# PYRITE AT THE HAILE MINE, KERSHAW, SOUTH CAROLINA.

[With a note on pyritization at the Brewer mine, near Jefferson.]

By Frank C. Schrader.

## INTRODUCTION.

During the World War, when the demand for increased supplies of sulphuric acid made it imperative that greatly extended domestic reserves of pyrite be developed and the available tonnage ascertained, the United States Geological Survey took an active part in examining and estimating the ore reserves, urging an increase in production from the known deposits, and seeking and encouraging the development of new deposits.

In connection with this activity the writer spent two days late in August, 1917, in a field examination of the Haile mine and submitted a report thereon in the following October. During most of the examination he was accompanied by Mr. R. L. Pellet, manager of the mine, and Mr. A. K. Blakeney, the former manager, both of whom generously furnished valuable information and courtesies. The writer would also express his thanks for information received from Mr. Joel H. Watkins, who during the last six months of its operation superintended the mine and published thereon a valuable paper,[1] on which the writer has freely drawn.

The broader geologic statements here made, such as those concerning the age of the rocks and the deposits, are based largely on earlier and more detailed work of L. C. Graton.[2]

As noted by Watkins, one of the most interesting and promising of recent developments in connection with the increase in the production of pyrite is the conversion of the Haile gold mine into a pyrite mine.

From the present examination the mine was roughly estimated to have 100,000 tons of pyrite ore and concentrates in sight and to contain approximately 600,000 tons, which is 48 per cent of the amount now annually used by the United States and 1.3 times the domestic annual production.[3] These estimates seem to be fully corroborated by subsequent development and the more recent examination made by Watkins.

[1] Watkins, J. H., Pyrite mining at Kershaw, S. C.: Eng. and Min. Jour., vol. 106, p. 517, 1918.

[2] Graton, L. C., Reconnaissance of some gold and tin deposits of the southern Appalachians: U. S. Geol. Survey Bull. 293, p. 77, 1906.

[3] Smith, P. S., Sulphur, pyrites, and sulphuric acid in 1917: U. S. Geol. Survey Mineral Resources, 1917, pt. 2, p. 48, 1918.

## LOCATION.

The Haile mine is in the southern part of Lancaster County, S. C., on Lynches Creek, 3½ miles northeast of Kershaw, the nearest station on the Southern Railway. It is owned by the Haile Gold Mining Co., of New York City. The property includes a 2,000-acre tract, comprising areas of timber land and numerous surrounding farms.

## HISTORY, PRODUCTION, AND MINING OPERATIONS.

The Haile mine is a well-known old gold mine and has been visited by many geologists and engineers. It was worked more or less continuously for gold from 1830 to 1908 and is reported to have produced during that period about $3,500,000 in gold. During approximately the last 20 years of this period it was under the efficient management of Capt. Adolph Thies, who here initiated the barrel-chlorination process and was later aided and succeeded by his son, Ernest A. Thies. As noted by Watkins, this is the most systematic and successful gold-mining operation and the largest single producer of gold in the Appalachian region.

From the summer of 1915 to June, 1917, the mine was worked chiefly for pyrite by A. K. Blakeney, of Kershaw, who from a lens of massive pyrite that had been opened by an old 100-foot shaft, now known as the Blakeney shaft, on Red Hill, and another lens which he later discovered by crosscutting, mined and shipped 8,500 tons of pyrite ore averaging 48 per cent in sulphur. The ore was shipped to Virginia and Alabama. By projecting his Red Hill work to the southeast, excavating the Blakeney pits and their associated underground workings to a depth of 100 feet, and boring calyx drill holes to the maximum depth of 140 feet in quest of high-grade ore, Mr. Blakeney developed two bands of good milling ore 130 and 110 feet wide, separated by about 50 feet of lean pyritic sericite schist.

In 1917 the property was leased by the Kershaw Mining Co., a close corporation, for a period of three years, principally for the purpose of mining pyrite, with the option of extending the lease or purchasing the property. This company began work in June, 1917, and steadily and successfully extended its scope of operations. It planned soon to produce the ore at the rate of 50,000 tons a year. A total of $90,000 was to be expended for installing a new pyrite mill, blocking out ore, and putting the property in good producing condition. The mill was to be built immediately by experts from Webb City, Mo., who had made a special examination and tests of the deposits and ores. It was expected to be in operation early in January, 1918, and to produce 125 tons of concentrates a day, though its capacity was to be somewhat greater. The company expected also to ship daily 12 to 15 tons of lump ore averaging 40

per cent or more in sulphur. However, owing to shortage of labor, difficulty encountered in the process of ore concentration, lack of capital to operate on a large scale, and the fact that new lenses of lump ore were not found to be as plentiful as had been supposed, the company was but partly successful and ceased operations in January, 1919. By midsummer of 1918 the big stamp mill had been remodeled, with the installation of jigs, rolls, and crushers, giving a capacity of 300 tons of ore a day, and was producing daily about 25 tons of concentrates containing 47 per cent of sulphur; several thousand tons of milling ore had been proved, and surface indications were said to be excellent.[4]

The concentrates and ore containing not less than 40 per cent of sulphur, it was said, can be mined and delivered at Kershaw f. o. b. for $9 a ton. At the time of visit the company had just contracted to deliver 3,000 tons for a firm at Columbia, S. C., at $10.32 a ton. In 1918 ore was hauled from the mine to Kershaw by two 3-ton autotrucks over 3½ miles of good sand-clay road at a cost of about 50 cents a ton.

Apart from war needs of pyrite the location of the mine is peculiarly favorable for the use of its pyrite in the fertilizer trade of the South, in which the demand for sulphuric acid is steadily increasing.

In mining the pyrite certain siliceous zones containing $1 to $3 in gold to the ton are occasionally encountered. Owing to the urgent need for pyrite during the war the company was, so far as possible, mining around these gold deposits and leaving them for future operations. The plan was to build later an acid plant at the mine and concentrate the ore by cyaniding the cinder. By this method of treatment the gold, it was said, can be saved for about $1 a ton of ore, but as the siliceous zones are not numerous the process to be profitable will involve plans extending through a period of eight years or more.

## DEVELOPMENT AND EQUIPMENT.

The developments at the mine or camp, as shown on the accompanying map (Pl. XV), are distributed over an area nearly half a mile square. They are on both sides of Lynches Creek, from which the surface rises gently to the northwest and the southeast. The main openings are from 20 to 60 feet above the creek. Nearly all the work was done in mining for gold. There are five large open pits or cuts, from 120 to 200 feet deep, whose outlines are shown on the accompanying map, also about 6,000 feet of drifts, laterals, and winzes extending to a maximum depth of 400 feet, mostly beneath or in the vicinity of the Haile and Bumalo pits, in the southern part of the camp.

[4] Watkins, J. H., op. cit., p. 51.

In connection with the gold-mining operations considerable test drilling, extending to depths of several hundred feet, was done, of which some logs are proving to be of service in the present work. The Keystone drill hole No. 7, bored in Red Hill by Ernest Thies in 1914, was started in the lean band that separates the two parallel bands of pyrite mill ore and reached the ore body developed from the neighboring Friday shaft at about 125 feet below the surface. From this point to the bottom of the hole, which is 275 feet deep, the log records almost throughout "material soft and heavy, or very heavy in pyrite"; "no free gold"; at the depth of 163 feet, "quite heavy in pyrite, resembles ore"; at 207 feet, "pyrite at times as high as 50 per cent." The log concludes with the remark, "It looks very much as if we have here a vein of pyrite material of immense size."

The log of Keystone drill hole No. 9, also bored in 1914, about 300 yards southwest of the Haile pit, is similar to that of No. 7 so far as pyrite is concerned. The entry made at the depth of 85 feet reads, "Carrying at least 90 per cent sulphides; it may be of value as a sulphuric-acid proposition."

By the end of 1918 the present managers had sunk a new 80-foot shaft, the Friday shaft, 240 feet south of the Blakeney shaft, in the 110-foot ore band, and on the 80-foot level had opened nearly 1,000 feet of workings, consisting chiefly of a 150-foot crosscut and drifts. They had also done more than 4,000 feet of test drilling; the drill holes averaged 100 feet in depth, and some extended to the depth of 160 feet. The cost of drilling was about 50 cents a foot. The ground-water level is not definitely known. When mining was begun it stood at about 60 feet below the surface, and from that level downward sulphides became increasingly abundant.[5] All the large pits are about half filled with clear greenish water which stands from 20 to 50 feet below the surface. This water, however, is regarded as chiefly surface water, for the deeper workings in the mine are said to be dry and dusty. The water in the Haile and Bumalo pits is said to contain approximately 0.3 per cent of sulphur, but that in the Beguelin pits contains presumably much less.

The equipment at the time of visit consisted principally of a 60-stamp amalgamation and concentration gold mill, with a large Corliss engine in excellent condition, boilers, 14 Wilfley tables, cyaniding plant, assay and chemical laboratory, machine shop, shaft house and hoist, good office, store and living buildings, 1 mile of narrow-gage steam tramway connecting mines and mill, ore cars and locomotive, a reservoir impounding an ample supply of good creek water for mine, mill, and other uses, and a well of excellent water for domestic use.

There is an abundance of mature unturpentined pine suitable for mine timber growing on the property—an important item, because,

[5] Graton, L. C., op. cit., p. 81.

owing to the sliding character of the ground by reason of its sericite content, the steep dip of the deposits, and the foliation of the rocks, good timbering will be required in deep mining, especially where the ground is wet.

## THE ROCKS.

The mine is situated in the Coastal Plain belt in an area of gently rolling topography, at an altitude of about 300 feet. In this belt the surface in general is underlain by a sheet of unconsolidated sandy sediments of Cretaceous age. At and in the immediate vicinity of the mine, however, from an area nearly half a mile square the thin cover of Cretaceous sediments has been removed by erosion, and the underlying strata form the country rock (Pl. XV). This rock, in which the deposits occur, is light-gray quartz-sericite schist, thought to be of pre-Cambrian age. It has been derived by foliation from a fine-grained well-banded porphyry tuff and seems, in part at least, to be sedimentary.

The unaltered tuff is composed of fragments, mainly of microscopic size, consisting chiefly of quartz, feldspar, mica, and other rock-forming minerals. The altered portions, however, have been so changed by pressure, metamorphism, alteration, and recrystallization of the minerals that, as noted by Watkins, the rock in large part now appears as more or less alternating parallel bands of almost pure slaty sericite and highly silicified schists. Though locally silicified and pyritized, it contains much sericite, and specimens from the Haile workings are reported to have shown by chemical analysis a content of 7 per cent of potash, a fact which suggests that the large dump of finely ground tailings from the gold mill probably contains considerable potash, which might in some way be utilized.

The schistosity of the rock dips about 50° NW. A series of large and small nearly vertical dikes of diabase, of Triassic (?) age, several of which are shown on the map, strike north-northwestward across the foliation of the rock. The dikes are younger than the ore and do not seem to have anything to do with the origin of the deposits. Watkins [6] reports another eruptive, a feldspar porphyry exposed in the road about a quarter of a mile southeast of the Haile pit, which is older than the diabase dikes, trends parallel with the schist, and is slightly crushed.

From unaltered portions of the tuff that have escaped shearing to the intensely folded schist the rock shows all gradations of alteration. The schistosity is in general dominant in the soft sericitic phases. Graton's statement [7] that silicification generally corresponds in intensity with the amount of foliation seems to be confirmed by the writer's observations. Pyritization is widespread and deep-

[6] Op. cit., p. 517.
[7] Op. cit., p. 79.

seated. Pyrite is a common constituent of all the altered phases of the rock, but recent developments in mining show that the pyrite is more abundant in the soft sericitic zones and sericite. It is also abundant in much of the hard silicified rock but occurs in crystals so minute that they appear small even under a high-powered microscope.

## THE DEPOSITS.

### GENERAL FEATURES.

The pyrite deposits are large bodies formed by replacement of the quartz-sericite schist, with whose foliation, dipping approximately 50° NW., they are in general conformable. They are irregularly distributed in three pyritic zones. (See Pl. XV and pp. 340–344.) They occur in the form of large, irregular, crudely lenticular and ellipsoidal bodies, with fairly distinct boundaries, and are more or less connected by stringers and veins of pyrite and quartz. They are generally covered by about 25 feet of gossan or other oxidized material, in which limonite is the dominant iron oxide. Most of the bodies of relatively pure pyrite are more or less tabular. The lenses in general are short and thick and pinch out abruptly. For instance, the two lenses that were stoped out by Mr. Blakeney measured about 20 by 30 feet and 18 by 25 feet in horizontal section and pinched out at a depth of about 100 feet below the surface.[8] They were about 20 feet apart. The one toward the footwall side of the zone is said to have yielded 5,000 tons of ore, and that toward the hanging-wall side 3,500 tons. The lump ore in these workings is said to have been especially well developed in contact with the quartz vein, which traverses them longitudinally.

In mode of occurrence the deposits are geologically and mineralogically similar to bodies of pyritic ore found in schistose rocks in different parts of the world and to those occurring in the older volcanic rocks elsewhere in the Appalachian region. The porous tuffs, being easily penetrated by ore-bearing solutions, afford good repositories for replacement deposits. Remains of the original rock bedding are still preserved in certain siliceous phases of the ore. In the footwalls of the Haile and Bumalo pits outlines of fragments of the tuffs are well preserved, and some of the fragments have been completely replaced by pyrite, exhibiting striking examples of selective replacement.[8]

The ores consist of pyrite diffused in a gangue composed principally of sericite and quartz. The pyrite on the whole is very fine grained, much of it being so fine that the grains, even where embedded in light-colored quartz, are invisible to the naked eye. The grains include cubes, octahedrons, and some of irregular shape. The pyrite is relatively pure, containing very little marcasite or pyr-

[8] Watkins, J. H., op. cit., p. 518.

rhotite, but a slight amount of copper, and only here and there a trace of arsenic and zinc. Locally in the Haile and Bumalo pits narrow bands of molybdenite occur. Pyrrhotite is sparingly present in the ore of the Beguelin pits, where there is also a little zinc.

The deposits are closely jointed, and slickened surfaces indicate that considerable movement has taken place along the strike, particularly on shear zones. Examples of postmineral movement are well shown in the hanging wall of the Haile ore body in the new Haile pit and in the Bumalo pit, where molybdenite in narrow parallel bands in very pyritic gold ore plainly shows the effect of sliding motion.

Within and to a less extent outside the limits of the ore bodies occur lenticular quartz veins and stringers, some of which were deposited in fractures or fissures, but they are relatively devoid of valuable minerals and, as suggested by Graton, seem to have been formed later than the general silicification which produced the ore bodies.

The sulphur content of the deposits is said to range from 10 per cent to more than 50 per cent and to average at least 23.5 per cent. As most of the gangue material is soft sericitic schist, from which the disseminated pyrite in grains of microscopic size is easily separated, the deposits on the whole were thought to form an ideal mill ore. This is not wholly the case, however, for according to Hornor,[9] who in 1919 examined the deposits for the Bureau of Mines, much of the pyrite is too fine grained to be saved by the concentration process that was used by the Kershaw Co.

About 88 per cent of the material in the deposits consists of concentrating ore or fines averaging approximately 22.5 per cent in sulphur; the remaining 12 per cent consists of relatively pure pyrite, known as shipping or lump ore, averaging approximately 42 per cent in sulphur. A mill test made in 1917 of a carload of supposedly average grade of the concentrating ore indicated a concentrating ratio of 3:1, with the concentrates averaging 46.5 per cent in sulphur. This ratio, however, seems to be too high, as that of most of the ore treated in 1918 was about 4:1.

Specimens of the ore collected by the writer were analyzed by Benedict Salkover in the laboratory of the United States Geological Survey with the following results.[10]

*Analyses of pyrite ore from the Haile mine, Lancaster County, S. C.*

| | 1 | 4 | 5 |
|---|---|---|---|
| Sulphur | 44.89 | 31.56 | 36.11 |
| Zinc | .048 | .056 | None. |
| Arsenic | .136 | Trace. | .153 |
| Copper | None. | None. | None. |
| Insoluble matter | 10.22 | 31.52 | 12.81 |

[9] Hornor, R. R., oral communication.

[10] Smith, P. S., op. cit.

The insoluble matter given in the analyses is almost entirely silica. The specimens all contain considerable quartz.

Specimen 1 was taken from the bench in the Haile pit 50 feet below the surface. It is lump ore, unusually heavy, and is essentially massive, with traces of schistosity barely visible to the naked eye. It is mostly fine grained, in places almost aphanitic, but varies in texture and contains phenocrystic pyrite and aggregates of coarser pyrite and quartz. On examination with the lens it is seen to contain disseminated throughout much very fine grained sugary quartz or silica, a few dark constituents thought to be remnants of rock minerals, and a book of altered mica or some micaceous mineral, possibly sericite.

Specimen 4, said to be lump ore, came from the Friday shaft at a depth of 80 feet. Except on a fracture surface transverse to the foliation it has the appearance of being merely a pyritic phase of the schist, the schistose structure being more or less completely preserved. On cross fracture, where the mineral composition is best shown, the replacing visible pyrite is seen to form less than 50 per cent of the specimen. The pyrite is fine grained and very uniformly distributed throughout, except that it shows a tendency to favor the planes of foliation.

Specimen 5 is a lean specimen of lump ore from the Blakeney shaft. In appearance it is similar to specimen 1 except that it contains more quartz and is almost devoid of the coarser pyrite-quartz crystals and their aggregates.

Watkins concluded that the deposits at Red Hill can, with little additional cost, be best worked in open cuts with the steam shovel, thereby making possible easy selection of the better grades of ore, so that the ore sent to the mill could give an average yield of 1 ton of concentrates to 3 tons of ore, instead of 1 ton to 4 tons, as at present.

Jigs, settling tanks, and Wilfley tables are used in concentrating the ore. The overflow from the tanks is a talcky-feeling powder consisting chiefly of sericite from the schist and contains considerable potash, for which it may prove a valuable by-product, analyses of it made in McCandle's laboratory at Atlanta, Ga., having yielded 8.52 per cent of potash.[12]

Nearly all the pyrite deposits lie within three zones of pyritization which are indicated on the accompanying map as pyritic zones 1, 2, and 3, beginning on the southeast. The zones seem to represent zones of weakness along which dynamic stress, fracturing, faulting, and shearing have freely taken place.

The pyritic zones likewise contain practically all the excavations that have been made in mining for gold. Most of the gold deposits are contained in or associated with the pyrite deposits and, like

[12] Watkins, J. H., op. cit., p. 521.

them, consist of large lenses of porous tuff which has been altered mainly by silicification and pyritization. They are remarkable for their large size. For instance, the Haile gold ore body is about 200 feet long and 100 feet thick from wall to wall and was workable from the surface down nearly to the 300-foot level. The gold ore bodies, like the pyrite bodies, also occur as large conformable replacement lenses in the schist, but they are more silicified, and locally the schist is more or less completely replaced by a gangue of gold-bearing pyritic quartz.

The gold content of the deposits ranges from $2 to $40 to the ton, but they are essentially of low grade and so far as present development extends may be said to decrease in gold tenor with depth or descent into the sulphide zone. The average value of the gold ore which had been mined to a depth of 75 feet in 1883 was estimated to be about $11 a ton, and that of the ore mined and milled in 1914 was about $3 a ton. Of the highly siliceous ore the most pyritic contains the most gold. The gold occurs mostly inclosed in the pyrite and quartz, but some is also free. The free gold is best shown as thin flakes on slickensided surfaces of molybdenite contained in the ore—for instance, on the 200-foot level of the Bumalo mine and in the new Haile pit.

Quartz and pyrite are therefore the chief gangue minerals of the gold ore. Sericite, which may also locally be regarded as a gangue mineral, is less abundant. The associated minerals are molybdenite, chlorite, apatite, rutile, and pyrrhotite. In concentrating the gold ore pyrite ranging in amount from 1 to 30 per cent of the ore is saved by the Wilfley tables. The gold ore is concentrated about 12 into 1, and the pyritic portion of the concentrates is practically pure iron sulphide.

The quartz and the pyrite, however, are far more widely distributed than the gold. From their intimate association and mixture the three minerals seem to be essentially contemporaneous and of deep-seated origin and to have been deposited in pre-Cambrian time by concentrated hydrothermal solutions at high temperature and pressure. These conditions under which deposition took place are of economic importance, as they favor continuity of the deposits in depth. An additional argument in favor of continuity of the deposits is afforded by the extreme fineness of grain of the pyrite and the intimate manner in which it permeates the schist.

From the character of the deposits and the presence of the massive granite which is exposed at a point about 2 miles northeast of the mine and which, covered by the sediments of the Coastal Plain, may occur much nearer, the source of the depositing solutions is regarded as granitic magmas.

The general increase of pyrite in depth, so far as present development extends, and the filling of crevices and partings along joint planes with pyrite at the depth of 100 feet below the surface are regarded by Watkins [13] as evidence of enrichment by descending meteoric solutions. This interpretation seems to be correct, but the enrichment has apparently not been sufficient to affect the quantity or value of the deposits materially.

The mapping of the pyrite zones on Plate XV is based on field observations made in the present examination and the best available underground data. These zones contain practically all the known deposits of the camp and are believed to include the most likely places to prospect for pyrite.

### PYRITIC ZONE NO. 1.

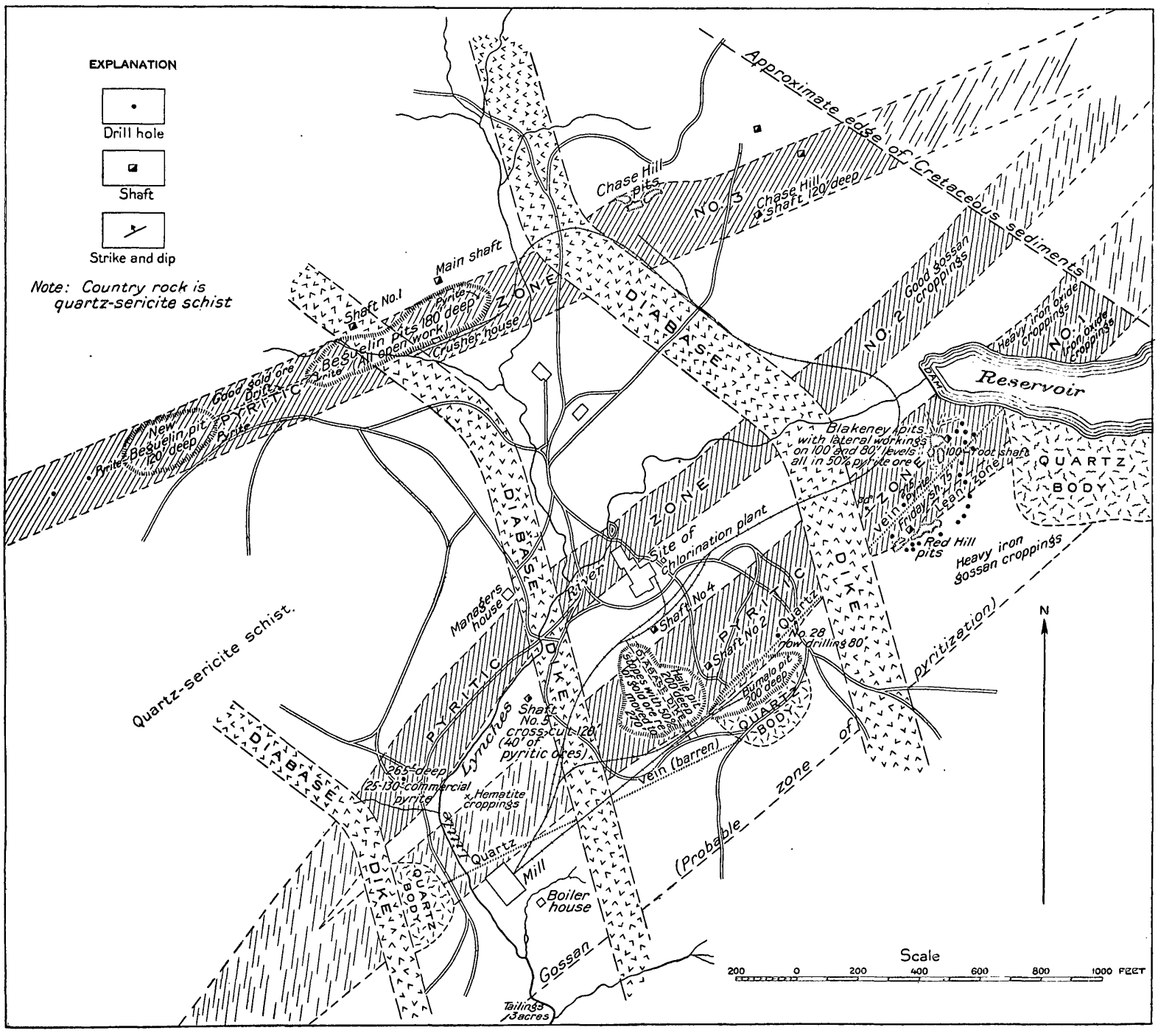
The most productive pyritic zone and the one which was receiving the most attention at the time of visit (August, 1917) is zone 1, on the southeast, which might well be termed the Haile-Blakeney zone. It has a known length of approximately 2,400 feet and a width of 250 feet. As exploitation for concentrating ore was begun during the summer of 1917 not much ore had yet been actually blocked out. Preliminary developments, however, indicated the presence of a large amount of ore between the Haile and Bumalo pits on the southwest and the Blakeney pits, near the reservoir, on the northeast.

In the Haile pit a band of pyritic ore about 25 feet wide shows in the south walls and a band nearly twice this width in the northeast walls. In shaft 4, north of the pit and 40 feet from the ore zone on the hanging-wall side, the pyrite deposits are known to extend to a depth of 350 feet, and for the first 80 feet below the 350-foot level a 130-foot 50° inclined winze, the deepest working in the mine, is said to be all in pyritic gold ore of good milling grade.

On the opposite side of the zone, near the hanging wall of the Bumalo pit, is exposed a 15-foot pyrite band which from old mine records is known to be 25 feet in width on the 200-foot level, is rich in pyrite, and is estimated to carry about 30 per cent of sulphur.

In both the Haile pits and the Blakeney pits, which are 1,100 feet apart and in alinement on the zone, the pyrite deposit is more than 50 feet in width and 100 feet in depth. It contains a siliceous streak with associated coarsely crystalline pyrite, and at about 20 feet from the streak on the footwall side there is a nearly continuous body of lump ore. From these showings in the pits and from intervening drill holes and shafts that disclose good pyrite ore to depths of more than 200 feet it is believed that the deposit is practically continuous between the pits.

[13] Watkins, J. H., op. cit., p. 518.




MAP SHOWING PYRITIC ZONES AT THE HAILE MINE, KERSHAW, S. C.

62636°—21. (To face page 340.)

A calyx drill hole (No. 28) that was being sunk in this deposit just north of the Bumalo pit at the time of visit had reached a depth of 80 feet. The writer examined the lower 22 feet of the core and most of the sludge. The log, which agrees very well with that of the Keystone drill hole, made farther northeast some years ago, seemingly in the same deposit, is approximately as follows:

*Log of calyx drill hole No. 28, near Bumalo pit.*

| | Thickness (feet). | Depth (feet). |
|---|---|---|
| Overburden | 5 | 5 |
| Heavily iron-stained schist | 16 | 21 |
| Good concentrating pyrite ore | 15 | 36 |
| Lump ore averaging 45 per cent in sulphur | 9 | 45 |
| Good concentrating ore | 16 | 61 |
| Lump ore averaging 45 per cent in sulphur | 6 | 67 |
| Mostly good concentrating ore averaging 30 per cent in sulphur | 13+ | 80+ |

The Friday shaft, about midway between hole No. 28 and the Blakeney pits, was being sunk for the purpose of driving crosscuts at the time of visit and had attained a depth of 75 feet. Its lower 60 feet was nearly all in soft schistose ore averaging about 28 per cent in sulphur and containing siliceous bands running about $1.80 to the ton in gold.

Just southeast of the Friday shaft are the Red Hill pits, so named from the deep-red hematite staining of the croppings and oxidized portion of the deposit. They had been opened to a depth of 60 feet, the approximate lower limit of oxidation, and had produced considerable gold from a lens 100 feet in maximum width. Continuity of the heavy iron stain throughout the workings suggested that the deposit was probably continuous with that in the Friday shaft and encouraged the hope of finding workable pyrite in depth. This view has already been corroborated by subsequent development. Watkins, who has since examined the mine, reported that the shaft had been extended to a depth of 80 feet, from which a 50-foot crosscut had been made to the southeast beneath the Red Hill pits, and that in the shaft, the crosscut, and drifts extending from it the deposit of good-grade milling ore is continuous.

At a point 80 feet north of the Friday shaft a drill hole 275 feet in depth is said to show much good pyrite, corresponding with that in hole No. 28, the Friday shaft, and the Blakeney pits.

The Blakeney pits and their accompanying 600 feet or more of underground workings, which are the most northeasterly developments on the zone, were practically all in ore said to average 50 per cent of pyrite, or about 25 per cent in sulphur. The laterals, which are on the 80-foot and 100-foot levels, showed the deposit at these depths to have a width of at least 60 feet. As the pits were excavated in

search of lump ore only, the entire dump of more than 8,000 tons then on the ground was to be milled and according to tests made should yield 3,000 tons of concentrates containing 25 per cent of sulphur. In these workings were found the two lenses of lump ore already described, mined by Mr. Blakeney.

At a short distance beyond the Blakeney workings surface indications are interrupted by the pond and partly also by the quartz body on the east (Pl. XV). Beyond the pond, however, the probable continuation of the pyritic zone is indicated by heavy croppings of iron oxide and gossan, from which it is inferred that the deposit in the Blakeney workings, except such portion of it as may be cut out by the northward extension of the quartz body under the pond, probably continues through beneath the pond and underlies the outcrops on the other side. At a short distance beyond the croppings the pyritic zone and the schistose rocks in which it lies disappear beneath the cover of Cretaceous sands on the northeast.

Although, as stated, not much ore had yet been blocked out at the time of visit, nevertheless from the developments, tests, and indications above described it seemed reasonable to estimate that this zone of pyritization between the Haile pit and the croppings beyond the pond contained about 300,000 tons of available concentrates and ore.

### PYRITIC ZONE NO. 2.

Pyritic zone No. 2 parallels zone 1 on the northwest and is separated from it by a strip of mostly barren ground about 200 feet in width. As but little prospecting or development work has been done in this zone its mapping rests almost entirely on surface indications, such as gossan, iron oxide croppings, and heavily iron-stained schist, some of which occur in or near the bed of the creek and others on the northeast, where the zone passes beneath the Cretaceous sedimentary cover. Its probable continuity under the cover is indicated by much quartz débris strewn over the surface. The log of a drill hole sunk to a depth of 265 feet near the southwest end of the zone records 105 feet of commercial pyrite between depths of 25 and 130 feet. This measurement indicates for the deposit at this locality a width of about 70 feet.

At a point 480 feet to the northeast of the drill hole and 80 feet from the zone and the creek on the footwall side, a crosscut to the northwest from shaft No. 5 at a depth of 120 feet is said to show a width of more than 40 feet of good pyrite ore. It is quite possible that this ground and that containing the croppings to the south, on the same side of the creek, as shown on the map, may be a part of the zone and should be so mapped.

This zone, as inferred in part from the manner in which zone 1 is being developed and from the similarity of indications between the two zones, is estimated to contain 100,000 tons of concentrates and ore.

### PYRITIC ZONE NO. 3.

Pyritic zone No. 3, or the Beguelin zone, is about 700 feet northwest of zone 2. It has a more easterly trend than the other two zones, its course being approximately N. 68° E. It has a known length of 2,800 feet and an average width of about 200 feet. It has not been exploited for pyrite, but the development work done for gold indicates that there is probably considerable pyrite present. Owing to the presence of water the workings, comprising the Beguelin pits, the New Beguelin pit, and the Chase Hill pits and shafts, could not be entered. However, pyrite is indicated in the northeast and southwest walls of the Beguelin pits and in practically all the walls except the north one of the New Beguelin pit, as shown on the map. It is also reported to occur in the northeast submerged wall of the Beguelin pit at a depth of 75 feet. There is reason to believe that the pyrite increases with depth, for according to John Falkenberry,[14] who was locomotive engineer for the company when the deep portions of the Beguelin pits were being mined, the weight of the gold ore there finally became so great by increase in its pyrite content that three carloads of ore instead of four, the former customary number, constituted a full haulage load for the engine.

From the bottom of the New Beguelin pit a drift with laterals connects with the Beguelin pit and is said to show that the several hundred feet of intervening ground is nearly all good gold ore, more or less pyritic. Similarly drill tests show that this pyritic ore deposit extends at least to a point 250 feet southwest of the New Beguelin pit under the Cretaceous cover.

In Chase Hill, about 600 feet northeast of the Beguelin pits and 30 feet above them, are the pits described by Graton as "shallow open pits which have been dug in siliceous rock, with numerous quartz-rich streaks, and plentiful in pyrite. The strike of these pits is in direct line with that of the Beguelin pit, and it seems highly probable that the two ore bodies are connected by a band of lower-grade material underground, if not at the surface."

About 400 to 500 feet east of the Chase Hill pits are several shafts, of which the deepest is the Chase Hill shaft, 120 feet in depth. It was sunk in quest of gold before the Civil War, and none of the men who did the work remain to give information. The large weathered dump, which was soon to be tested by the company for both its gold and pyrite contents, showed about one-tenth of the mass to be dark pyritic schist or possibly low-grade pyrite ore, presumably of too low grade to compete with the deposits then being developed in zone 1, unless it occurs in a body that can be mined on a large scale.

From the indications above set forth zone 3 is estimated to contain about 200,000 tons of available pyrite concentrates and ore.

[14] Oral communication.

This quantity, together with that from the other two zones, makes a total of 600,000 tons of concentrates and ore for the Haile camp.

### OTHER PROSPECTS.

More recent prospecting by the company has revealed a new alinement of gossan and iron oxide croppings which strongly indicates the probable presence of an additional or fourth zone of pyritization at about 400 feet to the southeast of zone 1, approximately as indicated by the broken line on the map.[15] This zone, which has a supposed width of nearly 200 feet, seems to extend from the quartz body at the pond southwestward through a distance of nearly 3,000 feet. It crosses the creek at a point about 300 feet south of the big stamp mill. In case it proves to be workable, the likelihood of its continuity to the northeast of the quartz body should be investigated.

### NOTE ON PROSPECTING AND CONTINUITY OF THE ZONES.

From the conditions here described, the pyritic zones seem to continue beneath the Cretaceous cover both on the northeast and the southwest, and there is no apparent reason why they should not carry commercial pyrite there as well as in the present productive area, from which the cover has been removed by erosion. The continuity of the zones and the size and content of the ore bodies can best be determined by drilling through the cover on the projected course of the zones, as has been done on a small scale with encouraging results southwest of the New Beguelin pit. As the cover is thin it can not prove to be much of an impediment to mining operations.

In this connection it may be noted that the courses of zones 1 and 3 and of zones 2 and 3 converge on the northeast, where the zones pass beneath the Cretaceous sediments. If these courses are maintained, the zones must join or intersect a short distance beyond the edge of the cover. Such junctions, by reason of relatively greater dynamic disturbance in the rocks at those points, are in general peculiarly favorable for the accumulation of ore deposits and should therefore be given attention commensurate to their prospective importance.

Owing to the dip of the zones it seems preferable to sink the preliminary drill hole a short distance, say 50 to 75 feet, to the northwest or hanging-wall side of the point of intersection, or even farther if the proposed hole is expected to be much more than 150 feet in depth.

The site of the junction for zones 2 and 3, as indicated in the upper right-hand corner of the map, is estimated to be about 1,110 feet beyond the margin of the Cretaceous cover and 1,600 feet from the

[15] Watkins, J. H., oral communication.

Chase Hill shaft. That for zones 1 and 2 is about 2,300 feet beyond the margin of the Cretaceous beds, measured on the projected course of zone 1, and 3,000 feet from the Blakeney shaft and pits.

Similarly on the southwest, the site of the junction for zones 1 and 2 is approximately 1,100 feet beyond the margin of the Cretaceous sediments, 2,100 feet from the center of the Haile pit, and 1,200 feet from the big stamp mill.

## PYRITIZATION AT THE BREWER MINE, JEFFERSON, S. C.

The Brewer mine is 4 miles southwest of Jefferson, the nearest railroad station, in Chesterfield County, S. C. It is 10 miles northeast of the Haile mine, above described, and like it is an old gold mine.

The principal developments consist of two large open pits. The old or main pit is 140 feet deep and 200 to 300 feet in diameter. The geologic and mineralogic conditions are more or less similar to those at the Haile mine. The rocks and ores contain finely disseminated pyrite, but they are more siliceous and less pyritic than those at the Haile mine.

From a two-hour visit made in August, 1917, chiefly in the main pit, the writer concluded that the mine contains no deposit that could be worked commercially for pyrite under conditions then existing. As shown in the walls of the pits, the greater portion of the rock and ore is composed of a hard bluish massive siliceous porphyritic rock or quartz which is more or less pyritic. It is too lean in pyrite, however, to be workable for this mineral, whose best showings are in small bodies or kidneys that are too widely separated to merit consideration.

As the mine is approximately on the projected northeasterly trend of the deposits at the Haile mine it has been suggested that the two mines are on the same zone of mineralization. The field indications, however, were not traced in this examination. In the intervening 10 miles of country the older rocks are mostly covered by Cretaceous deposits and much of the surface is heavily timbered, and at 2 miles northeast of the Haile mine there is a mass of younger granite which is thought to be the source of the mineralization at that mine.