IRON AND MANGANESE.

IRON ORES IN THE MONTEVALLO-COLUMBIANA REGION, ALABAMA.

By CHARLES BUTTS.

INTRODUCTION.

In the course of an areal and economic survey of the Bessemer quadrangle, Alabama, in 1910, the writer had the opportunity of examining a number of ore deposits, chief of which is the noted limonite deposit at Shelby, in Shelby County. There is another extensive deposit of brown ore southwest of Montevallo, and small deposits exist at other points. Stratified hematites also occur in the region. The most important of these deposits have been described by Henry McCalley [1] and P. S. Smith.[2]

LIMONITE AT SHELBY.

The limonite deposit at Shelby is the most important in the area treated here and the only one now being worked. Through the interest of Mr. W. W. Jacobs, president, and Mr. Linn W. Searles, consulting engineer, of the Shelby Iron Co., the writer is enabled to present the following historical statement of operations at Shelby. Operations were begun in 1844 to 1846 with the construction of a furnace having a daily capacity of 5 tons of cold-blast charcoal pig iron, and work has been practically continuous since that time. The original furnace was burned in 1853 or 1854 but was soon rebuilt by Horace Ware, the owner. The iron made here early acquired a high reputation, and as a result of a comparative test of Alabama, Georgia, and Tennessee irons made at Columbus, Ga., in 1852, an order for 1,000 tons was given to Mr. Ware, the largest order ever placed in Alabama up to that time. A rolling mill was completed in 1860, at which armor plates were made for the Confederate Government. The *Merrimac* was armored with these plates. In 1862 the name Shelby Iron Co. was adopted. In 1863 a larger furnace was built, with a daily capacity of 30 tons. This was equipped

[1] Report on the valley regions of Alabama, pt. 2, Geol. Survey Alabama, 1897, pp. 494–495, 510–512, 518–519.

[2] Bull. U. S. Geol. Survey No. 315, 1907, pp. 173–174.

with warm-blast ovens and was the first furnace to make warm-blast charcoal iron in Alabama. In 1865 this furnace was burned at the time of Wilson's raid. In 1867 or 1868 the furnace was rehabilitated and in 1869 it was blown in. In 1874 the present No. 2 furnace, with a capacity of 75 tons daily, was completed and it has been in service ever since except when shut down for repairs. In 1889 the old No. 1 furnace was blown out, and later in the year the present cupola furnace was completed and blown in. It also has a capacity of 75 tons daily.

The area and location of the ore deposit are shown in figure 34. The workings have been confined to an area roughly computed at 100 acres, and the topography of the surrounding land does not indicate any considerable extension of the workable ore. The ore deposit occurs in and beneath a mound, the top of which was originally 100 feet above the surrounding surface. In a rough way the drainage of the immediately surrounding country radiates from this mound. Such relations of limonite deposits to drainage exist in other parts of the State and have also been observed in central Pennsylvania. They suggest that topographic conditions have had something to do with the preservation of the larger bodies of unconsolidated ore-bearing material, and thus indirectly with the origin of the ore itself.

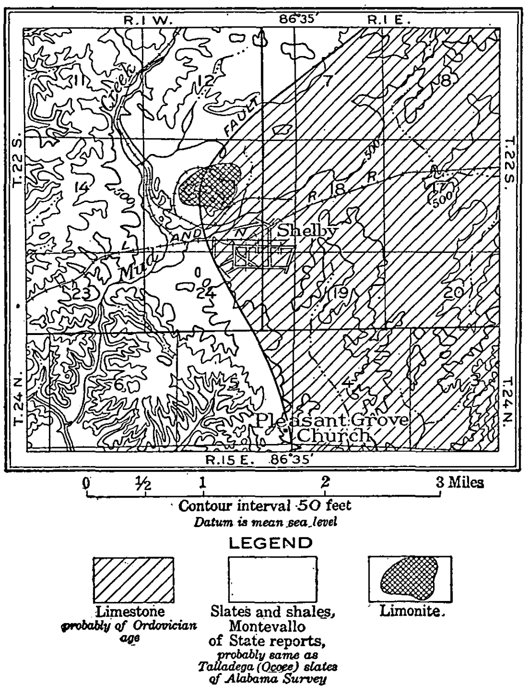

FIGURE 34.—Sketch map showing location of limonite deposit at Shelby, Shelby County, Ala.

The eastern two-thirds of the ore-bearing area is underlain by limestone and the western third possibly by shale, the limestone and shale being separated by a fault. The limestone has been uncovered at a few points in course of digging for the ore. Where the dip of the limestone could be determined it is 20° E. No shale has been exposed in the ore banks and it is not positively known to underlie the ore, but outcrops of shale both north and south of the ore warrant the inference that it is under the western part of the deposit. The limestone is believed to be of Ordovician ("Lower Silurian") age, heretofore included in the upper part of the Knox dolomite of this region, and the shale is the east marginal part of a great mass called Montevallo by the State Survey and regarded by the writer as the equivalent of the Talladega (Ocoee) slates of the State Survey.

The ore occurs in two quite different kinds of material sharply separated from each other, and the ore of the one differs from that of the other. Over most of the ore-bearing area is, or was, a layer of compact red loam about 15 feet thick, called the "blanket." Underlying the "blanket" in most of the area is a heterogeneous mass of more or less iron-stained clay, sand, and rock fragments. On the south margin of the workings, and apparently only there, a white and orange sand comes in between the "blanket" and the clay, as shown in the following section:

Section at south margin of Shelby workings.

	Feet.
Loam, red, compact, with lump ore ("blanket")	15
Sand, pink and white, slightly clayey, with quartz pebbles abundant	6
Sand like above, but orange-colored, with abundant quartz pebbles	6
Clay, tawny, with ore powder and streaks of slabby ore, with chert inclusions, probably residual from limestone	20
	52

The red loam of the "blanket" resembles the red loam of the Lafayette formation in other parts of the State. The 12 feet or so of sand and pebbles has all the appearance of Cretaceous material and probably is such. Test pits south of the workings have encountered this sand and gravel. It has been found impracticable to utilize the ore where the gravel and sand occur, on account of the difficulty of separating the pebbles. The clayey material below, composing the great bulk of the deposit, appears to be residual from the underlying limestone and shale. In places pinnacles of limestone project up into the clay to a height of 25 feet or so.

The ore in the "blanket" is designated lump ore. It is scattered rather irregularly through the red loam or to some extent aggregated into richer bodies having the form of thin lenses. Generally it is in small pieces 2 inches or less in diameter, compact and pure, reported to average 52 per cent of metallic iron and to yield a ton of ore to 3 or 4 cubic yards of material. The ore in the underlying clayey material is of all forms occurring in such deposits—small spongy lumps, slabby, wavy layers, and concretionary masses. Much of this ore contains more or less of impurities, such as inclusions of chert, clay, and sand. Some large masses are too sandy for use. All gradations occur, down to sandstone composed of detrital sand and fine chert fragments, originally occurring loose in the deposit, with just enough iron oxide for cement. According to a report of the former superintendent, W. H. Walker, the ore in this part of the deposit runs 45 per cent iron and the yield is a ton of ore to 10 cubic yards of material.

The thickness of the deposit has never been determined, but it is known by test pits in the bottom of the deepest workings to be over 100 feet thick and to contain ore to the greatest depths explored.

Mr. Linn W. Searles, of Birmingham, Ala., states that a recent drill hole in the bottom of the old workings, 30 feet below the original surface, had reached a depth of 100 feet and passed through 40 feet of almost solid brown ore and the remaining 60 feet through wash ore with varying proportions of ore and clay, but all apparently minable. These facts are interesting and important in view of the apparently approaching exhaustion of the more superficial ore and show besides that the original deposit was at least 130 feet thick.

Most of the ore at the present time appears to be of the fine, brown, spongy variety. The richer "blanket" ore has been nearly exhausted and also apparently the most productive part of the clayey deposit just under the "blanket." In previous working the plan has been to follow the lead of the richer ore bodies as they were discovered, either in the course of excavation or by drilling; consequently the area has been deeply trenched in an irregular manner, leaving large masses of undisturbed material between the excavations. The deposit appears to have been worked around the margins about to the limit of profitable operation. Future operations will therefore of necessity be confined to the unworked material between the old workings and to the material of unknown depth still remaining at the bottom of the deposit. As stated above, this bottom material has been explored to some extent with promising results.

The ore is all taken out with steam shovel, the ore bodies being first located by hand drill in front of the advancing shovel. Ore and dirt are taken out together, loaded into tram cars of about one shovel or one cubic yard capacity, and conveyed to log washers, by which the ore and dirt are separated, with the assistance of hand picking, to remove the coarser impurities.

The following are analyses of ore from the Shelby bank:

Analyses of iron ore from Shelby, Ala.

	1	2	3	4
Ferric oxide (Fe_2O_3)	78.86	81.35	82.82	72.620
Silica (SiO_2)	7.06	11.74	.29	7.815
Phosphorus (P)	.37	.11	.15	.527
Alumina (Al_2O_3)	2.37	1.59	.35	....
Manganese oxide (Mn_2O_3)	1.49	.75	.77	....
Lime (CaO)	.58	.57	Trace.	....
Magnesia (MgO)	Trace.	.12	....	....
Sulphur (S)	.14	.16	....	....
Water (H_2O)	9.25	3.80	14.62	....
	100.12	100.19	99.00	80.962
Metallic iron	55.20	56.19	57.97	50.85
Phosphorus in iron	.29	.09	....	....

1, 2. Smith, E. A., Geol. Survey Alabama, Report of progress for 1875, 1876, p. 109. Analyst, C. F. Chandler.
3. Tuomey, M., Bienn. Rept. Alabama Geol. Survey for 1855, 1858, p. 201.
4. McCalley, Henry, Report on the valley regions of Alabama, pt. 2, Geol. Survey Alabama, 1897, p. 519.
Analyses 1, 2, and 3 are also reprinted in McCalley's report, p. 519.

The following analyses, made in January, 1911, have been furnished by the company.

Analyses of limonite from the Shelby ore bank.

	1	2	3	4	5	6
Iron (Fe)	51.02	54.19	51.09	54.46	48.70	48.99
Silica (SiO_2)	12.88	12.92	11.95	7.30	11.35	12.27
Alumina (Al_2O_3)	2.19	....	1.55	3.55	2.39	6.20
Phosphorus (P)	.22	.16	.09	.10	.12	....
Manganese (Mn)	.90	.88	.53	.45	.81	.60
Sulphur (S)	....	....	....	....	.026	.033

These analyses show a somewhat higher percentage of iron and less silica and phosphorus than the brown ores of the Woodstock district. The manganese is about the same.

The character of the pig iron is shown by the following analyses:

Analyses of pig iron from Shelby furnace.

Grade of iron.	Silicon.	Sulphur.	Phosphorus.	Manganese.
1	1.91	0.016	0.35	0.61
1	2.05	.018	.34	.85
2	1.28	.019	.34	.76
2	1.25	.017	.36	.61
3	.70	.021	.38	.47
3	.77	.022	.40	.46
4	.49	.018	.39	.56
4	.65	.021	.42	.58
5	.28	.022	.48	.45
5	.36	.022	.47	.52

There is enough manganese in the iron to give it toughness, and it is all used in the manufacture of car wheels and chilled rolls and for special castings.

Charcoal is the fuel used and is obtained mostly from the surrounding country. The average consumption is 106.21 bushels of charcoal to a ton of iron. The flux at present is obtained from the marble quarries in the vicinity of Sylacauga. The furnace burden is about as follows:

	Pounds.
Charcoal	2,000
Ore	4,220
Flux	810

The output for the two furnaces is about 25,000 tons a year, and the present price (March, 1911) is from $22 a ton up, on the cars at Shelby.

BROWN ORE WEST OF BRIERFIELD.

Three miles west of Brierfield is a deposit of brown ore from which ore was obtained for the Bibb furnace from the time of its establishment in 1862 until its abandonment about 1895. The furnace was half a mile east of the ore bank and was connected by railroad with the bank and with the Southern Railway at Brierfield. The old stack is still standing, but the railroad has been torn up. (See sketch map, fig. 35.) It is said that iron smelted at the Bibb furnace was manufactured into cannon at Selma for use by the Confederate Army during the Civil War. At a later date the furnace supplied iron to a nail mill located at Brierfield. Cut nails were made at this mill, but the introduction of wire nails forced it out of business about 1895; this compelled the furnace to go out of operation also. The capacity of the furnace is reported to have been 45 tons a day, about three times that much ore being required.

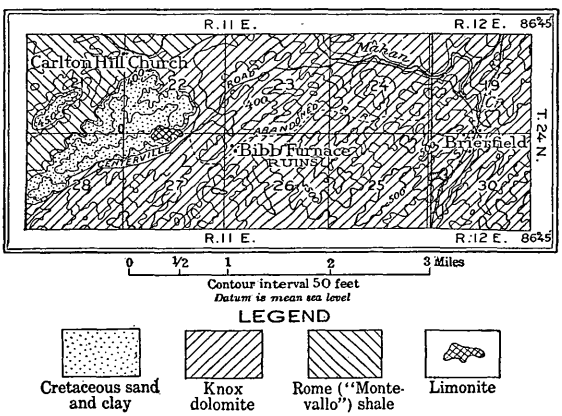

FIGURE 35.—Sketch map showing location of limonite deposit 3 miles west of Brierfield, Shelby County, Ala.

The old ore diggings are in the southern part of sec. 22 and the northern part of sec. 27, T. 24 N., R. 11 E. They extended over an area of about 10 acres and reached a depth estimated at 60 feet. The ore occurs in red or orange-colored sand or sandy clay, containing also many chert bowlders and much smaller chert débris. The deposit is underlain by Knox dolomite. At one point in the bottom of the ore pit is a boss of dolomite, and not over 200 feet distant on the same level is an exposure of variegated, crumpled clay that seems clearly of Cretaceous age. Apparently in Cretaceous time clay was deposited in the hollows in the Knox dolomite and subsequently covered by unstratified sand and clay, probably derived for the most part from the adjacent ridges, which also furnished the intermixed chert débris. In this heterogeneous mass of material the ore was segregated. According to report, no ore occurs in the variegated clay at the bottom.

The ore appears to be of the same types as in the Shelby bank, being in compact lumps near the top and of platy and concretionary character below. So far as could be judged from the walls of the old diggings, most of the ore occurs in the top 20 feet. The lump ore appears as small lumps aggregated in more or less distinct bands in the face of the workings, the bands being probably cross sections of lenticular aggregations of ore. As usual with this class of ore, it occurs in irregular pockets, and excavation might continue for several days without encountering much ore.

A large area in this locality is covered with Cretaceous or later deposits, apparently identical in character with that at the Bibb furnace banks and presumably carrying workable ore, evidences of which may be seen here and there on the surface. (See sketch map, fig. 35.) There are reports of ore in the region immediately southeast of the Bibb furnace, and some ore from this locality was supplied to the furnace by individuals who hauled it in wagons.

The ore from the Bibb bank is reported to have yielded about 40 per cent of iron in the furnace. Analyses of the ore are given below.

Analyses of iron ore from Bibb furnace bank in secs. 22 and 27, T. 24 N., R. 11 E.[a]

	1	2	3	4
Ferric oxide (Fe_2O_3)	74.540	81.421	78.945	57.459
Silica (SiO_2)	7.442	1.133	3.043	34.423
Phosphoric acid (P_2O_5)	1.389	.863	2.3+	....
Oxide of manganese (MnO)	....	....	....	.278
Metallic iron (Fe)	52.19	57.00	55.27	40.22

[a] McCalley, Henry, Report on the valley regions of Alabama, Geol. Survey Alabama, pt. 2, 1897, p. 494.

1. An average sample of the ore of the banks in the SW. ¼ NW. ¼ sec. 27, T. 24 N., R. 11 E.
2. A compact ore with a slight metallic appearance and with irregular velvety-looking seams. Locality, Mechanics' bank. Collected by T. J. Peter, Brierfield.
3. Labeled "From hill opposite Bibb furnace." Collected by T. J. Peter.
4. A concretionary limonite with the cavities lined with a fibrous limonite and holding a well-bleached white siliceous or cherty rocky material, carrying over 97 per cent of silica.

It may be noted here that west and northwest of the Bibb bank for a distance of 4 miles a number of other ore-bearing areas have long been known. They are described by E. A. Smith in his report of progress for 1875, pages 86–95, and Smith's account is republished by McCalley in his report on the valley regions, part 2, pages 488–495. One locality in the NW. ¼ sec. 13, T. 24 N., R. 10 E., was visited by the writer. A number of test pits had been recently dug covering a considerable area, and ore had been taken out of them which appeared to be of about the usual grade. It occurs in Cretaceous material. There is clearly a great deal of ore in this general region, but it is to be presumed that the deposits are not rich enough in iron of a satisfactory grade to compete with such deposits as exist in the Woodstock district and the other localities in the State where brown ores are being mined. It seems highly probable, however, that this general region holds large reserves of workable ore that will be exploited as soon as the richer deposits of the State are exhausted or greatly depleted.

MINOR LIMONITE DEPOSITS.

In the NE. ¼ sec. 20 and the NW. ¼ sec. 21, T. 24 N., R. 14 E., on property belonging to W. W. Shortridge, of Birmingham, are two small areas containing high-grade limonite. (See sketch map, fig. 36.) Some of the limonite is manganiferous.

These deposits occur in residual clay from shale classed as the Montevallo formation by the Alabama Geological Survey, but

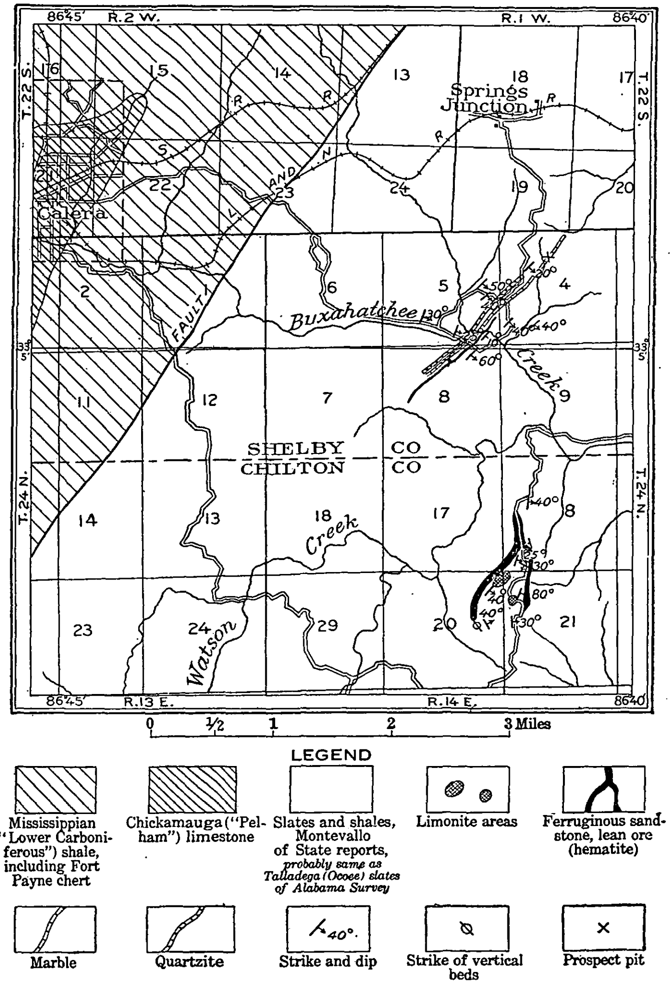

FIGURE 36.—Sketch map showing location of iron-ore and marble deposits southeast of Calera, Shelby County, Ala.

probably the same as the Talladega (Ocoee) slates of that Survey. One patch of the ore lies on the flank of a ridge and the other on top of a ridge. Along each of these ridges there is an outcrop of highly rruginous sandstone or lean hematite on opposite sides of a syncline. ese outcrops converge northward; their relations are shown on the ch map (fig. 36).

The larger ore-bearing area, on the north, is 200 to 300 yards long by 75 yards or so in width. The patch on top of the ridge to the south is very small. Test pits in these areas show the presence of a considerable proportion of high-grade ore in large masses and fine particles in the clay. It is believed by those competent to judge that this clay carries a large content of wash ore, some of which is rich in manganese. No analyses are at hand. It is highly probable that the brown ore has been derived from the lean hematite outcropping on the ridges and dipping under the areas holding the limonite.

Notwithstanding the richness of these deposits the areas are too small to be of much value, for they do not contain ore enough to warrant building a railroad or installing a plant for mining. The deposits are of interest, however, because of their occurrence in an area underlain by shale or slate instead of limestone or dolomite.

Just south of Mosteller, on a ridge in the SW. ¼ sec. 23, T. 22 S., R. 1 E., is a small deposit of ore underlain by very cherty Knox dolomite. Some good lump ore occurs in a "blanket" of red loam similar to that at Shelby. Considerable ore has been taken out, having been hauled by wagon to the railroad near by for shipment. The ore-bearing area is very small, and below the blanket, which is only a few feet thick except on one side, the ore is so full of chert fragments as to be worthless. Much of it can be regarded as nothing more than a chert breccia cemented by limonite. The deposit is not commercially important.

About half a mile south of the Mosteller deposit, near the center of the NW. ¼ sec. 6, T. 24 N., R. 16 E., a little ore shows on the surface and some small test pits have been dug. There is nothing here to indicate the presence of a deposit of commercial importance.

About 2 miles northeast of Shelby, in the SE. ¼ sec. 8., T. 22 S., R. 1 E., is a small patch of ore-bearing material that has been prospected. It is of no importance.

The region included in this discussion has been fully explored for ore deposits, and nothing of importance has been discovered outside of the occurrences at Shelby and the Bibb furnace. It seems a safe conclusion that no other limonite deposits of economic importance occur in the region.

HEMATITE ORE.

Hematite ore occurs in the rocks which are classed by the Alabama Geological Survey as Montevallo (Variegated) shale but which are equivalent to the Talladega (Ocoee) slates of the State Survey. The only deposit of possible value occurs in Columbiana Mountain, east of Columbiana, in association with the quartzite beds to which that ridge owes its existence. (See sketch map, fig. 37, p. 225.) Reports are in circulation, however, of the existence of an ore bed extending southwest of Columbiana in the same slate formation. The probable basis for this report is discussed on page 228.

The rocks of Columbiana Mountain are shale or slate inclosing strata of sandstone or quartzite, the whole mass, beginning at the lowest quartzite stratum, being some 1,600 feet thick if there is no repetition due to faults or folds. A roughly approximate section is as follows:

Section of rocks in Columbiana Mountain.

[Compiled from section west of Leeper's mill on Beeswax Creek, half a mile northwest of Kingdon Church, and from section on crest of mountain on road to Mardis Ferry, 1½ miles northeast of Columbiana, in the SW. ¼ sec. 19, T. 21 S., R. 1 E.]

	Feet.
1. Quartzite	10
2. Shale, stiff, blue, calcareous (?); ore at base (see p. 227)	180
3. Quartzite	5
4. Shale, stiff, blue, calcareous (?); ore at base of this shale on Mardis Ferry road and northward (see sections, p. 227)	618
5. Quartzite, thin bedded	75
6. Quartzite, thick bedded, conglomeratic	25
7. Shale (mainly), greenish	85
8. Ore and shale (see p. 227)	11
9. Shale with a few thin quartzite layers	300
10. Quartzite	3
11. Concealed; a little shale or shaly sandstone at top	250
12. Quartzite, conglomeratic	30
13. Shale, great thickness.	
	1,592

The part of the section on Beeswax Creek, Nos. 1 to 6, inclusive, was measured by the writer; the part on the mountain northeast of Columbiana was measured in part by the writer, but some gaps were filled in from the section by P. S. Smith,[1] who studied the section along the old road down the east side of the mountain, while the writer saw only the section in the newly located road, where the rocks are not so fully exposed as in the old road.

Columbiana Mountain is a curving ridge of elliptical form which is well enough delineated by the outcrops of the sandstone strata shown on the map (fig. 37). The form of the mountain is due to the geologic structure, which is synclinal, with an axis pitching steeply to the northeast, so that the strata lie in a basin shaped like the prow of a canoe and the outcropping edges necessarily take an elliptical outline. Along the western outcrop the rocks dip to the east or southeast; on the southeastern outcrop the rocks dip to the northwest.

[1] The gray iron ores of Talladega County, Ala.: Bull. U. S. Geol. Survey No. 315, 1907, pp. 161-184.

Partly inclosed within the ellipse of Columbiana Mountain is another ridge of triangular form, lying in secs. 9 and 16, T. 21 S., R. 1 E., which, like Columbiana Mountain, is the result of the presence of several strata of resistant sandstone or quartzite. The rocks of this ridge lie in the center of the syncline and are underlain at great depth by the rocks of Columbiana Mountain. Ore occurs at a number of points in both Columbiana Mountain and the triangular ridge, but the only bed that shows any promise of economic importance lies close above the quartzite given as Nos. 5 and 6 of the

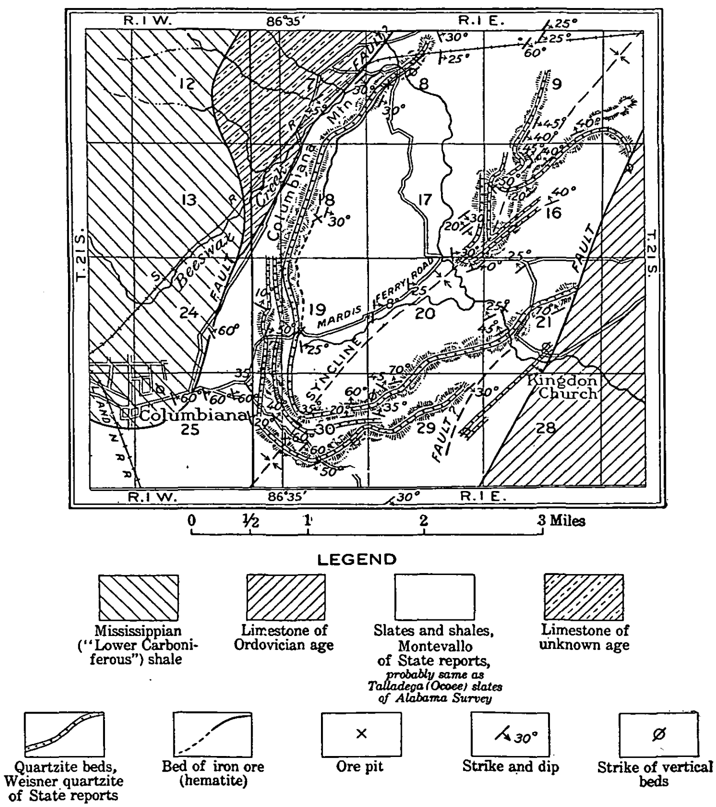

FIGURE 37.—Sketch map showing location of hematite ore in Columbiana Mountain, Shelby County, Ala.

section on page 224. This quartzite is shown on the map as a continuous outcrop from the fault at a point north of Kingdon Church to the northwest corner of sec. 8, T. 21 S., R. 1 E., where it disappears, apparently by thinning out. The above-mentioned ore bed is known only north of the Mardis Ferry road. It has been thoroughly prospected for about 2 miles along its outcrop in secs. 7, 8, and 18, T. 21 S., R. 1 E., and its outcrop in these sections is shown on the sketch map (fig. 37).

The ore consists of layers in shale, as shown in the following section:

Section of ore in pit on knoll half a mile northeast of Nelson, in the NW. ¼ sec. 8, T. 21 S., R. 1 E.

	Feet.
Shale, pale gray, fissile, soft	10
Ore, apparently of good grade	7
Ore, low grade	3
Sandstone	2
Shale, pale gray, fissile, soft	15
Sandstone (?).	

Another pit 50 feet farther north showed about 8 feet of ore. At these pits the beds are vertical and strike N. 50° E. On the crest of the ridge one-sixth of a mile southeast of Nelson station is a pit at which the following section was measured:

Section of ore in pit one-sixth mile southeast of Nelson station, in western part of sec. 8, T. 21 S., R. 1 E.

	Ft.	in.
Shale	12	
Shale, ferruginous, lean ore, worthless		8½
Ore, probably low grade and worthless		7
Shale, ferruginous		2
Ore(?), low grade, probably worthless		11
Shale, more or less ferruginous		8½
Ore, low grade, probably worthless		7
Ore, apparently fair grade		5
Shale, ferruginous	2	4
Ore, apparently high grade	3	6
Shale(?)	10	
Quartzite, conglomeratic		

At this pit the strike is N. 20° E. and the dip 30° E. A little over a mile southwest of this pit, in the NW. ¼ SE. ¼ sec. 18, T. 21 S., R. 1 E., another measurement was obtained as follows:

Section of ore bed at pit in the NW. ¼ SE. ¼ sec. 18, T. 21 S., R. 1 E.

	Ft.	in.
Shale.		
Ore, fair grade	1	
Shale, with ore streaks up to 2 inches	5	
Ore, fair grade (?)	2	6
Shale		10
Ore, bottom not certainly seen		2
Shale, ferruginous.		

The strike here is N. 10° E. and the dip 30° E. On the Mardis Ferry road, according to Smith,[1] this same ore bed is made up of a number of thin layers of hematite separated by shale and the ore is somewhat quartzose.

The extent of this bed south of the road and around the syncline to the northeast above the underlying quartzite, shown on the map,

[1] Smith, P. S., op. cit., p. 174.

is unknown. In the Beeswax Creek section, where the exposure of the rocks is unbroken, it is not present above the quartzite, Nos. 5 and 6 of the section (p. 224).

On Beeswax Creek a much higher ore bed is exposed, a section of which is shown below.

Section of ore bed on Beeswax Creek, on west side of sec. 21, T. 21 S., R. 1 E.

	Feet.
Shale, blue, calcareous (?) (No. 2 of section, p. 224).	
Ore, rounded quartz grains size of clover seed, cemented with iron oxide, apparently high in iron	1
Sandstone, green, with fine quartz grains, as in ore	1
Shale, blue, ordinary type	12
Ore, apparently good grade	1
Shale	3
Sandstone, fine grained, ferruginous, lean ore (?)	3
Sandstone, conglomeratic (No. 3 of section, p. 224)	5

At this point the strike is N. 30° E. and the dip 25° NW. On the Mardis Ferry road in the SW. ¼ sec. 19, T. 21 S., R. 1 E., Smith[1] noted the following section:

Section of ore bed on Mardis Ferry road in the SW. ¼ sec. 19, T. 21 S., R. 1 E. (No. 8 of section, p. 224.

	Ft.	in.
Shale.		
Ore	2	
Shale (?)	4	6
Ore		6
Shale (?)	1	
Ore	3	

The dip of this bed is 27° E. McCalley[2] reports the following sections from test pits in the SW. ¼ sec. 29, T. 21 S., R. 1 E.:

Sections of ore bed in test pits in the SW. ¼ sec. 29, T. 21 S., R. 1 E.

No. 1.

	Ft.	in.
Shale, greenish	3	
Ore, red; shales interstratified	1	2
Ore, red, compact, about	1	1
Shale, nearly		2
Ore, red, compact		11
Shale		1
Ore, red	1	3
Shale.		

No. 2 (40 feet from No. 1, on same bed).

	Ft.	in.
Débris.		
Ore, red, very fine; amount visible about		7
Shale, about		3
Ore, red, and shale; ore shaly	1	6
Shale; dove and greenish colors		9
Ore, red, not very good	1	2
Débris.		

From the geographic location of these sections it appears that the ore bed is stratigraphically considerably below the lowest quartzite stratum of Columbiana Mountain, No. 12 of the section (p. 224). Ore débris or float occurs at several points on Columbiana Mountain in association with the quartzite strata, but most of such ore appears

[1] Smith, P. S., op. cit., p. 170.
[2] McCalley, Henry, Report on the valley regions, pt. 2, Geol. Survey Alabama, 1897, p. 511.

to be of low grade and does not warrant extended description. At some points highly ferruginous quartzite débris occurs at the outcrop of one or another stratum of quartzite and evidently is derived from the quartzite. Highly ferruginous sandstone occurs also in association with the stratigraphically much higher rocks of the triangular ridge in secs. 9 and 16, T. 21 S., R. 1 E. These ore beds clearly occur as lenses in the great mass of shales and quartzites of the region.

Highly ferruginous fine-grained sandstone or lean hematite occurs several miles southwest of Columbiana, near Buxahatchee Creek, in the same formation as that of Columbiana Mountain. (See sketch map, fig. 37, p. 225.) One occurrence is in secs. 4 and 8, T. 24 N., R. 14 E., where a bed of unknown thickness outcrops for a mile or so, as shown by the distribution of its débris. A bed stratigraphically higher occurs in secs. 17, 18, 20, and 21, T. 24 N., R. 14 E. This bed lies along the axis of the great syncline extending northeastward through Columbiana Mountain. The axis in this region pitches southwestward, so that the outcrops of the rocks on opposite sides of the syncline converge northeastward, as shown on the map (fig. 37).

It is the occurrence of these ferruginous sandstones or lean ores that has given rise to the reports of ores of supposed value in the great area of shales and slates to the southwest of Columbiana, and the occurrence of the ore beds at and southwest of Columbiana has served as foundation for a rather current though erroneous belief that there are continuous ore beds between this region and the beds of gray ore at Talladega. Although the Talladega gray ores, the ores in Columbiana Mountain, and the lean ores farther southwest probably all occur in the same formation, they occur as discontinuous beds or lenses in the region discussed in this paper. All the ore of the shale and quartzite formations in this region is hematite, whether in the better grades or in the ferruginous sandstones, some of which may rank as lean ore. They are all stratified deposits and in some of their aspects resemble Clinton ore. The layers of the better ore of Columbiana Mountain, such as that of the bed above the quartzite (Nos. 5 and 6 of the section on page 224), sections of which are given on page 226, are intersected by joints and bedding planes which divide the ore into smooth-faced rhombohedral pieces generally less than 6 inches in diameter. In the lean ores and ferruginous sandstones this manner of jointing is less conspicuous. The areal extent of any of the ore beds is not known, but as they give out along their outcrop when traced far enough, as shown by the disappearance of their float or débris, it is a reasonable presumption that they give out underground also. In other words, the ore beds are lenticular deposits. The extent underground depends also on their manner of origin—whether they are original deposits or have been formed through partial replacement by iron compounds of other beds subsequent to their deposition. If the iron is an original deposit, the ore beds are likely to have a larger extent than if it is a replacement, for replacement to a sufficient extent to form a workable ore bed probably would not occur under the conditions existing in this region.

The only facts bearing on the underground extent of the ores are reported by W. H. Walker, former superintendent of the Shelby iron works, who says that in a prospect pit driven in for about 30 feet the ore layers passed into shale. This might be due either to the replacement of shale by ore near the surface or to the accidental circumstance that the location of the pit was near the margin of a lens of ore which feathered out at the depth reached. It was not stated whether the ore layers thinned out or passed into shale without thinning. No prospecting has been carried to a sufficient depth to permit a reliable conclusion regarding the persistence of the ore beneath the surface.

Microscopic examinations of thin sections of the ore show it to be composed of quartz grains, minute pebbles of the size of clover seed, fragments of feldspar, particles of a green mineral that may be chlorite, and probably other minerals, all cemented by iron oxide. The sections examined do not show whether the iron oxide replaces other minerals originally present or whether it was of sedimentary origin like the inclosing slates. These slates are commonly calcareous, and the ore layers may have been originally highly calcareous and the calcareous matter may have been later replaced by the iron oxide.

No recent analyses of the ores from Columbiana Mountain are at hand. It is stated by Mr. Walker that analyses by the Shelby Iron Co. showed 42 to 43 per cent of metallic iron. The following analyses from different reports of the Alabama Survey probably represent the average composition of the ore:

Analyses of iron ores from Columbiana Mountain.[a]

	1	2	3	4
Ferric oxide (Fe_2O_3)	67.73	70.09	76.87	43.840
Silica (SiO_2)	29.06	23.45	20.74	31.594
Sulphur (S)		.11		
Phosphoric acid (P_2O_5)	.69	.77	Trace.	.453
Alumina (Al_2O_3)	3.66	5.58	1.55	
Manganese oxide (Mn_2O_3)	1.00		.51	
Metallic iron (Fe)	47.41	49.08	53.81	30.72

[a] McCalley, Henry, Report on the valley regions, pt. 2, Geol. Survey Alabama, 1897, p. 512.

1. Ore from Columbiana Mountain. Analyst, J. B. Britton.
2. Ore from Columbiana Mountain. Analyst, C. F. Chandler. Smith, E. A., Report of progress for 1875, Geol. Survey Alabama, 1876, pp. 124, 125.
3. Ore from Columbiana Mountain. Tuomey, M., Second Bienn. Rept. Geology of Alabama, 1858. p. 80.
4. Average sample of ore from pits in the SW. ¼ sec. 29, T. 21 S., R. 1 E., dried at 100° C. (See sections on p. 227.)

It is not unlikely that the samples of analyses 1 to 3 in the above table are from the bed above the quartzite, Nos. 5 and 6 of the section on page 224, the bed prospected so extensively, as described on pages 225–226. This bed makes the greatest show on the surface by débris and would be more likely to attract attention than any other.

A furnace test on a carload of this ore was made at the Shelby iron works. According to W. H. Walker, former superintendent of the works, the ore was found to be very refractory, its fusion requiring a very high heat. Enough is known about this bed to warrant the opinion that it may be a future source of ore of moderate importance, but no other bed of which as much can be said is known either in the Columbiana region or in the Buxahatchee region to the southwest.

SURVEY PUBLICATIONS ON IRON AND MANGANESE ORES.

A number of the principal papers on iron and manganese ores published by the United States Geological Survey or by members of its staff are listed below. The Government publications, except those to which a price is affixed, can be obtained free by applying to the Director, United States Geological Survey, Washington, D. C. The priced publications may be purchased from the Superintendent of Documents, Government Printing Office, Washington, D. C.; the folios from either that official or the Director of the Survey. Several geologic folios not given in this list contain descriptions of iron-ore deposits of more or less importance.

BALL, S. H. The Hartville iron ore range, Wyoming. In Bulletin 315, pp. 190–205. 1907.

——— Titaniferous iron ores of Iron Mountain, Wyoming. In Bulletin 315, pp. 206–212. 1907.

BANCROFT, HOWLAND. Reconnaissance of the ore deposits in northern Yuma County, Ariz. Bulletin 451. 130 pp. 1911.

BARNES, P. The present technical condition of the steel industry of the United States. Bulletin 25. 85 pp. 1885. 10c.

BAYLEY, W. S. The Menominee iron-bearing district of Michigan. Monograph XLVI. 513 pp. 1904. $1.75.

BAYLEY, W. S., and others. Passaic folio (No. 157), Geol. Atlas U. S. 1908. 25c.

BIRKINBINE, J. The production of iron ores in various parts of the world. In Sixteenth Ann. Rept., pt. 3, pp. 21–218. 1894. $1.20.

BOUTWELL, J. M. Iron ores in the Uinta Mountains, Utah. In Bulletin 225, pp. 221–228. 1904. 35c.

BURCHARD, E. F. The iron ores of the Brookwood district, Alabama. In Bulletin 260, pp. 321–334. 1905. 40c.

——— The Clinton or red ores of the Birmingham district. In Bulletin 315, pp. 130–151. 1907.

——— The brown ores of the Russellville district, Alabama. In Bulletin 315, pp. 152–160. 1907.

——— The Clinton iron ore deposits in Alabama. In Trans. Am. Inst. Min. Eng., vol. 39, 1908, pp. 997–1055.

——— An estimate of the tonnage of available Clinton iron ore in the Birmingham district, Alabama. In Bulletin 340, pp. 308–317. 1908.

——— Tonnage estimates of Clinton iron ore in the Chattanooga region of Tennessee, Georgia, and Alabama. In Bulletin 380, pp. 169–187. 1909.

——— Iron ore, pig iron, and steel. In Mineral Resources U. S. for 1909, pt. 1, pp. 71–99. 1911.

——— Manganese ore. In Mineral Resources U. S. for 1909, pt. 1, pp. 107-119. 1911.

BURCHARD, E. F., BUTTS, CHARLES, and ECKEL, E. C. Iron ores, fuels, and fluxes of the Birmingham district, Alabama. Bulletin 400. 204 pp. 1910.

BUTTS, CHARLES. Mineral resources of the Kittanning and Rural Valley quadrangles, Pennsylvania. Bulletin 279. 198 pp. 1906.

CLEMENTS, J. M. The Vermilion iron-bearing district of Minnesota. Monograph XLV. 463 pp. 1903. $3.50.

CLEMENTS, J. M., SMYTH, H. L., BAYLEY, W. S., and VAN HISE, C. R. The Crystal Falls iron-bearing district of Michigan. In Nineteenth Ann. Rept., pt. 3, pp. 1–157. 1898. $2.25.

——— The Crystal Falls iron-bearing district of Michigan. Monograph XXXVI. 512 pp. 1899. $2.

DILLER, J. S. Iron ores of the Redding quadrangle, California. In Bulletin 213, pp. 219–220. 1903. 25c.

——— So-called iron ore near Portland, Oreg. In Bulletin 260, pp. 343–347. 1905. 40c.

ECKEL, E. C. Utilization of iron and steel slags. In Bulletin 213, pp. 221–231. 1903. 25c.

——— Iron ores of the United States. In Bulletin 260, pp. 317–320. 1905. 40c.

——— Limonite deposits of eastern New York and western New England. In Bulletin 260, pp. 335–342. 1905. 40c.

——— Iron ores of northeastern Texas. In Bulletin 260, pp. 348–354. 1905. 40c.

——— The Clinton hematite. In Eng. and Min. Jour., vol. 79, pp. 897–898. 1905.

——— The iron industry of Texas, present and prospective. In Iron Age, vol. 76, pp. 478–479. 1905.

——— The Clinton or red ores of northern Alabama. In Bulletin 285, pp. 172–179. 1906. 60c.

——— The Oriskany and Clinton iron ores of Virginia. In Bulletin 285, pp. 183–189. 1906.

HARDER, E. C. Manganese deposits of the United States; with sections on foreign deposits, chemistry, and uses. Bulletin 427. 208 pp. 1910.

——— The Taylor Peak and Whitepine iron-ore deposits, Colorado. In Bulletin 380, pp. 188–198. 1909.

——— The iron ores of the Appalachian region in Virginia. In Bulletin 380, pp. 215–254. 1909.

——— Manganese deposits of the United States. In Bulletin 380, pp. 255–277. 1909.

——— Some iron ores of western and central California. In Bulletin 430, pp. 219–227. 1910.

——— Iron ores near Dayton, Nev. In Bulletin 430, pp. 240–246. 1910.

——— Deposits of brown iron ore near Dillsburg, York County, Pa. In Bulletin 430, pp. 250–255. 1910.

HARDER, E. C., and RICH, J. L. The Iron Age iron-ore deposit near Dale, San Bernardino County, Cal. In Bulletin 430, pp. 228–239. 1910.

HAYES, C. W. Geological relations of the iron ores in the Cartersville district, Georgia. In Trans. Am. Inst. Min. Eng., vol. 30, pp. 403–419. 1901.

——— Manganese ores of the Cartersville district, Georgia. In Bulletin 213, p. 232. 1903. 25c.

——— Iron ores of the United States. In Bulletin 394, pp. 70–113. 1909.

HAYES, C. W., and ECKEL, E. C. Iron ores of the Cartersville district, Georgia. In Bulletin 213, pp. 233–242. 1903. 25c.

HOLDEN, R. J. The brown ores of the New River-Cripple Creek district, Virginia. In Bulletin 285, pp. 190–193. 1906. 60c.

IRVING, R. D., and VAN HISE, C. R. The Penokee iron-bearing series of Michigan and Wisconsin. In Tenth Ann. Rept., pt. 1, pp. 341–507. 1889. $2.35.

IRVING, R. D., and VAN HISE, C. R. The Penokee iron-bearing series of Michigan and Wisconsin. Monograph XIX. 534 pp. 1892. $1.70.

KEITH, ARTHUR. Iron-ore deposits of the Cranberry district, North Carolina-Tennessee. In Bulletin 213, pp. 243–246. 1903. 25c.

KEMP, J. F. The titaniferous iron ores of the Adirondacks [N. Y.]. In Nineteenth Ann. Rept., pt. 3, pp. 377–422. 1899. $2.25.

KINDLE, E. M. The iron ores of Bath County, Ky. In Bulletin 285, pp. 180–182. 1906.

LEITH, C. K. The Mesabi iron-bearing district of Minnesota. Monograph XLIII. 316 pp. 1903. $1.50.

——— Geologic work in the Lake Superior iron district during 1902. In Bulletin 213, pp. 247–250. 1903. 25c.

——— The Lake Superior mining region during 1903. In Bulletin 225, pp. 215–220. 1904. 35c.

——— Iron ores in southern Utah. In Bulletin 225, pp. 229–237. 1904. 35c.

——— Genesis of the Lake Superior iron ores. In Econ. Geology, vol. 1, pp. 47–66. 1905.

——— Iron ores of the western United States and British Columbia. In Bulletin 285, pp. 194–200. 1906.

——— The geology of the Cuyuna iron range, Minnesota. In Econ. Geology, vol. 2, pp. 145–152. 1907.

——— Iron ore reserves. In Econ. Geology, vol. 1, pp. 360–368. 1906.

——— A summary of Lake Superior geology with special reference to recent studies of the iron-bearing series. In Trans. Am. Inst. Min. Eng., vol. 35, pp. 454–507. 1904.

LEITH, C. K., and HARDER, E. C. The iron ores of the Iron Springs district, southern Utah. Bulletin 338. 102 pp. 1908.

PAIGE, SIDNEY. The Hanover iron-ore deposits, New Mexico. In Bulletin 380, pp. 199–214. 1909.

——— Preliminary report on pre-Cambrian geology and iron ores of Llano County, Tex. In Bulletin 430, pp. 256–268. 1910.

——— Mineral resources of the Llano-Burnet region, Texas, with an account of the pre-Cambrian geology. Bulletin 450. 102 pp. 1911.

PHALEN, W. C. Iron ores near Ellijay, Ga. In Bulletin 340, pp. 330–334. 1908.

——— Origin and occurrence of certain iron ores in northeastern Kentucky In Econ. Geology, vol. 7, 1906.

——— Economic geology of the Kenova quadrangle (Ky.–Ohio–W. Va.). Bulletin 349. 158 pp. 1908.

SMITH, G. O., and WILLIS, BAILEY. The Clealum iron ores, Washington. In Trans. Am. Inst. Min. Eng., vol. 30, pp. 356–366. 1901.

SMITH, P. S. The gray iron ores of Talladega County, Ala. In Bulletin 315, pp. 161–184. 1907.

SPENCER, A. C. The iron ores of Santiago, Cuba. In Eng. and Min. Jour., vol. 72, pp. 633–634. 1901.

——— Manganese deposits of Santiago, Cuba. In Bulletin 213, pp. 251–255. 1903. 25c.

——— Magnetite deposits of the Cornwall type in Berks and Lebanon counties, In Bulletin 315, pp. 185–189. 1907.

——— Three deposits of iron ore in Cuba. In Bulletin 340, pp. 318–329. 1908.

——— Magnetite deposits of the Cornwall type in Pennsylvania. Bulletin 359. 102 pp. 1908.

——— The Jauss iron mine, Dillsburg, Pa. In Bulletin 430, pp. 247–249. 1910.

SPENCER, A. C., and others. Franklin Furnace folio (No. 161), Geol. Atlas U. S. 1908. 25c.

SWANK, J. M. Iron and steel and allied industries in all countries. In Eighteenth Ann. Rept., pt. 5, pp. 51–140. 1896.

VAN HISE, C. R. The iron-ore deposits of the Lake Superior region. In Twenty-first Ann. Rept., pt. 3, pp. 305–434. 1901.

VAN HISE, C. R., and BAYLEY, W. S. Menominee special folio (No. 62), Geol. Atlas U. S. 1900. 25c.

VAN HISE, C. R., and LEITH, C. K. The geology of the Lake Superior region. Monograph LII. 626 pp. 1911. Price not yet fixed.

VAN HISE, C. R., BAYLEY, W. S., and SMYTH, H. L. Preliminary report on the Marquette iron-bearing district of Michigan. In Fifteenth Ann. Rept., pp. 477–650. 1894.

——— The Marquette iron-bearing district of Michigan, with atlas. Monograph XXVIII. 608 pp. 1897. $5.75.

WOLFF, J. E. Zinc and manganese deposits of Franklin Furnace, N. J. In Bulletin 213, pp. 214–217. 1903. 25c.

ALUMINUM ORES.

SURVEY PUBLICATIONS ON ALUMINUM ORES—BAUXITE, CRYOLITE, ETC.

The following reports published by the Survey or by members of its staff contain data on the occurrence of aluminum ores and on the metallurgy and uses of aluminum. The Government publications, except those to which a price is affixed, can be obtained free by applying to the Director, U. S. Geological Survey, Washington, D. C. The priced publications may be purchased from the Superintendent of Documents, Government Printing Office, Washington, D. C.; the folio from either that official or the Director of the Survey.

Burchard, E. F. Bauxite and aluminum. In Mineral Resources U. S. for 1906, pp. 501-510. 1907. 50c.

Canby, H. S. The cryolite of Greenland. In Nineteenth Ann. Rept., pt. 6, pp. 615-617. 1898.

Hayes, C. W. Bauxite. In Mineral Resources U. S. for 1893, pp. 159-167. 1894. 50c.

——— The geological relations of the southern Appalachian bauxite deposits. In Trans. Am. Inst. Min. Eng., vol. 24, pp. 243-254. 1895.

——— Bauxite. In Sixteenth Ann. Rept., pt. 3, pp. 547-597. 1895. $1.20.

——— The Arkansas bauxite deposits. In Twenty-first Ann. Rept., pt. 3, pp. 435-472. 1901.

——— Bauxite in Rome quadrangle, Georgia-Alabama. Geol. Atlas U. S., folio 78, p. 6. 1902. 25c.

——— The Gila River alum deposits. In Bulletin 315, pp. 215-223. 1907.

Hunt, A. E. In Mineral Resources U. S. for 1892, pp. 227-254. 1893. 50c.

Packard, R. L. Aluminum and bauxite. In Mineral Resources U. S. for 1891, pp. 147-163. 1892. 50c.

——— Aluminum. In Sixteenth Ann. Rept., pt. 3, pp. 539-546. 1895. $1.20.

Phalen, W. C. Bauxite and aluminum. In Mineral Resources U. S. for 1907, pt. 1, pp. 693-705. 1908. $1.00.

——— Bauxite and aluminum. In Mineral Resources U. S. for 1909, pt. 1, pp. 561-572. 1911.

Schnatterbeck, C. C. Aluminum and bauxite [in 1904]. In Mineral Resources U. S. for 1904, pp. 285-294. 1905. 50c.

Spurr, J. E. Alum deposits near Silver Peak, Esmeralda County, Nev. In Bulletin 225, pp. 501-502. 1904. 35c.

Struthers, J. Aluminum and bauxite [in 1903]. In Mineral Resources U. S. for 1903, pp. 265-280. 1904. 70c.

ASPHALT.

SURVEY PUBLICATIONS ON ASPHALT.

The following list comprises the more important papers relative to asphalt published by the United States Geological Survey or by members of its staff. The Government publications, except those to which a price is affixed, can be obtained free by applying to the Director, U. S. Geological Survey, Washington, D. C. The priced publications may be purchased from the Superintendent of Documents, Government Printing Office, Washington, D. C.

ANDERSON, ROBERT. An occurrence of asphaltite in northeastern Nevada. In Bulletin 380, pp. 283–285. 1909.

BOUTWELL, J. M. Oil and asphalt prospects in Salt Lake basin, Utah. In Bulletin 260, pp. 468–479. 1905. 40c.

DAY, D. T. Asphalt. In Mineral Resources U. S. for 1909, pt. 2, pp. 731–734. 1911.

DAY, W. C. The coal and pitch coal of the Newport mine, Oregon. In Nineteenth Ann. Rept., pt. 3, pp. 370–376. 1899. $2.25.

ELDRIDGE, G. H. The uintaite (gilsonite) deposits of Utah. In Seventeenth Ann. Rept., pt. 1, pp. 909–949. 1896.

——— The asphalt and bituminous rock deposits of the United States. In Twenty-second Ann. Rept., pt. 1, pp. 209–452. 1901.

——— Origin and distribution of asphalt and bituminous-rock deposits in the United States. In Bulletin 213, pp. 296–305. 1903. 25c.

HAYES, C. W. Asphalt deposits of Pike County, Ark. In Bulletin 213, pp. 353–355. 1903. 25c.

TAFF, J. A. Albertite-like asphalt in the Choctaw Nation, Indian Territory. Am. Jour. Sci., 4th ser., vol. 8, pp. 219–224. 1899.

——— Description of the unleased segregated asphalt lands in the Chickasaw Nation, Indian Territory. U. S. Dept. Interior, Circular 6. 14 pp. 1904.

——— Grahamite deposits of southeastern Oklahoma. In Bulletin 380, pp. 286–297. 1909.

TAFF, J. A., and SMITH, C. D. Ozokerite deposits in Utah. In Bulletin 285, pp. 369–372. 1906. 60c.

VAUGHAN, T. W. The asphalt deposits of western Texas. In Eighteenth Ann. Rept., pt. 5, pp. 930–935. 1897.