0.33	0.75
Moisture	0.38	0.32
Barytes ($BaSO_4$)	98.82	98.24
Total	100.00	100.00

Development work on lot 157 included an open-cut 200 feet long, 85 feet wide, and 18 feet deep. The opening is 150 feet south of the washing plant, part of which still remained in 1919 though in useless condition. The equipment included a double log washer and a 2-cell jig. Several carloads of ore are reported to have been shipped from the Keith property in 1907 or shortly after that time. Surface fragments and exposures in the open-cut indicate a more ex-

[1] McCallie, S. W., A preliminary report on the mineral resources of Georgia: Geol. Survey of Ga. Bull. 23, p. 38, 1910.

A MILL CREEK VALLEY CONTAINING BARYTES DEPOSITS. ETON, MURRAY COUNTY.



B. ETOWAH RIVER AND PINE MOUNTAIN EAST OF CARTERSVILLE, BARTOW COUNTY.

tensive deposit than that shown by the size of the mine, but a large part of the ore is evidently ferruginous and being somewhat porous or cavernous in character, it might prove difficult to concentrate without preliminary crushing. The property is situated near a water supply from Mill Creek and on the Louisville & Nashville Railroad.

W. F. HAMPTON PROPERTY

W. F. Hampton, of Summerville, W. Va., owns 32 acres, more or less, in the south part of lot 157, adjoining the property of C. C. Keith. A few fragments of barytes are mixed with the red soil on this property indicating a continuation of the same ore deposit.

G. W. HAMPTON PROPERTY

George W. Hampton owns 40 acres in the south part of lot 132, 9th district, 3d section, 2½ miles south-southwest of Eton. The situation of this property and the character of the ore are similar to those just described on lot 157 which is south of lot 132. Fragmental barytes occurs in the red and yellow soil of the cultivated fields. There are no indications, however, of anything but a small deposit. No prospect pits have been dug to determine the presence of a workable ore body. Quartz gravel is common in the red soil.

J. W. BONDS PROPERTY

J. W. Bonds of Eton owns 120 acres, more or less, comprising the north part of lot 132, 9th district, 3d section, 2 miles south-southwest of Eton. Barytes fragments ranging in thickness from a few inches to more than a foot occur in the cultivated field east of Mill Creek. No test holes have been dug, but float ore may be found in the brown loam within an area of 3 or 4 acres between the creek and a ridge rising about 40 feet higher than the stream. Small fragments of impure limestone, or dolomite, are mixed with the hillside soil accumulation, and the top of the ridge is covered with quartz gravel.

The barytes is most plentiful near the base of the western slope where it has accumulated by the slow downward movement of the material derived from the weathering of the Knox dolomite. Many fragments of ore are clean, white, and crystalline; others show sili-

ceous impurities and dark ferruginous stains resulting from the oxidation of pyrite which still remains in some fragments in a finely granular and crystalline condition. The barytes is commonly white and rather coarsely crystalline, showing cleavage faces, but some specimens are dark and show a radiating structure of fibrous crystals in small groups about an inch in diameter.

J. E. LOVE PROPERTY

J. E. Love of Eton owns 120 acres in lots 87 and 88, 9th district, 3d section, within the corporate limits of Eton. That part of lot 88 on which barytes occurs is about a quarter of a mile northeast of the Louisville & Nashville Railroad station, on the east side of the main public road, and just west of Mill Creek. The property formerly belonged to C. M. Harris of Eton and was worked for barytes about 1907, or soon thereafter, by W. F. Fisher & Son for the Georgia Barytes Company. Some time later Colvin & Davis of Asheville, N. C., mined the ore,[1] but in recent years no ore has been produced.

The locality is marked by a low partially cleared ridge which rises 10 to 12 feet higher than the surrounding bottom land along the creek. The ridge is about 150 yards long and 50 yards wide. Its east side at one place forms the west bank of the stream which pursues a course more or less meandering and changeable. East of Mill Creek, a prominent north-south ridge reaches an elevation more than 1000 feet above sea level or approximately 350 feet higher than the stream. This ridge is one of the foothills of the Cohutta Mountains that form the rough Appalachian Mountain province east of the Cartersville fault.

The low ridge that contains the ore deposit on the west side of Mill Creek is made up of Cambrian limestone probably belonging to the Conasauga formation. An outcrop in the west bank of the stream strikes N.65°E. and dips 45°-50°SE. Water-worn quartz gravel is scattered through the yellow soil of the bottom land surrounding the ridge. The depth of the soil covering is probably shallow since the rock where encountered in mining is only a few feet below the surface.

[1] Information from G. W. Bruce of Cartersville, who formerly had charge of mining operations on the Harris (Love) and Keith properties for Colvin & Davis.

Barytes occurs as loose fragments in the yellow soil and as vein-filling and breccia cement in the limestone. A dozen prospect pits dug along the ridge and in the bottom land, uncovered good ore at depths of 4 and 5 feet. The deposit was formerly worked by means of an open-cut in the loose and broken material of the ridge. The opening is 50 feet long, 30 feet wide, and 10 feet deep. Barytes of good quality is exposed in fractures in the limestone in the sides and bottom of the cut. The fractures are a few inches wide and very irregular, so that in places the formation is a limestone-barytes breccia, in which the barytes encloses angular fragments of limestone a fraction of an inch thick. The ore that remains on the surface and in the cut is generally high-grade with both crystalline and granular texture. Small spots of pyrite occur in very minor amounts and the common rusty yellow ferruginous stain covers the fragments that have been broken out of the limestone and are now embedded in the soil. The quality of the ore is shown by the analyses of barytes from this property and the Keith property previously described. These analyses (see p. 130) show as much as 98.82 per cent of barium sulphate.

When the mine was being worked, a log washer and a 2-cell jig were used to clean the ore. In 1919 none of the machinery remained on the property and the mine had been idle several years. The quantity of ore still in the deposit probably amounts to several hundred tons in small pockets and at shallow depths. It is improbable that the barytes breccia could be profitably worked because of the small quantity.

C. C. AND J. H. KEITH PROPERTY

Property of C. C. and J. H. Keith on lot 57, 9th district, 3d section, ¾ mile northeast of Eton was leased in 1917 and worked for brown iron ore by W. M. Graham of Chatsworth. The pits are at the west base of a wooded ridge on the east side of Mill Creek. Brilliant yellow, green, blue, and black colorings of iron oxide coat the ore fragments and in places these beautiful crusts hide small perfectly tabular crystals of barytes as large as ¼ inch in length. No barytes ore occurs here.

WHITFIELD COUNTY

W. R. CLINE PROPERTY

W. R. Cline of Ruralvale,[1] 9½ miles northeast of Dalton, owns 80 acres in the east part of lot 271, 11th district, and 15 acres in the southwest corner of lot 288, 10th district, 3d section, in the northeast-central part of Whitfield County.

Barytes has been mined in small quantities from a pit in the southwest part of lot 288, a few hundred yards northwest of Cline's store at the crossroads. The surface of the land is gently rolling and is drained eastward by a small branch of Spring Creek to Conasauga River about 3 miles away. The general elevation of lot 288 is 800 feet above sea level. There are no outcrops of rock near the ore deposit, but the soil is yellow and reddish-yellow clay loam containing a few cherty fragments representing the Knox dolomite formation. About 100 yards southwest of the pit, there are ferruginous ore fragments in the soil.

A small prospect pit about 4 feet deep exposes many irregular fragments of heavy white crystalline barytes in the yellow soil. A few masses of ore as large as 3 feet in thickness have been unearthed in plowing. The ore is generally massive and contains some fragments of white chert. Barytes is commonly plowed up in the vicinity of the prospect pit and several tons have been thrown into a little gully in the cotton field. The depth of the deposit is not known, but it forms part of a larger deposit that extends northward through several other properties to the Beaverdale-Praters Mill road, a distance of 3 miles. Ore does not occur continuously within this distance, but it has been found at several intervening places.

As the deposit is small and between 6 and 7 miles from the nearest point on the Southern Railway, either at Varnell or near Dalton, it could hardly be worked at a profit.

The analysis of ore here given represents an average sample from the prospect pit. The chert and iron impurities were not removed.

[1] The locality known as Ruralvale in 1919 is the place where the public road from Dalton to Beaverdale crosses the road from Lower Kings Bridge to Praters Mill. On the Dalton topographic sheet of the U. S. Geological Survey Atlas, the old post office of Ruralvale is shown at a point 2 miles northeast of the crossroads now known by that name.

Analysis of barytes ore. W. R. Cline property (Hu-393)

Silica (SiO_2)	2.62
Alumina (Al_2O_3)	0.00
Ferric oxide (Fe_2O_3)	1.12
Magnesia (MgO)	0.11
Lime (CaO)	0.06
Moisture at 100°C	0.12
Loss on ignition	0.42
Sulphur trioxide (SO_3)	32.62
Manganous oxide (MnO)	0.31
Barium oxide (BaO)	62.55
Total	99.93
Barium sulphate ($BaSO_4$)	95.20

GEORGE CLINE PROPERTY

George Cline of Ruralvale owns 115 acres in lot 288, 10th district, 3d section. The barytes deposit has been prospected on the west side of the lot about a quarter of a mile north of the opening on W. R. Cline's property just described. Three or four pits have been dug to a depth of 4 feet showing white crystalline ore in yellow clayey soil containing a few fragments of chert. Several tons of barytes have been taken out of the ground but none has been shipped.

Lot 288 formerly belonged to Mrs. M. E. Morgan. The mineral collection in the State Museum at the Capitol includes several excellent specimens of barytes crystals from the Morgan property. Groups of transparent and translucent tabular crystals arranged in crested form are held in an ocherous cherty matrix.

A quarter of a mile northwest of the George Cline barytes prospects, and half a mile northwest of Cline's store at the crossroads, some fragments of smooth-textured red iron ore (hematite) occur in the soil east of J. S. Jarrett's house. This locality is about on the line between lots 270 and 271, 11th district, 3d section.

BRYANT PROPERTY[1]

Claud, R. L., and W. H. Bryant of Ruralvale own 35 acres in lot 253, 80 acres in lot 252, and 40 acres in lot 217, 10th district, 3d sec-

[1] Information about this property was given by W. R. Cline. It was not visited by the writer.

tion. The property specified lies north of Ruralvale crossroads along the strike of the barytes deposits between Ruralvale and the Beaverdale-Praters Mill road. There are other properties along this northward strike of the ore, but barytes has been prospected for especially in the northwest corner of lot 217 about half a mile south of the Beaverdale-Praters Mill road. The grade of the ore and size of the deposit are reported as being similar to those on the properties nearer Ruralvale.

SAM AND J. W. CLINE PROPERTY[1]

Sam and J. W. Cline own lot 181, 10th district, 3d section, 3 miles west-southwest of Beaverdale or Upper Kings Bridge and 2 miles northeast of Praters Mill. This is the northernmost locality where barytes has been reported in the lead extending 3 miles north from Cline's store at Ruralvale crossroads. The Beaverdale-Praters Mill road cuts through a loose soil accumulation in the southwest corner of lot 181 that contains fragments of barytes having the same desirable qualities as that found on the properties previously described.

GORDON COUNTY

FLOYD PROPERTY

L. L. and Scott Floyd of Plainville own 76 acres in lot 26, 15th district, 3d section, southwestern part of Gordon County. The property is on the east side of the Chattanooga and Brunswick line of the Southern Railway, 1½ miles north of Plainville.

A small deposit of barytes has been prospected with several 5-foot pits in the dark brown loam of the bottom land along a small stream flowing northwest about 1½ miles to Oostanaula River. The pits are west of the branch 100 yards north of the tenant house on the Floyd property. The elevation is less than 700 feet above sea level.

Barytes is in fragmental form in the brown soil of the branch bottom and in the limestone outcrops as vein-filling. The rock is ex-

[1] Information about this property was given by W. R. Cline. It was not visited by the writer

posed in a number of places along the branch. It is fine- to medium-grained Cambrian limestone, probably magnesian, belonging to the Conasauga formation.[1] The ore deposit is small and of doubtful commercial size. Fragments of high-grade barytes ranging in thickness from a fraction of an inch to 6 inches occur within an area about 100 yards long and 30 yards wide. The depth of the loose soil deposit has been prospected to 5 feet and the shallowness of the unconsolidated material is also indicated by the exposures of rock in the stream and within a few feet of the surface. The veins of barytes do not appear to be of sufficient size or persistence to be profitably worked.

L. L. Floyd says that a carload of the ore was mined and hauled to Plainville years ago, but no recent mining has been done.

FLOYD COUNTY

BRADEN PROPERTY

G. H. Braden, Adairsville, owns lot 222, 24th district, 3d section, northeastern part of Floyd County. This tract of land lies east of the Chattanooga and Birmingham line of the Southern Railway, about 2 miles south of Plainville. Woodward Creek, a tributary of Oostanaula River, follows a generally southeasterly course across the rolling topography of the property.

The rocks belong to the Conasauga shale and limestone formation of Cambrian time. Several outcrops occurring in the vicinity of the barytes prospects indicate that the fragmental ore in the hillside and residual soil accumulations has been weathered out of veins and fractures in the limestone. Fragments of clean white crystalline barytes of high quality are scattered through the soil within an area of 2 or 3 acres. The deposit has been but slightly prospected.

WHATLEY PROPERTY

S. J. Whatley of Adairsville owns 225 acres in lots 224 and 257, 24th district, 3d section, northeastern part of Floyd County. Lot 224 on which barytes has been mined is 2 miles south-southwest of

[1] Hayes, C. W., U. S. Geol. Survey Geol. Atlas, Rome folio (No. 78), 1902. See map.

Plainville which is near the county line in Gordon County, about 10 miles north-northeast of Rome. Barytes was mined on this property sometime aboupt 1897 by S. J. Whatley's father, who shipped several carloads of ore to Lynchburg, Va.[1] Scarcely any work has been done on the deposit since that time.

The old mine opening is on the west side of Woodward Creek which follows a generally southwest course several miles to Oostanaula River. About 100 yards east of the stream is the Chattanooga and Birmingham line of the Southern Railway, and half a mile east is the public road from Plainville to Rome. The topography in the vicinity of the ore deposit is almost level, though farther from the creek it is gently rolling. The elevation is about 700 feet above sea level. In the cultivated bottom land gray and brown soil forms a rich, but in places thin, mantle on the limestone, which is exposed in both banks of the creek. The rock represents the limestone member of the Conasauga formation of Cambrian time.[2] Two hundred feet west of the stream and the mine, fragments of gray shale occur in the soil beneath scattered deposits of quartz gravel.

The barytes deposit is in vein form in the limestone. As exposed in an outcrop in the right bank of the stream, the vein of ore is 3 feet wide within fairly definite limestone walls, although the strike and dip could not be determined. Other veins and fractures are probably covered by soil which also hides the length of the vein deposit. Ore that has weathered out of the rock occurs as fragments of different sizes in the loose earth. The area in which the ore was mined is only 50 feet on each side, and the depth of the open pit is 4 feet, or at about the same level as the stream. Float ore doubtless occurs at many places in the soil mantle outside this restricted area.

The ore where unmixed with limestone fragments is clean, white, and crystalline. Boulders of high-grade barytes comprised the shipments made from this place years ago. The quality of the ore may be seen in the chemical analysis here given.

[1] Information from S. J. Whatley. Adairsville. 1917.
[2] Hayes, C. W., U. S. Geol. Survey Geol. Atlas, Rome folio (No. 78), 1902. See map.

Analysis of barytes ore. Whatley property (Hu-362)

Silica (SiO_2)	0.94
Alumina (Al_2O_3)	0.00
Ferric oxide (Fe_2O_3)	0.24
Lime (CaO)	0.05
Moisture at 100°C	0.02
Loss on ignition	0.09
Carbon dioxide (CO_2)	trace
Sulphur trioxide (SO_3)	33.97
Barium oxide (BaO)	64.64
Total	99.95
Barium sulphate ($BaSO_4$)	98.38

In 1918, R. F. Griffis of Rome held an option on the Whatley property. Barytes is reported on lot 218 about half a mile northeast of the Whatley mine.[1] The profitable ore remaining on the property is in scattered fragments and in uncertain quantity.

GIBSON PROPERTY

The property of Mrs. George Gibson, Rome, on which there is a barytes prospect, is near the line between lots 337 and 338, 23d district, 3d section, eastern part of Floyd County. This was formerly known as the Miss Mat Hurt property. The locality is half a mile south of Bass Ferry on Etowah River, 6 miles in an air line east of Rome. The Western & Atlantic Railroad parallels the north or right bank of the river. In 1918, R. M. Pattillo, Rome, held an option on the ore deposit but no ore has been mined.

About 100 yards west of the tenant house on the public road that leads north to Bass Ferry, an open field slopes gently westward to Etowah River. The elevation is 600 feet, or more, above sea level. Barytes fragments of good quality occur in the dark red soil within an area of 2 or 3 acres, and in half of this surface the fragments are plentiful and as large as 4 to 5 inches thick. The depth of the deposit has not been prospected, but it is probably shallow since weathered seams of dolomite are exposed at the surface still *in place* in the residual soil within 50 feet of the ore accumulation.

[1] Information from S. J. Whatley, Adairsville, 1917.

The barytes fragments have doubtless weathered out of veins or fractures in the Knox dolomite which forms the country rock of the vicinity. Outcrops of this Cambro-Ordovician formation may be seen at Bass Ferry. Water-worn gravel occupies scattered areas on the slopes along the river. The red soil also contains a few ferruginous ore fragments.

Barytes probably occurs under similar conditions on other properties in the vicinity of Bass Ferry. One locality where it has been observed is a few hundred yards south-southeast of the Gibson prospects, on part of the Emma W. Gordon estate. One or two small fragments were noticed in the soil on an east slope less than a hundred yards east of the public road, but there is no evidence of a workable deposit.

CHEROKEE COUNTY

WHITE PROPERTY

Lot 164, 22d district, 2d section, western part of Cherokee County, is owned in part by Mrs. Thursa White Biddy, Miss Mary White, and Miss Volumnia White of Waleska. The property is a mile north of Moore Mill, 4 miles southwest of Waleska, and 8 or 9 miles by road northwest of Canton the nearest station on the Louisville & Nashville Railroad.

The elevation at the opening is about 1000 feet above sea level or 50 feet higher than the creek. It is said in this vicinity that the prospect pit was made in a search for copper ore many years ago. Indications of a copper deposit however, are unpromising. A few grains of pyrite speck the barytes and some small rusty limonitic cavities occur in the rock but there is no evidence either of an iron pyrites, or of a copper pyrites ore deposit.

An old pit partially filled but still open to a depth of 6 feet exposes a bedded vein of barytes about a foot thick between walls of light gray to yellowish-gray quartzite of finely granular texture and sheared structure. Though this exposure was not definitely recognized as being in place on account of the vegetation and debris in the opening, its attitude corresponds to that of the slaty outcrops on the

opposite, or east, side of Shoal Creek, the strike being N.20°-30°E. and the dip 20°-25°SE. Up the slope a few feet higher than the prospect, the rock strikes north and dips 70°E. Gravel was observed on the hillside along the settlement road south of the barytes deposit, at an elevation 25 feet higher than the stream.

The rock containing the ore deposit was somewhat tentatively mapped as Wilhite slate of Ocoee series (Algonkian?) by Hayes.[1] The Wilhite formation, as mapped, is characterized by dark foliated carbonaceous schist and slate in places largely graphitic and pyritic. It also contains lentils of limestone with sandy phases. Excepting the light gray quartzite enclosing the barytes ore at the prospect pit, the rock outcropping in the vicinity is dark somewhat foliated slate and schist. It is significant to observe in connection with a description of the ore-bearing formation and the origin of the deposit that marble and light gray sandy limestone form extensive outcrops a fraction of a mile to the north and northwest along Lost Town Creek.[2] Both east and west of this narrow strip of the Wilhite formation along Shoal Creek, there are larger masses of Corbin granite of Archean time.

Since the barytes occurs in the sheared quartzite and banded schist as layers parallel to the schistosity of the rock, it seems probable that the ore has replaced certain calcareous beds or layers. The ore and rock fragments observed in the talus material on the steep hillside below the prospect pit show no evidence of deposits in veins or fractures cutting across the schistosity of the rock. The small layers, or lenses, of barytes 1 or 2 inches thick are in sharp contact with the enclosing quartzite and schist, but the contact of the larger ore body about a foot thick is marked by thin alternating layers of barytes and siliceous schist.

Many fragments of high-grade ore are scattered down the slope and a few tons of clean barytes are in sight. As a whole, however, the deposit is evidently small and of doubtful commercial importance, because of both size and distance from the railroad. No prospecting has been done here in recent years.

[1] Hayes, C. W., Manuscript map of the Cartersville quadrangle: U. S. Geol. Survey.

[2] McCallie, S. W., A preliminary report on the marbles of Georgia (2d edit.): Geol. Survey of Ga. Bull. 1, p. 72, 1907.

It is reported[1] that barytes also occurs on the Puckett property about 1½ miles north of the White sisters' prospect.

POLK COUNTY

No definite locations of occurrences of barytes are known in Polk County, although the mineral has been reported as having been found near Esom Hill in the southwestern part of the county. There is in the collections of the Survey a specimen that is supposed to have come from that vicinity. It is high-grade ore, coarsely crystalline, apparently quite free from impurities. The weathered surface of the 5- or 6-inch fragment in question is slightly brown in color but is not coated with ferruginous crusts. When struck repeatedly with the hammer it gives out a faint oily or somewhat nut-like odor, that is not noticed in the other ores examined.

The writer visited Esom Hill and vicinity in 1917, but found no barytes deposits in that part of Georgia. Esom Hill is just east of the Georgia-Alabama state line and it is not improbable that small deposits similar to those that have been prospected in northeastern Cleburne County, Ala., which joins southwestern Polk County, Ga., do occur near the state line of Georgia.

Besides the reported occurrence a mile or two south of Esom Hill, barytes was reported near Treat in the northwestern part of Haralson County, about 3 miles south of Esom Hill, but no occurrence was found by the writer.

The rocks in the vicinity of Esom Hill belong to the Rockmart slate and the Knox dolomite formations of Cambrian and Cambro-Ordovician age. Less than a mile south of Esom Hill, the Cartersville fault which extends southwestward from the Cartersville district marks the northern limit of the highly metamorphosed Paleozoic sediments and Archean crystalline rocks.

[1] Information from H. G. Landrum, Cartersville, 1918.

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