STATE OF ARKANSAS
ARKANSAS GEOLOGICAL SURVEY

George C. Branner
State Geologist

INFORMATION CIRCULAR 1

A BARITE DEPOSIT IN HOT SPRING COUNTY, ARKANSAS

Field Work by Bryan Parks
Text by Bryan Parks with the assistance of
George C. Branner

LITTLE ROCK
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LETTER OF TRANSMITTAL

ARKANSAS GEOLOGICAL SURVEY

Little Rock, Arkansas

January 7, 1932

Hon. Harvey Parnell,
Governor, State of Arkansas,
Little Rock, Arkansas.

Sir:-

I have the honor to submit herewith the report, "A Barite Deposit in Hot Spring County, Arkansas." The field work on this report is by Bryan Parks and the text by Bryan Parks with the assistance of George C. Branner.

The barite deposit described is unique in this country as to its size and method of occurrence and will, it is believed, eventually form the basis of a new mineral industry in this state. There is a possibility of finding other barite deposits in the area which has been studied and suggestions are made for further prospecting.

Respectfully submitted,

George C. Branner

George C. Branner,
State Geologist.

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ABSTRACT

The presence of barite in the northwest part of Hot Spring County, Arkansas, in Chamberlain Creek Valley, has been known since about 1900. However, until October, 1930, no serious attempt was made to prospect the locality. Since this time, a test shaft has been sunk, 27 trenches and pits dug, and 34 holes drilled. Ninety chemical analyses and two flotation tests have been made. A geological survey has been made, both of the deposit and the adjacent area, for the purpose of determining the extent and origin of the barite and the possibility of other deposits.

The deposit is an impure barite, probably of hydrothermal origin, which has apparently replaced relatively porous, sedimentary beds at the base of the Stanley formation of Mississippian age. As now defined, the barite lies on the north flank of a synclinal valley, the west end of which is in contact with the igneous rocks of Magnet Cove.

The greatest known thickness of the barite stratum is 44 feet, measured normally to the bedding plane but this is not known to be the total thickness of the bed. The deposit has been traced for more than three-fourths of a mile. It is probable that at least one million tons of barite over an area of about seven acres are available 100 feet or less below the surface of the ground.

Averages of 15 chemical analyses of the barite give 86.10 per cent barium sulphate, 10.29 per cent silica, 1.28 per cent iron and alumina, and small percentages of magnesia, calcium, and titanium oxides. Flotation tests indicate that concentrates having a tenor of 97 per cent barium sulphate can be obtained.

INTRODUCTION

Barite is a mineral which is widely distributed in small quantities in various types of rocks in Arkansas. It has been found in the manganese and in the lead and zinc districts of northern Arkansas, in southern Pike County, and in Garland County. However, with the exception of the deposit in Pike County, the occurrences which have been known are not likely to be deposits of commercial value, the barite being an accessory mineral of only minor importance.

A deposit of barite has recently been discovered in the extreme northern part of Hot Spring County. It has been prospected and shows promise of becoming an important addition to the non-metallic mineral resources of Arkansas. The deposit, which is an impure, bedded barite, is at present unique in the state in its character, its magnitude, and in its method of occurrence.

In the following report the geology of the region in which the barite occurs is interpreted and the results obtained through exploration of the area and the analyses of samples are given.

Exploration of the barite area has not been completed and many problems remain to be solved, but a start has now been made and it is hoped that this report may encourage further investigation and commercial development of the deposit.

ACKNOWLEDGMENTS

The writer wishes to express his appreciation to the following individuals for valuable assistance rendered:

George C. Branner, State Geologist, for assistance in the preparation of the manuscript; Moritz Norden, of the Wil-Nor Development Company, for valuable personal assistance; S. L. Nevins, of the Southern Acid and Sulphur Company, Inc., for valuable personal assistance and information supplied; Joe W. Kimzey, of Magnet, for information supplied; and John Inglis, Hot Spring County Surveyor, who assisted with the land surveying and the topographic mapping.

NATURE AND USES OF BARITE

Barite, which is sulphate of barium ($BaSO_4$), sometimes called barytes, is a heavy, non-metallic mineral and is usually white, but when impure may be any color. Pure barite has a specific gravity of about 4.5 and has a hardness of 3, about the same as calcite which it sometimes resembles. Barite usually occurs as a granular, coarsely or finely crystalline material, and is easily identified by its heaviness and softness. Barium sulphate can be expressed chemically as 65.7 per cent barium oxide (BaO) and 34.3 per cent sulphur trioxide (SO_3).

Barite commonly occurs as a gangue mineral in metallic ore veins and as thin lenses and veins in almost all kinds of rocks. It is also found in residual clays which have been formed by the weathering of limestone and dolomite, in bedded deposits which have replaced an original rock, and in salt domes associated with gypsum, anhydrite, and other minerals.

Since barite is a heavy, inert, white mineral and can be mined and milled comparatively cheaply, it finds many uses. Its principal use is in the manufacture of lithopone, a white paint pigment consisting of approximately 70 per cent barium sulphate, 26 to 28 per cent zinc sulphide, and 1 to 3 per cent zinc oxide. Other important uses are in the manufacture of barium chemicals and as a filler in the paint, paper, rubber, linoleum, and cloth industries. Crude, finely ground barite is often used to increase the specific gravity of rotary drilling muds.

Table 1 gives the quantity of barite consumed in the United States, (1) in the manufacture of lithopone, (2) as crude ground barite, and (3) in the manufacture of barium chemicals. The figures are taken from the records of the U. S. Bureau of Mines and cover the period 1920-1929 inclusive.

TABLE 1. - Consumption of Barite in the United States
U. S. Bureau of Mines
(1920-1929 Inclusive)

	1920	1921	1922	1923	1924	1925
Lithopone (Short tons)	113,181	61,354	94,259	128,547	137,127	146,693
Crude Ground Barite (Short tons)	79,052	28,296	48,280	47,713	42,855	56,851
Barium Chemicals (Short tons)	37,210	10,952	25,303	34,327	33,181	29,141
Totals (Short tons)	229,443	100,602	167,842	210,587	213,163	232,685

	1926	1927	1928	1929	Totals 1920-1929	Per Cent
Lithopone (Short tons)	178,889	222,791	211,592	206,315	1,500,748	62.1
Crude Ground Barite (Short tons)	69,048	73,119	74,814	54,472	574,500	23.9
Barium Chemicals (Short tons)	33,119	34,280	48,289	38,438	324,240	14.0
Totals (Short tons)	281,056	330,190	334,695	299,225	2,399,488	100.0

PRODUCTION

During 1929 barite was produced in the United States in Missouri, Georgia, Tennessee, California, South Carolina, Virginia, and Wisconsin. Deposits of barite occur in other states but those either have not been developed to any great extent or have not been worked in recent years.

Imports of barite into the United States in 1929 were 85,729 short tons, which amount represented 15.6 per cent of the domestic production during that year. The imports are principally from Germany and are used chiefly by manufacturers along the Atlantic seaboard.

Table 2 shows the annual United States production by states during the period 1920-1929 and the imports during the same period. The figures were taken from the records of the U. S. Bureau of Mines. No exports of barite are reported.

TABLE 2. - Production and Importation of Barite
in the United States
U. S. Bureau of Mines
(1920-1929 Inclusive)

	1920	1921	1922	1923	1924	1925
Missouri						
Sh.tons	99,654	25,200	66,421	81,701	77,189	101,056
Value	$1,013,570	$217,913	$421,568	$629,097	$604,097	$794,927
Av.pr.*	$10.17	$8.65	$6.36	$7.70	$7.38	$7.78
Georgia						
Sh.tons	84,644	24,614	57,045	83,291	71,776	65,936
Value	$790,362	$191,442	$468,517	$670,343	$574,208	$475,618
Av.pr.	$9.34	$7.78	$8.21	$8.05	$8.00	$7.21
Tennessee						
Sh.tons	29,319	8,180	16,642	34,384	39,643	47,012
Value	$213,657	$ 61,148	$124,204	$259,005	$302,873	$345,038
Av.pr.	$7.29	$7.48	$7.46	$7.53	$7.64	$7.34
California						
Sh.tons	2,250	942	3,338	2,925	Not available	
Value	$ 20,850	$ 5,084	$ 17,707	$ 16,053		
Av.pr.	$9.27	$5.40	$5.30	$5.49		
So. Car., Va., & Wis.						
Sh.tons	12,246	7,433	11,594	14,807	7,724	14,059
Value	$104,025	$ 56,371	$ 91,954	$105,711	$ 59,273	$ 87,514
Av.pr.	$8.49	$7.58	$7.93	$6.62	$7.67	$6.22
Total						
Sh.tons	228,113	66,369	155,040	217,108	196,332	228,063
Value	$2,142,464	$531,994	$1,123,950	$1,680,214	$1,540,744	$1,703,097
Av.pr.	$9.39	$8.02	$7.25	$7.77	$7.85	$7.47
Imports						
Sh.tons	24,874	11,054	23,239	15,045	21,502	28,655
Value	$146,858	$ 59,371	$104,680	$ 93,721	$104,264	$ 91,016
Av.pr.	$5.90	$5.37	$4.50	$6.23	$4.85	$3.18
Total of domestic consumption and imports						
Sh.tons	252,987	77,423	178,279	232,153	217,834	256,718
Value	$2,289,322	$591,329	$1,228,630	$1,773,935	$1,645,008	$1,794,113

*Av.pr.-Average price per short ton.

TABLE 2. - (continued)

	1926	1927	1928	1929	Totals 1920-1929	Per cent
Missouri						
Sh.tons	118,919	111,456	114,274	118,679	914,549	42.9
Value	$946,595	$797,465	$810,203	$880,319	$7,116,047	
Av.pr.*	$7.96	$7.15	$7.09	$7.42	$7.40	
Georgia						
Sh.tons	77,654	94,039	112,316	94,118	765,433	35.8
Value	$532,705	$580,300	$675,509	$546,212	$5,505,217	
Av.pr.	$6.86	$6.17	$6.01	$5.80	$6.21	
Tennessee						
Sh.tons	20,910	20,537	20,260	26,140	263,027	12.3
Value	$155,780	$129,999	$150,937	$181,725	$1,924,368	
Av.pr.	$7.45	$6.33	$7.45	$6.95	$7.04	
California						
Sh.tons	4,978	13,919	12,557	24,471	65,380/	3.1
Value	$ 39,326	$ 71,708	$ 51,502	$147,762	$ 369,997/	
Av.pr.	$7.90	$5.15	$4.10	$5.98	$5.78/	
So. Car., Va. & Wis.						
Sh.tons	20,392	14,314	10,137	13,631	126,337	3.9
Value	$138,212	$ 91,406	$ 66,773	$ 94,688	$ 895,927	
Av.pr.	$6.78	$6.39	$6.59	$6.89	$6.66	
Total						100.0
Sh.tons	242,853	254,265	269,544	277,039	2,134,726	84.4
Value	$1,812,619	$1,670,878	$1,754,924	$1,850,706	$15,811,590	
Av.pr.	$7.45	$6.57	$6.51	$6.67	$6.80	
Imports						
Sh.tons	51,016	70,274	61,765	85,729	393,153	15.6
Value	$195,004	$253,284	$190,756	$284,436	$1,523,390	
Av.pr.	$3.82	$3.60	$3.09	$3.20	$3.43	
Total of domestic consumption and imports						
Sh.tons	293,869	324,539	331,309	362,768	2,527,879	100.0
Value	$2,007,623	$1,924,162	$1,945,680	$2,135,142	$17,334,980	

*Av.pr.-Average price per short ton.
/Not including 1924-5.

DISCOVERY AND PRESENT INVESTIGATION

Barite was first discovered in Arkansas in Hot Spring County about 1900 when a water well was dug on the Casey homestead two miles east of Magnet Cove. Because of its heavy weight, the mineral was thought to be a lead mineral and some search for lead minerals was made in this vicinity. Then in 1911 when the well was cleaned out, some of the barite was seen by John Inglis, Hot Spring County Surveyor, of Magnet, Arkansas, who recognized that it was not a lead mineral but who was unable to make a correct identification. Mr. Inglis later took samples to Joe Kimzey, of Magnet, and to A. E. Perkins, a mining engineer, both of whom identified the mineral as barite. In 1915 Mr. Kimzey, in examining the locality, found small fragments of barite mixed with clay and gravel which had been brought to the surface by uprooted trees near the Casey well. By examining the pits made by the uprooting of these trees, Mr. Kimzey was able to trace the barite in a narrow zone for approximately three-fourths of a mile, and by digging in the bottom of the pits encountered solid barite in a few places.

Samples of the barite were first brought to the Arkansas Geological Survey in September, 1928, by E. E. Bonewits, of Little Rock. A specimen was analyzed and found to contain 82.60 per cent barium sulphate and 12.98 per cent silica, the samples being identified as impure barite. The locality in which the mineral occurred was recommended for testing to several persons including Moritz Norden, of the Wil-Nor Development Company, who was referred to Joe Kimzey by the Survey in the late summer of 1930 in regard to the location of the deposit. Mr. Norden became interested and, through the Wil-Nor Development Company, acquired leases and began prospecting.

Soon after the prospecting was begun, the Survey was asked by Mr. Norden to aid in the investigation of the deposit and a cooperative agreement was reached for a geological survey of the area. The writer first visited the locality in November, 1930, and continued field work intermittently until the spring of 1931. At the time of his first visit a test shaft had been put down 16 feet into the barite and a 53-foot trench dug across the deposit. The only exposures then available for study were in these openings. Prospecting was continued slowly during the winter of 1930-1931 and during that period the test shaft was deepened to 43 feet 4 inches and a second trench 83 feet long and a number of small trenches and pits were dug across the barite-bearing beds.

In May, 1931, the Southern Acid and Sulphur Company, St. Louis, Missouri, became interested in the deposit, and acting in accordance with an agreement with the Wil-Nor Development Company, undertook to prospect the north side of Chamberlain Creek Valley with the intention of locating and developing any barite of commercial grade found there. Drilling and chemical work was begun during the third week in May, under the direction of S. L. Nevins, chemical engineer with the company. The writer was employed temporarily by this company to supervise the exploration of the property. Prospecting was continued for four weeks, during which time 34 holes were drilled along the deposit and about 75 analyses made of drill hole cuttings. The drilling and analytical work were suspended on June 15, 1931, and up to the present time (December 30, 1931) the exploration work has not been resumed.

Results obtained from drilling and from analyses made by the Southern Acid and Sulphur Company make up a mass of valuable data which have not been released for publication by this company. With the permission of the company, however, a few references are made to drill hole findings in this report. Even with this additional information knowledge of the barite deposit is not complete. Much remains to be learned.

GEOGRAPHIC RELATIONS

Location and Access

The barite deposit described in this report is located in the northern part of Hot Spring County in the central part of Township 3 S., Range 17 W. (See Plate I). The deposit lies mostly in the SE.$\frac{1}{4}$ of Section 10 on the north side of a valley drained by Chamberlain Creek, a small intermittent stream. This valley lies immediately northeast of Magnet Cove and north of the postoffice of Magnet.

The railroad nearest to the barite deposit is the Chicago, Rock Island and Pacific, which crosses the region about three miles south of Chamberlain Creek Valley. The nearest loading switch on this railroad is at Butterfield station. The distance by road to Butterfield is 5.6 miles, all of which, except three-fourths of a mile in Chamberlain Creek Valley, is over improved state and county roads. The Benton-Hot Springs branch of the Missouri Pacific Railroad passes five miles north of Chamberlain Creek Valley but there are no improved roads in this direction. The distance from the deposit by improved road to Malvern on the main line of the Missouri Pacific Railroad is 8.5 miles, and to Hot Springs 16.5 miles.

Culture and Vegetation

There are no towns near Chamberlain Creek Valley which warrant the name and the region as a whole is sparsely settled. Magnet, the nearest postoffice, consists of a general store, garage, and filling station.

With the exception of the area within Magnet Cove, the soil for the most part is not very fertile. The rough, broken character of the terrain and the sandy character of the soil make the country more adaptable to timber growing than farming. Much of the land, particularly along the slopes of the hills and in the more rugged valleys, is at present given over to timber growing.

TOPOGRAPHIC RELATIONS

Relief

Chamberlain Creek Valley is in an area of low, parallel or nearly parallel ridges and valleys. (See Plate II). The relief of the ridges usually does not exceed 225 feet. The ridges gradually become lower to the east, disappearing beneath the Coastal Plain sediments a few miles east of Magnet and trend from a northeast-southwest to a nearly east-west direction. North and east of Chamberlain Creek Valley they belong to the Zigzag Mountain group, a system of northeast-southwest trending ridges and valleys of the Novaculite Uplift, and are the topographic expression of plunging anticlines and synclines. The ridges of this group are steep, sharp, and even-crested, usually connected at one or both ends, and are disposed in a characteristic zigzag pattern. The crests are formed usually by the resistant beds of Arkansas novaculite formation. The small streams which drain the steep slopes have cut back into the ridges and formed numerous spurs and hollows. The larger streams have, in a few places, cut their courses across the resistant strata and formed rugged water gaps. Plate III, A, shows the typical relief of a ridge of Arkansas novaculite in the vicinity of Chamberlain Creek Valley.

Cove Creek, the master stream of this area, flows in a valley about 225 feet below the tops of the adjacent ridges. Lucinda and Chamberlain Creeks, which are tributaries of Cove Creek, have cut the valleys they drain to only about 125 feet below the crests of the adjacent ridges.

A. SCULL CREEK WATER GAP THROUGH NOVACULITE RIDGE

Scull Creek water gap showing typical relief of novaculite ridge in vicinity of Chamberlain Creek Valley.

B. VIEW AT SHAFT

The Zigzag ridges adjacent to Chamberlain Creek Valley stand at an elevation of about 700 feet above sea level. Northwest of the Valley they become increasingly higher, and north of Hot Springs they have an elevation of more than 1,400 feet. The ridges along the present Coastal Plain boundary are poorly defined and their elevation is approximately 550 feet.

Drainage

The Arkansas novaculite ridges north and east of Magnet Cove act as a water shed separating the Saline and Ouachita River drainage systems. The Ouachita River drains the Mazarn Basin south of the Zigzags, and the Saline River drains the basin lying north of these mountains. Both rivers escape from their respective topographic basins and follow meandering courses in a southeasterly direction across the Arkansas Coastal Plain area.

The drainage system of the area under discussion is shown on Plate I, page 10. The streams for the most part conform to the structural features and their courses are strongly influenced by the location of alternating hard and soft strata. Some of the creeks, such as Cove Creek, Chamberlain Creek, and Teager Creek, flow through synclinal valleys, while a few, such as Scull Creek, Boss Allen Creek, and Basin Creek, have cut rough, irregular valleys along the crests of truncated anticlines. In some of the synclinal valleys, notably Chamberlain Creek Valley, the trellis type of drainage system, characteristic of parallel ridges and valleys, is well exhibited.

GEOLOGIC RELATIONS

Physiography

The Ouachita Province of Arkansas lies south of the Ozark Highlands and north of the Gulf Coastal Plain. The Ouachita Province is divided into two sub-provinces, the Arkansas Valley, a great topographic and structural trough, and the Ouachita Mountains, a complexly folded area. The Ouachita Mountains are divided into the Fourche Mountains on the north, and the Novaculite Uplift and the Athens Piedmont Plateau on the south. The Novaculite Uplift occupies the central portion of the folded area and several minor groups of mountains or ridges are distinguished in this Uplift.[1] These minor mountain groups are separated by relatively broad basins or structural troughs. The Zigzag Mountains and Trap Mountains, separated by the Mazarn intermontane basin, are examples of this relation. Chamberlain Creek Valley is located in the extreme southeastern part of the Zigzag Mountain group. The zigzag arrangement of the ridges in this group causes the synclinal valleys to open into the Mazarn Basin and the anticlinal valleys into the Saline basin.

Stratigraphy

The sedimentary rocks exposed over the region discussed in this report are principally sandstones, shales, novaculites,

[1] Croneis, Carey G., The geology of the Arkansas Paleozoic area; Arkansas Geol. Survey Bull. 3, 1930, p. 447.

and cherts, and several geologic periods are represented. Igneous and metamorphic rocks also occur and are described in the next section.

The oldest sedimentary rocks which outcrop are of Paleozoic age and represent the Ordovician, Silurian, Devonian, and Carboniferous periods. Except for a few scattered areas, the younger rocks, mostly unconsolidated, lie east of the present Coastal Plain boundary and are of the Tertiary and Quaternary periods. Terrace deposits, probably of Tertiary age, occur at a few points west of the Coastal Plain boundary.

Geologic Section

The geologic section of the Chamberlain Creek Valley area, together with a description of its character and the thickness of each formation, follows.

TABLE 3. - Geologic Formations
Exposed in the Chamberlain Creek Area

System	Series	Formation and Thickness	Character of Rock	Distribution
Carboniferous	Mississippian	Stanley Shale 300'+	Bluish-black and black, fissile clay shale and fine-grained, compact gray sandstone in thin and thick layers. In the Chamberlain Creek area the sandstone is best developed near the base of the formation. Immediately adjacent to Magnet Cove, the Stanley shale has been metamorphosed to a dark, compact rock resembling hornestone. Numerous joints occur in the shale and sandstone.	Surface rock over the Mazarn Basin and the synclinal valleys of the Zigzag and Trap Mountains. Outcrops are not uncommon but are best exposed along the stream beds and in the road cuts.
		Hot Springs Sandstone 50'±	Hard gray, massive, quartzitic sandstone. The fresh rock has a glazed appearance, but weathered specimens are soft and porous and often tinted with iron oxides. Adjacent to Magnet Cove the sandstone has altered to a white, coarse-grained, porous sandstone.	Occurs along the synclinal slopes of the ridges of Arkansas novaculite, and sometimes forms low, well rounded ridges.
Devonian ?		Middle* 200'±	Thin bedded novaculite with much siliceous shale, generally black, but contains beds of red flinty shale, some of which is high in iron oxides.	Occurs along slopes of the ridges of Arkansas novaculite. Outcrops are very few because of soft character. The position of the Middle Arkansas novaculite is usually determined by the presence of surface soil between the Hot Springs sandstone and the massive novaculite. Road cuts sometimes expose the shale.
?	-	Arkansas - -Novaculite- 500'±	- - - ? - - - ? - - - ? - - -	- - - ? - - - ? - - -

* C. L. Cooper classifies the Middle Arkansas novaculite as Mississippian. See bibliography.

TABLE 3. - (continued)

System	Series	Formation and Thickness	Character of Rock	Distribution
Devonian		Lower 300'±	Massive white novaculite some of it tinted red, gray, green, yellow, and brown. Easily identified by its smooth, compact appearance, conchoidal fracture, and by sharp angular fragments. Novaculite adjacent to Magnet Cove has metamorphosed to a dark, fine-grained rock, composed of small, clear crystals of quartz, some of which have a smoky appearance.	Most conspicuous rock in the area and forms the crests of all the high ridges adjacent to Chamberlain Creek Valley. Where outcrops are not exposed, presence of the massive novaculite is readily detected by the abundance of fragments of Arkansas novaculite, some of large size.
Silurian		Missouri Mountain Shale 50'-100'	Mostly black, clay shale which in places has developed slaty cleavage. Weathers light gray to white and forms light colored clay.	Occupies a narrow belt along the slopes of the anticlinal ridges. Usually covered by surface soil.
		Blaylock Sandstone 0'-500'	Thin bedded, fine-grained, gray sandstone, separated by layers of dark shale. The sandstone beds are prominently jointed, the smaller joint cracks being usually filled with quartz. Quartz crystals occur in larger cavities. Some of the beds are hard and quartzitic.	Found along the slopes of the anticlinal ridges. Outcrops are not uncommon but are usually not continuous. Sometimes forms low, well rounded ridges and bluffs. Can be distinguished from the Hot Springs sandstone by its thin beds, smaller sand grains, less quartzitic appearance, and prevalence of quartz veins.
Ordovician	Upper Ordovician	Polk Creek Shale 50'-100'	Black, fissile shale, rather easily identified by the presence of graptolites. In a few places has developed slaty cleavage.	Best exposed in stream beds in the anticlinal valleys. Along the slopes of the anticlinal ridges is usually covered by surface soil.

TABLE 3. - (continued)

System	Series	Formation and Thickness	Character of Rock	Distribution
Ordovician	Middle Ordovician	Big Fork Chert 300'+	A dense textured, dark, siliceous rock which is usually chert. The rock is highly jointed. Many of the joints are invisible. Fresh specimens are hard to obtain because of the ease with which the rock breaks down into small smooth sided, angular pieces. Some of the rock has the appearance of dense quartzite.	Forms low, well rounded hills, which are covered with an abundance of angular fragments in the anticlinal valleys. Best exposures are found in creek beds, but the presence of the rock can be detected by an abundance of talus, which is distinguished from novaculite talus by its darker color and lack of conchoidal fracture.
	Lower Ordovician	Womble Shale 250'+	Black and green clay shale.	Found in the Saline Basin but does not occur in the close folded anticlinal valleys of the Zigzag Mountains.

Igneous and Metamorphic Rocks

Igneous areas, other than dikes and sills, occur at three places as follows: (1) Magnet Cove in the eastern part of the Mazarn Basin with an area of 5.1 square miles; (2) the Potash Sulphur Springs area, three miles west of Magnet Cove, less than one-third square mile in extent; and (3) a smaller area located near the mouth of Gulpha Creek in Section 34, Township 2 S., Range 18 W. In addition to these relatively large areas, more than 200 dikes and sills are known in the Mazarn Basin, most of which lie west of Magnet Cove. The igneous rocks of the three large areas are largely nepheline syenites and related alkaline rocks. The dikes and sills are composed of nepheline syenite and the more basic tinguaites and monchiquites which are high in ferro-magnesian minerals.

The igneous area known as Magnet Cove lies immediately west of the postoffice of Magnet, Arkansas. The area is roughly elliptical in outline, about three miles across, and includes about 5.1 square miles. The area has been well known for nearly one hundred years as a collecting place for rare igneous rocks and mineral specimens. The presence of minerals of commercial value has been suspected and some prospecting has been done, but the sale of rare mineral specimens has been the only profitable endeavor. At the present time the Titanium Corporation of America is installing a plant in Magnet Cove for concentrating the rutile-bearing soils. A detailed discussion of the rocks and minerals found at Magnet Cove is given in a former publication of the Arkansas Geological Survey.[2]

No attempt is made to describe Magnet Cove in detail in this bulletin, but attention is called to the importance of this area as a source of mineralizing solutions. Rutile, brookite, pyrite, and barite minerals which have been found in considerable quantity in the sedimentary rocks adjacent to the Cove were probably deposited by solutions which invaded the nearby metamorphic and unaltered rocks.

The igneous rocks of Magnet Cove were intruded into highly folded Paleozoic rocks in post-Pennsylvanian time. The period of the intrusion is thought by Miser[3] to have occurred during the late Lower Cretaceous or early Upper Cretaceous time.

Structure

An interpretation of the structural forms in the area discussed in this bulletin was gained from a study of the truncated edges of the exposed highly inclined beds. These beds represent the flanks of anticlines and synclines, the crests of the folds having been eroded. The prevalence of folds which have approximately the same degree and direction of dip on each flank, and the difficulty in correlating formations, often make the interpretation of structure difficult. Fossil remains as an aid to correlation are very rare with the exception of graptolites in the Ordovician shales.

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[2] Williams, J. Francis, Igneous rocks of Arkansas; Arkansas Geol. Survey Ann. Rept., 1890, vol. 2, pp. 193-322.

[3] Purdue, A. H., and Miser, H. D., U. S. Geol. Survey Geol. Atlas, Hot Springs folio (No. 215), 1923.

The anticlines and synclines are of the overturned isoclinal type, that is, the beds on both flanks of the structures have dips of approximately the same degree and direction. In the Zigzag Mountains, the folds are overturned toward the southeast, the strata dipping to the northwest. In the Trap Mountains, the folds are overturned toward the north, and the beds dip to the south. The folds exposed in the Zigzag and Trap Mountains presumably continue beneath the Mazarn Basin, but are covered by an immense thickness of Stanley shale which only shows minor wrinkling on the surface.

Major folding was accompanied by some faulting, but this is not a pronounced structural feature within the area. The faults observed occur along the crests of the anticlines and are of the thrust type.

Another effect of the intense folding to which the region has been subjected can be seen in the highly jointed condition of the massive and rigid beds which occur especially in the Arkansas novaculite and the Bigfork chert. These joints appear in several sets but are most prominently developed normal to the bedding planes. Joints also occur which are invisible but which become apparent when the rock is struck a sharp blow, causing it to break up into many smooth-sided fragments.

Joints are known to facilitate the movement of underground water and mineralizing solutions, and may have been, therefore, of considerable importance in connection with the formation of the barite deposit.

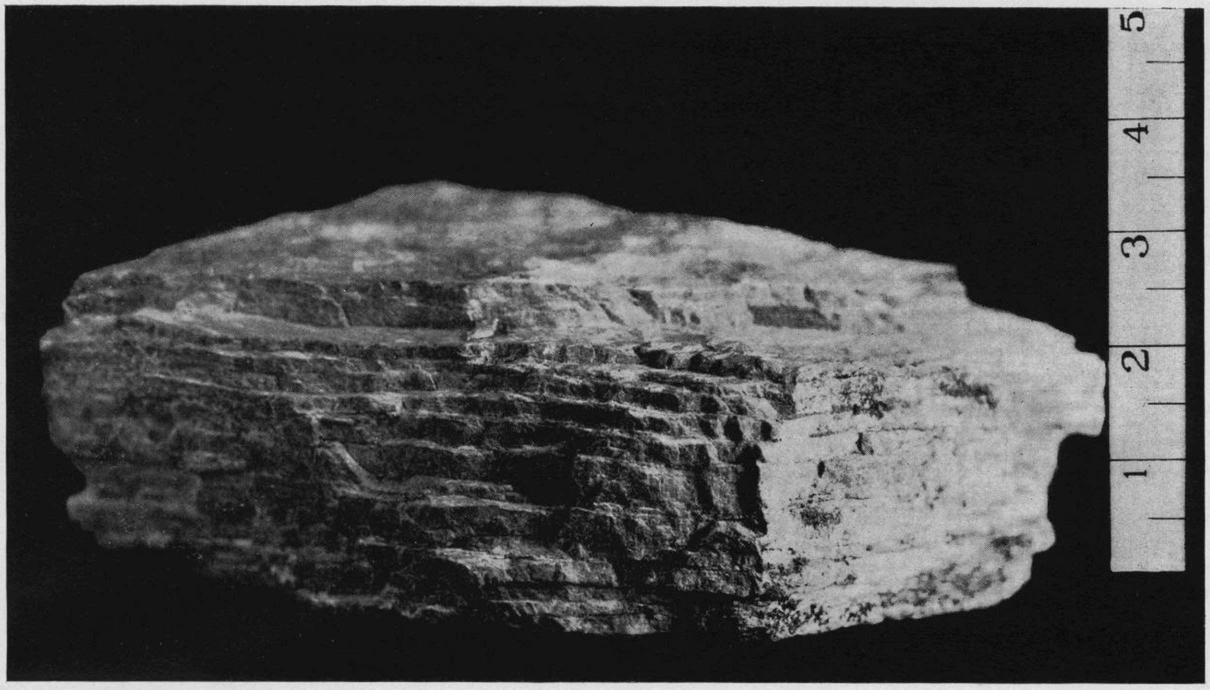
DESCRIPTION OF THE BARITE DEPOSIT

Character and Physical Properties

The barite in Chamberlain Creek Valley is stratified and has the appearance of fine-grained, sedimentary rock. The individual beds are from less than one inch to about two feet in thickness and are, for the most part, light or dark gray in color. The barite is interbedded with layers of light and dark colored clay, which vary in thickness from the thinness of a knife blade to twenty inches.

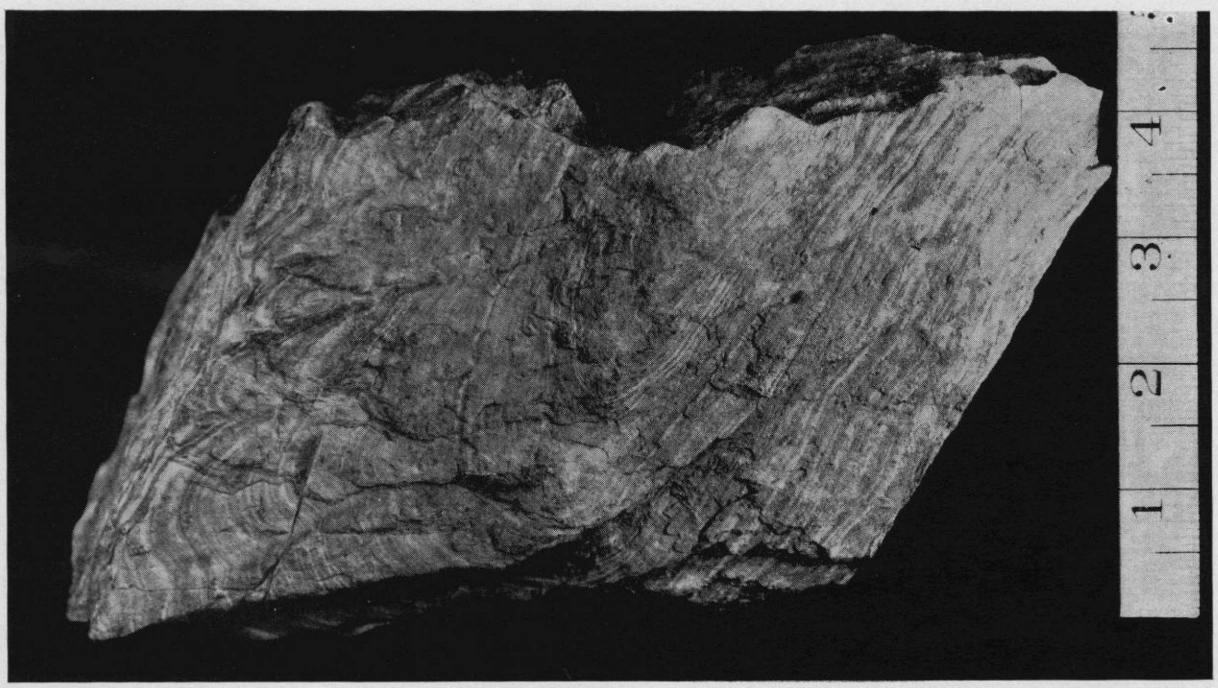
The barite beds are jointed and for this reason break up into parallelogram-shaped blocks when loosened. The small joint cracks are usually filled with white, coarsely crystalline barite. Distinct lamination is noticeable in most of the beds which often causes them to have a shaly appearance. The texture does not vary materially and when examined under a hand lens it appears dense and fine grained. When examined under a microscope it has an angular, crystalline structure, usually without definite crystal outlines.

The specific gravity of fifteen barite samples varied from 3.4 to 4.0 with an average of 3.7. This range of density is less than the figures ordinarily given for pure barite which are from 4.3 to 4.6. This may be due to the high silica content and possibly, to some extent, to porosity. The greater part of the barite may be classed as a soft variety while portions of the deposit are comparatively hard.



A. SPECIMEN OF THINLY BEDDED BARITE

These beds are separated by seams of clay which is banded with hematite and limonite. Bands are shown on B, below.



B. SAME SPECIMEN AS ABOVE, ON EDGE, SHOWING BANDING ON BEDDING SURFACE

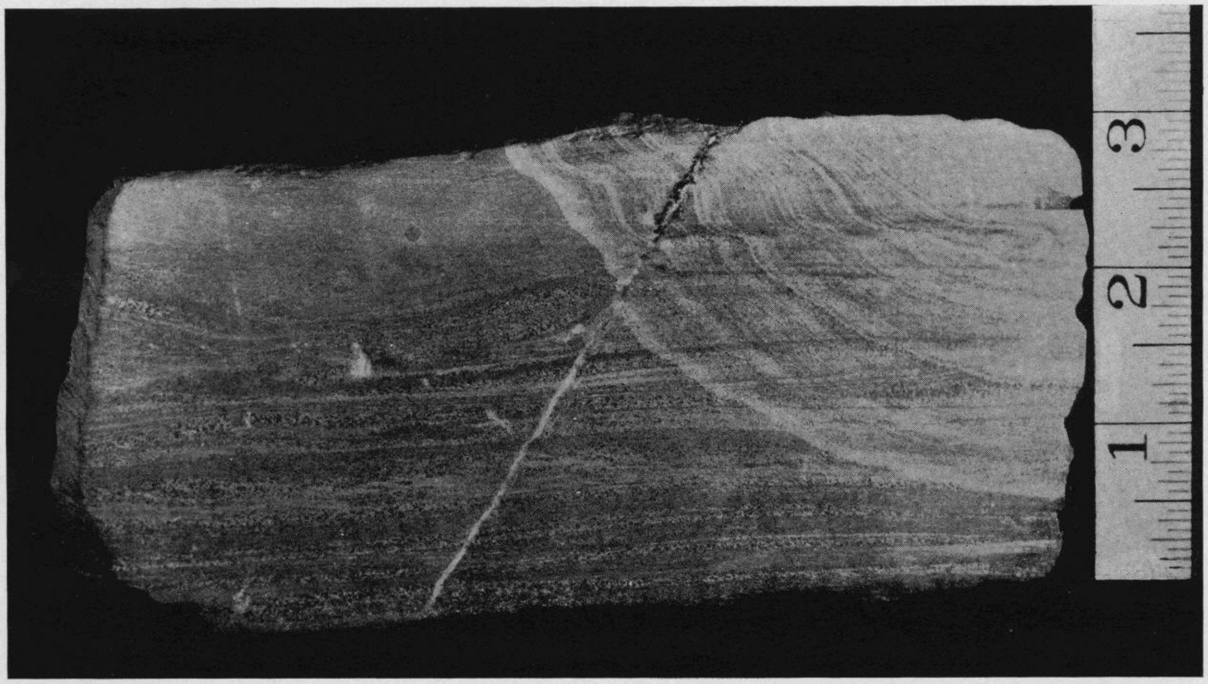
The thin bedded barite is usually crossed by bands of pink hematite less than two-tenths of an inch in width. The bands are not straight but are irregular or wavy and are more pronounced along the bedding planes. (See Plates IV and V). The pink banding is due to the oxidation of the pyrite to hematite and limonite, and it is the writer's opinion that this was caused by surface waters. The nature of the pink banding was determined by examinations of thin sections of the barite by W. Harold Tomlinson, petrographer. The pyrite lies in bands in the barite which are more or less parallel to the bedding plane whereas the pink banding usually is best exhibited along the bedding surfaces. The petrographic report by Mr. Tomlinson follows:-

"Sample 1 (from specimen shown on Plate V,A) is a fine-grained, crystalline, granular barite of more than 95 per cent purity. The structure shows a banding due, in part, to difference in coarseness of grain and, in part, to inclusion of impurities. The grain varies from .01 to .001 inch in diameter. Impurities consisting of clay and colloidal hematite were found in very small amounts. These lend color to the banding.

"Sample 2 (from specimen shown on Plate IV). Some bands of this sample are nearly pure crystalline barite, others show a considerable percentage of clay, pyrite, and mica shreds. The gray and green banding is due to differences in amounts of impurities in adjacent bands.

A. LIGHT GRAY, MASSIVE BARITE

Laminations appear very indistinctly. The smooth faces shown are joint planes which are covered with a thin layer of white, coarsely crystalline barite.



B. LAMINATED, COMPACT, GRAY CLAY SHOWING PINK AND WHITE BANDS

Barite is disseminated as fine crystals through the clay. The joint crack shown is filled with white, coarsely crystalline barite. The pink bands are composed of fine particles of soft, reddish hematite caused by oxidation of pyrite.

"Sample 3 (from specimen shown on Plate IV). The apparent banding showing red and yellow on the flat face of this sample is a surface oxidation of pyrite along fracture planes in the barite and not a true banding. The red color is due to colloidal red hematite and the yellow to a stain of hydrated oxide of iron. There is not any true banding in this sample. The formation has been broken up and invaded along straight planes of fracture by oxidizing waters. The impurities, where found, are in irregular stringers.

"Sample 4 (from specimen shown on Plate V,B) is relatively impure. Section shows about 8 per cent quartz sand, 6 per cent mica, a considerable quantity of clay and about 4 per cent pyrite in the green bands or hematite in the red bands. As in the other samples, the red bands are due to hematite coloring and the green or gray to pyrite and mica.

"Sample 5 (from specimen shown on Plate V,B) resembles sample 4. The green bands contain a considerable amount of pyrite which in its arrangement conforms to the banding. The red bands contain a similar amount of hematite but in these bands the hematite does not conform in its arrangement to the arrangement of the pyrite in the green bands. In other words the red bands depend for their direction on penetration of oxidizing conditions which did not follow the original banding but cut across it at an angle."

Chemical Properties

Twelve carefully selected representative samples were collected by the writer for analysis from the shaft, holes, and trenches, the locations of which are given on pages 28 and 29. Two samples collected by Moritz Norden and one by E. E. Bonewits were also analyzed. In all of the samples collected for analysis the clay seams were excluded. The samples were crushed, thoroughly mixed and, if wet, were dried but were not washed or cleaned in any way. The results are given in Table 4, page 27. A description of the locations from which the samples were obtained follow Table 4.

The chemical composition of the barite affords an interesting study. The barium sulphate content of the 15 samples varies from 75.98 per cent to 92.92 per cent. The principal mineral associated with the barite is silica which in the 15 samples varies from 3.30 per cent to 21.73 per cent. The remaining impurities are principally iron and aluminum oxides with lesser amounts of magnesium and titanium oxides. The presence of titanium oxide in 12 samples submitted, although small, may be significant in view of the abundance of titanium in the Magnet Cove rocks. No iron sulphide as such was reported although this mineral did appear in barite cuttings from a few of the test holes drilled down the dip of the stratum and in small amounts near the base of the barite beds in the shaft. In all of the analyses, sulphate is present in small excess of the amount necessary to satisfy the barium sulphate requirements. Part or all of this excess may be present as iron sulphide.

In the three samples from the test shaft the average barium sulphate content is 89.30 per cent and the silica 6.93 per cent. In three samples from Trench 1, the average barium sulphate content is 86.95 per cent and the silica 9.27 per cent. In three samples from Trench 2, the average barium sulphate content is 87.60 per cent and the silica 9.16 per cent, which is approximately the same as Trench 1. The average barium sulphate content for the entire 15 samples is 86.09 per cent and the silica 10.49 per cent.

TABLE 4. - Results of Analyses of 15 Barite Samples

W. F. Manglesdorf, Analyst

February 28, 1931

	Loss on ig.	SiO_2	Fe_2O_3	Al_2O_3	MgO	TiO_2	Ba	$BaSO_4$	Total SO_4	Sulphur from excess SO_4
#1	0.92	3.30	0.56	0.55	0.25	0.06	54.68	92.92	39.28	0.34
#2	0.88	6.61	0.88	0.40	0.29	0.08	52.88	89.86	37.84	0.29
#3	0.82	10.88	1.16	0.38	0.33	0.10	50.09	85.12	35.81	0.26
#4	0.94	8.52	0.30	0.22	0.36	0.08	51.83	88.08	36.99	0.25
#5	0.98	5.06	0.68	0.46	0.17	0.07	53.70	91.25	38.33	0.26
#6	1.02	14.15	1.56	0.64	0.25	0.07	47.97	81.52	34.25	0.23
#7	0.89	8.62	0.64	0.44	0.22	0.07	52.07	88.48	37.04	0.22
#8	0.88	10.20	0.72	0.44	0.24	0.05	51.07	86.78	36.37	0.22
#9	1.10	8.66	0.84	0.64	0.41	0.08	51.46	87.44	36.59	0.20
#10	1.26	10.25	1.20	0.54	0.19	0.09	50.32	85.50	35.93	0.25
#11	0.92	5.28	0.96	0.90	0.26	0.07	53.48	90.88	38.10	0.23
#12	1.24	16.85	1.04	0.48	0.33	0.08	46.70	79.36	33.25	0.20
Average	0.99	9.03	0.92	0.51	0.28	0.08	51.35	87.26	36.65	0.25

	SiO_2	Fe_2O_3+Al_2O_3	MgO	CaO	Ba	$BaSO_4$	Total SO_4	Sulphur from excess SO_4
#13	12.98	0.75	0.12	1.18	48.41	82.60	34.90	0.24
#14	21.73	0.52	0.00	0.00	44.70	75.98	32.10	0.27
#15	11.32	0.79	0.10	0.08	50.44	85.72	36.20	0.31
Average	15.34	0.68	0.07	0.42	47.85	81.43	34.40	0.27
Av. 15 samples	10.29	1.28	0.23		50.65	86.10	36.20	0.25

Location and Description of Sample

SAMPLE 1

From shaft, $32\frac{1}{2}$ feet below surface. Sample trench 2 inches deep, 3 inches wide, and 12 inches long. Soft, pink banded, gray and thin bedded.

SAMPLE 2

From shaft, 16 feet below surface. Sample trench 2 inches deep, 3 inches wide, and 18 inches long, cut approximately at right angles to the bedding plane. Gray and thick bedded.

SAMPLE 3

From shaft, 4 feet below top of barite. Sample trench 2 inches deep, 4 inches wide, and 30 inches long, cut at right angles to bedding plane between two bands of pink banded, gray clay. Pink banded, thin bedded.

SAMPLE 4

From near north wall in Trench 1. Sample trench 2 inches deep, 6 inches wide, and 30 inches long, cut across exposed edges of barite beds. Thin seams of yellow clay separated some of the barite layers. Overburden 24 inches of yellow gravel and clay.

SAMPLE 5

From 5 feet south of sample 4, Trench 1. Sample trench 2 inches deep, 6 inches wide, and 40 inches long. Same appearance as sample 4.

SAMPLE 6

From near south end of Trench 1. Sample trench 2 inches deep, 6 inches wide, and 20 inches long. Gray with pink bands and thin bedded.

SAMPLE 7

From Trench 2 near the base of the barite. Cut from exposed ledge. Sample trench 2 inches deep, 4 inches wide, and 60 inches long. Gray and massive bedded. Overburden 27 inches, yellow and red clay and gravel.

SAMPLE 8

From 15 feet south of sample 7, Trench 2. Sample trench 2 inches deep, 3 inches wide, and 48 inches long. Thick bedded and gray. Overburden 54 inches, yellow clay and gravel.

SAMPLE 9

From south end of Trench 14. Sample trench 2 inches deep, 4 inches wide and 36 inches long. Overburden 36 inches, yellow clay.

SAMPLE 10

From Hole 8. Sample trench cut across edge of bed 2 inches deep, 3 inches wide, and 18 inches long. Thin bedded. Overburden 42 inches, yellow clay and gravel.

SAMPLE 11

From Hole 9, south end of trench. Sample trench 2 inches deep, 6 inches wide, and 20 inches long. Gray with pink banding and thin bedded. Overburden 48 inches, yellow clay and gravel.

SAMPLE 12

From Hole 27, from ledge 30 inches thick near center of hole. Purplish and thick bedded. Much of the sample is made up of nodular pieces having a radiating or rosette structure.

SAMPLE 13

Barite float collected near shaft by E. E. Bonewits.

SAMPLES 14 and 15

Collected by Moritz Norden from the shaft. Depths not known.

Description of Prospects

Following is a description of the prospecting done by the Wil-Nor Development Company and others prior to May 18, 1931. The location of the shaft, trenches, and holes are shown on Plate VI, A.

Shaft and Trenches

SHAFT

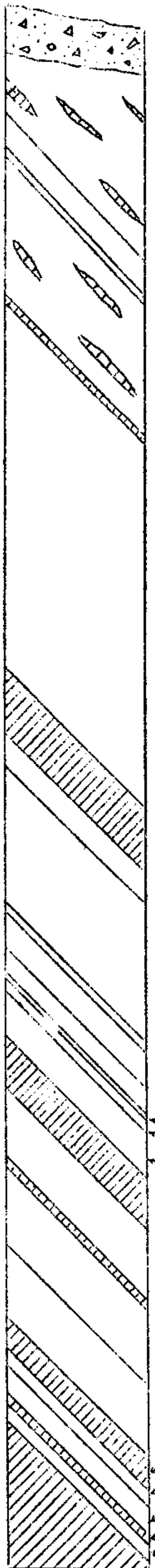
The sinking of a test shaft represented the first major prospecting effort. The shaft, 4 feet by 6 feet, was sunk in the SW.$\frac{1}{4}$ SE.$\frac{1}{4}$ of Section 10, Township 3 S., Range 17 W., where small fragments of the barite float were found. A view at the shaft is shown on Plate III,B, page 13. The overburden consisted of 15 inches of yellow clay and gravel containing barite float. Solid barite was then encountered and it continued, interbedded with clay seams of different thickness, to a depth of 40 feet 11 inches below the surface. Below this, a dark gray, almost black clay was encountered and digging was stopped after penetrating this clay 29 inches. The total depth of the shaft is therefore 43 feet 4 inches. The analyses of three channeled samples from the shaft (No. 1, 2, and 3) are given in Table 4, page 27.

The barite layers from top to the bottom of the shaft dip uniformly 43°, South 10° East.

The origin of the compact dark gray clay below the barite is not known. This material was encountered in 33 of the drill holes of the Southern Acid and Sulphur Company below the barite, with possibly one exception. The maximum thickness penetrated in drill holes was 22 feet. It contains a few thin streaks of barite and carries pyrite in small cubes and in thin, nodular, concretionery layers. After exposure to weathering, this clay gradually turns white. The fragments of the weathered clay are soft but not plastic and are distinctly fissile.

A test hole drilled in the bottom of the shaft encountered pink tinted quartzite at $11\frac{1}{2}$ feet (54 feet 10 inches below the surface). What is probably the same bed of quartzite, outcrops about 60 feet north of the shaft at which position it would be expected to appear, assuming the dip of the quartzite to be the same as the barite. The outcropping quartzite is part of the Hot Springs sandstone formation.

The thickness of the barite in the shaft is 39 feet 8 inches, measured vertically, and 29 feet measured at right angles to the bedding plane. However, as the shaft was not started at the upper contact of the barite with the Stanley shale, the entire thickness of the barite stratum at this point is not known. Excluding the overburden and the layers of black clay below the barite, the percentages of barite and clay as exposed in the shaft are approximately 84 per cent and 16 per cent respectively. It is not known whether or not this ratio of barite to clay will hold for the entire deposit but it probably does not, as the layers of clay in the shaft are lenticular and pinch out across the face of the shaft. A detailed columnar section of the beds penetrated by the shaft is given in Figure 1.



15½ in.	- Surface soil and yellow clay with small fragments of novaculite, quartzite, and barite.
40 "	Thin bedded barite with thin, yellow clay seams.
16 "	Thin bedded, pink banded barite.
4½ "	Thin bedded, gray barite.
45 "	Thin bedded, pink banded, gray barite with thin irregular seams of yellow clay.
4 "	White, plastic clay.
120 "	Thin bedded, pink banded, gray barite.
20½ "	Pink and white banded compact clay.
11 "	Thick bedded, gray barite.
45 "	Thick bedded, pink banded, gray barite.
4 "	White barite and pink banded, gray barite, all thin bedded.
12 "	Thin bedded, pink banded barite.
10 "	Soft white barite.
2 "	Thin bedded, pink banded barite.
4 "	White barite.
12 "	Pink banded, gray barite.
18 "	Dark gray, compact clay.
22 "	Thick bedded, pink banded, gray barite.
4 "	Pink and white banded clay.
25 "	Thick bedded, pink banded, gray barite.
24 "	Thin bedded, pink banded, gray barite.
12 "	Pink banded, compact clay.
6 "	Pink banded barite.
10 "	Thin bedded, dark gray barite.
4½ "	Dark gray, compact clay.
6 "	Dark gray barite.
29 "	Dark gray, compact clay, containing small cubes and nodules of pyrite.

Figure 1. - Detailed section of barite bed as exposed in shaft. Total depth, 43 ft. 4 in.

TRENCH 1

At the time the test shaft was being sunk, Trench 1 was dug 100 feet to the east. This crosses the edge of the barite beds in a South 10° East - North 10° West direction. The depth of the trench is from 3 to 6 feet, the width 2 to 5 feet, and the length 53 feet. At the north end, the barite was found under about 18 inches of yellow soil and gravel, and at the south end, down the slope of the hill, the overburden increased to 3 feet. One hundred feet south of the south end of the trench over 12 feet of surface soil was penetrated in a drill hole. The bottom or foot wall of the barite seems to have been uncovered at the north end of the trench in the form of yellow sandy clay which may be a weathered phase of the dark clay encountered at the bottom of the shaft. The barite dips 43°, South 10° East. Clay seams are interbedded with the barite, but could not be correlated with the layers of clay in the shaft because weathering had changed their color and texture. Three samples of barite (Nos. 3, 4, and 5) were obtained from this trench and the analyses are given in Table 4, page 27. A cross section of Trench 1 is shown on Plate VI,B, page 30.

TRENCH 2

Trench 2 was the second trench dug and was located 140 feet west of the shaft. This trench is not parallel to Trench 1, but was dug in a South 20° West - North 20° East direction. The depth is 5 feet, the width 4 feet, and length 83 feet. Pink banded, gray barite in thin and thick beds is exposed in the entire length of the trench. The barite dips 47°, South 10° East. The amount of overburden in this trench increases down the slope of the hill from 2 feet to 4 feet. The north end of the trench was dug 6 feet in red clay and gravel which seems to be below the base of the barite. A cross section of Trench 2 is shown on Plate VI,B, page 30.

Information Obtained from Shaft and Trenches 1 and 2

The information obtained from digging the shaft and two trenches proved the possibility of a large deposit of the barite within a small area.

Prospects

Following the completion of the shaft and Trenches 1 and 2, small trenches and holes were dug east and west of Trenches 1 and 2, along the strike of the beds to determine the length of the deposit. A description of the small trenches and holes, beginning in the eastern portion, follows:

PROSPECT 3

Hole 11 feet north of the north end of Trench 1. Depth, 6 feet. No barite was found.

PROSPECT 4

Hole originally dug as a water well on the Brady farm. Three feet of barite was penetrated under 3 feet of clay and gravel overburden. The barite dips 30°, South 30° West. No barite fragments were found on the surface near this well.

PROSPECT 5

Hole 4 feet deep and 3 feet square. Barite was found in the debris, but no bedded material was encountered. No barite fragments were found on the surface near this hole.

PROSPECT 6

Hole originally dug as a water well on the Casey farm and in which the barite was first discovered. Hole 18½ feet deep, and penetrates sandy barite one foot. Overburden consists of 7 feet of yellow clay and gravel and 10½ feet of gray, sandy shale with thin seams of barite.

PROSPECT 7

Circular pit 3 feet deep and 9 feet in diameter. According to rumor, hole was dug as a lead prospect. The pit which perhaps was originally deeper than at present does not pass through any bedded barite. The debris around the pit contains barite fragments.

PROSPECT 8

Trench 6 feet deep, 2½ feet wide, and 21 feet long. Bedded barite is exposed in the south half and dips 32°, South 35° West. A hard, yellow, sandy clay which is tinted pink, is exposed in the north half of the trench near the barite. The overburden is 4 feet of clay and gravel.

PROSPECT 9

Trench 5 feet deep, 2 feet wide, and 16 feet long. Solid barite was encountered which dips 30°, South 20° West. The overburden is 3½ feet of clay.

PROSPECT 10

Trench 6 feet deep, $2\frac{1}{2}$ feet wide and 11 feet long. Barite is well exposed in solid layers in the south half of the trench, but is not well exposed in the north half which contains mostly pink and yellow sandy clay. The barite dips 26°, South 20° West and is pink banded, gray in color and thin bedded. It closely resembles the barite found in Prospects 4, 5, 6, 7, 8, and 9.

PROSPECT 11

Trench 4 feet deep, $2\frac{1}{2}$ feet wide and 10 feet long. Bedded barite was encountered but is not well exposed, probably because the hole was not dug deeply enough. The clay debris contains an abundance of barite fragments mixed with small boulders and fragments of quartzite and novaculite.

PROSPECTS 12 and 13

Two holes dug about 80 feet east of Trench 1. No barite was found in either hole. Prospect 12 was evidently dug north of the barite. Prospect 13 was only $3\frac{1}{2}$ feet deep and probably not of sufficient depth to reach the barite.

PROSPECT 14

Trench 6 feet deep, $2\frac{1}{2}$ feet wide, and 11 feet long. It trends east-west and is 30 feet east of Trench 1. Bedded barite was exposed. The beds dip 42°, South 10° East. There are 4 feet of overburden of yellow clay containing small, angular fragments of novaculite.

PROSPECT 15

Hole dug 200 feet west of Trench 2. Hole is $4\frac{1}{2}$ feet deep and 5 feet square. Solid barite in thin layers is exposed interbedded with clay and soft brown sandstone. The barite dips 66°, South 10° East.

PROSPECT 16

Hole dug 20 feet south of Prospect 15. Hole is $4\frac{1}{2}$ feet deep and 5 feet square. Barite is solid in the bottom of this hole and dips 66°, South 10° East.

PROSPECT 17

Hole $4\frac{1}{2}$ feet deep and 5 feet square. A light gray, massive bed of barite was encountered in this hole beneath $2\frac{1}{2}$ feet of overburden. The barite dips 62°, South 15° East. A small fragment of a crinoid stem was discovered in the barite.

PROSPECTS 18, 19, 20, 21, 22, 23, and 24

None of these holes was over 6 feet deep and no solid barite was found. Much float, however, was found in the clay debris in each of the holes. A test hole was drilled in the bottom of Prospect 22 and hard bedded barite was encountered at 15 feet. This very probably indicates that none of these holes was dug deeply enough to reach the barite.

PROSPECT 25

Hole 3 feet deep, 2 feet wide and 5 feet long. No barite was found. The hole was probably not deep enough to reach barite.

PROSPECT 26

Trench 5 feet deep, 3 feet wide, and 15 feet long. Apparently located north of base of barite as no fragmental barite was found.

PROSPECT 27

Trench 3 feet wide, 6 feet deep, and 16 feet long. A ledge of barite $2\frac{1}{2}$ feet thick was encountered under 3 feet of overburden. The barite dips 70°, South 20° East. The barite differs in appearance from that found in the shaft or any of the trenches or holes. It is slightly purplish, massive in character, and is made up of small nodules having a radial or rosette structure. Purplish, shaly sandstone was found on both sides of the barite bed. Thin streaks of barite occur in this sandstone, the color of which is probably due to the barite.

Information Obtained from Prospects 3 to 27

Prospects 3 to 27 extended the length of the deposit about three-fourthes of a mile along the north flank of Chamberlain Creek Valley. However, no estimate of thickness can be made based on the exposed barite in these prospects.

Size and Tonnage Estimate

Size

The relatively soft character of the bedded barite has prevented the formation of ledge outcrops. Although highly insoluble in surface waters, there is a strong tendency for the relatively soft material to break down into small fragments which are found in the surface soil where the overburden is thin. As these fragments disintegrate rapidly due to the action of surface waters, they are found only directly above or near the barite beds.

The quantity and direction of the dip of the barite varies along the strike of the beds. This variation, however, conforms to the curvature of the synclinal limb. In the prospect pit at the most western exposure the barite dips 70°, South 10° East. At or near the eastern end of the deposit, however, as exposed in the prospect holes, the dip is 26°, South 10° West. The lateral extent of the deposit as determined by prospecting is a little more than three-fourths of a mile. However, more extensive prospecting may prove the deposit to be longer than this. The total thickness of the stratum measured normally to the bedding plane is 29 feet in the shaft. Calculated from surface measurements, the thickness measured normally is 28 feet in Trench 1 and 44 feet in Trench 2. Forty-four feet is the maximum thickness thus far determined but this does not represent the entire thickness of the barite stratum at the point measured. These three thicknesses referred to correspond to vertical drill hole depths of 39.8, 39, and 68 feet respectively. The overburden varies from less than one foot to over 50 feet depending principally on the slope of the ground.

Tonnage

It is obvious that the tonnage of barite in Chamberlain Creek Valley cannot be estimated with a great deal of accuracy until the area has been more thoroughly prospected. In the opinion of the writer, however, sufficient information has been obtained to justify a conservative estimate of approximately one million short tons of barite in the SE.$\frac{1}{4}$ Section 10, Township 3 S., Range 17 W., lying at 100 feet or less below the surface. A ground slope of 3° is assumed and a reduction of 16 per cent in the estimated cubic feet of the barite stratum is made to allow for that assumed percentage of interbedded clay. It is probable that barite will be found considerably deeper than 100 feet, but in the present estimate, tonnage below that depth is not being considered. The area included in this estimate is shown on Plate VI,A, page 30.

In estimating this tonnage a specific gravity of 3.7 is assumed. This is equivalent to 230.5 pounds per cubic foot or 5,020.3 short tons per acre foot. The tonnage estimate for each ten-acre tract, together with the average dip and thickness assumed for each tract, follows:

TABLE 5. - Summary of Tonnage Estimate

Ten-acre tract in Sec. 10-3S-17W.	East-west length of tract (feet)	Acres underlaid with barite at 100' or less	Assumed average dip	Assumed average thickness (feet)	Estimated short tons
SE SE SE	744	3.24	30°	34	432,936
SW SE SE	670	1.74	43°	34	262,976
SE SW SE	700	1.12	56°	34	200,515
SW SW SE	700	1.12	56°	34	200,515
Total	2,814	7.22			1,096,942

Origin

In the writer's opinion, the most satisfactory explanation of the origin of the barite is that it was deposited by replacement from water solution. Evidence leading to this conclusion is as follows: (1) the fine-grained, angular, crystalline texture is indicative of deposition from solution; (2) some specimens show an apparently sharp line of demarkation between the barite and the sandstone or shale which is indicative of partial replacement; (3) the jointing, lamination, and bedding planes apparently represent the original structure of a replaced rock.

Evidence in favor of the barite being of sedimentary origin is, (1) the stratified appearance of the deposit, (2) the conformity of the barite to adjacent sedimentary beds, and (3) the grained appearance.

Assuming a replacement origin of the barite the following is the writer's view of the history of the formation of the deposit: (1) the barium was originally a constituent of certain of the rocks of Magnet Cove;* (2) it was carried in solution, probably by magmatic waters, and this hydrothermal solution migrated up the dip of the sedimentary beds which constitute the Chamberlain Creek Valley syncline and permeated the porous beds at the base of the Stanley shale; (3) the barite was deposited from solution under favorable conditions which

* This is inference only as no barium has been reported as occurring in any of the rocks of Magnet Cove.

may have been the decrease in water temperature or pressure, or both, or precipitation by chemical action; (4) iron pyrite was brought in probably by the same solutions which carried the barite and was precipitated with it in bands more or less parallel to the bedding plane of the replaced rock. Later, surface waters penetrated the barite beds partially altering the pyrite to hematite and limonite and causing the irregular pink banding. This suggests that below the zone of oxidizing surface waters, the pyrite content of the barite may increase materially.

MINING METHODS

The shallow overburden of the barite, particularly in the SE.$\frac{1}{4}$ of the SE.$\frac{1}{4}$ of Section 10, leads to the belief that a considerable tonnage of barite can be recovered there by stripping and open pit mining. The overburden which can be economically stripped is dependent upon the thickness and quality of the barite and the surface topography. The degree of dip may be important but this is dependent upon the thickness of the barite bed as may later be determined.

In the 40-acre tract mentioned these conditions seem to be favorable. At the shaft the vertical thickness is 39 feet or 29 feet measured at right angles to the bedding plane. The dip of the barite in this tract, while still relatively high, is as low as 26 degrees. The ground surface is relatively even and slopes about 10 per cent in the direction of the dip of the barite.

Shaft and slope mining methods can doubtless be economically applied to the deposit as now visualized, provided selective mining is necessary to procure ore of some certain quality. Unless selective mining is required, however, shaft and slope mining will probably not need to be used in the near future as there seems to be a large tonnage available which can be mined by cheaper open pit methods.

POSSIBILITY OF OTHER DEPOSITS

Since the discovery of the quantity of barite present in the Chamberlain Creek Valley the possibility of other deposits occurring in the region around Magnet Cove has aroused much interest.

In discussing the possibility of locating new deposits of barite, it is important to remember that the known deposit in Chamberlain Creek Valley has not been completely prospected. Further drilling there is justified in order to define the limits of the deposit on the north flank of the valley both laterally and down the dip. Prospecting may well be extended to other parts of the valley working from the known mineralized locality. The fact that basal beds of Stanley shale are found along the south flank of Chamberlain Creek Valley apparently justifies some prospecting along that belt.

It is apparent that in prospecting for other deposits of barite in the vicinity of Chamberlain Creek Valley, a full understanding of the method of occurrence and the origin of the known deposits is desirable. However, as has already been stated, our knowledge is incomplete although as a result of such geological, exploratory, and chemical work as has been completed, some helpful conclusions can doubtless be drawn. In the writer's opinion, the pertinent points to be kept in mind in regard to the Chamberlain Creek Valley deposit are as follows:

1. The barite apparently occurs as a replacement deposit of bedded character and is conformable to adjacent sedimentary beds.

2. The replaced rock was sandstone and shale composing the basal part of the Stanley shale which lies immediately above the Hot Springs sandstone. This in turn overlies the Arkansas novaculite which is the prominent ridge-forming rock of the region.

3. The deposit occurs along the northern flank and at the eastern extremity of a closed syncline, the western end of which is in contact with the igneous rocks of Magnet Cove.

4. Chamberlain Creek syncline plunges towards Magnet Cove.

5. The distance from the edge of Magnet Cove to a point where the deposit is relatively thick is 2 miles.

In searching for new deposits of barite outside of Chamberlain Creek Valley, it is assumed that the safest procedure is to locate areas which, as nearly as possible, duplicate the structural and stratigraphical relations present at the deposit in Chamberlain Creek Valley. In the writer's opinion, either of the two synclinal valleys which lie immediately north of Chamberlain Creek Valley fulfills the above requirements fairly well. These valleys are shown on Plate I, preceding page 10.

The area including the valleys referred to is drained by the upper part of Cove Creek and Lucinda Creek, and is divided by a closely folded anticline into two parallel, synclinal valleys. The two synclines are closed at their eastern extremities and the southwestern ends are relatively close to the igneous rocks of Magnet Cove. Both of the synclines plunge toward Magnet Cove and the entire area is underlain by the Stanley shale. The synclinal valleys are bordered with the Hot Springs sandstone and ridges of Arkansas novaculite.

No surface evidence of any barite deposit was observed during the examinations of these two valleys. However, this fact should not be discouraging. The discovery of the deposit in Chamberlain Creek Valley was, to some extent, accidental and it is possible that other deposits, if any occur, may be discovered only by drilling or digging. The most favorable points for prospecting cannot be determined with any degree of certainty although it would seem a reasonable procedure to begin by prospecting the northern flanks of the synclines near the base of the Stanley shale. Completion of the prospecting in Chamberlain Creek Valley may throw some light on the subject. Until this is completed and the history of the barite deposit in Chamberlain Creek Valley better understood, testing in other areas surrounding Magnet Cove will have to be largely a wildcat matter.

APPENDIX

I.

The impure character of the barite in Chamberlain Creek Valley caused the question to be raised as to whether or not it could be used by the lithopone trade. A 50-pound selected, composite sample, from which clay had been excluded, and which was taken from the test shaft, was sent to the U. S. Bureau of Mines Experiment Station at Rolla, Missouri. The results of flotation tests are given in the following letter from Fred D. Devaney, Assistant Metallurgist of the U. S. Bureau of Mines, to George C. Branner, State Geologist:

United States
Department of Commerce
Bureau of Mines
Mississippi Valley Experiment Station
P. O. Box 111
Rolla, Missouri

March 16, 1931.

Mr. George C. Branner,
State Geologist,
Rooms 443-447 State Capitol,
Little Rock, Ark.

THRU: Supervising Engineer.

Dear Mr. Branner:

The sample of barite ore which you sent us some time ago was received and we have recently completed tests on it to determine if it could be concentrated for the paint trade.

We find that this material can be readily concentrated by a flotation process after grinding to 150 mesh. Flotation concentrates were made which had a tenor of 97.25 $BaSO_4$, 1.76 per cent SiO_2, and 0.11 per cent Fe, with a recovery of a large percentage of the barite.

The details of the test are given below, the first table showing the results obtained by a roughing treatment without recleaning the concentrates:

Product	Weight Percent	Assay, Per cent $BaSO_4$	SiO_2	Fe	Per cent of Total $BaSO_4$	SiO_2	Fe
Rougher flotation concentrates	88.9	94.49	3.64	0.22	95.3	42.3	29.8
Rougher flotation tailing	11.1	37.40	39.90	4.08	4.7	57.7	70.2
Composite	100.0	88.16	7.67	0.65	100.0	100.0	100.0

In order to observe the effect of a cleaning operation, the rougher concentrate was re-floated. The following results were obtained:

Product	Weight Percent	Assay, Per cent $BaSO_4$	SiO_2	Fe	Per cent of Total $BaSO_4$	SiO_2	Fe
Flotation concentrate	70.5	97.25	1.76	0.11	77.8	16.2	11.9
Flotation middling	18.4	83.95	10.87	0.63	17.5	26.1	17.9
Rougher concentrate	88.9	94.49	3.64	0.22	95.3	42.3	29.8
Rougher tailing	11.1	37.40	39.90	4.08	4.7	57.7	70.2
Composite	100.0	88.16	7.67	0.65	100.0	100.0	100.0

Assay of Head Sample

Percent $BaSO_4$	Percent SiO_2	Percent Fe
88.60	7.56	0.64

Reagents used	Pounds per ton of Crude Ore Rougher cell	Cleaner cell
Pine oil.	0.16	
Oleic acid.	0.32	
Na_2CO_3.	1.00	
Na_2SiO_3	0.50	1.00

As you undoubtedly know flotation concentrates are generally refloated several times and the middling products are retreated. In plant operation the recovery of barite would be considerably higher than shown in the above table, as some of the barite in the middlings would be recovered. The overall recovery would probably be close to 90 per cent.

Inasmuch as barite is at present being successfully concentrated by a similar flotation process in California, the process may be said to have gone beyond the experimental stage and there is every reason to believe that the ore you sent us can be satisfactorily concentrated by the flotation process.

Very truly yours,

(Signed) Fred D. Devaney

Fred D. Devaney
Associate Metallurgist.

II.

The following report is contributed by Moritz Norden of the Wil-Nor Development Company. It represents the results of flotation tests made by the Denver Equipment Company, Denver, Colorado.

METALLURGICAL TEST REPORT

Denver Equipment Company — E-2360 Order No.

1419 17th Street, Denver, Colorado

Date 1-15-31

Tested for: Wil-Nor Development Co.,
305 Dugan-Stuart Bldg., Hot Springs, Ark.

Process: Recovery of Barite by flotation

TEST NO. 60

Product	Product %	ANALYSIS %		
		$BaSO_4$	Fe	SiO_2
Sample as submitted	-	87.5	0.55	-
Concentrates	87.0	94.55	0.25	2.88
1st Middling	3.7	40.24	2.80	-
2nd Middling	2.7	42.62	3.20	-
Tailings	6.6	52.64	2.90	-

PER CENT RECOVERY

Amount tested	Product	$BaSO_4$
Dilution: 1-1	Concentrate	93.0
Grinding: 3 periods 3 min. each classified grinding so all would pass through 60 mesh	1st Middling	1.7
	2nd Middling	1.4
	Tailings	3.9
Time required for Conditioning 9 minutes Flotation 9 minutes Total 18 minutes		

Remarks:

Procedure was: added(1# Sodium Silicate conditioned 5 min.
(1/4# Oleic acid " 2 "
(1/8# Yarmor Steam Dist-Pine Oil 2 "

Then floated for 3 min. pulled 1st froth.

After which added (1/4# Oleic acid
(1/8# Yarmor

And floated 3 min. and 2nd froth obtained.

After which again added (1/4# Oleic acid
(1/8# Yarmor

Third froth obtained and tailings discarded

Then 3 froths combined and to these added (1/4# Oleic acid
(1# Sodium Silicate
(1/8# Yarmor

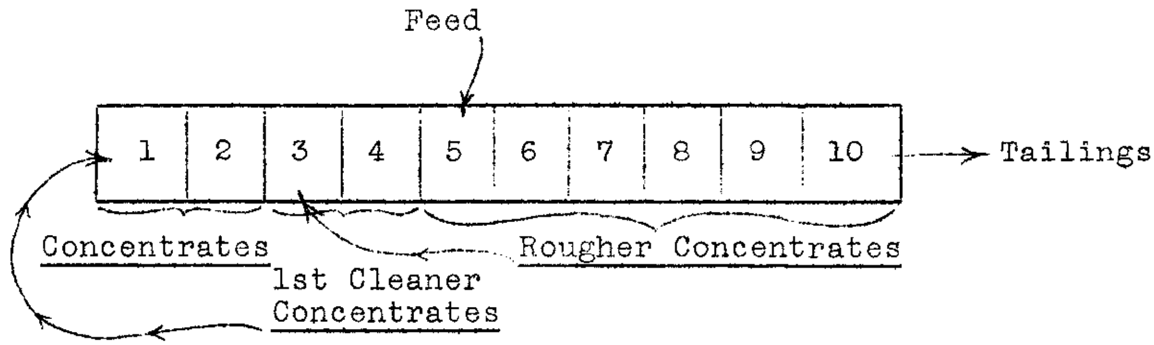
Cleaned, giving concentrates and 1st middlings.

Concentrates from this cleaning were cleaned by adding

1/8# Oleic acid and 1/16# Yarmor.

This gave us our concentrate and 2nd middlings.

Weights of reagents as given were in pounds per ton treated. Flow through Denver "Sub-A" Flotation Machine to duplicate these results would be as follows:



III.

The maximum permissible iron content of barite for the manufacture of lithopone, as given by several manufacturers in correspondence with the Arkansas Geological Survey, is as follows:

Lithopone Manufacturer	Maximum Permissible Iron Content for Lithopone Manufacture (Per cent)
Eagle-Picher Lead Company, Argo, Ill.	1.0
Grasselli Chemical Company, Inc., Cleveland, O.	1.0
Krebs Pigment & Color Corporation, Newport, Del.	1.0
New Jersey Zinc Company, New York City.	1.0
Ozark Smelting & Mining Company, Coffeyville, Kan.	1.0

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