UNITED STATES
DEPARTMENT OF THE INTERIOR
HAROLD L. ICKES, Secretary

GEOLOGICAL SURVEY
WALTER C. MENDENHALL, Director

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IRON ORE
IN THE RED MOUNTAIN FORMATION
IN GREASY COVE, ALABAMA

BY

ERNEST F. BURCHARD

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Prepared in cooperation with the Geological Survey of Alabama, Walter B. Jones, Director

WASHINGTON

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Iron ore in the Red Mountain formation in Greasy Cove, Alabama

By Ernest F. Burchard

Introduction

Greasy Cove, a small valley in northeastern Alabama a few miles southwest of Attalla, contains beds of hematite that in places attain a thickness greater than elsewhere in Alabama northeast of Birmingham, and this fact, together with the structural deformations that the beds have undergone, which bring them into positions favorable for prospecting and mining, makes it a district of both geologic and economic interest.

The data presented herewith on these red iron ores have been gathered by the author in a study of the iron ores of the Red Mountain formation in northeastern Alabama, in cooperation with the Geological Survey of Alabama. As publication of the complete bulletin contemplated by the Geological Survey of Alabama is delayed temporarily, it seems desirable to present the facts concerning the iron ore beds in Greasy Cove while the interest in developments is still active, and also because there is less interest at present in prospecting and mining the ore beds in other parts of northeastern Alabama. The present paper endeavors to state all the important facts that could be gathered concerning the ore beds in this area during visits to the field, principally in the autumns of 1928, 1929, and 1930, but including data obtained while making surveys of the ores tributary to Birmingham, Ala., and Chattanooga, Tenn., in earlier years.

A few measurements of ore beds recorded in this report were made by the late J. R. Ryan, who superintended prospecting for the Chattanooga Chamber of Commerce in 1911. Many local residents and owners of property furnished information during the course of the field work, and data of great value have been placed at the disposal of the writer in reports by companies and individuals who have investigated the resources of the area. Grateful acknowledgments are hereby made for data received from the Alabama Co., the Gulf States Steel Co., the Jirama Ore Co., the Sloss-Sheffield Steel & Iron Co., the Tennessee Coal, Iron & Railroad Co., the Woodstock Iron Co., the Alabama Great Southern Railroad, the Louisville & Nashville Railroad, the Nashville, Chattanooga & St. Louis Railway, and the following individuals: C. S. Blair, L. E. Geohegan, David Hancock, the late T. H. Aldrich, and the late Henry Badham, all of Birmingham; E. I. Weil, F. G. Lee, M. D. Corey, and E. W. Capen, of Gadsden; R. A. Drake, of Attalla; and Wilbur A. Nelson and the late J. S. Grasty, of Charlottesville, Va. The writer has drawn freely upon the reports of the late Henry McCalley, of the Geological Survey of Alabama, and is also indebted to Dr. Walter B. Jones, State geologist, and to Dr. R. S. Hodges, chemist, of the Geological Survey of Alabama, for their interest and helpful cooperation in the work.

Location and transportation facilities

Greasy Cove[1] is the V-shaped or reentrant valley that lies between the plateau of Blount Mountain on the northwest and its outlier, Chandler Mountain, on the southeast and opens toward the northeast into Wills Valley near Attalla. The cove may also be entered at its upper or southwest end by a road that passes through a low gap between Blount and Chandler Mountains about 4 miles northwest of Whitney station on the Alabama Great Southern Railroad. The upper end of the cove is in St. Clair County and is drained by the headwaters of Little Canoe Creek, but the larger northeastern part, in Etowah County, is drained by Clear Creek, a tributary of Big Wills Creek. In addition to the Alabama Great Southern Railroad, which passes a few miles east of the cove, the Louisville & Nashville Railroad line between Birmingham and Attalla enters Greasy Cove through a tunnel in Blount Mountain at Tumlin Gap and extends through the lower part of the cove, but is 1½ to 4 miles from the ore outcrops in the upper part of the cove. In 1928-29 a 30-inch gage tramway was built from Tumlin Gap to some mine workings in sec. 25, T. 12 S., R. 3 E., a distance of more than 3 miles. These geographic relations are shown on plate 1.

Geologic relations

Stratigraphy

The rocks within and on the borders of Greasy Cove are Paleozoic sediments described by Charles Butts, [2] of the United States Geological Survey, consisting, in ascending order, of the Upper Cambrian cherty Copper Ridge and Chepultepec dolomites; the Chickamauga limestone, of Ordovician age; the Red Mountain formation (sandstone, shale, and iron ore), of Silurian age; the Chattanooga ("Black") shale, of Devonian or Mississippian age; the Fort Payne chert and Tuscumbia limestone, the Hartselle sandstone, and the Bangor limestone, of Mississippian age; and the Pottsville formation, or sandstone and shale containing thin beds of coal, of Pennsylvanian age. The whole section of rocks comprises a thickness of 5,000 to 6,000 feet, but as this paper is concerned essentially with the iron-ore-bearing Red Mountain formation, that is the only formation that warrants individual consideration here.

Red Mountain formation

The Red Mountain formation consists of sandstone, shale, and beds of ferruginous limestone and iron ore. Its thickness in Greasy Cove appears to be between 350 and 500 feet. In sec. 35, T. 11 S., R. 4 E., about 2½ miles

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1/ The name is said to have been derived from the greasy looking scum of iron oxide that appears on water seeping from beds of iron ore on the borders of the cove.

2/ Butts, Charles, and others, Geology of Alabama: Alabama Geol. Survey Special Rept. 14, p. 139, 1926.

west of Ivalee, the whole formation is well exposed in a gap cut by a creek flowing southeastward. Here the rocks stand practically vertical and measure about 425 feet across the edges of the beds. The black Chattanooga shale overlies the Red Mountain rocks conformably here and is about 60 feet thick, and the Chickamauga limestone may be recognized below at the southeast. No other rocks of similar character occur near the Red Mountain formation or are likely to be confused with it, except possibly some sandy limestone of Sequatchie type at the top of the Chickamauga limestone, immediately below the Red Mountain. The top of the Red Mountain formation is sharply limited by the black Chattanooga shale, which forms a very characteristic marker about 200 feet stratigraphically above the iron-ore beds. Many hundreds of feet higher in the section Mississippian and Pennsylvanian rocks contain sandstone and shale but are separated from the Red Mountain beds by a considerable thickness of limestone and cherty limestone.

In his description of the Paleozoic rocks Butts states:

"As determined by Ulrich, through the study of its fossils, the Red Mountain formation is correlated with two divisions of the general Silurian stratigraphic succession. The lower part, which differs in thickness from place to place, is of late Medina (Albion) age, and the upper part is of early Niagaran (Clinton) age. The Medina part extends to the top of the Irondale [ore] seam. * * * The Medina part of the Red Mountain is about 100 feet thick at Birmingham, 250 feet thick along the east side of Big Wills Valley, 200 feet in Sequatchie Valley. * * * In Greasy Cove, about 10 miles west of Ashville, there appears to be a thickness of over 200 feet, and every fossiliferous layer observed up to layers within the upper third carry the Brassfield fauna, so that the whole thickness there is of Medina age.

"The Median part of the Red Mountain formation corresponds to the Brassfield limestone of Ohio and Kentucky and perhaps in part or in whole to the Clinch sandstone of Tennessee and Virginia and to the Tuscarora quartzite of Pennsylvania, and these formations occupy the position and doubtless correspond in part or whole to the upper part of the old Medina sandstone of New York, now known as the Albion sandstone, which is well displayed in Niagara Gorge opposite Queenston, Canada, and at many places between Niagara River and Median, N. Y. The white sandstone at the base of the Red Mountain in Beaver Creek Mountain east of Ashville and in Colvin Mountain is also regarded as of Medina age."

In the upper part of Greasy Cove a bed of ferruginous limestone rich enough to be a good ore in places, especially on its weathered or thinly covered portions, reaches a thickness of 3 feet 6 inches to 7 feet 6 inches. A noteworthy feature of this bed wherever opened for mining in Greasy Cove is the abundance of fossil remains that it contains. One of the most common forms is a coral (Ptychophyllum) having a round base about 1 inch to 1½ inches in diameter, and other corrals that have branches extending 1 foot to 1 foot 6 inches long, and locally the bed is called the "big coral bed." Dr. E. O. Ulrich, of the U. S. Geological Survey, identified certain fossils collected by the writer from the "big coral bed" near the head of Greasy Cove and commented as follows:

"The rock is largely composed of remains of corals and bryozoans. Unfortunately they are preserved in such a manner that exact determination of the species is impossible. As near as I can make them out at this time [May 7, 1914; revised in 1930], the following species are represented:

Corals:	Bryozoa:
Favosites aff. F. niagarensis	Lioclemella ohioensis
Favosites aff. F. forbesi	Hallopora magnopora
Heliolites interstinctus	Rhinopora verrucosa
Halysites catenulatus microporus	Phaenopora fimbriata
Halysites catenulatus, large var.	Pachydictya fiburcata
Streptelasma hoskinsoni	Hemitrypa ulrichi
Ptychophyllum aff. P. ipomoea	Polypora aff. P. incepta
Dyphyphyllum cf. D. multicaule	

"The fauna represented by these fossils is one that invaded the continental basins repeatedly during the Silurian. So far as known, the first of these invasions occurred in late Medina time, the last clearly recognizable during the Cayugan. Apparently this Greasy Cove occurrence is to be correlated with the late Medina invasion which is represented in the southern Appalachian, Ohio, and Mississippi Valleys by the Brassfield limestone ("Ohio Clinton" of the last century) and approximately by the Cataract formation in New York and Ontario."

In 1930 Butts examined some additional fossils from this locality and commented upon them as follows: "The collections from Greasy Cove include Halysites catenulatus microporus, a common form of the Cataract of Ontario, and Ptychophyllum ipomoea foerste (not Davis), of which there are, in the [National] Museum collections specimens from the Brassfield near Dayton, Ohio, identical with those from Greasy Cove. All the rocks, including the ore beds, of these localities from which fossils have been obtained are certainly of Brassfield age."

There are generally one to three distinct beds of ferruginous material or of iron ore in the formation at any one place, although the higher number of beds may be due to repetition of beds by faulting. The beds of ore themselves in places are split by partings of shale or sandstone. The ore beds range in thickness from a few inches to 7½ feet. In places there are notable variations in the thickness of the same ore bed within a few hundred feet. The ore beds cannot everywhere be correlated with certainty unless followed continuously from place to place by mine workings, and this fact lends support to the belief that the iron-ore beds in Greasy Cove are lenticular and of limited extent.

Structure and distribution of formations

Greasy Cove represents the eroded surface of an anticline, the southwestern extremity of which plunges with a gentle dip below the Blount-Chandler Mountain plateau. It is, in fact, the southwestern termination of the Wills Valley anticline, which borders the Lookout Mountain syncline on the northwest, but the Greasy Cove area lies southwest of the line where Lookout Mountain is abruptly terminated by an east-west fault.

The Chepultepec and Copper Ridge dolomites form the surface of the interior of the cove along the axis of the anticline, and the later formations, listed above, lie on the northwest, southwest, and southeast margins of the Upper Cambrian rocks, dipping away from them, generally at low angles, but in places where involved in faults the dips are steep and to some extent reversed in direction by overturn of the beds.

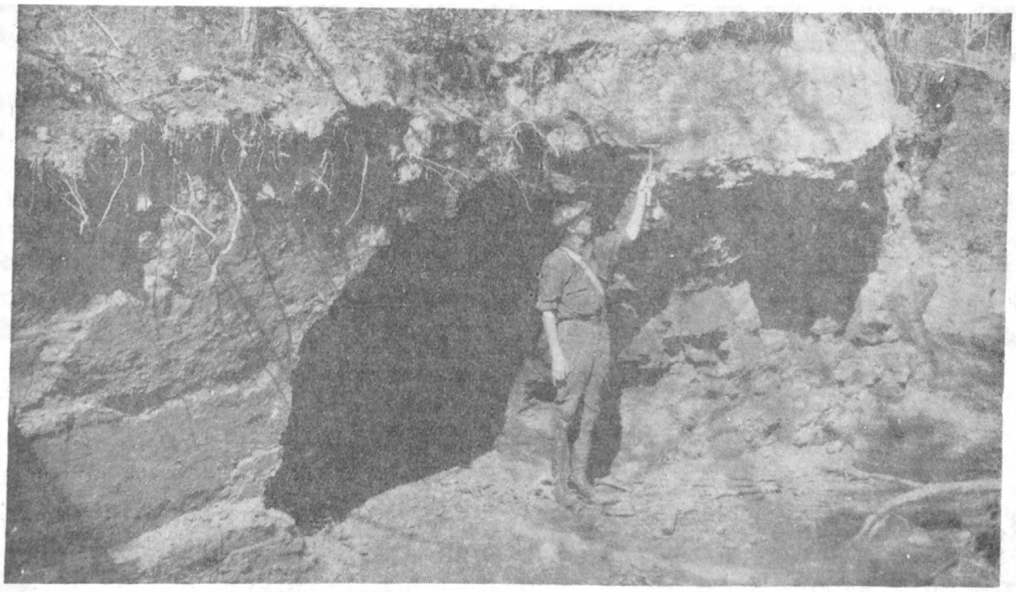
Faults are present in Greasy Cove, principally on its northwest margin and near the head of the cove, and have affected the ore-bearing formation by cutting out its outcrop almost entirely between Littleton and the Louisville & Nashville Railroad and by repeating its outcrop in narrow strips west and southwest of Gallant, thereby making mining operations less certain and more complicated. At the northeast the formations above the Upper Cambrian are broken in continuity with those of Red Mountain in Wills Valley by the great fault that terminates Lookout Mountain and Red Mountain on the southwest. The higher rocks in the section, such as the Hartselle sandstone, Bangor limestone, and Pottsville formation, have been less disturbed than the ore-bearing and adjacent formations and generally show only moderate dips. The irregularities of surface are due to the forces of erosion and solution working on rocks of varying degrees of hardness and solubility. The broader uplands of Blount and Chandler Mountains are developed on the gently dipping resistant sandstone of the Pottsville, the narrow ridges consist of the more steeply dipping sandstone of the Red Mountain formation, the narrow "back valleys" between these ridges and the uplands lie along the easily soluble Mississippian limestone, and the rolling knolls within Greasy Cove are made up of the cherty dolomite of the Upper Cambrian.

The general distribution and structure of the rocks in Greasy Cove are shown on a small scale on the geologic map in Special Report 14 of the Geological Survey of Alabama, and those features in the northeastern part of the cove are shown in greater detail in Folio 35 of the Geologic Atlas of the United States (Gadsden quadrangle). Plate 1 indicates the outcrops and dips of the Red Mountain formation within Greasy Cove and around the northeast end and along the southeast margin of the Chandler Mountain syncline.

The iron ore

The iron ore in Greasy Cove consists of beds of limestone, sandstone, and shale containing hematite in varying proportions. The thickness of these ferruginous beds ranges from a few inches to 7½ feet (see figs. 1 and 2), but only those more than 2 feet thick are of value. The hematite is present as amorphous ferric oxide (Fe_2O_3), which stains and replaces limestone and shale and cements together fragments of fossils and grains of calcite and silica; it also forms concentric layers about minute nuclei, thus building up flattened granules called "oolites." In places certain beds do not contain sufficient iron to be considered ore, but in others the percentage is sufficiently high. In present blast-furnace practice rock containing less than 30 percent of iron is below the acceptable limit, but a limestone containing moderate percentages of silica, alumina, and phosphorus, and 15 to 30 percent of iron should be desirable as a fluxing material. The Red Mountain formation in Greasy Cove contains much of this that should prove of value in metallurgical operations.

The ferruginous limestones where weathered have lost their soluble constituents, mainly calcium carbonate, and the less soluble constituents such as iron, manganese, silica, alumina, and phosphorus are proportionately increased within a given mass. The material high in lime is popularly termed "hard" ore and the weathered material "soft" ore, and these terms thus have both a chemical and a physical significance. About the head of Greasy Cove, where the beds of ore lie nearly horizontal under a moderate thickness of overlying rocks and soil and have evidently been subjected to long-continued weathering, much of the soft ore has become partly hydrated, so that the unusual occurrence of bedded limonite, in place of bedded hematite, is displayed. Ore of this type contains in places a slight excess of aluminous material, evidently a result of original deposition, as some of the original hard ore was slightly clayey.



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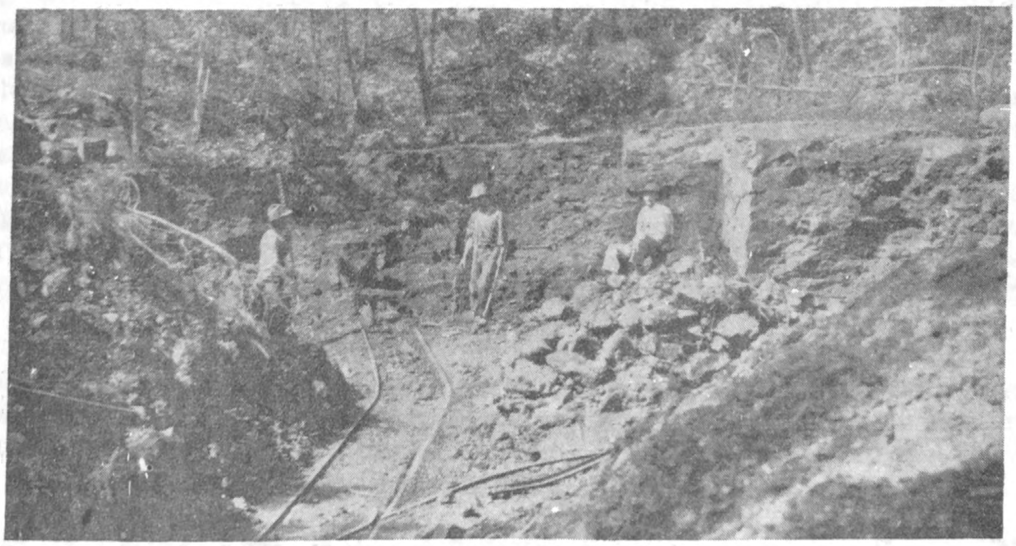

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Figure 1.- Face of red iron ore bed 7½ feet thick near head of Greasy Cove.

Figure 2.- Open-pit mining of red iron ore near head of Greasy Cove.

Many chemical analyses of ores from Greasy Cove are given in the following pages. The ores vary greatly within the same mine workings and also from place to place, but if the requirements of present practice in blast furnaces and open-hearth steel plants are kept in mind it can readily be seen whether or not a particular ore can be used. For instance, hard and semihard ores ranging in metallic iron from 32 to 45 percent, lime from 5 to 20 percent, magnesia from 1 to 3 percent, silica from 2 to 25 percent, alumina from 2 to 5 percent, manganese from 0.1 to 0.3 percent, phosphorus from 0.1 to 0.9 percent, sulphur from a trace to 0.5 percent, and water from 0.3 to 3 percent should be acceptable; if the ore is soft, its metallic iron may be found as high as 56 percent, with its other insoluble ingredients also higher than in the hard ore but with little or no lime present.

Description of the ore outcrops

A V-shaped strip of Red Mountain formation borders Greasy Cove, terminating at the southwest about 2 miles southwest of Little Canoe Creek and extending along the northwest and southeast sides of the cove from a point about 2 miles west of Ivalee to a point about 2 miles west of Attalla. Measured roughly on plate 1, the total length of this strip of outcrop, including the circumference of the elliptical area southwest of Attalla but not around the southeast side of Chandler Mountain, is about 21.3 miles. Of this outcrop about 6.46 miles contains beds of ore 2 feet or more in thickness, but in the rest the beds are less than 2 feet thick. The continuity of this outcrop with those of Wills Valley northeast of Littleton and Attalla is interrupted by faults. Part of the strip of Red Mountain rocks in Greasy Cove is in the Gadsden quadrangle, the geology of which has been mapped in Folio 35 of the Geologic Atlas of the United States, but the part around the head of the cove where the thickest outcrops of ore have been found is in the Springville quadrangle, of which there is a reconnaissance topographic map but no geologic folio.

The data on red iron ore in Greasy Cove are given beginning along the northwest side of the cove, west of Ivalee, and extending southwestward and southward around the head of the cove, thence northeastward along the southeast border to a point within about 2 miles from Attalla.

<u>West of Ivalee</u>.--The strip of Red Mountain formation on the northwest border of Greasy Cove, as shown on the geologic maps of the Gadsden quadrangle and of the State of Alabama, appears about $1\frac{1}{2}$ miles west of the station of Ivalee on the Louisville & Nashville Railroad and extends toward the southwest. Northeast of this point, which is in the southwestern part of sec. 25, T. 11 S., R. 4 E., the ore-bearing formation is faulted below the surface for a distance of about 3 miles, or as far as Littleton. There have been unconfirmed rumors, however, that traces of ore have been found within the 3 miles next southwest of Littleton, but this is difficult to explain because in this locality the Red Mountain formation seems to be definitely involved in a fault that has buried its outcrop beneath the Carboniferous rocks at the base of Blount Mountain, between the Nashville, Chattanooga & St. Louis Railway at Littleton and the point where the Louisville & Nashville Railroad enters sec. 25, T. 11 S., R. 4 E., from the east.

The northeast end of the outcrop of the iron-ore-bearing formation is apparently in the southwestern part of sec. 25, T. 11 S., R. 4 E., northwest of the Louisville & Nashville Railroad, as no further outcrops are recorded between that locality and Littleton. In a series of test pits, which extend over a distance of about 1,000 feet on the strike of the beds, near the middle of sec. 35, T. 11 S., R. 4 E., the ore is reported to range from 1 foot to 1½ feet in thickness and to vary in dip from 41° SE. to 84° NW., with the beds vertical in places. Samples of the ore, which was soft and contained no lime, showed 43 to 49 percent of iron, 11 to 16 percent of silica, 6 to 10 percent of alumina, and 8 to 14 percent of water.

In a gap in the ridge half a mile or more southwest of the abovementioned test pits there is a good section of the Red Mountain formation, mainly sandy shale and thin sandstone, dipping 85° to vertical and measuring between 400 and 425 feet in thickness. As well as can be ascertained this exposure is near the northwest corner of the SW¼SW¼ sec. 35, T. 11 S., R. 4 E. A secondary road passes through this gap in the ridge, and on the northeast side of the road two thin seams of ore separated by 6 feet of shale have been exposed in the road cut. A section of these seams measured by the writer is as follows:

Section of ore-bearing portion of Red Mountain formation in gap of ridge about 3 miles west of Ivalee

	Ft.	in.
Shale.		
Ore, soft..		3
Shale..		4½
Ore, soft, fossiliferous.........................		10
Shale and shaly sandstone......................	6	
Ore, soft, fossiliferous.........................		10
Sandstone...	1	
Ore, fine-grained, sandy........................		1
Shaly sandstone.		

Dip nearly vertical, strike N. 55° E. Total ore, upper bench 1 foot 1 inch, lower bench 11 inches.

The ore is fine-grained and firm, though leached. Fossil crinoids are common, but the ore seams do not contain certain large fossil corals that might serve to correlate them with a thicker bed of ore that occurs farther southwest, near the head of Greasy Cove. Toward the northwest, about 200 feet higher stratigraphically than the ore seams but at nearly the same altitude, the Chattanooga shale, 60 feet thick, is well exposed in the road and creek. On the south side of this gap a sample of ore was taken during a private survey, the records of which indicate a thickness of 1 foot 10 inches, with constituents averaging about as follows: Iron, 36.5 percent; silica, 25 percent; alumina, 9 percent; lime, 0.8 percent; phosphorus, 0.45 percent; manganese, 0.7 percent; and water, 15.6 percent. The ore dips 85° NW.

Schoolhouse Gap.--Between the gap just mentioned and Schoolhouse Gap, about $1\frac{1}{4}$ miles toward the southwest, or in the southwest corner of the SE$\frac{1}{4}$ NE$\frac{1}{4}$ sec. 4, T. 12 S., R. 4 E., the ore outcrop appears to be fairly continuous, and the Red Mountain formation has been prospected in several places. Tunnels have been driven into the ore bed from the southeast side of the ridge at 3,400 feet and 2,400 feet northeast of Schoolhouse Gap; a shaft, reported to be nearly 150 feet deep, was sunk 1,800 feet northeast of the gap; and some drifts have been made at the northeast and southwest sides of the gap. In this area the ore bed is much thicker than shown in the section west of Ivalee, giving rise to the belief, locally entertained, that ore here occupies the interval of shale and shaly sandstone between the two thin seams indicated in that section. The thickness of the bed here ranges from about 4 feet at the north tunnel to 6 feet 5 inches at the top of the deep shaft. There is also the possibility that thrust faulting along the plane of the ore bed has increased locally the apparent thickness of the ore.

A noteworthy and interesting feature of the ore in this bed at this locality, as shown in the dumps from shaft and tunnels, is the presence of many peculiar flat pebbles or "kidneys" of iron ore. (See fig. 3.) These pebbles range in thickness from one-eighth to three-fourths inch, and in diameter from half an inch to 6 inches, though most of them are 2 to 3 inches in diameter. The flat sides of the pebbles show slight pitting due to the action of solution and abrasion on uneven-textured material, and the surfaces are coated with soft, shiny amorphous hematite, probably derived from the beds in which they lie. When broken the pebbles are found to consist chiefly of calcareous granular hematite typical of the Red Mountain iron-ore beds, but some of them are composed of fine-grained sandy limestone, more or less ferruginous. These pebbles are found in both the "hard" or limy condition, and the "soft" or nonlimy condition, corresponding to the condition of the enclosing bed of ore, which is generally hard below a depth of 85 feet in this shaft. The shape of the pebbles indicates that they have been subjected to wave action long enough to round the edges to some extent but not enough to produce typical well-rounded gravel. The distribution of the granules of hematite and streaks of calcite in the pebbles of ore indicates that they have been split from a bed of ore along the bedding of the sediments, and the position of the pebbles within the present matrix, which is itself typical Red Mountain ore, is parallel to the bedding. The pebbles contain small fossils, among which crinoid buttons and fragments of imperfectly preserved corals and brachiopods are readily discernible. The evidence thus far adduced indicates that the pebbles were derived from ore-bearing beds that had been deposited and consolidated before this bed was formed. Possibly the source bed was a portion of this same bed that rose temporarily nearly to or slightly above sea level. As stated above, the pebbles occur in the basal part of the ore bed, which is the natural position for a conglomeratic deposit.

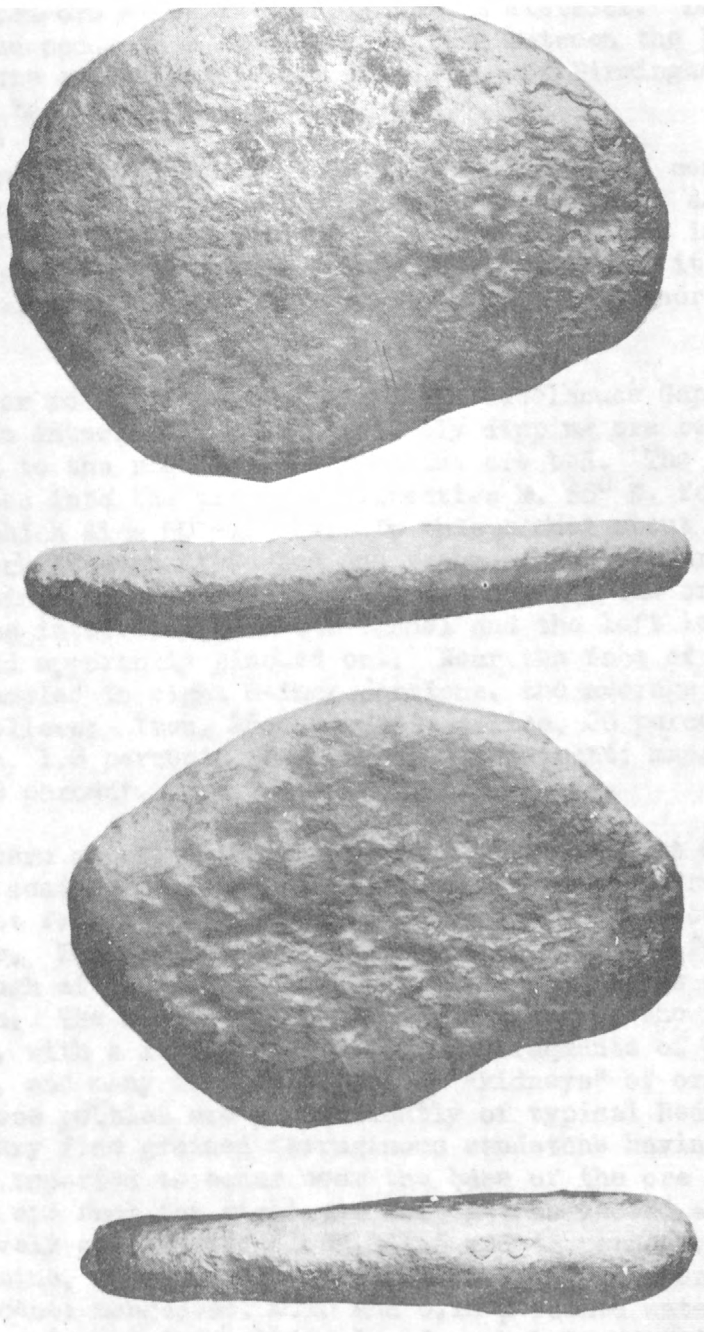


Figure 3.— Pebbles of red iron ore from Schoolhouse Gap, showing flat sides and edges.

This deposit of ore pebbles, although unusual, is not the only one of the sort to be observed in Alabama, for similar pebbles occur at the Citico mine, on Shinbone Ridge north of Gadsden, 17 miles N. 75° E. of the Schoolhouse Gap shaft, and others have been noted by the writer in ore from the Shannon and other red-ore mines in the Birmingham district. Large discoid pebbles of limestone occur in a sandstone parting between the Irondale and Big seams of iron ore at the Helen-Bess mine, east of Birmingham, 3/ which is thought to have been formed as a conglomerate.

Fossils consisting of crinoids, brachiopods, and small cone-shaped corals are common in the ore bed, but none of the large corals that are abundant in the ore bed farther southwest in Greasy Cove were noted, so, in view of the occurrence of ore pebbles in the ore bed on Shinbone Ridge, it seems more reasonable to correlate this bed with the ore bed in areas northeast of Greasy Cove.

The tunnels, or rock drifts, northeast of Schoolhouse Gap were driven through rock to the intersection of the steeply dipping ore bed, and thence levels were driven to the right and left on the ore bed. The northeastern or no. 2 tunnel goes into the hill in a direction N. 65° W. for about 125 feet to the ore, which dips 60°-70° NW. In this tunnel about 20 feet from the ore bed the rock is much disturbed and fragments of ore are mixed with the shale, indicating a fault plane along which some of the ore bed has been dragged, and at the intersection of the tunnel and the left level the ore has been overturned and apparently pinched out. Near the face of the right level the ore bed was sampled in eight 6-inch portions, the average of the analyses of which was as follows: Iron, 25.6 percent; silica, 36 percent; alumina, 12.5 percent; lime, 1.5 percent; phosphorus, 0.4 percent; manganese, 0.13 percent; water, 12 percent. The bed here dipped 70° NW.

The southwestern or no. 1 tunnel, variously reported at 800 feet to a quarter of a mile southwest of tunnel 2, is similar in construction, reaching the ore at 150 feet from the entrance and 80 feet below its outcrop on the crest of the ridge. The ore bed has a thickness of about 4 feet, with a dip of 83° NW., although at the entrance to the tunnel the rocks dip only 50° in the same direction. The ore on the dump at the mouth of the tunnel was mainly soft and semihard, with a little hard ore. The fragments of ore were more or less slickensided, and many flat "pebbles" or "kidneys" of ore and other rock were present. These pebbles are predominantly of typical Red Mountain ore, but some are of very fine grained ferruginous sandstone having a calcareous cement. They are reported to occur near the base of the ore bed. Analyses of samples of the ore from the right and left levels showed approximate averages respectively as follows: Iron, 41.5 and 42 percent; silica, 19 and 18.5 percent; alumina, 8 and 7 percent; lime, 1.8 and 2.5 percent; phosphorus, 0.64 and 0.70 percent; manganese, 0.15 and 0.15 percent; water, 13 and 15 percent. The ore from tunnel 1 is obviously of much better grade than that from tunnel 2.

3/ Butts, Charles, Geology of Alabama: Alabama Geol. Survey Special Rept. 14, p. 137, pl. 41, B, 1926.

If the hard ore in depth proves to be of suitable grade, loading and transportation can be accomplished economically, because the Louisville & Nashville Railroad is practically at the mouths of these tunnels. There are certain structural features here, however, which may give some difficulty. Theoretically, the ore bed at some depth should dip moderately and evenly toward the northwest and pass beneath Blount Mountain. In order to test this inference a hole is reported to have been drilled northwest of the shaft to a depth of 1,500 feet and at an angle of 60° SE., but it encountered only limestone and no Red Mountain formation or iron ore. This may indicate that the ore bed has been cut off at considerable depth by a fault, probably of the overthrust type.

The prospect shaft 1,800 feet northeast of Schoolhouse Gap and 600 feet southwest of tunnel 1 is just east of the crest of the ridge. It follows a nearly vertical bed of ore that strikes N. 35°-40° E. and is about 6 feet 5 inches thick including partings. When visited in 1928 and 1930 the shaft could not be entered to obtain detailed measurements, but shaly and sandy seams in the bed would reduce the total thickness of ore. Although the beds at the top of the shaft are badly weathered and the ore appears dark and clayey, the soft ore on the dump appears to be of better grade. The shaft reached hard ore, and some specimens show considerable calcium carbonate. Many fragments of ore are strongly slickensided, showing movement of the beds during the folding and faulting.

The Schoolhouse Gap shaft was sunk at considerable expense by some Chicago business men shortly after the World War, and each foot of the cross section of the ore bed was carefully sampled at several depths. A summary of the results of sampling and analyses at certain of these depths within the hard ore is as follows:

Data concerning vertical ore bed in shaft north of Schoolhouse Gap a/

Depth (feet)	Thickness of bed	Fe (percent)	SiO_2 (percent)	Al_2O_3 (percent)	CaO (percent)	P (percent)
70	8 ft. 9 in. (1 in. shale parting)	25.80	25.45	8.90	10.25	0.45
85	5 ft. 6 in.	32.30	17.80	7.02	11.00	.48
			Insoluble			
93	8 ft. 4 in.	(17.60 to (35.40 (26.69 av.	14.10 to 39.80 28.94 av.		9.51 to 19.93 13.00 av.	
114	7 ft. 6 in.	(20.90 to (38.70 (28.45 av.	15.60 to 39.30 26.98 av.		10.23 to 17.80 13.00 av.	
126	7 ft. 2 in.	(23.80 to (35.70 (31.18 av.	13.70 to 35.60 23.64 av.		10.14 to 17.30 13.16 av.	
140	7 ft. 4 in.	(22.10 to (40.40 (29.91 av.	12.90 to 43.00 27.38 av.		8.60 to 15.20 11.94 av.	
150	6 ft.	(21.10 to (36.50 (30.82 av.	9.60 to 41.90 25.54 av.		7.20 to 18.90 12.33 av.	

a/ Courtesy of David Hancock, Birmingham, Ala.

The detailed analyses show variations between every foot of the bed and no definite regularity in the quality of the ore according to its stratigraphic position, except that in general the lower part of the bed is of better quality than the upper part. The averages of the analyses show that the hard ore is below present-day commercial grade.

In addition to the deep shaft two test pits were dug nearby. A section in one of them and analyses of the soft ore from both pits are given below.

Section at bottom of north test pit near Schoolhouse Gap shaft

	Ft.	in.
Clay.		
Ore........................		4
Clay.......................		2
Ore........................		2
Clay.......................		1
Ore........................		5
Clay.......................	1	3
Ore........................	1	7
Clay.......................		1
Ore........................	1	9
Clay.		

Total ore, 4 feet 3 inches

Analyses of soft ore from test pits near Schoolhouse Gap shaft
[David Hancock, analyst, Birmingham, Ala.]

	Fe	SiO_2	Al_2O_3	P
North pit, 4 ft. 3 in. of ore...	52.10	12.77	5.49	0.34
South pit, 5 ft. of ore........	43.90	19.65	8.40	0.36
South pit, 3 ft. 6 in. of ore in lower pit................	49.40	15.35	6.58	0.35

The soft ore, as would be naturally expected, contains sufficient iron to be of value, but the alumina is undesirably high.

At the northeast side of Schoolhouse Gap, in a small hollow in the ridge, a large prospect cut extends southeastward into the ridge. These workings are of many years' standing and so overgrown and caved in that little could be seen except some dark-red clayey beds. Pieces of good soft ore 2 to 3 inches thick were noted on the dump and as float in the gully. At the southwest side of the gap a drift 30 feet long was filled with water at the time of visit.

Southwestward from Schoolhouse Gap for nearly three quarters of a mile, to the gap in which the Louisville & Nashville Railroad passes through the ridge south of the center of sec. 4, T. 12 S., R. 4 E., the ore outcrop is traced by several small test pits just east of the crest of the ridge, and the ore bed appears to be thin. About half a mile southwest of Schoolhouse Gap two small pits show a badly weathered red ore, dipping steeply northwest, associated with shale. Streaks of good, fine-grained "flaxseed" ore containing specks of limonite are present, but much of the seam is shaly. The southwest pit shows about 2 feet 6 inches of ore merging into shaly ferruginous material above; the northeast of the two pits shows the following section:

Section of ore bed in test pit half a mile southwest of Schoolhouse Gap

	Ft.	in.
Shale, yellow.		
Shale, purplish, with streaks and nodules of ore..............		8
Ore....................	1	10
Shale.		

Dip 65°-70° N. 30°W. Ore, not more than 2 feet.

An analysis of ore reported to have been sampled near this pit showed averages of 34 percent of iron, 29 percent of silica, 12 percent of alumina, 0.23 percent of lime, 0.25 percent of phosphorus, 0.10 percent of manganese, and 9 percent of water. The thickness of this ore is reported as 1 foot 11 inches, and the grade is low for a soft ore.

Between these pits and the hollow where the Louisville & Nashville Railroad crosses the ore-bearing ridge several more small pits were noted on the ridge. Some of them showed no ore, and others showed small debris of good soft ore. The thickest block noted was 7 inches thick. The railroad cut does not show any ore beds, probably because ravines have been eroded in the ridge parallel to the strike of the rocks and the ore outcrops have probably been removed by erosion.

McCalley 4/ gives the following section of an ore bed in a gap near the point where the railroad crosses the Red Mountain formation:

Section of ore bed in the NE¼SW¼ sec. 4, T. 12 S., R. 4 E.

	Ft.	in.
Debris.		
Ore........................		5
Shale......................		8-10
Ore, good..................		2
Shale......................	1	
Ore, good..................		6

Total ore 1 foot 1 inch; dip 20°-60° NW.

4/ McCalley, Henry, Report on the valley regions of Alabama, pt. 2, p. 207, Alabama Geol. Survey, 1897.

Gilliland Spring Branch.--Southwest of the Louisville & Nashville Railroad along the ridge to Gilliland Spring Branch, near the northeast corner of sec. 8, T. 12 S., R. 4 E., for a distance of about half a mile, the ore outcrop is not well displayed. In a test pit 500 feet southwest of the point where the railroad crosses the line of outcrop a bed of ore 1 foot 6 inches thick dipping 53° SE., or overturned, was sampled. No lime was present, and the soft ore showed approximately the following average composition: Iron, 41.5 percent; silica, 21 percent; alumina, 11 percent; water, 10 percent.

Southwest of Gilliland Spring Branch up the slope of the ridge there are 10 or 12 prospect pits and trenches, none of which show ore, but at the top of the ridge a prospect shows a trace of ore, and 600 feet from the gap a shaft about 30 feet deep has been sunk on the dip of the ore, which is 71° SE. The ore here was found to be about 2 feet 3 inches thick, very firm, and of a fair grade except that the alumina was high. An average of the analyses of five 6-inch sections showed 47 percent of iron, 15 percent of silica, 8.8 percent of alumina, 0.22 percent of lime, 0.33 percent of phosphorus, 0.12 percent of manganese, and 10 percent of water.

About 200 feet southwest of the prospect shaft a drift has been driven northwest into the east side of the ridge, intersecting two ferruginous beds at about 115 and 150 feet. The ferruginous beds are 5 to 7 feet thick but of very poor quality, containing only 6.5 to 15 percent of iron, with 45 to 56 percent of silica, 22 to 26 percent of alumina, and 14 to 16 percent of water. The beds have been badly disturbed by folding and faulting, and the ferruginous beds, if they represent the normal ore zone, have been greatly altered or else were originally of poor grade.

About 1,450 feet southwest of Gilliland Gap a test pit in a hollow on the east side of the ridge is reported to show 2 feet 6 inches of ore dipping 76° NW. The average of five samples taken across this ore seam is reported to show 24 percent of iron, 41 percent of silica, 13 percent of alumina, 0.05 percent of lime, and 10 percent of water. Two more prospects, a well and a trench, within a few hundred feet farther southwest show ore about 2 feet 10 inches thick in the well and only a few inches thick at the trench, both seams standing nearly vertical. Between these prospects, which are probably near the middle of the NE$\frac{1}{4}$ sec. 8, T. 12 S., R. 4 E., and the Gallant-Tumlin Gap-Altoona road, about three quarters of a mile to the southwest, several test pits have been dug but no ore was found. It is probable that some of the ore outcrop along here has been cut out by a fault to a point 300 feet southwest of the highway, where, on the crest of the ridge, the ore is again cut in a test pit. From this point southwestward for more than half a mile are the workings of the Tumlin Gap mine.

Tumlin Gap mine.-- The mine openings are half to three quarters of a mile south of Tumlin Gap, in the SE$\frac{1}{4}$ sec. 7 and the northern part of sec. 18, T. 12 S., R. 4 E., and consist of levels driven northeast and southwest on the strike of the ore bed from an entry in a hollow on the northwest side of the ridge opposite the Louisville & Nashville Railroad station at Tumlin Gap, levels driven similarly from a slope on the southeast side of the ridge farther southwest, a shaft, and another slope farther southwest from which levels have been driven in both directions connecting with a drift in a hollow at the southwest end of the workings.

In 1913 this mine was first visited by the writer, who measured the following section in a level in the northeastern part of the workings:

Section of ore bed in drift of Tumlin Gap mines

	Ft.	in.
Shale.		
Shale, sandy, limonitic..........		3
Ferruginous sandstone, or "jack" rock........................		4-6
Ore............................		5-6
Shale..........................		1-2
Ore............................	2	6
Shale.		

Total ore about 3 feet. Dip 83° N. 35° W.

The ore was obtained by overhead stoping, and the mine was at that time reported to be furnishing small quantities of semihard and soft ore to the blast furnace of the Gulf States Steel Co. at Alabama City. The semihard ore is fine to medium grained, shows a little calcite and silica, and is much slickensided.

In 1917 the level at this mine was reported to be 500 feet long and the ore bed to average about 2 feet 4 inches in thickness. The bed was found to be nearly vertical, and as the drift was driven practically on the top of the hard ore the product was principally soft ore. When visited in 1928 the mine had long been idle and the workings could not be entered, so that little could be seen. The old slope (Hammond?) in the southwestern part of the workings is driven at an inclination of 41° NW. The ore on the dump was fine-grained, compact, well-leached material. No large fossil corals were noted such as are common in the thick bed of ore farther southwest in Greasy Cove. It is reported that within the slope the ore in places showed a thickness of 4 feet 5 inches and in other places thinned out considerably, which indicates local squeezing by movement of the rocks.

Movement of the rocks is further indicated by the fact that this line of outcrop is terminated within a short distance to the southwest and the Red Mountain formation is offset by faulting a distance of 500 feet toward the northwest. The faulting, folding, and fracturing of the ore bed and associated strata have greatly handicapped mining operations here and do not lend encouragement to the expectation that more than a moderate tonnage of soft ore is to be available for future mining. From what could be learned of the history of operations a large part of the soft ore originally available has been obtained, and it is doubtful whether the hard ore can be considered a resource of value.

One sample of the completely hard ore taken in 1917 contained only 22 percent of iron, but the soft ore showed more than 53 percent of iron.

Data on sampling the ore disclose in the upper workings a soft ore carrying a good percentage of iron with a moderate quantity of silica but rather high alumina. Lower in the slope the ore becomes thinner and calcareous, or "hard" to semihard, variable in composition.

Analyses of iron ore from Tumlin Gap mine

Description	Authority[a]	Fe	SiO_2	Al_2O_3	CaO	P	Mn	H_2O
Semihard ore...	GS	39.15	29.86[b]		-	-	0.54	-
Top foot.......	GS	39.82	25.50	8.95	-	0.34	.66	-
2d foot........	GS	40.71	24.62	8.91	-	.36	.67	-
3d foot........	GS	36.24	31.10	8.66	-	.33	.80	-
4th foot.......	GS	38.43	28.64	7.11	-	.21	.83	-
5th foot.......	GS	37.04	28.56	7.53	-	.29	1.04	-
Bottom sand....	GS	28.50	45.04	6.40	-	.26	.77	-
Test pit, 2 ft. 11 in.	GS	41.03	17.95	6.89	None	.52	.68	15.8
Stope, 2 ft. 4 in.	GS	40.90	19.60	9.72	0.22	.47	.12	13.4
Outcrop, 4 ft. 2 in.	GS	55.16	6.94	4.28	None	.21	.08	16.1
Drift, av., 4 ft	GS	47.50	12.30	8.64	None	.44	.33	18.1
Pile of ore....	P	49.39	5.60	4.31	7.15	-	-	-
Ore, 2 to 3 ft.	P	53.72	6.80	5.02	2.26	-	-	-

a/ GS, Gulf States Steel Co., dry basis; P, Wm. B. Phillips.

b/ Insoluble.

The following analyses made at different places down the slope show a similar composition for the ore:

Analyses of iron ore from Tumlin Gap mine a/

Distance down slope (feet)	Thickness Ft.	Thickness in.	Part of bed	Ft.	in.	Fe	SiO_2	Al_2O_3	CaO	P	Mn
30	4	5				48.60	13.75	5.92	-	0.46	0.17
35	4	4	Top	1		42.50	19.20	6.35	-	.59	0.20
			2d	1		51.00	10.20	5.14	-	.52	
			3d	1		48.20	12.13	6.16	-	.51	
			Bottom	1	4	49.60	12.00	5.10	-	.45	
100	b/4	1	Top	1		47.30	10.65	5.39	1.60	.69	
			2d	1		52.30	9.25	4.81	1.20	.58	
			Bottom	1	8	47.50	12.05	5.72	1.80	.67	
			Computed Average			48.85	10.92	5.39	1.58	.65	
120	c/3					35.70	9.30	5.87	12.05	.49	
141	4		Top		10	37.75	8.25	5.60	11.70	.78	.14
			Middle	2		42.30	7.25	4.35	9.90	.51	.12
			Bottom	1	2	24.00	27.25	10.82	6.30	.48	.16
181	2	6	All			37.90	4.70	3.63	13.45	.50	(d/)
186 (below "knuckle")	2	6	All			36.90	5.60	4.31	13.40	.62	
						39.40	5.90	4.97	10.45	.62	
190	2	9	All			40.70	5.40	4.64	8.65	.65	
210	2		All			34.70	10.10	6.37	8.15	.52	

a/ Analyses by David Hancock, Birmingham.
b/ Top 5 inches left as roof not sampled.
c/ Top 1 foot or more left as roof not sampled.
d/ Organic matter, 9.58 percent; also present in many other samples.

Southwestward for about a mile on the outcrop of Red Mountain formation that has been offset toward the northwest in the vicinity of the Tumlin Gap mine workings, several test pits and trenches have been dug and some drifts driven into the ridge on both sides of a gap. These prospects are reported to have disclosed only ferruginous sandstone and low-grade float ore. On the northwest side of this ridge is a narrow-gage railroad that extends from the Louisville & Nashville Railroad at Tumlin Gap southward 3¼ miles to some mine workings near the head of Greasy Cove. This narrow-gage railroad crosses from the northwest to the southeast side of the iron-ore-bearing ridge in the gap made by Little Canoe Creek in the NE¼SE¼ Sec. 13, T. 12 S., R. 3 E.

Little Canoe Creek.--On the north bank of Little Canoe Creek in this gap a prospect drift 25 feet long, reported to have been dug about 1902, exposed 3 feet of dark sandy ferruginous material. The strata are disturbed and squeezed here and overturned so as to dip 45° SE. The ferruginous material is far too low in grade to be available as iron ore, but on the dump are traces of large fossil corals such as are found in the thick ore bed not far southwest of this locality.

From Little Canoe Creek south-southwestward nearly to McClendon Gap, near the middle of sec. 24, T. 12 S., R. 3 E., a distance of a little more than 1 mile, the Red Mountain formation follows a line of low hills separated by several gaps. On the hill just south of Little Canoe Creek several test pits and a drift failed to disclose ore, although pieces of float ore are found on the hill slopes. Valuable ore is absent also for about three quarters of a mile southwest of the creek. On each side of the first gap two drifts have been driven and a spur was built into this gap from the narrow-gage railroad. Analyses of two samples of ore from these drifts showed 10 and 28 percent of iron, 58 and 36 percent of silica, and 19 and 13.6 percent of alumina, indicating a material of too low grade for an ore. The beds are overturned and dip 75° E. Between this gap and the McClendon Gap mine there are several more test pits, only one of which showed ore. This was in a seam 1 foot 6 inches thick carrying 21 percent of iron and about 60 percent of silica plus alumina. Here also the rocks are overturned and dip 39° E. It is thus evident that in the strip of Red Mountain formation between the Tumlin Gap mine and the mine workings near McClendon Gap there is little promise of valuable ore.

McClendon Gap.--On the north and south sides of the public road through McClendon Gap near the middle of sec. 24, T. 12 S., R. 3 E., mine drifts were first driven many years ago, and mining was resumed there, principally on the north side of the gap, in 1928. These workings, recently made accessible, consist of seven drifts on the northeasterly strike of the ore bed at different levels from that of the road up to about 270 feet higher.

When first visited by the writer in 1913 two trenches in the north hillside, not far above the road, showed a bed of dark-red soft, porous ore composed mainly of hematite but containing many specks of limonite and in places a scale of limonite at the top. The ore contains an abundance of fossils, including large corals, thus probably representing the "big coral" bed that is well displayed in open cuts near the head of Greasy Cove. A section, measured at that time, is as follows:

Section of ore bed on north side of McClendon Gap

	Ft.	in.
Shale and sandstone.		
Ore, soft, good........................	3	3
Ore, shaly, poor.......................	1	2
Shale.		
	4	5

Dip 25°-29° S. 83° W.

An analysis of a sample from McClendon Gap, cited by McCalley, 5/ averaged from an upper bench 1 foot 6 inches thick and a lower bench 6 inches thick, dried at 105°, gave 35.8 percent of iron, 10.45 percent of silica, 20.06 percent of lime, and 0.382 percent of phosphorus, apparently indicating a good grade of hard ore.

In a drift on the north side of the road and 110 feet above it the following section is reported:

Section of ore bed on north side of McClendon Gap

	Ft.	in.
Ore, clayey, black and yellow bands...	1	1
Ore, red, fossiliferous, fairly firm..	1	6
Ore, clayey...........................	2	5
	5	

Dip, 47° NW.

An analysis of a sample from this place showed 46 percent of iron, 13 percent of silica, 8 percent of alumina, 1.4 percent of lime, 0.8 percent of phosphorus, 0.5 percent of manganese, and 15 percent of water.

In the next higher drift, 130 feet above the road level, 5 feet 1 inch of the bed was sampled, although only about 4 feet was reported as good ore. The ore was semihard to hard except for the top foot, which was nearly a soft ore. The average for the material showed 34 percent of iron, 4.9 percent of silica, 3.2 percent of alumina, 18.8 percent of lime, 0.36 percent of phosphorus, 0.28 percent of manganese, and 8.8 percent of water.

The next higher drift, 158 feet above the road, showed a thickness of about 5 feet dipping 26° NW. The top 10 inches is reported as lean, rotten ore, somewhat sandy, with 4 feet 2 inches of semihard to hard ore below. An average of analyses of nine layers of this bed gave 37 percent of iron, 6 percent of silica, 3.7 percent of alumina, 15 percent of lime, and 11 percent of water. The bottom 2 feet was of low grade, carrying only 12 to 27 percent of iron and 25 to 39 percent of lime.

In a drift 170 feet above the road level a thickness of about 8 feet of ferruginous material is shown. The upper 4 feet of the bed carries 44 percent of iron, 13 percent of silica, 8 percent of alumina, no lime, and 12 percent of water, but the lower 4 feet carries 16.5 percent of iron, 44 percent of silica, 20 percent of alumina, no lime, and 12 percent of water. An average of these two analyses shows only a little more than 30 percent of iron. There are two drifts higher on the hillside, at 240 and 270 feet above the road level, connected by a raise. In the lower of these two drifts a fault cuts the ore bed, which is 4 feet thick. The upper drift contains 4 feet of ore dipping 27° NW., and considerable soft ore is reported to have been mined here.

The following analyses of ore taken from a water-level drift on the north side of the road at McClendon Gap in 1923 were made by David Hancock, of Birmingham. The hard ore was reported as the main seam, 6 feet 6 inches thick;

5/ McCalley, Henry, Report on the valley regions of Alabama, pt. 2, p. 282, Alabama Geol. Survey, 1897.

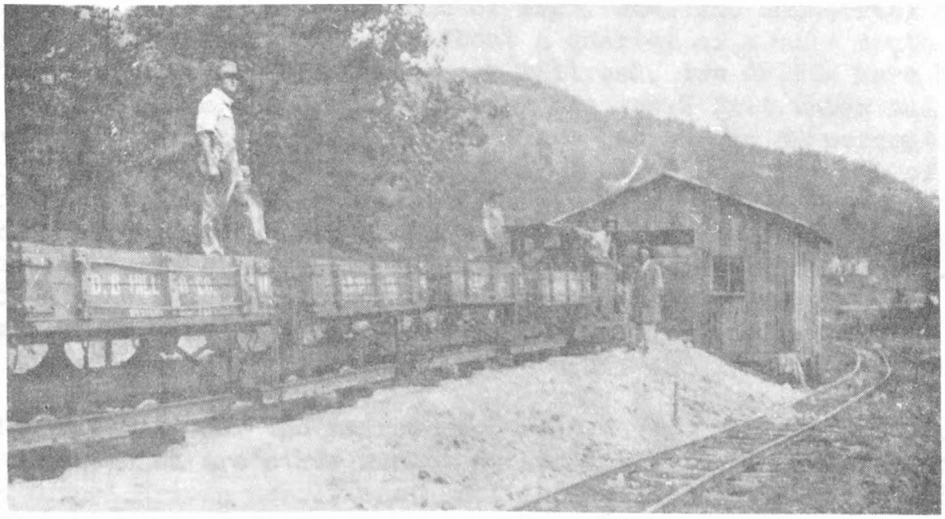
the soft ore was reported as "No. 2" seam, but no thickness was given:

Analyses of hard and soft ores from McClendon Gap

	Hard ore	Soft ore
Metallic iron (Fe)............	16.70	38.30
Insoluble material...........	3.90	31.30
Lime (CaO)....................	34.80	1.60

On the south side of McClendon Gap two drifts have been driven on the strike of the ore bed. When visited in 1928 the lower drift could be entered for only about 50 feet, to a point where a cave-in had occurred. The ore, which had become decomposed to soft sand and clay and hydrated iron oxide, dipped toward the northwest and appeared to be nearly 4 feet in thickness. Fossils of large branching fossil corals, one measuring 2 feet in diameter (probably Halysites), were noted in the waste dump. Reports of an examination made later of the other drift, about 130 feet higher than the road, indicate that at 80 feet from the mouth the ore is 3 feet 6 inches thick, dips 58° NW., and yielded a sample of ore containing 47 percent of iron, 9 percent of silica, 6 percent of alumina, 3.7 percent of lime, and 18 percent of water.

The recent mine workings at McClendon Gap are connected with the narrow-gage tramway that follows the southeast base of the ridge in this vicinity. In 1928-29 shipments of ore were made from McClendon Gap and from mines farther south in Greasy Cove to the open-hearth steel furnace of the Gulf States Steel Co. at Alabama City and to the blast furnaces of the Sloss-Sheffield Steel & Iron Co. at Birmingham. On this tramway, which connected with the Louisville & Nashville Railroad at Tumlin Gap, trains of cars having a capacity of 3 tons each were hauled by a gasoline-driven dinkey locomotive. (See fig. 4.)



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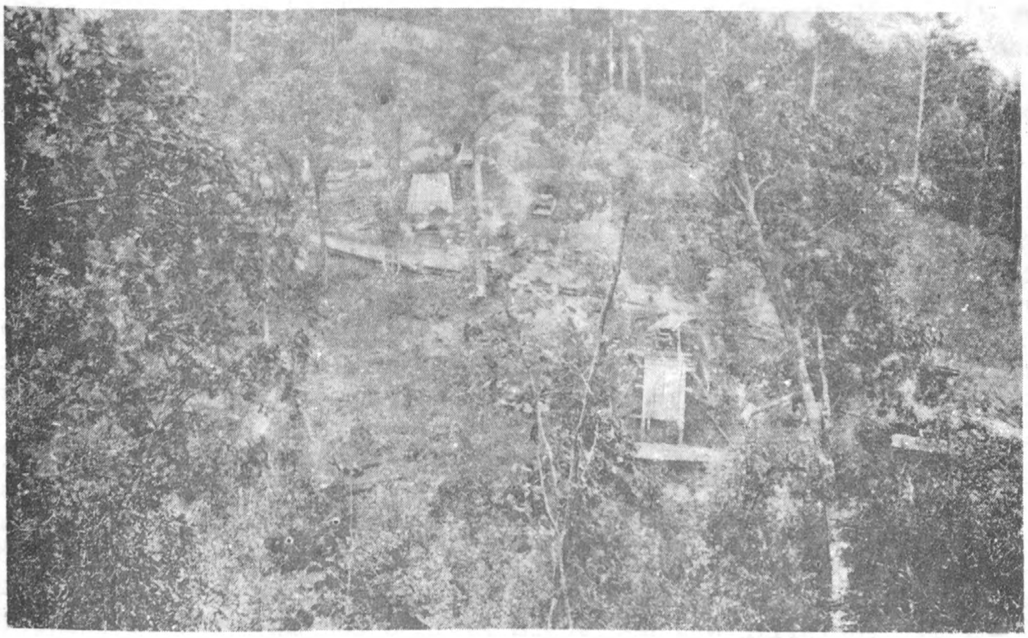

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Figure 4.—Ore train drawn by gasoline dinkey engine on narrow-gage railroad at Tumlin Gap.

Figure 5.—Drift entries on red iron ore bed on northeast side of Moodys Gap. A line-up of the entries shows that the dip of the ore bed is nearly the same as the slope of the ridge.

In the area south of McClendon Gap on both sides of the hollow followed by the narrow-gage railroad considerable new prospecting and mining work had been done until as late as the autumn of 1929, when the industrial depression curtailed the demand for iron ore. About a quarter of a mile south of the gap, on the west side of the narrow-gage railroad, two drifts have been driven into the hillside. In the north drift the ore was 2 feet thick and dipped 18° NW. An analysis of the full thickness of the bed showed 48 percent of iron, 11 percent of silica, 8 percent of alumina, no lime, 0.3 percent of phosphorus, and 8 percent of water. In the south drift possibly a different bed of ore was encountered, because it showed a thickness of 4 feet 6 inches, dipped 75° NW., and was of lower grade. The change in attitude, however, may readily be explained by a much folded and faulted condition of the strata. This ore showed on analysis 40 percent of iron, 20 percent of silica, 10 percent of alumina, 0.90 percent of lime, 0.7 percent of phosphorus, and 15 percent of water.

On the east side of the narrow-gage road a few hundred feet south of the drift just mentioned are other recent workings, the most elaborate of which is a rock tunnel driven nearly east into the hillside with right and left levels and an upraise. The bed of ore on which these workings are projected ranges from 3 feet to 4 feet 6 inches in thickness. This ore bed is apparently 85 to 100 feet lower stratigraphically than the "big coral" bed that is present on the west wide of the hollow and farther south in Greasy Cove. It was not observed to contain the corals with a round base (Ptychophyllum) so characteristic of the "big coral" bed, but it does contain many crinoid buttons and small gastropods. The ore is fine to medium grained, and in places some of it is oolitic.

The two outcrops are shown on plate 1, because they occur on opposite sides of the narrow-gage tramway. The eastern strip of outcrop is comparatively short and may represent a local, abnormally thick development of a seam of ore that is thin or missing in other places. The possibility that it represents a strip of ore repeated by faulting should not be dismissed, but the bed on the eastern outcrop differs so markedly in character from the "big coral" ore bed west of the tramway and farther south in Greasy Cove that the two ore beds cannot be correlated with confidence. Locally this bed has been called the "Attalla" seam, in the belief that it represents the bed of ore formerly mined at Attalla, but there is no certainty as to their continuity, because the ore beds in this vicinity are lenticular in shape, limited in extent, and variable in their position within the formation. The bed crops out on the hillside east of the hollow 50 feet higher than the tramway, and there is another outcrop probably of the same bed 55 feet higher on the hillside. At the lower outcrop the bed dips steeply toward the southwest, but at the higher outcrop it dips 53° ESE. In each place the hanging wall of the bed, which is apparently its roof, is thick-bedded sandstone, and the lower part of the bed is shaly, poor ore, so that the two divergent outcrops apparently represent the same bed folded into a small anticline. From a point 20 feet above the tramway a tunnel was driven eastward and encountered the ore bed, 4 feet 6 inches thick, at 83 feet from the entrance, but on being continued in the same direction it had not reached the supposed other limb of the bed at the time it was found advisable to discontinue work. About 144 feet beyond the ore bed the dip of the strata changed abruptly to nearly horizontal, probably because of a fault and in order to cut across the measures, which consisted of a very hard calcareous sandstone, it was necessary to turn the grade of the tunnel upward. Iron-stained water was seeping into the tunnel when work was abandoned, which may indicate that an ore bed lay beyond and above, but the badly broken nature of the ground here leads to the suspicion that on the east the bed may have been faulted entirely out of the section.

Where the ore bed is followed in a drift to the right, or southward, the strike of the bed is sinous and the level does not follow a straight course. At 150 feet from the tunnel the ore is about 3 feet thick and dips 55° W. Two analyses showed the ore to be hard, containing 24 to 25 percent of iron, 5 to 7 percent of silica, 2.9 to 4.2 percent of alumina, 26 to 31 percent of lime, 0.34 to 0.38 percent of phosphorus, 0.3 percent of manganese, and 1.7 percent of water. Toward the north, in the left level, the ore changes in character to soft, and at a distance of 100 feet from the tunnel a face 3 feet 7 inches thick dipping 84° W. showed the following analysis: Iron, 40 percent; silica, 22 percent; alumina, 11 percent; lime, 0.30 percent; water, 17 percent. Where this level is driven out to the hollow at the north the ore is reported to be thinner.

About 500 feet south of these underground workings, also on the east side of the tramway, are two short drifts and two small surface cuts. The ore found there is chiefly a decomposed, soft ore, 3 feet 6 inches thick, dipping 70° W. Some mining has been done in the open cuts, and the ore was dumped from wheelbarrows into cars on the narrow-gage road.

In 1929 the narrow-gage line terminated a little more than half a mile south of McClendon Gap, and it was planned to extend the line to the open-cut mines of soft ore near the head of Greasy Cove, but it is understood that this has not yet been done. On the west side of the hollow about opposite the end of the narrow-gage line in 1929 the writer examined a drift 180 feet long, driven on a bed of soft ore that appears to lie stratigraphically above the bed worked underground on the east side of the tramway and probably is to be correlated with the "big coral" bed. A sample taken in this drift is reported to have contained 53 percent of iron, 7.3 percent of silica, 5.5 percent of alumina, no lime, and 8.5 percent of water. The bed is about 4 feet 6 inches thick and dips more than 50° NW. The bed here persists as soft ore to a greater distance below cover than in some other places, probably because of the steepness of the dip, which has facilitated the passage of surface water downward along the strata, leaching out their lime carbonate. Considerable soft ore is reported to have been shipped from this opening, the mining was done from several upraises from the tunnel. An ore bin was built on the west side of the track to facilitate storage and loading of ore.

About 300 feet south of the terminus of the tramway a test pit on an ore bed 3 feet 6 inches thick, dipping 66° SW., showed soft ore averaging 54 percent of iron, 6.4 percent of silica, 6.5 percent of alumina, no lime, and 13 percent of water. About 80 feet east of this pit a test well has been put down on another bed of ore, probably lower and at nearly the same horizon as the bed in the underground opening 1,500 feet to the north at the east side of the tramway. This bed showed 38 percent of iron, 25 percent of silica, 12 percent of alumina, no lime, and 11 percent of water. It was only 1 foot 3 inches thick, and its dip was 42° SW.

About 800 feet south of the tramway terminus, on the border of a swampy bottom land, two shallow test pits on outcrops 86 feet apart across the strata disclose ore beds each about 5 feet thick and dipping 45° W. At first it was thought that the western bed might be the "big coral" bed and the one at the east a lower bed, but from their structural relations and identical thickness it seems possible that they both represent the "big coral" bed, its outcrop having been repeated by a fault.

Head of Greasy Cove.--The presence of an exceptionally thick bed of soft ore and of one or two additional seams of ore in the upper part of Greasy Cove, a mile or more south of McClendon Gap, has for many years aroused interest among iron-ore producers and consumers in Alabama and even beyond the borders of the State, and consequently considerable prospecting and some small-scale mining development have been done in this area. The outcrop of the Red Mountain formation continues southward through secs. 24 and 25 and terminates in sec. 36, T. 12 S., R. 3 E., where it swings toward the northeast. In sec. 25 the outcrop of the ore is sinuous, making several reentrant loops due to folds and faults in the rocks as expressed in a ridge and valley topography, especially where the rocks have low dips. No adequate or exact representation of the actual traces and positions of the ore seams is possible without an accurate large-scale surface-contour base map. The most reliable data that are available are shown on plate 1, which has been compiled from several incomplete private land maps. This map carries the outcrop of the ore bed around the head of Greasy Cove and along the southeast limb of the anticline to a point northeast of Chandler Mountain. The mapping of the outcrop of the ore bed in the head of Greasy Cove is in places inconsistent with the field notes of the writer, and the several land maps from which certain details are derived disagree in places as to the location of the outcrop, mine openings, and diamond-drill holes, so that the map presents a generalized rather than an absolutely accurate picture of the locality.

A prospect cut on a ridge about a quarter of a mile northwest of the stripping operation disclosed a bed of soft ore 2 feet 6 inches thick dipping 18° W., which is reported by the Gulf States Steel Co. to have averaged about the following percentages: Iron, 52; silica, 8.4; alumina, 7.6; no lime; and water, 15. Three analyses made by David Hancock, of Birmingham, of soft ore from this vicinity are as follows:

Analyses of soft ore from head of Greasy Cove

Thickness	Fe	SiO_2	Al_2O_3	P	Mn
2 ft. 3 in.	53.40	7.20	6.02	0.27	0.14
2 ft. 6 in.	55.10	6.25	5.95	.25	-
2 ft. 2 in.	55.50	6.40	5.72	.31	.22

In the upper part of Greasy Cove, near the middle of sec. 25, T. 12 S., R. 3 E., the "big coral" bed of ore has been found to attain its greatest thickness. As early as 1913 on the west side of a small hollow that opens toward the south some open cuts, a drift, and several holes drilled at some distance from the outcrop showed ore ranging from 6 feet to more than 7 feet in thickness. On the east side of the same hollow the bed was from 3 feet 6 inches to 5 feet thick. The stripping of the cover reached a depth of 10 to 15 feet. A section of the ore measured in 1913 is as follows:

Section of ore bed in mouth of drift from open cut near head of Greasy Cove.

	Ft.	in.
Sandstone.........	8	
Shale, limy........	13	
Ore, good..........		9
Ore, dirty.........		7
Ore, good..........		2
Ore, dirty.........	1	1
Ore, good..........	1	8
Ore, dirty.........		11
Ore, good..........	1	3
Shale.		
Ore, good and poor	6	5

In 1928 mining was being done at these open cuts and drifts. (See figs. 1 and 2.) One open cut was about 500 feet long from northeast to southwest and 25 to 50 feet wide. The thickest faces measured 6 feet 6 inches to 7 feet 6 inches of dark-red, thoroughly leached hematite containing a little limonitic material. In places there are inclusions of shale and sandy material, and the bed is cut by many joints, some of which have been enlarged by solution and filled with clay. The soft ore extends as far into the hill as has been stripped--a distance of 25 to 50 feet, and continues into the hill under cover 60 to 75 feet farther, as shown by three drifts that had been driven N. 60° W. from the open cut.

The ore here dips 8°-11° S. 30° W., but this locality is near the south end of the outcrop of the strata around the nose of the anticline, so that south and southeast dips are found farther east and northeast. Mining of the soft ore is facilitated by the jointing, but underground a foot or more of ore has to be left as roof, because the ground above is loose. If the hard ore can be mined the shale roof probably will be found to be firm enough. The hard ore of the "big coral" bed in this vicinity is high in calcium carbonate in places where it may not average high enough in iron for an iron ore but would be of value as a flux on account of the iron content.

In October 1928 the soft ore was being shipped from these mines at the rate of about 90 tons (2 railroad carloads) a day. The ore was mined by contract, loaded on tram cars, pushed by hand to tipples, dumped into 1-ton automobile trucks, and hauled to the railroad at Tumlin Gap, a distance of a little more than 7 miles, over a dirt road, not very good in places. The soft ore was mostly shipped to the Gulf States Steel Co. at Alabama City, where it was used in the open-hearth steel plant, but a carload was sent to East St. Louis, Ill., for the manufacture of metallic paint. The high percentage of water in the ore is said to have caused it to decrepitate explosively in the open-hearth furnace. In the upper part of the cove there is more than one bed of ore: in places there is good evidence of the presence of as many as three, and some prospectors believe that they have discovered four beds or seams in the same section. In some places where there are apparently several beds certain of the outcrops are probably due to repetition of a bed by close folding or faulting, or both. The unusually thick bed of ore referred to as the "big coral" bed, which attains a maximum observed thickness of about 7 feet 6 inches, is probably the upper bed of the series.

A sample of ore, 6 feet 6 inches thick, taken 65 feet within the drift farthest northwest showed an average of 52 percent of iron, 7.6 percent of silica, 4 percent of alumina, 2 percent of lime, 0.56 percent of phosphorus, 0.21 percent of manganese, and 17 percent of water and is fairly typical of the ore obtained here. Other analyses of lump soft ore shipped from this place to the steel furnace of the Gulf States Steel Co. at Alabama City ranged from 41 to 56 percent of iron, 7.4 to 16 percent of silica, 2.5 to 7.8 percent of alumina, 0 to 0.78 percent of lime, 0.21 to 0.64 percent of phosphorus, 0.10 to 0.37 percent of manganese, and 8.3 to 12.3 percent of water. On the east side of the hollow a sample of ore from a face 4 feet 4 inches thick averaged 47 percent of iron, 15 percent of silica, 8 percent of alumina, no lime, and 15 percent of water. This bed dipped 18° S. 30° W.

In this hollow there was reported to be another bed of ore 40 feet below the "big coral" bed, but it was not exposed at the time of visit.

As indicated above, hard ore, low in iron and high in lime, is encountered in a rather abrupt change from soft ore in most drifts driven in less than 100 feet from the outcrop. In places the drifts have been driven through small areas of hard ore into soft ore again, but this is not the rule. To ascertain the nature of the ore under cover it is necessary to drill through the hard ore in places where the cover is fairly thick. The best results are obtained with core drills.

Several holes have been drilled to the ore bed a few hundred feet to nearly a mile west of the outcrop in secs. 25 and 36, T. 12 S., R. 3 E. The three following records were furnished in 1913 by Mr. Henry Badham (since deceased), of Birmingham, but the precise locations are uncertain. As these were vertical holes perforating beds dipping at low angles, the reported thickness of the beds is slightly in excess of the true thickness. For instance, if the dip of the beds is 10° a 10-foot thickness of iron ore measured in the drill hole would be equivalent to 0.9848 of that measurement or about 9 feet 10 inches, and other thicknesses would be in similar proportions.

Record of bore hole no. 1 in the $NW\frac{1}{4}SE\frac{1}{4}$ (?) sec. 25, T. 12 S. R. 3 E., near head of Greasy Cove.

	Thickness		Depth	
	Ft.	in.	Ft.	in.
Dirt	3		3	
Slaty limestone	22	7	25	7
Fire clay	8	7	34	2
Black shale	27	5	61	7
Sandy shale	107	7	169	2
Iron ore	4	4	173	6
Lean iron ore	5	1	178	7
Sandstone	10	1	188	8
Lean iron ore	14	9	203	5
Sandy shale	26	5	229	10

The 4 feet 4 inches of iron ore at a depth of 169 feet 2 inches to 173 feet 6 inches showed on analysis 29.58 percent of iron, 3.95 percent of silica, 3.80 percent of alumina, 22.62 percent of lime, and 0.39 percent of phosphorus, according to Mr. Badham.

Record of bore hole no. 2 in the $NW\frac{1}{4}SE\frac{1}{4}$ (?) sec. 25, T. 12 S., R. 3 E., near head of Greasy Cove.

	Thickness		Depth	
	Ft.	in.	Ft.	in.
Dirt	3	1	3	1
Shaly limestone	66	7	69	8
Fire clay	2		71	8
Limestone	12	6	84	2
Iron ore	2	8	86	10
Shaly limestone	7	11	94	9
Lean iron ore	8	6	103	3
Sandstone	3	11	107	2
Lean iron ore	7	6	114	8
Shale	1	5	116	1
Lean iron ore	2	9	118	10
Limestone	3	5	122	3
Shale	4	5	126	8
Limestone	1	7	128	3

The 2 foot 8 inch bed of iron ore beginning at a depth of 84 feet 2 inches was stated to have shown on analysis between 26 and 27 percent of iron.

Record of bore hole no. 3 in the NW$\frac{1}{4}$SW$\frac{1}{4}$ (?) sec. 25, T. 12 S., R. 3 E., near head of Greasy Cove.

	Thickness		Depth	
	Ft.	in.	Ft.	in.
Dirt	9	3	9	3
Sandstone	4	5	13	8
Limestone	14	1	27	9
Sandstone	3	4	31	1
Shaly limestone	29	4	60	5
Lean iron ore		4)		
Good ore	2	6)	63	7
Lean ore		4)		
Limy shale	2	5	66	

An analysis of 2 feet 8 inches of the iron-ore seam indicated above is reported to have shown 22.48 percent of iron, 2.68 percent of silica, 2.09 percent of alumina, 31.08 percent of lime, 0.26 percent of phosphorus, and 0.14 percent of manganese.

The following is a section of a bore hole made by a chilled-shot drill tting a $4\frac{1}{2}$-inch core:

Record of bore hole in $NW\frac{1}{4}SW\frac{1}{4}$ sec. 25, T. 12 S., R. 3 E., near head of Greasy Cove.

	Thickness		Depth	
	Ft.	in.	Ft.	in.
Alluvial........................	6		6	
Sand, gravel, and boulders.......	24	6	30	6
Chert (flinty matter)...........	1	6	32	
Fossiliferous limestone.........	52	6	84	6
Chert (flinty matter)...........	2		86	6
Sand and gravel.................	2	6	89	
Chert...........................		6	89	6
Sandstone.......................	1	6	91	
Chert...........................	1		92	
Light-gray shale................	4		96	
Black shale.....................	23	6	119	6
Limestone and shale.............	19	6	139	
Limestone.......................	74	4	213	4
Fossiliferous lean iron ore.....	4	8	218	
Dark-gray shale.................		8	218	8
Fossiliferous iron ore (sample A)		10	219	6
Iron ore (samples B,C, and D were saved; the remainder was soft and washed away)............	1	10	221	4
Iron ore high in lime (sample F)	4	5	225	9
Limestone (sample G shows contact with iron ore)..............		6	226	3

The following additional analyses of the ore in Greasy Cove are available. The first five may represent ore from the head of the Cove shipped from Tumlin Gap.

Analyses of soft and hard iron ores from head of Greasy Cove

Description	Authority a/	Fe	SiO_2	Al_2O_3	Insoluble	CaO	P	Mn	H_2O
Lump..................	GS	49.55	15.58	5.37	-	-	0.35	0.13	-
Do	GS	56.00	7.40	5.49	-	-	.24	.10	8.30
Do	GS	55.43	6.74	4.68	-	0.78	.64	.37	-
Do	GS	54.01	7.80	6.22	-	-	.24	.13	12.28
Do	GS	55.43	7.38	2.48	-	-	.21	.27	-
Drill core..........	GS	51.25	9.34	6.28	-	2.29	-	-	-
Do	GS	41.34	22.54	7.78	-	1.15	-	-	-
Do	GS	11.91	1.34	.90	-	43.15	-	-	-
Do	GS	22.48	2.68	2.09	-	31.08	.26	.14	-
7-foot bed..........	P	53.65	7.72	5.66	-	1.47	-	-	-
"Big seam"..........	O	29.58	3.95	3.80	-	22.62	.39	-	-
Do	O	32.32	-	-	4.50	21.44	-	-	-
Do	O	35.80	-	-	4.35	16.37	-	-	-
Do	O	54.70	-	-	9.17	Tr.	-	-	-
Do	O	54.79	-	-	9.06	Tr.	-	-	-
Do	O	59.20	-	-	9.54	.12	-	-	-
Seam below "big seam"	O	54.23	-	-	18.33	.10	-	-	-
Do	O	51.84	-	-	21.66	.13	-	-	-
Do	O	51.27	-	-	21.89	.11	-	-	-
2 ft. 3 in. bed.....	H	53.40	7.20	6.02	-	-	.27	.14	-
2 ft. 6 in. bed.....	H	55.10	6.25	5.95	-	-	.25	-	-
2 ft. 2 in. bed.....	H	55.50	6.40	5.72	-	-	.31	.22	-
Semihard............	U.S.	37.87	7.56	4.14	-	12.52	.31	.05	-

a/ GS. Gulf States Steel Co. (dry basis); H, David Hancock; O, owners of property; P, Dr. Wm. B. Phillips; U. S., U. S. Geological Survey (in addition, TiO_2, 0.41; K_2O, 0.17).

As nearly as could be ascertained locally the strike of the Red Mountain formation curves sharply around toward the northeast in the northern part of sec. 36, T. 12 S., R. 3 E., and extends diagonally across sec. 30, T. 12 S., R. 4 E., to and beyond Little Canoe Creek, forming the crest and part of the steep northwest slope of a high ridge. There are no available data concerning the ore bed in sec. 36 and but few concerning the bed in sec. 30, and in the absence of definite evidence of a thick bed of ore through a considerable distance in this locality it has been thought best to consider part of it as 2 feet and part as less than 2 feet thick. In a traverse along this ridge in November 1930 debris of soft ore was noted by the writer in several places, and a few small prospects made many years ago indicate the trace of the ore bed just northwest of the crest of the ridge in the southwestern part of sec.

30. The rocks along this ridge dip normally toward the southeast. Near the middle of sec. 30, at the head of a hollow half a mile or more southwest of the site of the Brothers mill, a large project cut now overgrown and caved down, shows on the dump large slabs of soft ore as much as 4 inches thick, whose fossil contents indicate that the bed is the "big coral" seam. From the middle of sec. 30 northeastward to Little Canoe Creek the ore bed becomes more prominent and displays thick ledges of rich soft ore in numerous outcrops and a few prospect pits. The dip of the bed is generally between 20° and 30° SE. On the southwest side of the gap of Little Canoe Creek a prospect drift has been made in a bed 4 to 5 feet thick of dark sandy ferruginous material, in general only slightly consolidated but containing a few thin layers of hard ferruginous sandstone. This same bed has been prospected northeast of Little Canoe Creek on the end of the ridge above the former dam at the Brothers mill, which is near the southeast corner of sec. 19, T. 12 S., R. 4 E. A reported test of this ferruginous bed south of the creek shows 36 percent of iron, 23 percent of silica, 16 percent of alumina, no lime, and 17 percent of water.

Brothers mill.--Massive beds of sandstone dip 29° SE. and strike N. 46° E. at the dam of the Brothers gristmill on Little Canoe Creek. Three seams of ore in the upper half of the Red Mountain formation have been cut here at the northeast side of the road. The upper one is 40 to 50 feet above the next lower, which in turn is 10 to 15 feet above the lowest. The highest is evidently the "big coral" seam, judged by the abundance of fossils. Only about 2 feet of this seam is visible. Part of it may have been eroded, and part is probably covered by debris, but the seam may be thinner here than at the head of Greasy Cove. The two lower seams are thin and are parted by shale but contain layers a few inches thick of good soft, granular ore. The dip of the beds is 25° SE. A section of one of the beds measured by J. R. Ryan showed 1 foot 4 inches of good soft ore, overlain and underlain by shale.

McCalley 6/ reports that in the gap at the Brothers mill there is an outcrop of ore about 2 feet thick, but to the northeast, in sec. 20, T. 12 S., R. 4 E., the ore seam is 20 to 21 inches thick with a parting of shale about 6 inches thick; in sec. 15, from 18 to 20 inches; and in sec. 12, 2 miles northeast of Chandler Mountain, about 18 inches thick.

The Chattanooga shale is well exposed in the gap near the Brothers mill, with a width of outcrop of 40 feet dipping 25° SE., which would represent a thickness of about 17 feet.

The three seams of ore have been prospected in a number of drifts on the hillside northeast of the Brothers mill. The lowest seam was measured as follows:

6/ McCalley, Henry, op. cit., p. 206.

Section of lowest bed of ore on hill northeast of Brothers mill

	Inches
Shale.	
Sandstone............	8
Shale................	$2\frac{1}{2}$
Ore..................	5
Shale................	$\frac{1}{2}$
Ore..................	3
Shale................	$2\frac{1}{2}$
Ore..................	3
Shale................	3
Ore..................	2
Shale................	1
Ore..................	1
Clay.................	2
Shale.	

Total ore, 1 ft. 2 in. Dip 25° S. 60° E.

A short distance up the southwest end of the hill a tunnel has been driven 110 feet N. 35° E. into dark soft earthy ferruginous material, about 4 feet of which is exposed vertically. This soft material, which was reported to contain 40 percent of iron with a high content of silica, is similar to that prospected on the southwest side of Little Canoe Creek. At the face of the tunnel is a small pit, also in the soft ferruginous material, which thus has an apparent thickness of 6 feet 8 inches. This material probably represents the second or middle seam, because higher on the hillside is a third ore bed containing the large fossil corals. This "big coral" bed is exposed in an old open cut near the top of the hill, from which some ore is reported to have been shipped to the blast furnaces of the Sloss-Sheffield Steel & Iron Co. at Gadsden about 1925-26. The bed dips 23° S. 40° E. Its base was hidden by rock debris and clay, and only 2 feet 9 inches of ore was exposed, including a 2-inch scale of limonite which had replaced shale at the top of the bed. The ore in this bed is soft, well-leached, fine-grained, flaxseed-textured hematite with a few specks of limonite. A reported analysis of ore from this bed showed 52.5 percent of iron, 8 percent of silica, 6 percent of alumina, no lime, and 11 percent of water. According to graphic measurements these two upper beds are about 36 and 88 feet stratigraphically above the lowest bed, which indicates a greater spread between the two lower beds than is shown on the road by the mill.

About 1,000 feet northeast of the Brothers mill on the southeast slope of the ridge are some underground mine workings. The ore bed is reached by a rock entry driven N. 45° W. for 75 feet, beyond which the entry turns up the slope of the ore bed and reaches the surface at the outcrop. A hoist and cable were used in this slope for lowering cars of ore down and out through the rock entry. The ore is dark and soft and contains abundant coral remains. Its thickness ranges from 3 feet to 5 feet, and in it are occasionally found "boulders" or rounded masses of more or less ferruginous fine to coarse grained siliceous limestone or "jack rock," in places the full thickness of the ore bed.

Moodys Gap.--On the ridge about half a mile northeast of the Brothers mill mines have been opened on both sides of Moodys Gap, probably in the NE¼SW¼ sec. 20, T. 12 S., R. 4 E. The ore bed here dips 22°-30° SE., is 2 feet 7 inches to 5 feet thick, and is said by the mining contractors to average 3 feet 6 inches. Fossils indicate that it is the "big coral" seam. The mine workings consist of five drifts driven on the strike of the ore bed on each side of the gap, at different levels on the bed as it dips southeastward down the hollow. (See fig. 5.) There is also a slope starting on the northeast side of the hollow and following down the dip of the bed. The greatest distance that had been driven in soft ore in 1928 was 650 feet. This was on the northeast side of the gap along the strike of the ore bed near the top of the ridge, but some of the lower drifts reached hard ore at 150 feet. Within the drifts the ore is mined up the dip of the bed. Much of the soft ore produced here was red, tough material that held together well enough to be mined in lumps, although in places toward the top of the ridge it has altered to soft ferruginous sand. The hard ore is not encountered at uniform distances from the outcrop, but at first rather in the form of irregular boulders or "horses," many of which are surrounded by soft ore. These areas of hard ore have to be drilled, as they are otherwise difficult to mine. Locally below the ore bed lies a gray to pink, very hard bed consisting of coarse grains or small rounded pebbles of quartz cemented by calcite but containing little iron. This bed is known as "jack rock" at these mines. Analyses of ore from the south side of the gap are reported to have averaged as follows for a thickness of 3 feet: Iron, 51 percent; silica, 11 percent, alumina, 6 percent; lime, none; phosphorus, 0.23 percent; manganese, 0.18 percent, water, 13 percent. On the north side of the gap a face of 4 feet 6 inches of ore gave the following average: Iron, 36 percent; silica, 30 percent; alumina, 9 percent; lime, none; water, 12 percent; but if only the top 3 feet is taken the percentages will be about as follows: Iron, 49; silica, 12; alumina, 9; water, 12.

The ore-bearing ridge in this vicinity consists of a series of "humps" with small gaps or saddles a quarter to a third of a mile apart. At two small gaps about a quarter and half a mile northeast of Moodys Gap the ore is reported to have been mined in a small way about 1924. The ore here is a little southeast of the crest of the ridge and has been traced by prospect trenches to Garigues Gap.

Garigues Gap.--About 1½ miles northeast of the Brothers mill and 1 mile southeast of the village of Gallant, probably near the southwest corner of sec. 16, T. 12 S., R. 4 E., a wagon road from the Little Canoe Creek Valley to Gallant crosses the ridge at Garigues (locally pronounced gorgas) Gap. The ore-bearing portion of the Red Mountain formation crops out near the crest of the ridge and dips 22°-25° SE., toward Little Canoe Creek. As the dip is nearly the same as the southeast slope of the mountain, the ore lies near the surface and consequently remains soft, for a long distance down the dip. On the southwest side of the gap on the southeast slope of the ridge 10 or 11 mine drifts have been driven on the strike of the ore at different levels, and ore was mined from them as late as 1929, a considerable production having been reported. The ore was the "big coral" bed, and its thickness was 3 feet 6 inches to about 4 feet. Analyses of 4 feet of this ore bed show an average of 50 percent of iron, 11 percent of silica, 6 percent of alumina, no lime, and 23 percent of water.

Within a few hundred yards northeast of Garigues Gap a thinner ore seam has been prospected in several places and has been mined by stripping at one place, from which two carloads were shipped late in 1929, according to local report. The ore is granular and contains many crinoid remains but none of the large corals characteristic of the bed mined in the drifts southwest of the gap, and it is probably lower stratigraphically than the "big coral" bed. On the southeast slope of the ridge the ore was also mined for a distance of about 75 feet from an open cut and drift. The bed dips 18°-23° S. 45°-50° E., and there is a possibility that some ore is still available for stripping, although it goes under thicker cover than the "big coral" bed, because it is lower in the section. The thickness of the bed ranges from 1 foot 1 inch to 1 foot 11 inches at a place about 2,200 feet north of Garigues Gap.

Analyses of ore from this thinner ore seam sampled at four places within half a mile northeast of Garigues Gap showed a range in percentages about as follows: Iron, 41 to 51; silica, 15 to 20; alumina, 6.6 to 8.7; phosphorus, 0.08 to 0.70; manganese, 0.06 to 0.17; water, 7.6 to 9.4; and none showed any lime.

Northeast of Garigues Gap along the ore-bearing ridge there seems to be no ore bed that can be definitely correlated with the "big coral" bed, and to explain its disappearance is difficult. Non-deposition may be one explanation, as this locality may be at the northeast edge of the lens represented by this bed. On the other hand, the position of the bed on the southeast slope of the ridge may be such that the projection of the bed would carry it above the top of the ridge, and the actual outcrop may be so completely buried by sandstone and chert debris as not to show beyond this locality on the slope of the ridge. In that event prospecting by drilling at right angles to the dip of the beds would be required in order to locate the ore.

<u>Turleys Gap</u>.--The next well-marked gap in the ridge is one through which a road passes, probably in the NE$\frac{1}{4}$NE$\frac{1}{4}$ sec. 16, T. 12 S., R. 4 E., opposite Mr. Turley's house. This is about 1$\frac{1}{4}$ miles northeast of Garigues Gap, but as no two land maps available to the writer are in agreement as to the position of section lines, creeks, ridges, and gaps in this vicinity, any location that is accepted is a compromise between several maps and is probably not accurate itself. In this locality there are outcrops of two beds of ore, one a short distance down the northwest slope and one on or near the crest of the ridge.

The ore bed that crops out a few feet below the crest on the northwest slope of the ridge is exposed southwest of the gap in a prospect slope driven down the dip of the bed to a depth of about 10 feet. This bed is 3 feet 6 inches to 3 feet 7 inches thick, including a wedge, or "middle-man" of sandstone which is 2 to 5 inches thick at the outcrop but which disappears a few feet down the dip. The ore dips 25° S. 20° E. and is overlain by 1$\frac{1}{2}$ inches of shale, above which is smooth hard sandstone similar to that overlying the bed locally called the "Attalla" seam east of the tramway south of McClendon Gap. This bed contains small crinoid and gastropod fossils but no large fossil corals, and it probably is not to be correlated with the "big coral" ore bed. The ore is soft on the outcrop but changes abruptly to hard ore at the face of the prospect slope, about 10 feet below the surface. A sample of the hard ore, averaged from the full width of the bed, 3 feet 7 inches, showed the following percentages: Iron, 33; silica, 18; alumina, 8.24; lime, 11.25; phosphorus, 0.29; manganese, 0.18; and water, 12.5.

Analyses of random hand specimens of the hard and soft ore from this prospect slope made by Dr. R. S. Hodges, of the Geological Survey of Alabama, showed the following percentages:

Analyses of ore from Turleys Gap

	Hard ore	Soft ore
Iron (Fe)...............	26.89	50.39
Silica (SiO_2).............	7.64	15.03
Alumina (Al_2O_3)...........	6.73	6.13
Calcium oxide (CaO)........	26.44	1.78
Phosphorus (P)............	.21	.56
Manganese (Mn)............	.06	.10

A test pit and drift at the northeast side of the road through Turleys Gap also shows the sandstone that overlies the ore bed dipping 27° S. 30° E., but the drift had caved in, obscuring the ore, at the time of visit. A trace of the ore crops out in the road, and there are several small prospect cuts on the ore bed in both directions from the gap.

In the vicinity of Turleys Gap and toward the northeast there is a bed of iron ore stratigraphically higher than the bed just described. This higher bed lies above the sandstone that caps the lower ore bed, but its outcrop is nowhere well exposed. Evidence of this upper ore bed may be seen on the crest of the ridge northeast of Turleys Gap in the form of debris of fine-grained iron ore containing some aluminous material, and prospect pits are reported to have been dug in it at several places along the crest of the ridge. It would appear, however, as if the actual outcrop of this upper ore bed may be buried under debris of sandstone and chert on the southeast slope of the ridge, and that the projection of the bed would pass above the crest of the ridge, so that only ore debris let down by erosion and disintegration of the rocks now appears along the crest of the ridge, except possibly at the highest points. The quantity and thickness of blocks of the ore debris do not indicate a thickness of the bed greater than 2 feet. For about 1½ miles northeast of Turleys Gap through sec. 10 and part of sec. 11, T. 12 S., R. 4 E., the ridge is high, with a steep northwest slope, cut by four small slight notches, or gaps. The Red Mountain formation makes the crest and part of both slopes of the ridge, and the lower of the two ore beds may be traced continuously near the top of the northwest slope by a series of prospect pits which show debris of ore, but as they were caved in, the ore could not be measured. The next low gap through which a wagon road passes is south of Clear Creek Church (Stanfield) in sec. 11, T. 12 S., R. 4 E., and in this gap on the west side of the road about half a mile south of the sawmill on Clear Creek a seam of soft ore, 3 to 4 inches thick, is visible on the outcrop. This seam dips 18° S. 15° E. and may be traced northeastward up the ridge, where an exposure of 1 foot 3 inches of soft ore was noted near the east line of sec. 11. In the western part of sec. 12, the ore bed crops out north of the crest of the ridge and also in a ravine on the south slope, where a thickness of 2 feet of good soft ore occurs. Here the dip of the ore, 10° S., is nearly the same as the slope of the ridge. Farther east, near the middle of sec. 12, a thinner seam of ore crops out in an abandoned road on the south slope of the ridge. This ore dips about 10° S.

Shores Gap.--In the western part of sec. 7, T. 12 S., R. 5 E., erosion has cut deeply into the Red Mountain formation and nearly if not wholly separated the areas of ore-bearing strata northeast and southwest of Shores Gap and exposed the underlying Chickamauga limestone well up on the northwest side of the gap. The lower part of the Red Mountain formation crosses this gap, however, with a low dip to the southeast. The upper bed of ore is probably cut out by the gap, but a lower bed may possibly continue across under cover, because about 600 feet southeast of the crest of the gap a seam of ore 3 to 4 inches thick crops out on the northeast side of the road with a dip of 6° S. 30° E. Southwest of the gap the upper ore bed is exposed on the dip slope and as float derived from a bed formerly lying just about at the present surface. This float is in chunks of good soft ore 8 or 9 inches thick. Northeast of Shores Gap the upper bed of ore lies practically on the dip slope of 10° S. In some places it is overlain by a thin cover of shale and soil, and in others it is partly eroded and fragmentary and shows as slabs and boulders of soft ore 8 to 10 inches thick. Slabs for building chimneys have been obtained from the ore bed near the crest of the ridge. This ore is granular and contains fossil crinoids but no large coral remains.

At Shores Gap the Red Mountain formation crosses the valley of Dry Creek. The southeast strip extends toward the southwest in the ridge that forms the southeast side of the synclinal Chandler Mountain basin, and toward the northeast it forms the border of a smaller, nearly closed synclinal basin. As the outcrop southeast of Chandler Mountain is outside of Greasy Cove, it will not be discussed here.

Southwest of Attalla.--Between Shores Gap, at the head of Dry Creek, and Big Wills Creek southwest of Attalla lies a roughly elliptical synclinal area of Mississippian rocks (Fort Payne chert and Hartselle sandstone) shown on the geologic map of the Gadsden quadrangle to be surrounded by a border of Red Mountain formation. This formation has moderate dips on the northwest side of the area but steep dips on the opposite side, forming an unsymmetrical basin. About half a mile northeast of Shores Gap some prospecting has been done in an old drift on a 3-foot bed of material, the top 10 inches of which is soft ore with alternations of shale and ore below. An analysis of the 10-inch seam of soft ore is reported to have shown 53 percent of iron, 12 percent of silica, 6.7 percent of alumina, no lime, and 9.5 percent of water. There is much ore float on the ridge forming the northwest rim of the basin, which suggests that the ore bed lies at and near the surface and has been partly removed by erosion. This widespread ore debris may be traced for nearly a mile northeast of Shores Gap, and there is some debris of a lower seam of ore on the steep northwest side of the ridge overlooking Clear Creek.

The elliptical basinlike area is cut nearly in the middle by Gaines Branch. At the headwaters of this stream there is a broad outcrop of Red Mountain formation, forming the northwest border of the basin. The beds, which consist of sandy shale, pass southeastward beneath the black Chattanooga shale, but no iron ore was noted. In the middle of the basin area a massive brown sandstone, probably the Hartselle, overlies the Fort Payne chert. This sandstone was not mapped in the Gadsden geologic folio, although it is shown on the State geologic map published in 1926. On the southeast rim of the basin the black Chattanooga shale, dipping 45° NW., is well displayed in a hollow 500 feet northeast of a sawmill site on Gaines Branch. A thin seam of ore is reported to occur near this place but was not seen.

The only place at which an ore bed has been noted by the writer on the southeast limb of this elliptical basin is on the steep southeast face of a ridge about 2 miles west of Attalla. Here several prospects have been cut on the outcrop beginning at the south side of a small branch of Big Wills Creek, ranging from about 25 feet to about 100 feet above the creek. Sections at two places about 50 feet apart are as follows:

Sections of ore bed near branch of Big Wills Creek 2 miles west of Attalla

1

	Ft.	in.
Shale.		
Shale with a few ferruginous streaks.......		10
Ore, hematite, with scale of limonite at top	1	10
Shale.		

2

	Ft.	in.
Shale.		
Shale with a few ferruginous streaks.......		10
Ore, hematite, with scale of limonite at top	1	3½
Shale.		

The dip of the beds is steep, nearly west.

The following section of the ore bed in this vicinity was made by J. R. Ryan:

Section of ore bed near branch of Big Wills Creek 2 miles west of Attalla

	Inches
Shale.	
Ore, soft, good..............................	6
Shale..	1½
Ore, good....................................	3
Shale..	½
Ore, good....................................	9
Shale.	

The bed is vertical. Total ore, 1 foot 6 inches.

Wilbur A. Nelson in a private examination in 1916 found the following section about $2\frac{1}{4}$ miles west-southwest of Attalla:

Section of ore bed in the $W\frac{1}{2}SW\frac{1}{4}$ sec. 4, T. 12 S., R. 5 E.

	Ft.	in.
Shale.		
Ore...........................		6
Shale.........................		$8\frac{1}{2}$
Ore...........................	1	
Shale.		

The bed is vertical. Total ore, 1 foot 6 inches.

A section by McCalley 7/ in this locality is as follows:

Section at northeast base of ridge in $NE\frac{1}{4}NW\frac{1}{4}$ sec. 4, T. 12 S., R. 5 E.

	Ft.	in.
Sandstone, yellow, shaly.		
Ore, red......................		4
Shale, yellowish gray..........		4
Ore, red......................	1	4
Sandstone, hard.		

Strike north, dip about 85° W. Total ore, 1 foot 8 inches.

From these records it would appear that there is not much ore of commercial thickness in the elliptical area of Red Mountain formation southwest of Attalla. Although the map shows the outcrop of ore as continuous around this elliptical area, the ore could not be traced completely around it, particularly at the northern extremity and along much of the southeast side, and its absence from these places may be due to faulting or squeezing out of the ore beds.

The best possibility of recovery of ore in this elliptical area seems to be on the northwest rim of the basin in secs. 6 and 7, T. 12 S., R. 5 E., where a thin bed of ore lies at or near the surface on the southeast dip slope. The loose ore present could be recovered and the overburden could be removed by scrapers, so that the operation would be in the nature of a stripping. Even here, however, the quantity of available ore is uncertain because some has been removed by erosion.

Physical tests of ore

The following analyses, mostly representing rich soft ores, made in connection with a private examination of the ore beds in Greasy Cove, are of more than ordinary interest in that they show certain physical data, such as cell or pore space in percentage by volume and the true and apparent specific gravities of the ore. These determinations enable a comparison to be made of the porosity of the hard and soft ores at the Tumlin Gap mine, but they do not indicate directly the percentage of lime that has been leached out to form the

7/ McCalley, Henry, op. cit., p. 206.

soft ore. If the observed relations are applied to other soft ores, they may possibly give some indication as to the character of the corresponding hard ores in depth. The relations between the analyses and cell space indicate that a better grade of hard ore should be found than has actually been found, and so it would be desirable if more of such first-hand data were available. The alumina (Al_2O_3), although higher than desirable, is not very much higher than the average for the soft ores formerly mined in the Birmingham district. The thickness of the bed sampled ranges from 1 foot 6 inches to 6 feet 8 inches, but if the maximum thickness is excluded the average thickness appears to be about 2 feet 7 inches.

Analyses and physical tests of red iron ore, Greasy Cove
[Dry basis]

Locality	Thickness		Fe	SiO_2	Al_2O_3	CaO	Mn	P	Cell space (percent by volume)	Specific gravity	
										True	Apparent
	Ft.	in.									
NE¼ sec. 8, T. 12 S., R. 4 E.; soft ore...	2	4	58.60	9.09	4.47	0.60	0.12	0.31	33.03	4.42	2.96
Tumlin Gap mine:											
Hard ore..	-	-	21.91	4.62	3.19	28.90	.21	.57	8.97	3.12	2.84
Soft ore..	-	-	53.62	7.72	5.43	2.87	.12	.81	33.83	4.14	2.74
Southern part séc. 7, T. 12 S., R. 4 E.; soft ore.......	2	6	57.99	7.05	4.97	.60	.08	.23	33.96	4.27	2.82
NW¼ sec. 18, T. 12 S., R. 4 E.; soft ore.......	1	6	57.87	5.66	5.35	.80	.26	.33	49.08	4.34	2.20
Gilliland Gap; soft siliceous ore.......	2	6	22.57	57.84	4.79	.40	.00	.11	24.36	3.12	2.36
McClendons Gap; soft ore.......	3	-	56.82	6.90	5.66	.40	.13	.32	43.33	4.27	2.42
Badham drift:											
Soft ore...	6	8	55.48	7.36	5.42	1.45	.05	.89	37.35	4.23	2.65
Soft ore...	2	11	56.68	7.71	5.52	.40	.06	.24	34.55	4.37	2.86
Near Brothers mill; soft ore.......	1	6	58.02	6.20	4.47	.20	.17	.23	39.49	4.33	2.62
Sec. 20, T. 12 S., R. 4 E., on ridge; soft ore...	3	4	57.05	7.12	5.61	.70	.27	.62	36.91	4.28	2.70

Beneficiation of ore

An iron ore is said to be beneficiated if its quality is in any way improved by physical or chemical treatment. In the South, beneficiation has been applied particularly to brown iron ore--in fact, it was in this region that the log washer had its inception. In Alabama mining practice the beneficiation of red ore has consisted chiefly of elimination in the mine, by hand, of waste rock, such as shale, sandstone, and excessively limy material, and of crushing the ore at the mine tipple. Picking tables have been employed at certain red-ore mines in Tennessee.

Research work on the problems of concentration of Alabama red ore containing excessive quantities of silica have extended over a long period. Some of the early work was done by Phillips, 8/ Wilkens, and Nitze, in 1895-97, and comprised crushing and magnetic separation. Most of this work was done upon the high-silica ore, but it included tests of some hard, limy red ore, with resulting improvement in grade, but ore of this type was not considered particularly in need of concentration at that time. It was believed that a 50 percent iron concentrate could be produced with an extraction as high as 85 percent of the iron in the soft red ore.

A few years later experiments were made on Alabama siliceous hematite at Wilmington, Del., by the Moxham-Du Pont haloid process, which involved crushing the ore finely and separation of the lighter siliceous impurities from the heavier iron oxide by means of haloid solutions of high specific gravity.9/ This process is effective but expensive and seems not yet to have been put upon a commercial basis.

Detailed experimental work on ores from the Birmingham district was carried on by J. T. Singewald, Jr., subsequent to 1910. In his paper Singewald,10/ who also used heavy liquid separation after fine grinding, gives some of the details of the Moxham-Du Pont experiments.

About 1916 one of the mining companies built a plant at the Helen-Bess mine, in the Birmingham district, and attempted to concentrate the ore by jigging and tabling, but the process was reported to have met with little success and the plant burned down after short periods of operation.

In the last decade the United States Bureau of Mines, at its experiment stations at Tuscaloosa, Ala., and Rolla, Mo., in cooperation with the Universities of Alabama and Missouri, has undertaken further work on the concentration of Alabama hematite. One of the first of these investigations was begun at the Tuscaloosa station in July 1923, and ores from several places within the Birmingham district were studied. The problem was to develop a

8/ Phillips, W. B., Iron making in Alabama, 3d ed., pp. 102-112, Alabama Geol. Survey, 1912.

9/ Burchard, E. F., The red iron ores of east Tennessee, northeast Alabama, and northwest Georgia: U. S. Geol. Survey Bull. 540, pp. 325-326, 1914.

10/ Singewald, J. T., Jr., Concentration experiments with the siliceous red hematite of the Birmingham district, Alabama: U. S. Bur. Mines Bull. 110, 91 pp., 1917.

process that would make the high-silica red hematites of the Birmingham district available for use in blast furnaces. A method of magnetic concentration was investigated which, it is believed, will successfully remove a large part of the gangue and incur a loss of only a small part of the iron. 11/

Certain experiments involved a study of the results of grinding the ore and the separation of the fine ore and gangue by means of heavy solutions. 12/ The same problem is also discussed by Singewald.13/ A special feature of the grinding of ore in which rubber covered rods were used has been described by the Bureau of Mines.14/

As the Greasy Cove hard ore is generally high in lime carbonate and low in iron, it has seemed desirable that studies of ore of this type be made with reference to the elimination of the excess lime. The Bureau of Mines is giving attention to this problem but has not issued any publication concerning its findings. Progress to the spring of 1932 is summarized in the following statement:15/

"We have investigated a number of high-lime red ores from the Gadsden and Chattanooga districts, and the process described in Bureau of Mines Reports of Investigations, Serial 2937, does not appear at all promising as far as these red ores are concerned, as rubber-covered rods for grinding would have no particular advantages. We have, however, gotten much better results than we expected by using the ordinary rod-mill process for grinding--that is, rods without the rubber covering. We are still continuing these experiments, but the outcome is doubtful, as a slime product is produced which is not particularly amenable to concentration, and we can not say at this time whether it will be possible to work out anything at all satisfactory for handling these slimes."

Summary

The outcrop of the Red Mountain formation in Greasy Cove, including the elliptical area southwest of Attalla, approximated 21.3 miles in length, of which 6.46 miles contains beds of hematite 2 feet or more in thickness and 14.85 miles contains ore beds less than 2 feet thick. Plate 1 shows the mapping of the ore bed outcrop differentiated as to thickness, but the tabular summary at the end of this chapter may be helpful in reviewing the essential data.

The dips of the strata indicate the intensity of the movement suffered by the beds and afford criteria as to the relative depths to which the soft or

11/ Lee, Oscar, Grandrud, B. W., and DeVaney, F. D., Magnetic concentration of iron ores of Alabama: U. S. Bur. Mines Bull. 278, pp. 2-33, 1927.
12/ Coghill, W. H., Degree of liberation of minerals in the Alabama low-grade red ores after grinding: Am. Inst. Min. Eng. Trans., vol. 75, pp. 147-160, 1927.
13/ Singewald, J. T., Jr., Beneficiation of Alabama siliceous red hematite: Am. Inst. Min. Eng. Pamphlet 1653-B, 10 pp., February 1927.
14/ DeVaney, F. D., Gandrud, B. W., and Coghill, W. H., Gravity concentration of Alabama oolitic iron ore: U. S. Bur. Mines Repts. Investigations Serial 2937, 7 pp., May 1929.
15/ Communication from B. W. Gandrud, acting supervising engineer, U. S. Bur. Mines Experiment Station, University, Ala., Mar. 28, 1932.

weathered ore may extend and also as to structural conditions that may affect mining. The lengths on the strike indicated in the table are measured on the map and are therefore only as accurate as can be expressed on a small-scale map of this character. The estimated width on the dip to which soft and semihard ore may extend is uncertain, but it is more or less arbitrarily determined by knowledge of several factors noted in mine drifts, shafts, and outcrops, such as the character of the roof, the dip of the beds, the thickness of overburden, and the degree to which the associated rocks are faulted and fractured. In some areas of red iron ore in Alabama the ore was found to be soft for a greater distance than it appears to be in Greasy Cove, but for any estimate of ore tonnages, however rough, it is necessary to assume a distance down the dip and use that factor in the estimate for the given conditions. Some of the distances given in the table may be in excess of the actual soft or semihard ore limit. The apparent average thickness is derived from many measurements in some places and from only a few measurements in others, so that at best it also is a figure that may be far from accurate. The number of cubic feet per ton is a factor that varies with the texture and original composition of the hard ore and will be found to differ within certain limits from place to place. The true specific gravity determined for certain ores from Greasy Cove varied between 3.12 and 4.42, and the apparent specific gravity between 2.20 and 2.96. If true specific gravity and apparent specific gravity have reference respectively to properties of pulverized ore without cell spaces and of the natural lump ore including its cell space, then the apparent specific gravity is the factor that should be applied in the present calculations of ore tonnage. The general average of the figures given for this factor on page 42 is 2.65, which corresponds with approximately 13.5 cubic feet to the long ton. This figure has been used for the most porous ore seen in the district--that at the stripping mines at the head of Greasy Cove. Ores from other places have been assigned volumes of 12 and 11 cubic feet to the ton according as their density increased. It does not seem consistent to consider any of the ore in Greasy Cove as approximating 10 cubic feet to the long ton, which would correspond with a specific gravity about 3.59. Experimental work on cubes and lumps of the Birmingham hard red ores showed specific gravities ranging from 2.93 to 3.56, which corresponded roughly to weights of 183 to 225 pounds to the cubic foot, or to volumes of 12.25 to 10 cubic feet to the long ton.16/ The Birmingham hard ores are generally denser and occupy less volume to the ton than any of the Greasy Cove ores.

Many analyses have been given in the foregoing text which indicate that the hard ore is generally low in iron and high in lime and that the soft ores are high in iron but also in many localities are high in alumina and in combined water. Measurements have shown that there is a wide variation in thickness of ore beds along the strike and to some extent at right angles to the strike, and so the possibility must not be overlooked that in places the beds at some distance from the outcrop may become thicker than at the corresponding points on the outcrop. Diamond core drilling appears to be the only satisfactory method of ascertaining the true conditions in this respect.

16/ Burchard, E. F., Iron ores of the Birmingham district, Alabama: U. S. Geol. Survey Bull. 400, p. 27, 1910.

The details in the table show that there are 10 acres ranging from 0.3 mile to 1.3 miles in length that contain outcrops of ore beds measuring 2 feet or more in thickness. Certain of these areas are continuous, but most of them are separated by areas of ore less than 2 feet thick. At present ore having a thickness of only 2 feet is not generally considered of value for mining, but this thickness has been taken as a minimum for consideration in this report because under certain circumstances, as for instance where the ore lies below a thin cover and has a low dip, a 2-foot bed of soft ore might be mined by stripping.

Because much of the hard ore in Greasy Cove appears to be of doubtful commercial grade, the estimates of ore reserves will be confined to the strip of soft to semihard ore on the outcrop, and it is believed that the depths to which the ore is assumed to be valuable are liberal. It should be borne in mind, however, that there is a large reserve here of ore that is low in iron and high in lime. Such material would prove of more than ordinary value as a flux on account of the excess of iron present as compared with that in ordinary blast-furnace flux.

By use of the factors length of outcrop along the strike (L), estimated width of the ore area on the dip (D), apparent average thickness (T), and estimated number of cubic feet per long ton (N), the calculation of the ore within any given area may be made by the simple formula $\frac{L \times D \times T}{N}$, but this does not take into account the percentage of recoverable ore nor the quantity of ore already removed from the area, estimated at about 50,000 tons. The figures given in the table represent estimates made on the above basis and will serve only to show what the tonnage of soft to semihard ore would be under the given conditions. Similar calculations to ascertain what the tonnage of hard ore might be if D were extended 1,000 feet farther would increase the total by many million tons, but in view of the unfavorable aspect of what is known of the hard ore and the lack of definite favorable drilling data concerning the actual presence of good ore beyond the limits assumed, it is not considered wise to sponsor a broader estimate at this time.

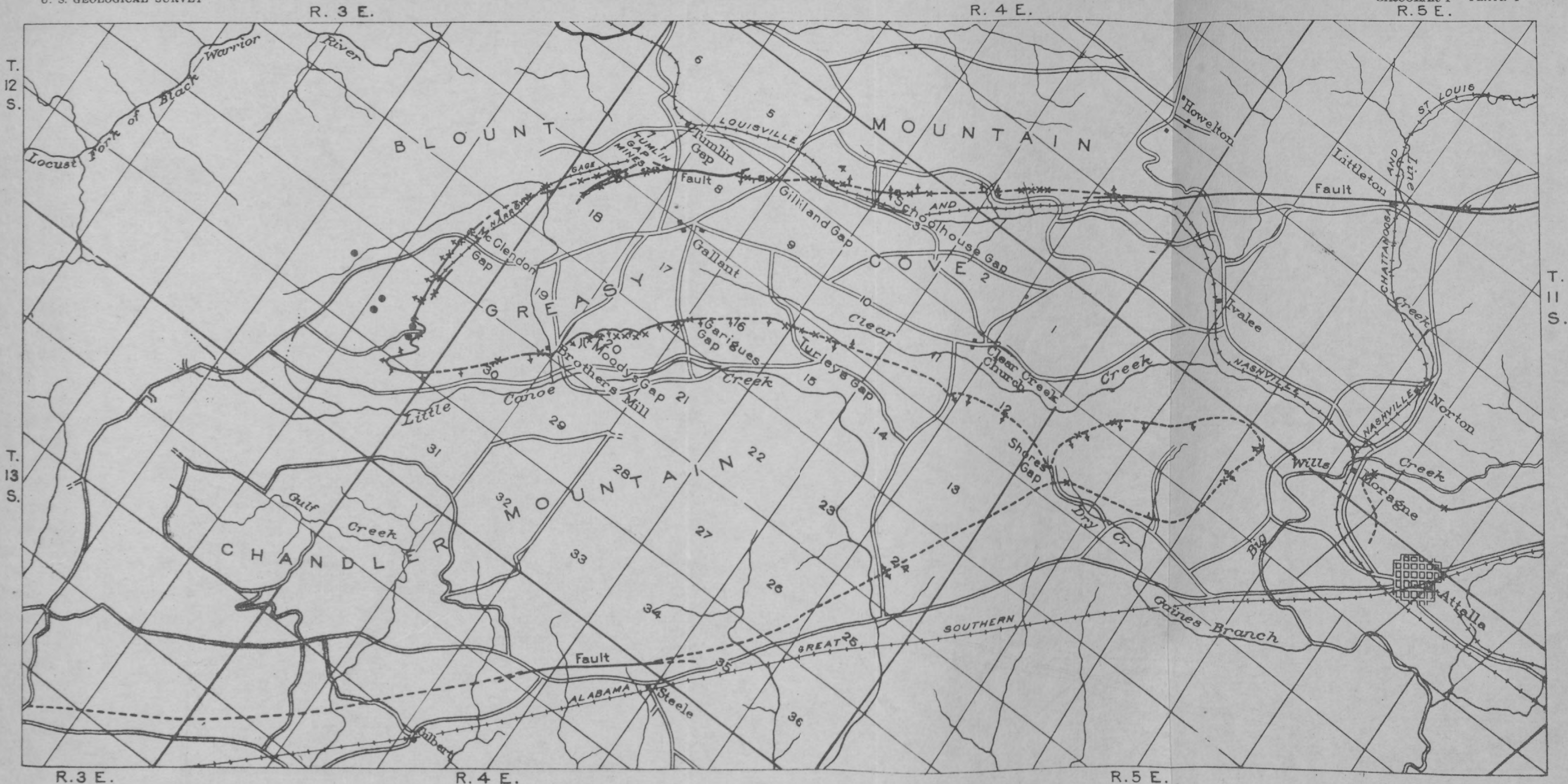
Summary of data

Summary of data on iron ore beds in Greasy Cove

Locality	Dips	Length of outcrop on strike (L)		Estimated width on dip (D)	Apparent average thickness (T)	Estimated cubic feet per ton (N)
		Feet	Miles	(feet)	(feet)	
West of Ivalee, SW$\frac{1}{4}$ sec. 25, T. 11 S., R. 4 E., to northern part sec. 3, T. 12 S., R. 4 E.	Generally steep northwest but in places vertical or overturned to southeast	10,560	2	--	1.25	--
Schoolhouse Gap area, northwestern part sec. 3, T. 12 S., R. 4 E.	do	3,960	.75	100	4	11
Schoolhouse Gap to Gilliland Gap, sec. 4, T. 12 S., R. 4 E.	do	5,708	1.1	--	1.5	--
Gilliland Gap, northern part sec. 8, T. 12 S., R. 4 E.	Steep northwest to steep northeast and vertical	1,100	.21	100	2.25	11
Tumlin Gap, secs. 7 and 18, T. 12 S., R. 4 E.	Steep northwest to vertical	3,432	.65	100	2.75	11
Little Canoe Creek area, between Tumlin Gap and McClendon Gap mines, sec. 18, T. 12 S., R. 4 E., and secs. 13 and 24, T. 12 S., R. 3 E.	Steep northwest and steep southeast	6,864	1.3	--	1.10	--

Locality	Dips	Length of outcrop on strike (L)		Estimated width on dip (D) (feet)	Apparent average thickness (T) (feet)	Estimated cubic feet per ton (N)	Estimated quantity soft and semihard ore (long tons
		Feet	Miles				
McClendon Gap mine to south end of tramway, secs. 13 and 24, T. 12 S., R. 3 E.	Moderate to steep northwest and southeast	3,960	.75	150	3.8	12	188,100
End of tramway to stripping mines, sec. 25, T. 12 S., R. 3 E.	Moderate southwest	2,640	.5	150	2.5	12	82,500
Stripping mines and adjacent area, sec. 25, T. 12 S., R. 3 E.	Low southwest and south	1,584	.3	200	5.25	13.5	123,200
Southeastern part sec. 25 and northeastern part sec. 36, T. 12 S., R. 3 E.	Moderate southwest, south, and southeast	4,752	.9	100	2	12	79,200
Middle and southwestern part sec. 30, T. 12 S., R. 4 E.	20°-30°SE.	5,280	1	--	1.5	--	--
Vicinity of Brothers mill, secs. 19, 20, and 30, T. 10 S., R. 4 E.	do	3,696	.7	250	3.5	12	269,500
Moodys Gap-Garigues Gap area, secs. 16, 17, and 20, T. 12 S., R. 4 E.	do	6,864	1.3	150	3	12	257,400

Locality	Dips	Length of outcrop on strike (L)		Estimated width on dip (D) (feet)	Apparent average thickness (T) (feet)	Estimated cubic feet per ton (N) (feet)	Estimated quantity soft and semihard ore (long tons)
		Feet	Miles				
Garigues Gap to Turleys Gap, sec. 16, T. 12 S., R. 4 E.	18^{o}-23^{o}SE.	3,696	.7	--	1.5	--	--
Turleys Gap, secs. 15 and 16, T. 12 S., R. 4 E.	25^{o}-30^{o}SE.	2,112	.4	100	3	11	57,600
Turleys Gap to road south of Clear Creek Church, secs. 10, 11, and 15, T. 12 S., R. 4 E.	Moderate to steep southeast	9,240	1.75	--	1.25	--	--
Road south of Clear Creek Church to Shores Gap, secs. 11 and 12, T. 12 S., R. 4 E., and sec. 7, T. 12 S., R. 5 E.	Moderate southeast to south	7,920	1.5	--	1.00	--	--
Elliptical area west and southwest of Attalla, secs. 4 to 9, T. 12 S., R. 5 E.	Steep to moderate southeast, southwest, west, north, northwest, and vertical	29,040	5.5	--	1.25	--	--
Total outcrop of ore beds less than 2 feet thick		78,308	14.85	--	--	--	--
Total outcrop of ore beds 2 feet or more thick		34,100	6.46	--	--	--	--
Total soft and semihard ore in beds 2 feet or more thick to depths indicated							1,309,800
Less estimated past production							50,000
							1,259,800



MAP OF GREASY COVE AND VICINITY, ALABAMA, SHOWING OUTCROP OF IRON-ORE BEDS IN RED MOUNTAIN FORMATION

1 0 1 2 3 4 Miles

Geologic and mine data by Ernest F. Burchard.

EXPLANATION

Ore 2 feet or more thick

Ore less than 2 feet thick

Mine shaft

Prospect or mine opening

Drill hole

Mine tunnel

Strike and dip of ore bed