

NOTES ON THE SAMPLES OF IRON ORE COLLECTED IN OHIO.

BY BAILEY WILLIS.

The workable iron ores of Ohio all belong to the Lower Coal Measures, and are found in nearly horizontal beds, interstratified with coals, limestones, shales, and sandstones. When unaltered they consist of carbonate of iron, with varying amounts of lime, clay, and sand; they are dark grayish blue, gray, and even white in color, and dense, cryptocrystalline, concretionary, or oölitic in structure.

When exposed to oxidation they form limonites, whose peculiarities of structure present many interesting features; the most common form is that of a rounded mass consisting of concentric layers, often aptly compared to the successive coats of an onion. The chemical change is accompanied by a shrinkage of volume, which accounts for the space found between the layers and the cellular structure of the "honeycomb" or "curly" ores. The ores are found in all stages of this transformation; on the outcrop they are limonite; under heavy cover, carbonate; while between, going from the outcrop inward, the former constantly decreases in proportion to the latter. In the alteration of the more compact carbonates the line of chemical change is usually very sharply defined, and the limonite covering can often be entirely removed from the inclosed core by a blow with a hammer. The oölitic carbonates generally change to a honeycomb ore, and the line of division is less distinctly marked. The original gray carbonate occurs in "kidneys", irregular oval masses, distributed through a bed of shale, and in compact, solid beds. The oxidation of a gray kidney necessarily results in a limonite kidney, while the alteration of a compact bed may result in a cellular limonite or a kidney by the rounding off of the corners, which are most rapidly attacked.

The term "kidney" is thus applied to some of the carbonates and to all the limonites having a concentric structure.

These ores are generally too thin to pay for drifting; hence their use is confined to localities where erosion has so exposed them in the hill-sides as to make them accessible by stripping off the overlying strata. The depth to which this stripping is profitable depends upon the thickness and quality of the ore, and the amount of ore of a given thickness obtained for a given depth of stripping depends upon the slope of the hill.

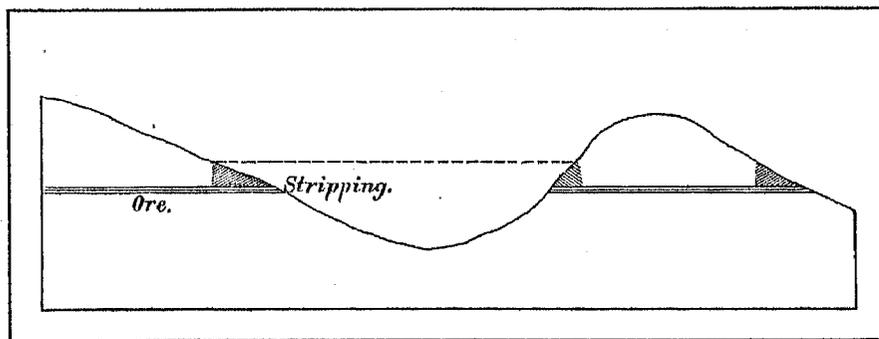
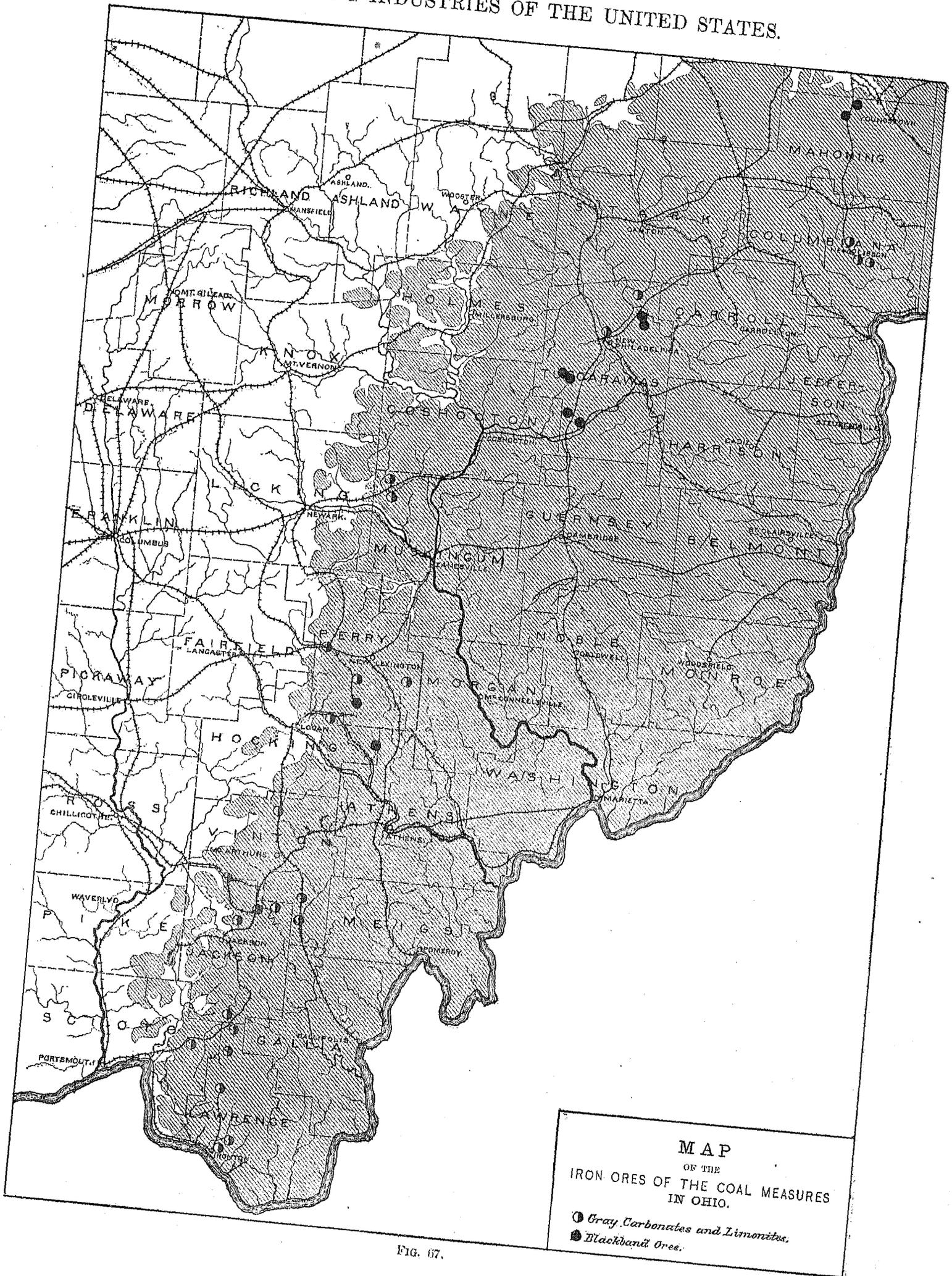


FIG. 66.

The strata are most deeply eroded and the ores are best exposed along the western edge of the Ohio coal-field, and the manufacture of iron from native ores is practically confined to a belt 20 to 30 miles in width, which follows this western limit. In districts where much ore has been taken out, the hills are girdled by a continuous line of such stripping, or, as it is there called, a "bench". As the ore-beds lie so nearly horizontal that the difference of level is perceptible only over long distances, the presence of ore in one hill is proof of the occurrence of a similar bed in any hills of the neighborhood that are high enough to "catch it"; and with the principal deposit of southern Ohio, the "limestone ore", the quality and thickness are so uniform that it can be safely relied upon. This is approximately true of most of the block-ores, though where they occur in the horizon of a limestone they are

MINING INDUSTRIES OF THE UNITED STATES.



MAP
OF THE
IRON ORES OF THE COAL MEASURES
IN OHIO.

● Gray Carbonates and Limonites.
● Blackband Ores.

Fig. 67.

a The columns headed "Limestones", "Coals", and "Ores in section" are carefully copied from Professor Orton's section, except that a question-mark is added after the Maxwell limestone, to indicate a doubt he himself expresses in regard to its position. In the column "Ores not in section" are placed those which belong to the northern part of the state, or are too local to have found a place in Professor Orton's classification. The positions of these ores are necessarily only approximate.

A real doubt as to the proper horizon is indicated by a question-mark.

Although this section is thus very general in its present application, it forcibly illustrates the fact that the iron industry of Ohio, so far as native ores are concerned, depends mainly on two horizons and in a lesser degree upon a third, namely, the Tuscarawas and Iron Point blackband, the limestone or Baird ore, and the block-ores of the **b** Zoar limestone horizon.

In the following pages the analyses of the ores will be accompanied by such notes on their peculiarities as may seem of importance.

The lowest ore in the section is the Mineral Ridge blackband. It lies, according to Professor Newberry (*Ohio Reports*, Vol. III, p. 790), about in the position of the Logan flint on Professor Orton's section, and I have therefore added it beneath that coal. The ore is represented by samples from the mine of Tod, Wells & Co., at Mineral Ridge, and the John Henry mine, a mile south of that place.

It occurs at a depth of about 130 feet beneath the surface; the ore has an average thickness of 9 inches, but varies from 5 to 13 inches; it is overlain by about 2½ feet of coal. The ore is dark colored and homogeneous, with **c** little seams of coal, one-sixteenth to one-fourth inch thick, in the upper layers of the bed. The following are the analyses:

Mineral Ridge blackband.

	TOD, WELLS & CO.		JOHN HENRY.	
	Roasted.	Raw.	Raw.	Roasted.
	1201.	1202.	1203.	1204.
	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>
Metallie iron	50.62	30.00	30.72	52.52
Phosphorus.....	0.224	0.150	0.182	0.398
Phosphorus in 100 parts iron ..	0.443	0.500	0.592	0.758

d Two and one-half miles northeast of Jackson, in Jackson county, the Springfield Southern Railroad Company has opened an ore-deposit, which lies just above the "Hill coal". The ore is a dark bluish gray, very compact carbonate; it occurs in five beds, of which the following is the section:

Number.	Ore.	Shale.	Coal.
	<i>Inches.</i>	<i>Inches.</i>	<i>Inches.</i>
5.....	12	1	.....
4.....	2	4	.....
3.....	6	12	.....
2.....	7	14	.....
1.....	1½	.....	.....
			86

e This gives 28½ inches of ore in 5 feet; of the five, however, only Nos. 1, 2, and 5 are always found; Nos. 3 and 4 occur in lenticular layers, and above No. 2 there are sometimes little kidneys scattered through the shale. Five samples were taken to represent the five different beds:

f *Davis ore, Lawrence county.*

	Bed No. 1.	Bed No. 2.	Bed No. 3.	Bed No. 4.	Bed No. 5.
	1228.	1229.	1230.	1231.	1232.
	<i>Per cent.</i>	Per cent.	Per cent.	Per cent.	Per cent.
Metallie iron.....	35.17	34.07	23.09	32.03	17.97
Phosphorus.....	0.420	0.270	0.240	0.344	0.216
Phosphorus in 100 parts iron ..	1.220	0.792	1.040	1.070	1.200

Another ore, mined near Jackson, at Byers station, is locally known as "Ray's ore"; the sample was taken from a car-load of the ore at the Star furnace, at Jackson, and as the deposit was not visited, its place in the

section is uncertain; it may correspond to the Maville block or it may be quite local. The ore is sandy limonite, a with a large number of fossil-plant impressions. The following is the analysis:

Ray's ore, Byers station.

	1242.
	<i>Per cent.</i>
Metallic iron	30.98
Phosphorus.....	0.877
Phosphorus in 100 parts iron.....	1.220

b

The "block ores" form one of the important ore-horizons, subordinate only to the limestone and blackband ores. Professor Orton's classification is given in the section; it is here compared with that used at Scioto furnace:

Professor Orton.	Scioto Furnace.
Fine Block	Fine Block.
Sand Block	Big Red block.
Rough Block	Little Sand block.
Upper Main Block.....	Big Sand block.
Lower Main Block.....	Little Red block.
	Flag-ore.

c

The six ores of Scioto furnace are represented by samples taken from a large stock-pile of mixed ores; they each represent a few pieces of ore picked out by the superintendent of the furnace and his workmen, it being impossible for any one not accustomed to the ores to distinguish them from each other; separate piles of each could not be found, as the furnace was not running.

Other more satisfactory samples of block ores were obtained at Monroe furnace, 7 miles north of Scioto, at Milton furnace, near Hamden Junction, at Junction City, and at Frazeyburg. The "Dunkel ore", sampled from five loaded cars at Creola, belongs to this class, and the "Rock ore", dug near Dover, Tuscarawas county, is probably of the same horizon as the upper main block. There is apparently considerable variety in the character of these ores.

d

The following are the samples and their analyses:

Scioto Furnace, Scioto county.

	Fine Block.	Big Red.	Little Sand.	Big Sand.	Little Red.	Flag-ore.
	1214.	1215.	1216.	1217.	1218.	1219.
	<i>Per cent.</i>	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.
Metallic iron.....	40.71	40.42	36.10	39.73	39.01	34.43
Phosphorus.....	0.211	0.579	0.252	0.420	0.515	0.180
Phosphorus in 100 parts iron ..	0.424	1.430	0.696	1.060	1.800	0.378

e

Block-ores.

	MONROE FURNACE.		MILTON FURNACE.		CREOLA.	JUNCTION CITY.	
	Little Sand (?).	Little Red (?).	Big Sand.	Big Red.	Dunkel ore.	Red.	Kidney.
	1225.	1220.	1243.	1244.	1252.	1264.	1265.
	<i>Per cent.</i>	<i>Per cent.</i>					
Metallic iron.....	41.85	42.26	31.56	40.12	41.62	38.73	36.64
Phosphorus.....	0.320	0.333	0.250	0.197	0.174	0.144	0.102
Phosphorus in 100 parts iron...	0.765	0.788	0.792	0.427	0.418	0.372	0.278
	SHAWNEE.	FRAZEYSBURG.				JACKSON COUNTY.	DOVER, TUSCARAWAS COUNTY.
	Block-ore.	Goff bank.	McGinnis bank.	Millstead bank.	McDonald bank.	Big Red block, Swarrington farm.	Rock-ore.
	1257.	1266.	1267.	1268.	1269.	1247.	1271.
	<i>Per cent.</i>	<i>Per cent.</i>	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.
Metallic iron.....	44.29	51.86	37.70	32.41	52.17	43.63	39.09
Phosphorus.....	0.230	0.532	0.281	0.181	0.187	0.665	0.188
Phosphorus in 100 parts iron...	0.540	1.026	0.745	0.558	0.263	1.520	0.480

f

a The Milton furnace "limestone-kidney" lies about 30 feet below the great "limestone bed". No sample of this ore could be obtained near Milton furnace. Another ore, mined near Zoar, Tuscarawas county, apparently belongs to the same horizon, and is so placed on the section. Two samples were obtained of it, one from pieces of ore near pits worked two years ago by the Zoar Society, the other from a stock-pile of about 200 tons at the Tuscarawas furnace, Dover. The analyses are:

	ZOAR SOCIETY.	ANMAN FARM, DOVER.
	1270.	1273.
	<i>Per cent.</i>	<i>Per cent.</i>
Metallic iron.....	26.89	34.15
Phosphorus.....	0.100	0.184
Phosphorus in 100 parts iron...	0.595	0.539

The ore is a light-gray carbonate, which forms peculiarly loose shells of limonite in weathering.

The limestone or Baird ore, the most regular and most reliable of the series, is persistent over Lawrence, western Gallia, eastern Jackson, and Vinton, and Hocking counties. It has throughout the same general characteristics, and is exceedingly uniform in quality. Where unaltered it consists of oölitic grains cemented by clay and silica; near the outcrop it is oxidized to a very porous limonite; it sometimes deteriorates locally to a ferruginous limestone, when it is known as "blue limestone ore". In the southern half of the area of its occurrence the ore-bed consists of two parts—a solid layer, resting on the Hanging Rock limestone, called the "Limestone vein", and rounded masses imbedded in the fire-clay immediately above, called "Limestone kidney". In the northern part of the same area there are no kidneys over the "vein", but a soft red variety appears in the latter, which was not observed farther south. The samples taken represent six varieties of the limonite ore.

Unaltered carbonates:

- (1) Gray limestone vein.
- (2) Gray limestone kidney.
- (3) Blue limestone ore.

Limonites:

- (4) Red limestone vein.
- (5) Red limestone kidney.

Hematite:

- (6) Soft red limestone vein.

A variety of compact crystalline carbonate, mined near Munroe furnace under the name of "Hudson ore", is considered by Professor Orton to belong to the horizon of the limestone ores. It is certainly a very local deposit; but it was stated to the writer that it rested on the "limestone coal", in which case it would form part of the Hanging Rock limestone. It is placed with the limestone ores.

e

	GRAY LIMESTONE VEIN.			GRAY LIMESTONE KIDNEY.			SOFT RED LIMESTONE VEIN.		BLUE LIMESTONE ORE.	RED HUDSON ORE.
	1234.	1233.	1256.	1209.	1212.	1223.	1246.	1254.	1253.	1265.
	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>
Metallic iron.....	30.50	32.59	34.68	34.27	33.20	43.23	51.97	52.08	35.57	53.82
Phosphorus.....	0.151	0.211	0.080	0.049	0.144	0.167	0.072	0.112	0.233	0.270
Phosphorus in 100 parts iron.....	0.413	0.647	0.231	0.143	0.433	0.386	0.139	0.215	0.655	0.518

f

	RED LIMESTONE VEIN.						RED LIMESTONE KIDNEY.			GRAY HUDSON ORE.
	1233.	1237.	1240.	1245.	1248.	1255.	1210.	1222.	1239.	1234.
	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>
Metallic iron.....	47.23	54.89	34.62	51.46	44.34	47.50	41.40	49.32	39.49	23.68
Phosphorus.....	0.240	0.199	0.074	0.127	0.211	0.205	0.150	0.145	0.156	0.172
Phosphorus in 100 parts iron.....	0.508	0.303	0.214	0.247	0.476	0.432	0.362	0.294	0.305	0.726

The "shell and kidney ore" of Tuscarawas county, which lies upon coal No. V, the "Snow Fork ore", and the "Norris yellow kidney" are less regular in their occurrence than the block or limestone ores. They are, however, especially the two latter, of considerable local value, on account of their quality. The yellow kidney is used at

Hecla furnace, and the special qualities of the iron, which ranks among the first of the a Hanging Rock cold-blast irons, are in part attributed to the mixture of this ore with the limestone. At Monroe furnace the Top Hill kidney or Snow Fork ore is much prized.

Samples were taken from stock-piles of these ores.

	SHELL AND KIDNEY.	SNOW FORK.	YELLOW KIDNEY.
	1272.	1224.	1211.
	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>
Metallic iron	40.65	31.00	32.97
Phosphorus.....	0.824	0.479	0.317
Phosphorus in 100 parts iron ..	0.027	1.510	0.961

The Buchtel ore occurs in the northern part of Hocking and Athens counties. The thickness of this deposit, "3 to 6 feet," excited great expectations of its value, and the Buchtel furnace, along with several others, was built where this ore is the principal local dependence. These furnaces are now using a large proportion of limestone and Dunkel ore, brought by rail 50 to 70 miles.

The following is the analysis of a sample carefully taken as an average of 200 tons, at the Orbiston furnace:

	BUCHTEL ORE.
	1251.
	<i>Per cent.</i>
Metallic iron.....	28.63
Phosphorus.....	1.450
Phosphorus in 100 parts iron.....	5.065

The level of coal No. VII is an important ore-horizon in Tuscarawas county. Immediately upon the coal lies a bed of blackband, and upon this a layer of more calcareous ore, which sometimes is oölitic in structure, called the mountain ore. The coal varies from

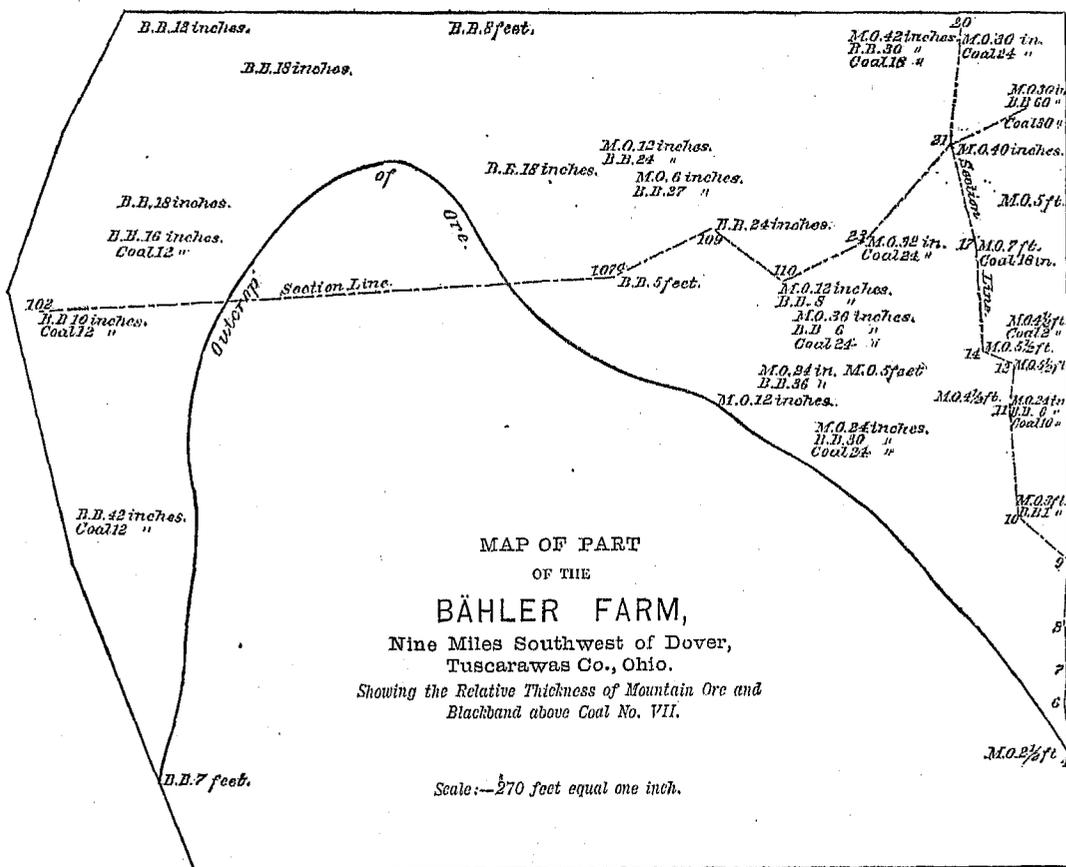


FIG. 69.

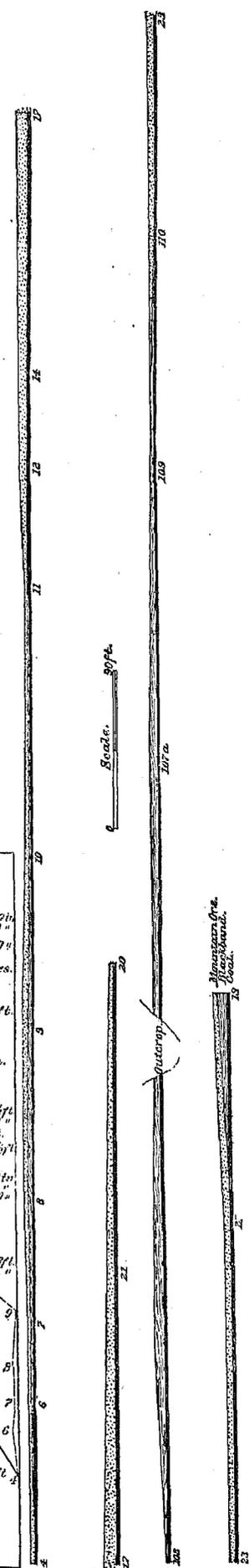


FIG. 70.

a. 6 inches to 2½ feet in thickness; the blackband from nothing to 8 feet, and the mountain ore the same. Variations in the thickness of the ores are very sudden. A reference to the accompanying map (Fig. 69) and sections (Fig. 70) of a typical bed on a property that has been thoroughly explored by boring will show the manner of occurrence of these ores. I am indebted to Mr. Croxton, of the Tuscarawas Iron Company at Dover, for the information there given.

Tuscarawas blackband.

b	GROEBLE FARM.	DÄHLER FARM.					DOVER FURNACE HILL.	
	Mountain ore.	Blackband.	Roasted blackband.	Blackband.	Mountain ore.	Mountain ore.	Blackband.	Roasted blackband.
	1274.	1275.	1276.	1277.	1278.	1279.	1280.	1281.
	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>
Metallic iron	82.36	26.31	44.07	27.92	34.68	43.00	23.95	40.91
Phosphorus.....	0.604	0.195	0.350	0.169	0.705	0.968	0.171	0.422
Phosphorus in 100 parts iron	1.867	0.741	0.704	0.619	2.033	2.293	0.714	1.032

c	HUGH KELLEY BANK.				WOLF STATION.				
	Roasted blackband.	Roasted mountain ore.	Blackband.	Mountain ore.	Dye bank.		Wyan farm.		
					Blackband.	Roasted blackband.	Blackband.	Blackband.	Roasted blackband.
1282.	1283.	1284.	1285.	1286.	1287.	1288.	1289.	1290.	
	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>
Metallic iron	41.12	45.36	27.56	29.52	25.20	42.18	23.90	20.82	44.48
Phosphorus.....	0.314	0.702	0.159	0.323	0.160	0.204	0.101	0.206	0.312
Phosphorus in 100 parts iron	0.764	1.548	0.577	1.143	0.635	0.623	0.674	1.011	6.704

d The next ore-horizon above that of Coal No. VII is one which is widely known in the southern counties as the level of the Iron Point blackband; the ore obtained from it varies very greatly in different localities, and the basin, from which it takes its name, Iron Point, near Shawnee, has been entirely exhausted.

The blackband occurs, however, elsewhere near Shawnee, but in much smaller beds and of inferior quality. An ore mined near Moxahala, a gray carbonate, is believed to belong to this horizon. The Orbiston blackband which lies just above the Buchtel ore undoubtedly does, and Professor Orton places the Peterson ore of Olive furnace, Lawrence county, here also. The latter is a peculiar earthy hematite and limonite, quite soft, with thin layers of coal in it, and rests on 18 inches of clean coal.

Ores of the Iron Point blackband horizon.

e	OLIVE FURNACE.		ORBISTON.	IRON POINT.		BOWMAN FARM.		MOXAHALA.	
	Peterson ore.		Blackband.	Blackband.	Limonite.	Blackband.	Limonite.	Upper beds.	Bottom beds.
	1220.	1221.	1250.	1258.	1259.	1260.	1261.	1262.	1268.
	<i>Per cent.</i>	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.
Metallic iron	45.08	46.17	35.08	34.41	46.34	31.96	42.78	34.99	30.23
Phosphorus.....	0.563	0.652	0.363	0.288	1.132	0.567	0.884	3.106	1.001
Phosphorus in 100 parts iron.....	1.240	1.410	0.949	0.837	2.443	1.774	2.066	8.877	3.311

f It remains to describe a very exceptional deposit of ore along the Middle fork of Little Beaver river, Columbiana county. This stream cuts through the Coal Measures from Coal No. VI down to Coal No. III. Within this range there are three beds of gray carbonate ore, too thin to pay for working in place. But along the river-banks the water-worn ore-pebbles are concentrated with 25 to 30 per cent. of granite and quartz drift-pebbles, in beds 8 to 16 feet thick, which lie upon Coal Measure sandstones and shales in place.

The exposed pebbles of gray carbonate become oxidized on the outside, and a brown polished shell of limonite results; this is frequently very loose and fragile, or again dark-colored, resembling a pebble of black quartzite. Where cracks in this shell admit of freer access of air and water to the core the latter is furrowed and often marked like an alligator's skin. The ore is shoveled into riddles, the large pebbles of granite are picked out, and the material remaining is roasted in piles. In a recent contract the Cherry Valley Iron Company specified that the proportion of foreign pebbles must be kept below 10 per cent.

Coal Measure fossils are occasionally found in these beds, and the pebbles themselves often assume very a curious shapes. These ores are represented by six samples taken from three workings along the stream near New Lisbon; they are those of Captain B. E. Lewis, William Denman, and A. G. Smith.

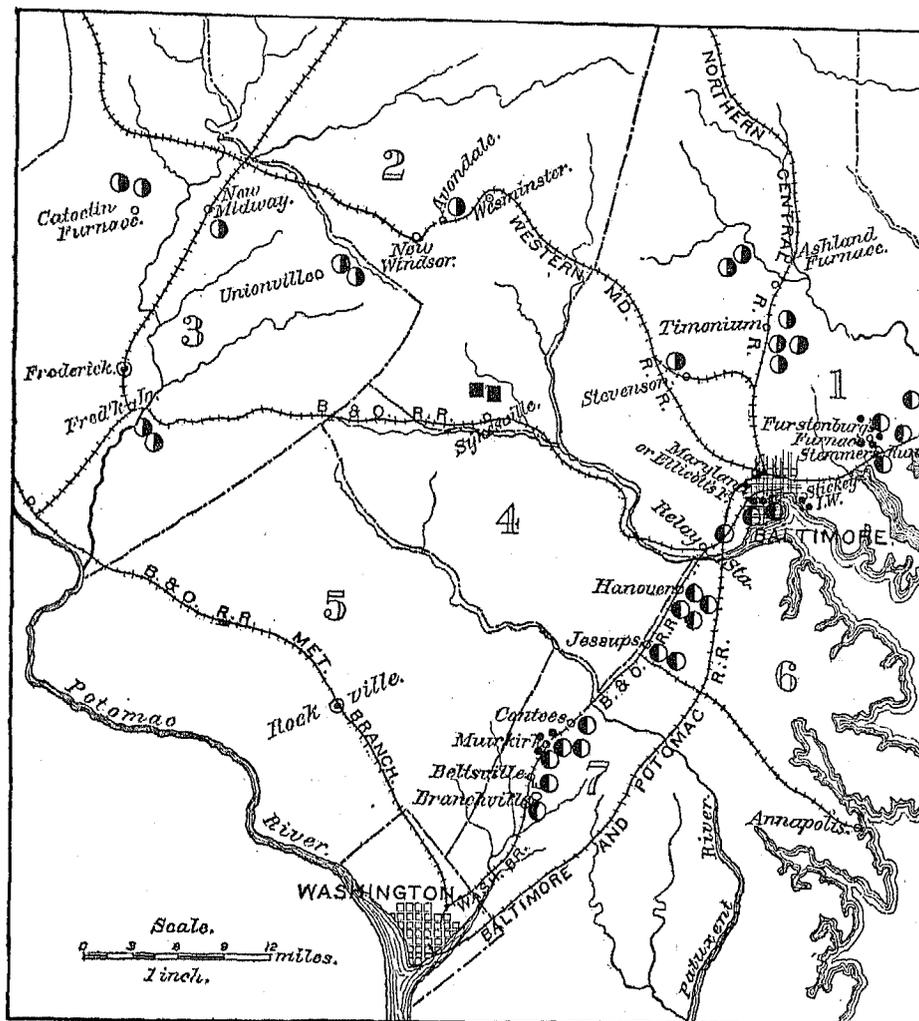
“Kidney” or pebble ores of Middle fork of Little Beaver river.

	CAPTAIN B. E. LEWIS.		WILLIAM DENMAN.		A. G. SMITH.	
	Raw.	Roasted.	Raw.	Roasted.	Raw.	Roasted.
	1295.	1296.	1297.	1298.	1299.	1300.
	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>
Metallic iron	38.21	46.07	30.77	48.34	38.04	38.55
Phosphorus.....	0.516	0.428	0.468	0.468	0.417	0.379
Phosphorus in 100 parts iron...	1.351	0.929	1.177	0.968	1.096	0.960

NOTES ON THE SAMPLES OF IRON ORE COLLECTED IN MARYLAND.

BY EDWARD R. BENTON.

BALTIMORE BELT—MESOZOIC ORES.



- | | |
|-----------------------|--|
| 1. Baltimore County. | ■ Magnetic ore. |
| 2. Carroll " | ● Carbonate ore and its alteration products, i.e. hematite and limonite. (Mesozoic.) |
| 3. Frederick " | ● Other limonites. |
| 4. Howard " | ● Furnace samples. |
| 5. Montgomery County. | |
| 6. Anne Arundel " | |
| 7. Prince George " | |

FIG. 71.—MAP OF EASTERN MARYLAND, SHOWING LOCATION OF IRON-ORE BANKS SAMPLED.

1029. *Jacob Smith's* ore-bank, Baltimore county. Carbonate ore, with hematite and limonite. Working mine situated 11 miles about northeast from Baltimore, and about 1 mile northwest of Jacob Smith's house, on the Philadelphia turnpike.

Considerable ore has been dug at this locality in past years. At least 300 tons were produced in the census year, but the excavations made previous to 1880 are so washed and weathered that little can be learned from them.

a The recent work consists of a drift or tunnel about 40 feet long, inclining downward a few degrees going from the entrance. The mine is entirely in a stiff dark-gray or brownish clay, dipping a few degrees toward the west. The extremity of the drift is about 25 feet below the surface. Above it lie 15 to 20 feet of clay, and above that 5 to 10 feet of sand and sandy loam (see section, Fig. 72).

The ore occurs in the shape of roughly ellipsoidal clay-ironstone nodules, from a few inches to 1 foot or more in longest dimensions, dark red to brown (hematite or limonite) on the exterior. This outer portion is a shell, and consists of several concentric shells, and may be readily broken off, leaving a hard, light-gray lump of argillaceous carbonate of iron or clay-ironstone. These nodules are arranged along certain planes in the clay-bed, and the beds of nodules thus formed have the same dip as the clay-bed.

b

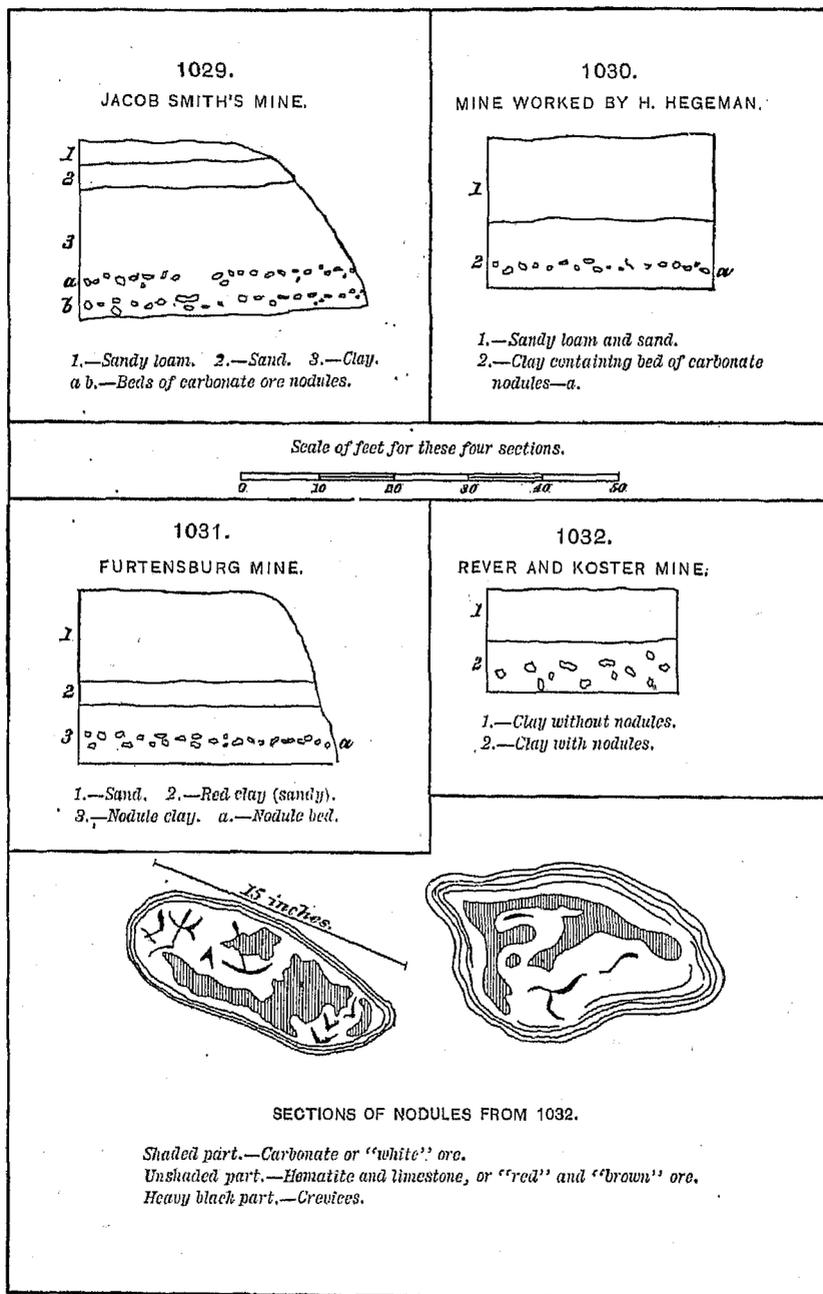


FIG. 72.

Two of these beds of nodules are exposed in section in this mine. In some places the nodules are contiguous, in others there are spaces between them.

° Mining here consists merely of digging ahead and taking out whatever nodules are found.

This ore is carted about 4 miles to Furstenburg's furnace, at Stemmer's run, or Rossville; it is then roasted in open piles or in kilns, and used in making car-wheel iron. The mine is owned and worked by Jacob Smith, Rosedale post-office, Baltimore county.

c

d

e

f

Analysis.

a

	1029.	Remarks.
Metallic iron	42.70	Sample taken from two parallel strings of nodules of ore at head of drift. Average thickness of the two strings together, about 1 foot.
Phosphorus.....	0.092	
Phosphorus in 100 parts iron ..	0.215	

1030. *Hegeman or Smith*, Baltimore county. Carbonate (hematite and limonite). Working mine, open cut, situated on land of Mrs. Henry Smith, about 2 miles east of Furstenburg's furnace, Stemmer's run, just north of Philadelphia, Wilmington, and Baltimore railroad. **b**

Several acres have been dug over in past years to a depth of 20 to 25 feet, and the nodules of carbonate ore with shells of hematite and limonite have been taken out from the stiff gray clay (see section, Fig. 72). Workings are all open. Mining consists merely of digging away the clay and overlying sand and sandy loam, and picking out the nodules. At least 450 tons were produced in the census year. These ore-nodules are entirely similar in appearance and structure to those of 1029. The nodules have a rather smaller average size. This ore is carted 2½ miles, to Furstenburg's furnace (Stemmer's run), and after roasting is used for making car-wheel iron.

Analysis.

c

	1030.	Remarks.
Metallic iron	46.23	Sample taken from pile of several hundred tons of carbonate nodules at the mine.
Phosphorus.....	0.127	
Phosphorus in 100 parts iron ..	0.275	

1031. *Furstenburg*, Baltimore county. Carbonate. Working mine, open cut. Just south of Stemmer's Run station on the Philadelphia, Wilmington, and Baltimore railroad, on land belonging to Levi Furstenburg.

This ore occurs in a horizontal bed of clay, and in the shape of nodules, thus resembling 1029 and 1030, but, unlike them, the nodules have no shells of hematite and limonite, but are composed entirely of the argillaceous carbonate. As a rule the nodules lie with their longer axes horizontal, though not invariably so. A thickness of about 8 feet of the clay-bed is exposed, and over it lies a 3-foot bed of red sandy clay, which again is overlaid by 12 feet of sand, with a slight amount of sandy clay at the top (see section, Fig. 72). The ore is carted about one-third mile to Furstenburg's furnace, and used, after roasting, for making car-wheel iron. **d**

Analysis.

e

	1031.	Remarks.
Metallic iron	35.75	Sample taken from a pile of several tons of nodules of carbonate ore at the mine.
Phosphorus.....	0.068	
Phosphorus in 100 parts iron ..	0.274	

1032. *Rever & Coster*, Baltimore county. Carbonate (hematite and limonite). Working open cut. Land of L. Furstenburg, about 1 mile northeast of Furstenburg's furnace. Worked by Rever & Coster.

The nodules in this excavation, though similar in mineral characters to 1029 and 1030, are much larger, some being 2 to 3 feet in longest dimension. They are not confined to so narrow a bed as the others, but are scattered through a bed of clay 5 to 6 feet thick, above which is 7 to 8 feet of clay entirely without nodules, but otherwise similar to that below (see section, Fig. 72). Sections of some of the larger nodules are exposed in the face of the excavation, and two of these are figured. The ore is carted 1 mile, to Furstenburg's furnace, and roasted to supply the furnace. It makes car-wheel iron.

Analysis.

f

	1032.	Remarks.
Metallic iron	40.58	Sample taken from pile of nodules at the mine.
Phosphorus.....	0.094	
Phosphorus in 100 parts iron ..	0.232	

1033. Furnace sample, *Furstenburg's furnace*, Stemmer's run, Baltimore county. Carbonate or white.

This sample represents the carbonate portion of the ore received at Furstenburg's furnace from Furstenburg, Jacob Smith's, Hegeman's, Rever & Coster's, and other banks.

a

Analysis.

	1033.	Remarks.
Metallic iron	36.56	Sample taken from a pile of about 500 tons of raw ore at Furstenburg's furnace.
Phosphorus.....	0.068	
Phosphorus in 100 parts iron ..	0.186	

1034. Furnace sample, *Furstenburg's furnace*, Stemmer's run, Baltimore county. Hematite and limonite.

For this sample the hematite and limonite or decarbonized portions were selected from the same pile from which sample 1033 was taken.

b

Analysis.

	1034.
Metallic iron	46.17
Phosphorus.....	0.113
Phosphorus in 100 parts iron	0.245

1035. Furnace sample, *Furstenburg's furnace*, Stemmer's run, Baltimore county. Carbonate (hematite and limonite).

This is the best average commercial sample of the carbonate ore, and its alteration products from the "Baltimore c belt", northeast of that city.

c

Analysis.

	1035.	Remarks.
Metallic iron	42.01	Sample taken from pile of 500 tons of raw ore at furnace (same pile as 1033 and 1034). All varieties of ore in the pile were sampled together.
Phosphorus.....	0.080	
Phosphorus in 100 parts iron ..	0.212	

1036. Furnace sample, *Furstenburg's furnace*, Stemmer's run, Baltimore county. Roasted ore.

Product obtained by roasting 1035. This gives an average sample of the ore of the "Baltimore belt" northeast d of the city ready for the furnace.

d

Analysis.

	1036.
Metallic iron	47.73
Phosphorus.....	0.079
Phosphorus in 100 parts iron	0.160

1037. *George L. Skaggs*, Prince George county. Carbonate (hematite and limonite). On land of George L. Skaggs, e 200 yards southeast of Branchville station, Baltimore and Ohio railroad.

The ore here is entirely nodular, and as in case of previous samples, the nodules lie along certain layers in stiff clay. The section (1037, on Fig. 73) illustrates the structure more in detail. There is every grade, from nodules composed wholly of carbonate ore to those wholly decarbonized, and composed of hematite and limonite. This gradation takes place from the bottom toward the top of the section.

An excavation about 120 feet long, 75 feet wide, and 10 to 11 feet deep has been made. It takes five men and two one-horse carts about a week to dig 50 tons and get it loaded on cars at the railroad, 200 yards distant. The ore goes to Baltimore furnaces.

The position of the layers which the hand-specimens 1037a and 1037b represent is indicated by the letters a and b on the section.

f

Analysis.

	1037.	Remarks.
Metallic iron	40.85	Sample taken from car-load of 20 tons at Branchville station, Baltimore and Ohio railroad.
Phosphorus.....	0.060	
Phosphorus in 100 parts iron...	0.147	

1038. *George Yokel's*. Carbonate and hematite. George Yokel's land, about 1½ miles east of Beltsville station, Prince George county, on the Baltimore and Ohio railroad.

Very large excavations have been made here, but weathering has obscured them so much that the structure cannot be seen except that the rock to a depth of 50 feet is composed of clay in beds of various colors.

The mine is worked at present on a very small scale at one end of the old workings. Here the depth reached **a** is not over 15 feet, and the mode of occurrence of the nodules is similar to that of 1037, except that scarcely any

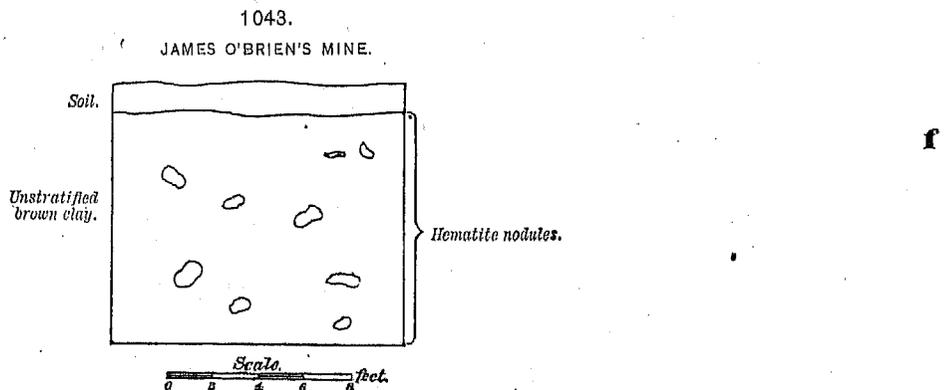
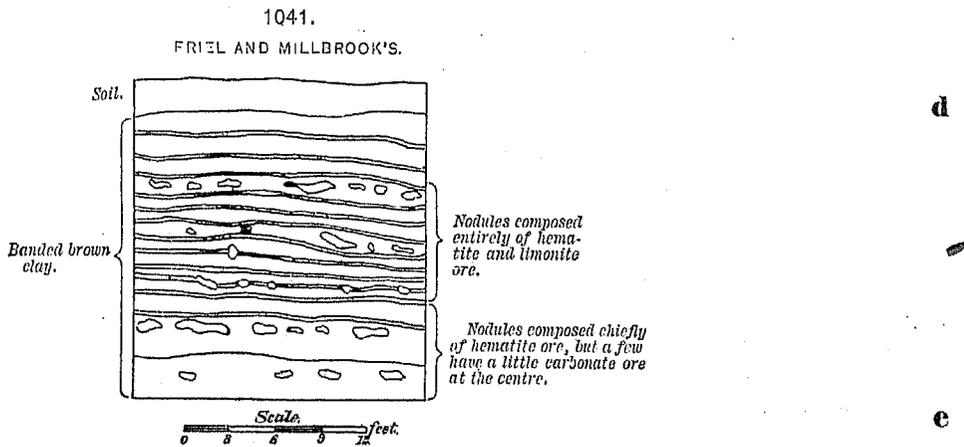
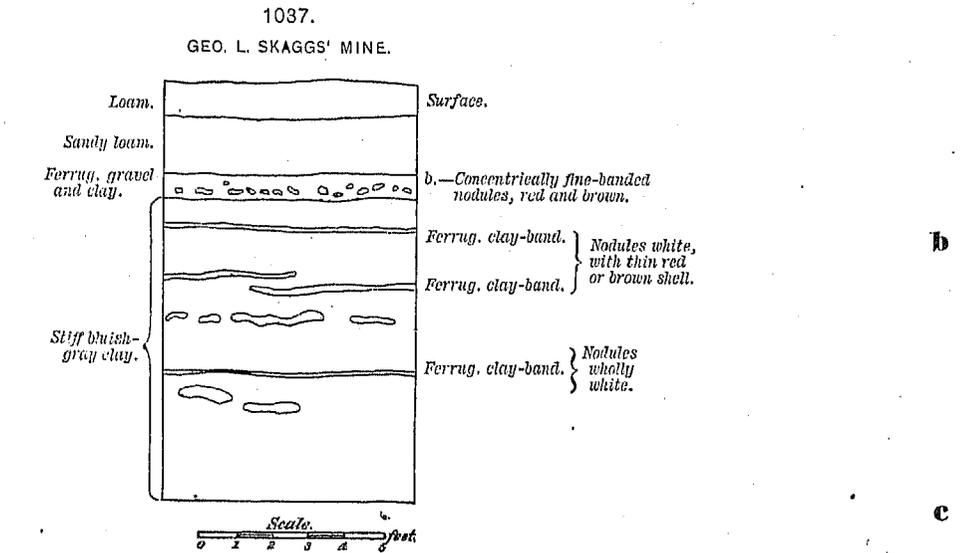


FIG. 73.

wholly carbonate nodules are to be found. The nodules are much fissured, and their decomposition has gone to a much greater depth than in 1037. The alteration has gone on with reference to fissures and crevices in the nodules rather than concentrically.

a The ore is carted $1\frac{3}{4}$ miles to Beltsville station, and shipped to Baltimore. At least 700 tons were shipped from this mine in the census year.

Analysis.

	1038.	Remarks.
Metallic iron.....	46.51	Sample taken from pile of about 10 tons of nodules at the mine.
Phosphorus.....	0.115	
Phosphorus in 100 parts iron...	0.247	

b

1039. Furnace sample, *Muirkirk furnace*, Prince George county. Carbonate (hematite and limonite). Three mines near Muirkirk furnace.

This sample represents the average quality, before roasting, of the ore used to supply Muirkirk furnace, Muirkirk station, Baltimore and Ohio railroad. The ore is a mixture of carbonate with its alteration products, hematite and limonite. It is from three banks situated $1\frac{1}{4}$ to $1\frac{1}{2}$ miles southeast of Muirkirk station, *i. e.*, Friel & Millhook's, Smith's, and Wood's.

Analysis.

	1039.	Remarks.
Metallic iron.....	42.91	Sample taken from pile of about 1,000 tons at Muirkirk furnace.
Phosphorus.....	0.073	
Phosphorus in 100 parts iron...	0.170	

c

1040. Furnace sample, *Muirkirk furnace*. Roasted ore.

This sample gives the average character of the product obtained by roasting 1039, and thus represents the ore as it goes into the furnace where it is made into car-wheel iron.

d

Analysis.

	1040.
Metallic iron.....	46.25
Phosphorus.....	0.108
Phosphorus in 100 parts iron.....	0.234

1041. *Friel & Millbrook*. Hematite (with some limonite). Situated $1\frac{1}{4}$ miles southeast of Muirkirk furnace, Prince George county, on land leased by C. E. Coffin, proprietor, Muirkirk furnace. Worked by Pat Friel and Carl Millhook.

e

At least 800 tons of ore were produced in the census year.

A circular excavation covering about 1 acre has been made. The depth reached is 20 feet, and all the rock exposed is stiff, dark-brown or gray clay, with the exception of 1 to 2 feet of soil.

The section on Fig. 73 show the general distribution of the nodules. The clay in this bank shows more perfect marks of stratification than is usual. These marks consist of five bands of reddish-brown clay. The ore, except near the bottom of the pit, is all hematite with a little limonite. Near the bottom a few of the nodules have cores of carbonate ore. The amount of strictly white ore in the sample is inconsiderable. This ore is carted $1\frac{1}{4}$ miles to Muirkirk furnace, and goes in with other red ores and with some white ores which, after roasting, are used in the furnace for making car-wheels, boiler-plates, and ordnance iron.

f

Analysis.

	1041.	Remarks.
Metallic iron.....	43.25	Sample taken from pile of 5 tons at Muirkirk furnace; 2 tons on carts and 3 tons at the ore-banks.
Phosphorus.....	0.101	
Phosphorus in 100 parts iron...	0.233	

1042. Furnace sample, *Muirkirk furnace*. White or carbonate.

This sample gives the average quality of the white or argillaceous carbonate portion of the raw ore supplied to the furnace by Friel & Millbrook's, Donaldson's, and Wood's banks, all near the furnace.

Analysis.

a

	1042.	Remarks.
Metallic iron.....	41.07	Sample taken by selecting the white or strictly carbonate portions of the nodules contained in a pile of about 1,000 tons at Muirkirk furnace.
Phosphorus.....	0.060	
Phosphorus in 100 parts iron...	0.146	

1043. *James O'Brien.* Hematite, with a little carbonate. Mine situated one-quarter of a mile south of Contee's station, Baltimore and Ohio railroad, on James O'Brien's land, Prince George county.

There are several acres of old workings here, but the work is now carried on upon quite a small scale. In one spot there is a fresh face 12 feet in height exposed, the structure of which is shown in the section, Fig. 73.

The nodules are not arranged, as a rule, along definite lines, and the clay is unstratified. The nodules are composed almost entirely of hematite, though some carbonate ore occurs near the bottom. This mine produced at least 800 tons in the census year. The ore is shipped at Contee's station, on the Baltimore and Ohio railroad, to Baltimore.

Analysis.

	1043.	Remarks.
Metallic iron.....	45.57	Sample taken from 30 tons of nodules at the mine and 40 tons at Contee's station.
Phosphorus.....	0.060	
Phosphorus in 100 parts iron...	0.197	

1044. *A. S. Linthicum.* Hematite, with small amount of carbonate. Two open cuts, 1 mile south of Jessup's station, Baltimore and Ohio railroad, on land of Dr. A. S. Linthicum.

Two excavations at this bank, the one circular, with a diameter of 150 feet and a depth of 25 feet; the other is 285 feet long, 80 to 100 feet wide, and 20 to 30 feet deep. The structure in both is similar to that of 1043. Here most of the nodules are composed of hematite, but a few at the bottom are, in part, carbonate ore. This latter was sampled separately (see No. 1045). This mine produced at least 2,200 tons in the census year. The ore is shipped at Jessup's station to Baltimore.

Analysis.

d

	1044.	Remarks.
Metallic iron.....	46.79	Sample taken from about 50 tons of nodules at the mine.
Phosphorus.....	0.150	
Phosphorus in 100 parts iron....	0.321	

1045. *A. S. Linthicum.* Carbonate. Same mine as 1044.

The carbonate ore contained in the lowest 6 feet of the mine was sampled separately, though it is not kept separate for shipment.

Analysis.

e

	1045.	Remarks.
Metallic iron.....	37.60	Sampled from about 20 tons of nodules at the mine. From lowest 6 feet.
Phosphorus.....	0.068	
Phosphorus in 100 parts iron...	0.170	

1046. *Mitchell, Wilson & Riley.* Carbonate. Open cut, one-quarter of a mile southeast of Hanover station, Baltimore and Ohio railroad, on Howard Brown's land, Anne Arundel county.

A cut 600 feet long, 100 feet wide, and 20 to 50 feet deep has been made, running east and west. A thickness of 5 to 8 feet at the top is soil, sand, and gravel; below this is 5 to 15 feet of light-brown, somewhat silicious clay, containing nodules of carbonate ore, of the same color as the clay, and also somewhat silicious; below that is a dark-gray plastic clay, containing nodules of white or very light-gray carbonate ore, of very fine texture, without the silicious appearance of the nodules in the upper part. These lowest nodules are the ones represented by this sample (*i. e.*, 1046), represented on Fig. 74.

Analysis.

	1046.	Remarks.
Metallic iron.....	37.87	Sample taken from 25 tons of nodules at the mine. These came from the dark-gray plastic clay forming the lower part of the exposure.
Phosphorus.....	0.068	
Phosphorus in 100 parts iron...	0.166	

a 1047. *Mitchell, Wilson & Riley. Carbonate. Same as mine 1046.*

This sample represents the somewhat silicious nodules which come from the light-brown silicious clay in the upper part of the exposure.

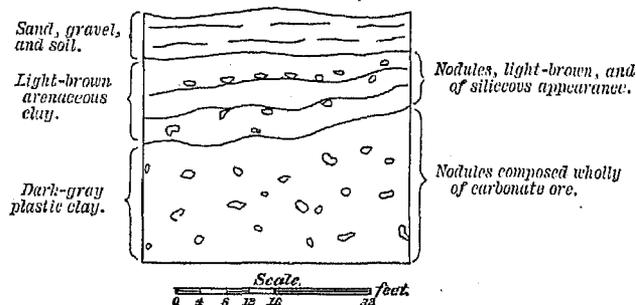
Analysis.

	1047.	Remarks.
Metallic iron	36.17	Sampled from 25 tons of nodules at the mine.
Phosphorus	0.049	
Phosphorus in 100 parts iron...	0.135	

b

1046.

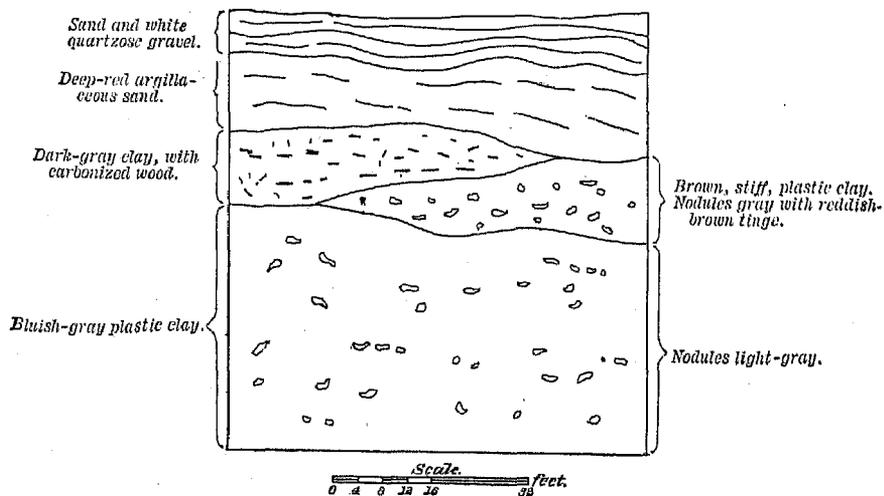
MINE OPERATED BY MITCHELL, WILSON AND RILEY.



c

1048.

MINE OPERATED BY REYNOLDS, KYNE AND ARNOLD.

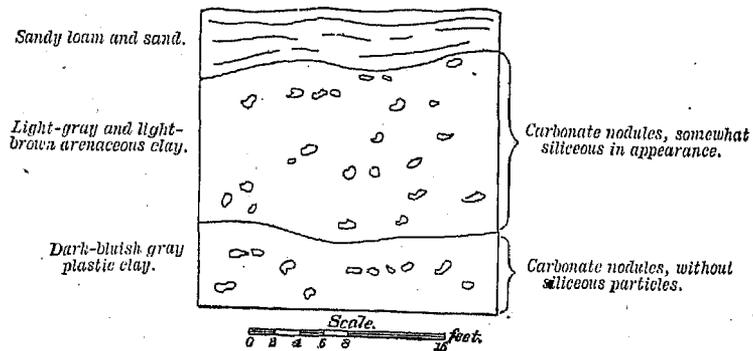


d

e

1050.

JACOB ODENSOSS' MINE.



f

FIG. 74.

1048. *Reynolds, Kyne & Arnold*. Carbonate. Open cut, one-half mile southeast from Hanover station, Baltimore and Ohio railroad, on Howard Brown's land, Anne Arundel county.

An excavation 500 feet long, 200 feet wide, and 50 to 75 feet deep has been made in the west side of the hill, longest from north to south.

The proportional thicknesses of the different beds vary greatly in different parts of the mine, some beds being *wanting* in some parts, others in others—(1) at the top is a thickness of 5 to 10 feet of yellowish sand and yellow and white quartz-gravel, below which are found beds of (2) red, somewhat sandy clay, in thickness 5 to 10 feet; (3) below the red bed is (in some parts of the excavation) dark-red clay, with sticks and lumps of charcoal imbedded in it; thickness, 0 to 12 feet; (4) next below this comes brown, stiff, plastic clay, with impure carbonate nodules having a reddish-brown tinge; these are represented in sample 1049; (5) below the brown clay, and forming the deepest material yet reached, is bluish-gray plastic clay, with nodules of carbonate ore of a light-gray color, very fine-grained, and often with a highly conchoidal fracture; these are represented by sample 1048. This bed forms the lowest 15 to 30 feet of thickness (see section, Fig. 74).

Analysis.

	1048.	Remarks.
Metallic iron	98.48	Sample taken from about 60 tons of nodules at the mine.
Phosphorus	0.025	
Phosphorus in 100 parts iron...	0.065	

c

1049. *Reynolds, Kyne & Arnold*. Carbonate. Same mine as 1048.

This sample represents the slightly reddish-brown carbonate nodules from the brown plastic clay of the upper nodules bearing bed.

Analysis.

	1049.	Remarks.
Metallic iron	36.10	Sample taken from a pile of about 40 tons of nodules at the mine.
Phosphorus	0.040	
Phosphorus in 100 parts iron...	0.111	

d

1050. *Jacob Odensoss*. Carbonate. Open cut, 4 miles southwest of Baltimore, on land of Jacob Odensoss, one-half mile northwest of Washington road, Baltimore county.

A circular excavation has been made 125 feet in diameter and 25 feet deep (see section, Fig. 74).

Analysis.

	1050.	Remarks.
Metallic iron	37.53	Sample taken from about 20 tons of nodules at the mine.
Phosphorus	0.041	
Phosphorus in 100 parts iron...	0.100	

e

1051. *Norris or Whitaker*. Hematite, with some carbonate. Mine situated 2½ miles south of Baltimore, on the Annapolis road, Baltimore county.

The old workings cover several acres. The banks have suffered so much weathering that it can only be seen that the chief material is a brown clay. There are two recent excavations of small size, and in these the brown clay contains nodules of hematite to a depth of 8 to 12 feet. Below that they contain, at the center, carbonate ore of a coarse texture and having a reddish tinge. The mine belongs to George P. Whitaker, and the ore goes to his Principio furnace, at Principio, Cecil county, Maryland.

Analysis.

	1051.	Remarks.
Metallic iron	40.73	Sample taken from 30 tons of nodules at the mine.
Phosphorus	0.149	
Phosphorus in 100 parts iron...	0.366	

a 1052. Furnace sample, *Stickney Iron Company's Furnace*, Baltimore. Carbonate. Ore from Spring Garden, Hanover, Jessups, Contees, and many small producers in Prince George and Anne Arundel counties.

This ore came chiefly from the above localities—from the mines which samples 1024, 1043, 1044, 1045, 1046, 1047, 1048, and 1049 represent. The object of taking this sample was to obtain the average quality of strictly "carbonate" ore of the Baltimore belt southwest of the city.

Analysis.

b

	1052.	Remarks.
Metallic iron.....	37.94	Sample taken from piles containing 3,000 tons of ore at Stickney Iron Company's furnace.
Phosphorus.....	0.055	
Phosphorus in 100 parts iron ..	0.145	

1053. Furnace sample, *Stickney Iron Company's Furnace*. Hematite, with small amount of limonite. Same pile ore as 1052.

Average sample of the non-carbonate portions of the nodular ore from the "Baltimore belt" southwest of the city.

c

Analysis.

	1053.	Remarks.
Metallic iron.....	44.41	Sample taken by selecting the hematite and limonite portions of the nodules in piles containing 3,000 tons.
Phosphorus.....	0.177	
Phosphorus in 100 parts iron ...	0.390	

1054. Furnace sample, *Maryland or Ellicott's Furnace*, Baltimore. Carbonate (hematite and limonite). Ore from Beltsville, Contees, Jessups, Hanover, and many small producers in Baltimore county.

d This sample gives the average quality of the carbonate ore with its alteration products for the whole of the Baltimore belt southwest of the city. The furnace obtained ore from over 200 small producers in Baltimore county, as well as from many small producers in Prince George and Anne Arundel counties.

Analysis.

	1054.	Remarks.
Metallic iron.....	40.87	Sample taken from pile of several thousand tons of nodular ore at Ellicott's furnace, Baltimore.
Phosphorus.....	0.073	
Phosphorus in 100 parts iron ...	0.170	

e 1055. Furnace sample, *Maryland or Ellicott's Furnace*, Baltimore. Roasted ore. From same localities as 1054.

Analysis.

	1055.	Remarks.
Metallic iron.....	45.84	This sample represents the product obtained by roasting in kilns the ore represented by sample 1054.
Phosphorus.....	0.123	
Phosphorus in 100 parts iron ...	0.268	

f

ORES FROM OTHER HORIZONS THAN THE MESOZOIC.

1056. *Ridgeley*. Limonite (lump). Open cut, situated on John Ridgeley's land, 8 miles north of Baltimore and one-half mile east of York road, Baltimore county.

Only a small excavation has been made at this mine, 50 feet long, 20 feet wide, by 20 feet deep. This and other small excavations on Ridgeley's land, which are now abandoned and washed in, produced 500 tons of ore in the census year. The ore in this mine is limonite, in lumps and fragments usually more or less angular, and disseminated irregularly through the clay. There is no solid bed or body of ore. The upper 3 feet of thickness here consists of red, yellow, and white clayey and gravelly strata. Below the material is a brown unstratified sandy clay, containing the ore in irregularly-distributed fragments and flat masses, some of which are 2 feet in largest dimensions. This ore is carted $2\frac{1}{2}$ miles, to Timonium station, on the Northern Central railroad, and shipped to Ashland furnace, 4 miles to the north, where it is used with other ores for making foundry iron.

Analysis.

a

	1056.	Remarks.
Metallic iron	54.42	Sample taken from pile of lump-ore containing 10 tons at the mine.
Phosphorus	0.200	
Phosphorus in 100 parts iron...	0.308	

1057. *Woods.* Limonite (washed). Open cut, situated 9 miles north of Baltimore, and three-fourths of a mile east of York road, Baltimore county.

Here, close to the steam-washer, two excavations have been made, one being 100 feet long, 50 feet wide, and 35 feet deep, the other 60 feet square and 40 feet deep. The ore is limonite, in lumps and bunches of irregular shape and distribution. The upper 10 to 5 feet of the material in these excavations consists of stratified mixtures of sand, clay, and gravel, while below is a heavy brown clay, mingled in places with argillaceous sand. Here and there irregularly horizontal sheets of ore, an inch or two thick and a few feet in extent, are found, in other places similar sheets occur variously inclined, but in general there is no regularity to be observed.

Mining could not be carried on with any chance of profit, were it not that all the ore-bearing parts of the material are put through the washer. It is sometimes the case that not more than one-tenth of the material washed is ore.

About 500 tons of ore were sent from this mine to Ashland furnace during the census year. The ore is carted 2 miles, to Timonium station, and thence shipped on the Northern Central railroad to the furnace.

Analysis.

	1057.	Remarks.
Metallic iron.....	40.80	Sample taken from pile containing 50 tons of washed ore at washer close to mine.
Phosphorus.....	0.102	
Phosphorus in 100 parts iron...	0.253	

1058. *Talbot.* Limonite (lump). Open cut, situated 9 miles north of Baltimore and three-fourths of a mile north of York road, Baltimore county, just southwest of the Woods mine washer.

An excavation has been made here 75 feet long, 25 feet wide, and 30 feet deep. The ore is limonite. Larger bunches of ore were seen here than in the Woods or the Ridgeley mines. It is said that there is a continuous layer of ore at the bottom 3 feet thick, but the mine was not in operation when visited, and this was not to be seen. All the washed ore had been carted away, so it was necessary to take the sample from a pile of lump-ore. The structure is essentially the same as that of the Woods mine. Ore goes to Ashland furnace.

Analysis.

e

	1058.	Remarks.
Metallic iron.....	52.72	Sample from pile of 40 tons of lump-ore at the mine.
Phosphorus.....	0.067	
Phosphorus in 100 parts iron ...	0.127	

1059. *Kelly.* Limonite (washed). Open cut, 10 miles north of Baltimore and one-half mile east of York road, Baltimore county.

Here an excavation 275 feet long, 190 feet wide, and 60 feet deep has been made, running northeast and southwest. Four thousand two hundred tons of ore were sent from this mine to Ashland furnace during the census year. The ore is limonite in small fragments of irregular distribution. Here and there a regular structure exists, and an instance of it is shown by the section (Fig. 75). Very little lump-ore is obtained. The material is nearly all washed at the mine by a steam-washer. The ore is carted 2 miles to Timonium station, and goes thence 4 miles on Northern Central railroad to Ashland furnace.

Analysis.

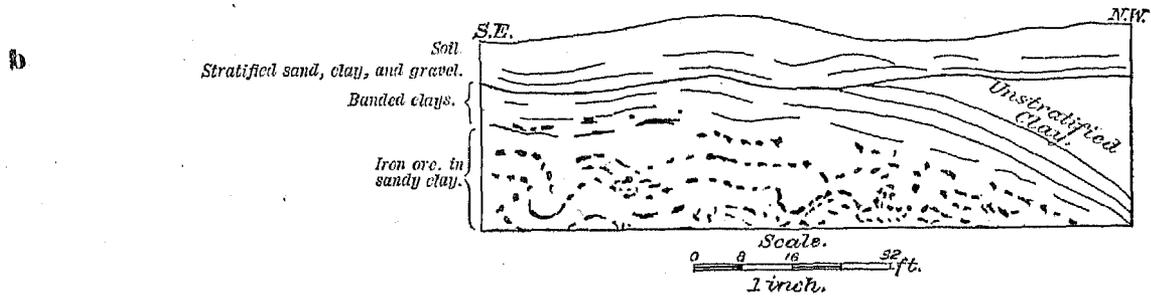
	1059.	Remarks.
Metallic iron.....	38.96	Sample taken from pile containing about 100 tons of washed ore at the washer, close to the mine.
Phosphorus.....	0.174	
Phosphorus in 100 parts iron ..	0.447	

a 1060. Oregon. Limonite (washed). Open cut, 3 miles west of Ashland furnace, Baltimore county.

Here an excavation running east and west, 1,200 feet long, 200 feet wide, and 80 feet deep, has been made. Five thousand tons of ore were shipped to Ashland furnace during the census year. The ore is limonite in fragments, *i. e.*, no solid continuous body of ore is to be observed. All or nearly all the ore-bearing material must be washed, and this is done by a steam-washer at the mine. Most of the ore occurs in sandy clay, as in the several

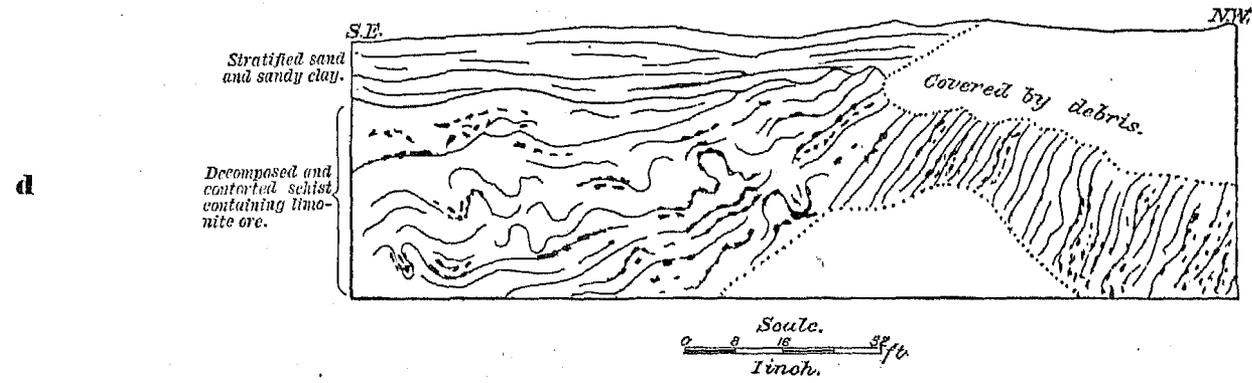
1059.

KELLY'S MINE.—SECTION ACROSS SOUTHWEST END.



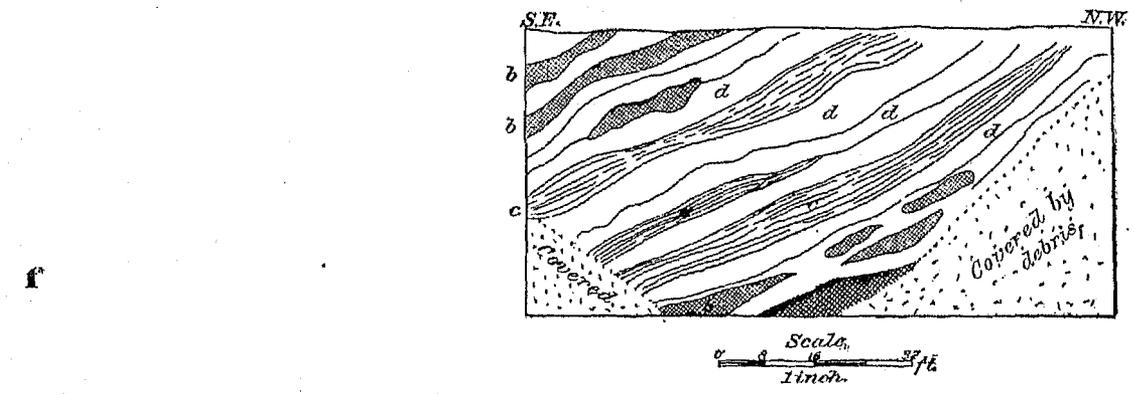
1060.

OREGON MINE.—SECTION ACROSS WEST END.
The heavier lines and dots indicate the ore (limonite).



1066.

ENSOR MINE.



a.—Limonite. b.—Limonite-bearing beds.
c.—Beds of soft, light-red schist (ferruginous).
d.—Barren clay beds (decomposed schist).

FIG. 75.

mines preceding, but at the western end is an exposure of very soft decomposed schist, containing much mica and a little quartz. This schist is of various colors—white, brown, yellow, and red—and contains in the darker layers above, limonite, occurring in seams which follow the direction of the folia of the schist. Below and to the left of the part represented by the section (Fig. 75) the schist is chiefly brown, and is very much contorted. The ore of the schist is most abundant in this latter part. The strike of the schist is north 30° east.

Analysis.

	1060.	Remarks.
Metallic iron	41.62	Sample taken from a pile of about 40 tons of washed ore at the mine.
Phosphorus	0.243	
Phosphorus in 100 parts iron ..	0.584	

1061. *Oregon.* Limonite (lump). Same mine as 1060.

The lump-ore was sampled separately from a pile of about 60 tons at the mine.

Analysis.

	1061.
Metallic iron	51.90
Phosphorus	0.262
Phosphorus in 100 parts iron	0.505

1062. *Green Spring.* Limonite (washed). Open cut situated one-half mile northwest of Stevenson's station, on the Green Spring branch of the Northern Central railroad, Baltimore county.

Here an excavation running nearly north and south, 700 feet long, 175 feet wide, and 90 feet deep, has been made. Three thousand six hundred tons of ore were sent from this mine to the Ashland furnace during the census year. The ore is limonite, occurring irregularly in clays, in a similar manner to the ore of 1059. It is all washed by a steam-washer at the mine.

Analysis.

	1062.	Remarks.
Metallic iron	45.91	Sample taken from about 150 tons of washed ore at Stevenson's station.
Phosphorus	0.482	
Phosphorus in 100 parts iron...	1.050	

1063. *Avondale.* Limonite (lump). Mine situated three-quarters, of a mile north of Avondale, or Beacham station, Western Maryland railroad, Carroll county.

This mine has not been in operation for over a year, has been partially filled in, and, when visited, nothing of the ore could be seen. The pile of 5,000 tons of ore at the station belongs to the Ashland Furnace Company, and most of it was mined before January, 1880. Six thousand six hundred and three tons of ore were received at Ashland furnace from this vicinity during the census year.

Analysis.

	1063.	Remarks.
Metallic iron	48.50	Sample taken from a pile of about 5,000 tons of lump-ore at Avondale or Beacham station.
Phosphorus	0.987	
Phosphorus in 100 parts iron ..	2.035	

1064. *Springfield.* Magnetite. Mine situated 2 miles north of Sykesville (Baltimore and Ohio railroad) on Mr. Brown's land, Carroll county. Leased by Reed, Stickney & Co., of Baltimore.

At this locality mining was carried on thirty years ago, and there are a number of old shafts on the same north and south line. One of the more northerly shafts has been reopened within six months, and another, one-half mile south of it, is being reopened. The latter is rather inaccessible, and no ore has been raised from it. Its depth is said to be 160 feet, and it is said that the deposit is 4 feet thick. The former is the one which was sampled. The shaft is about 100 feet deep, nearly vertical, but bending to the south (in the direction of the length of the deposit) near the bottom. Some ore has been shipped to Pittsburgh from this mine.

The rock is chloritic and hornblendic schist. The deposit is about 2 feet thick at the bottom of the shaft, and stands very nearly vertical. The strike of the schist and the magnetic bed is about north and south.

Analysis.

	1064.	Remarks.
Metallic iron	64.44	Sample taken from 10 tons of ore at mouth of shaft. This came from near the bottom of the shaft, and represents the whole thickness of the deposit (2 feet) at that point, including some poor ore.
Phosphorus	0.243	
Phosphorus in 100 parts iron...	0.377	

a 1065. *Springfield*. Magnetite. Same mine as 1064.

Sample taken across the 2-foot thickness of the deposit, at bottom of shaft, about 100 feet from surface.

Analysis.

	1065.
Metallic iron.....	64.85
Phosphorus.....	0.251
Phosphorus in 100 parts iron.....	0.387

b 1066. *Ensor*. Limonite (fine, unwashed). Open cut situated on Jos. Scholl's land, 1 mile northeast of Unionville, Frederick county.

An excavation 200 feet long, 60 feet wide, and 50 feet deep has been made, running north 30° east. The marketable product during census year was 1,744 tons. At the bottom of the excavation is a deposit of solid limonite at least 7 feet thick in the part of the excavation where it is now exposed. This is the sort of ore which has been shipped, and it is represented by Sample 1067. This bed is marked *a* on the section, Fig. 75. Above this bed, and to a great extent collected into layers, inclosed in clay-beds (which have apparently resulted from the decomposition of schist *in situ*), is a fine or "wash" limonite, of which about 2,000 tons are piled up at the mine *c* awaiting the completion of a washer in order to utilize it. This is the ore which Sample 1066 represents. The constituent fragments of this wash-ore resemble in quality the lump-ore of Sample 1067. In this section the beds from which 1066 was derived are marked *b*. This ore goes to the Wrightsville Iron Company's furnace at Wrightsville, Pennsylvania.

Analysis.

	1066.	Remarks.
Metallic iron.....	41.41	Sample taken from 2,000 tons of fine, unwashed ore at the mine.
Phosphorus.....	0.665	
Phosphorus in 100 parts iron...	1.600	

d 1067. *Ensor*. Limonite (lump). Same mine as 1066.

Sample represents the lump-ore of a pile of about 150 tons which came from the lowest part of the excavation.

Analysis.

	1067.
Metallic iron.....	49.52
Phosphorus.....	0.817
Phosphorus in 100 parts iron.....	1.650

e 1068. *Catoctin* or *Kunkel*. Limonite (fine, unwashed). Open cut one mile north of Catoctin furnace, J. B. Kunkel proprietor of mine and furnace.

There are four or five excavations or banks on the property, and this is the more northerly of the two at which there are steam-washers. The others were not being worked at time of visit. An excavation, about 300 feet long, 100 feet wide, and 70 feet deep has been made. The ore is limonite in fragments dispersed through a sandy clay which lies in horizontal beds, the ore fragments being also to some extent collected into beds. These beds, however, are not well defined, and are not regular in their occurrence throughout the mine, *i. e.*, vertical sections in various parts would differ considerably with regard to the distribution of the ore-beds through the clay. The ore-bearing clay is 20 to 50 feet thick. It rests upon limestone, and is overlaid by a bluish-gray, stiff clay, 20 to 30 feet thick, and unproductive. The proportion of the ore-bearing clay which is rich enough to go into the washer is very *f* variable, sometimes reaching as high as one-half the whole thickness. The amount of loss in washing is also very variable, the minimum being estimated at one-tenth, while the ordinary loss is one-half. A wire screen on the washer removes the finest particles (see Sample 1069 for the washed and screened ore). The ore after being washed and screened is run on a tramway to Catoctin furnace, where it is used for making charcoal iron.

Analysis.

	1068.	Remarks.
Metallic iron.....	40.05	Sample taken from about 25 tons of "ore thrown down" in the 150 feet long drift, and in two 10 feet long drifts near it.
Phosphorus.....	0.220	
Phosphorus in 100 parts iron...	0.549	

1069. *Catoctin or Kunkel*. Limonite (washed and screened). Same mine as 1068.

Sample represents several tons of washed and screened ore at the mine.

Analysis.

	1069.
Metallio iron.....	41.55
Phosphorus.....	0.188
Phosphorus in 100 parts iron.....	0.452

1070. *Grim's*. Limonite (lump). Open cut 1 mile south-southeast of New Midway station, on Frederick division of Pennsylvania railroad, on J. Grim's land, Frederick county.

A cut running northeast and southwest has been made along the southeast side of a belt just west of Jos. Grim's farm-house. The mine is leased by, and has been operated by, C. Duncan, Chambersburg, Pennsylvania. Some of the ore has been shipped to a furnace at Columbia, Pennsylvania. The excavation is 140 feet long, and about 15 feet average width; depth, 8 to 12 feet.

The greater part of the material exposed, and the source of most of the ore which has hitherto been obtained, is an imperfectly stratified mass of clay, sand, and fragments of limonite, usually a few inches in diameter, though they occur of all sizes downward, and a few are found as large as 2 feet in largest dimension.

Below the mass of ore-bearing clay and sand, along the bottom of the excavation, the edges of the upturned beds of a schistose rock, rather soft, and of a light color are exposed, and these beds inclose a conformable bed of limonite, the upper edge only of which can be seen. This bed is exposed here and there over a distance of about 75 feet, and its greatest thickness observed was 5 to 6 feet. A small portion of the lump-ore has been derived from this bed, the rest having come from the overlying material.

Analysis.

	1070.	Remarks.
Metallio iron.....	38.35	Sample taken from 50 tons of lump-ore at the mine. It represents the 6-foot bed, and also the lump ore left in the overlying debris.
Phosphorus.....	1.363	
Phosphorus in 100 parts iron...	3.550	

1071. *Thomas*. Limonite (screened). Open cut situated one-half mile a little east of south of Frederick junction, Baltimore and Ohio railroad, on C. K. Thomas' land, Frederick county.

An excavation running about north and south, about 140 feet long, 30 feet wide, and 20 feet deep has been made. The ore, most of which is quite friable, occurs in nests and bunches of irregular shape, inclosed in a soft, light-colored material, in places stratified, and made up of finer calcareous, argillaceous, and siliceous fragments.

The greater part of the material excavated has to be washed in order to obtain any ore; it is screened before washing. No ore has been mined for nine to ten months, *i. e.*, since the summer of 1880:

Analysis.

	1071.	Remarks.
Metallio iron.....	30.45	Sample taken from pile of 75 tons of screened but unwashed ore at the mine.
Phosphorus.....	0.752	
Phosphorus in 100 parts iron...	2.470	

1075. *Bowery*. Limonite. Situated 1 mile west of Bowery furnace, on furnace property, 1½ miles north of Borden shaft, on the Cumberland and Piedmont railroad, Alleghany county.

The mine and furnace belong to the Cumberland Coal and Iron Company. The agent, James Kane, at Frostburg, stated that the mine was about worked out; that the deposit lay horizontally, and was 4 to 5 feet thick, resting on clay, and covered by sandy clay and soil. The furnace has been supplied with ore largely from Bedford county, Pennsylvania. On visiting the mine it was found that it was entered by three horizontal drifts, which were inaccessible on account of the caving in and giving way of the timbering. The rock in the neighborhood is a fine-grained, hard, rough-weathering sandstone.

Analysis.

	1075.	Remarks.
Metallio iron.....	44.68	Sample taken from the only ore to be found, <i>i. e.</i> , 2 or 3 tons scattered about at the entrance to the mine.
Phosphorus.....	0.188	
Phosphorus in 100 parts iron...	0.421	

a 1076. *Frost. Fossil.* Mine situated just east of Ormon Frost's house, $3\frac{1}{2}$ miles west of Cumberland, Alleghany county.

This mine has not been worked for twelve years, and the drift leading to it is fallen in and entirely inaccessible.

Analysis.

	1076.	Remarks.
Metallio iron	46.59	Sample from about a ton of ore scattered about at the entrance to the mine.
Phosphorus.....	0.217	
Phosphorus in 100 parts iron...	0.466	

NOTES ON THE SAMPLES OF IRON ORE COLLECTED IN VIRGINIA.

BY EDWARD R. BENTON.

That part of Virginia which contains the iron mines which were sampled, may, for convenience of reference, be divided as follows:

- A.—East of the Blue Ridge.
- B.—Southwestern Virginia.
- C.—James River basin, west of the Blue Ridge.
- D.—Shenandoah valley.

The location and geological position of each mine or group of mines sampled is shown on Plate XXX. Fig. 76 indicates, with reference to its surroundings, the area represented on Plate XXX. As the sample numbers consist of three, and in some instances, four figures, it was found necessary, in order to avoid confusion, to use arbitrary numbers on the map. By reference to the *key to the numbers on the iron-ore sample map of Virginia* and the *index to the sample numbers* given below, the position on the map of a mine referred to in the text may readily be found.

Key to the numbers on the iron-ore sample map of Virginia.

Map No.	Sample No.	Name of mine or group of mines.	Page No.	Map No.	Sample No.	Name of mine or group of mines.	Page No.
1	617	North Garden	263	42	632 } 633 }	Panic or White Rock	276
2	610	Greenway	264	43	631	Glade	277
3	1014	Slippery Gut deposit	264	44	624	Semi-magnetic	277
4	1015 } 1016 }	East of Furnace vein	264	45	645	Wood's property	277
5	1017	Brown Hematite mine	265	46	644 } 645 }	Arcadia property	277
6	608	No. 13	266	47	650	Arcadia property	277
7	609 } 607 } 608 }	No. 10 } Adams, Scott & Co	265	48	646	Retreat	278
8	606 }	No. 11	265	49	647	Carnes	278
9	605 }	Dover Company, No. 11	266	50	648	Spengler	279
10	607	Dover Company, No. 6	267	51	651	May's	279
11	604 } 1018 }	Naylor & Co., No. 6 }	267	52	700 } 1001 }	Hickory Hollow (Salisbury furnace)	279
12	601 } 603 }	Maud vein, Stapleton	268	53	640	Salisbury furnace	279
13	602 } 603 }			54	652 } 653 }	Longdale (Lucy Selina)	279
14	600			55	654 }	Clifton Forge	280
15	1021			56	657	Callie furnace (Old bank)	281
16	1019	Chestnut Mountain	269	57	658 }	Callie furnace (New bank)	281
17	1020	Red Belt	269	58	659 }	Lowmoor	281
18	623 }	Railroad	269	59	658 }	A. Given's outcrop, Potts' Crossing	283
19	622 }	Cross-cuts on Archer's Creek property	269	60	1009	Dolly Ann	284
20	621 }			61	1010	Wills'	284
21	620 }			62	1008	Smith McAllister	284
22	619 }			63	1002	Dickey	284
23	618	Near Oxford furnace	270	64	1007	Gay and Lewis	284
24	611	Otter River	270	65	1008	Huddleson	285
25	612 }	Pittsville	270	66	1004	Trice	285
26	613 }			67	1005 } 1006 }	Sadler's or Stack	285
27	614 }			68	608	Kennedy	286
28	615 }	Rocky Mount (Franklin)	271	69	664	Mount Torrey or Virginia	286
29	616 }	Speedwell	273	70	673	Miller	286
30	634	Ravenscliffe	273	71	674	Raines and Weaver	286
31	635 } 636 }	Sayers and Oglesby	274	72	675	Raines	286
32	637 } 638 }			73	665 } 666 }	Fox Mountain	287
33	639	Sampson's, Cripple creek	274	74	667 } 668 }	Three-Top Mountain	287
34	640 }	Chadwell Farm	274	75	670	Grace (formerly Ferrol)	288
35	641 }			76	661 } 662 }	Buffalo Gap	288
36	642	Noble	274	77	660	Old bank (Liberty furnace)	288
37	630	Walton	274	78	671	Hollow bank (Liberty furnace)	288
38	625	Carter	275	79	672	West bank (Van Buren furnace)	288
39	627	Hurst	275	80	669		
40	626 } 628 }	Johnson	275	81			
41	620	Rich Hill	276	82			

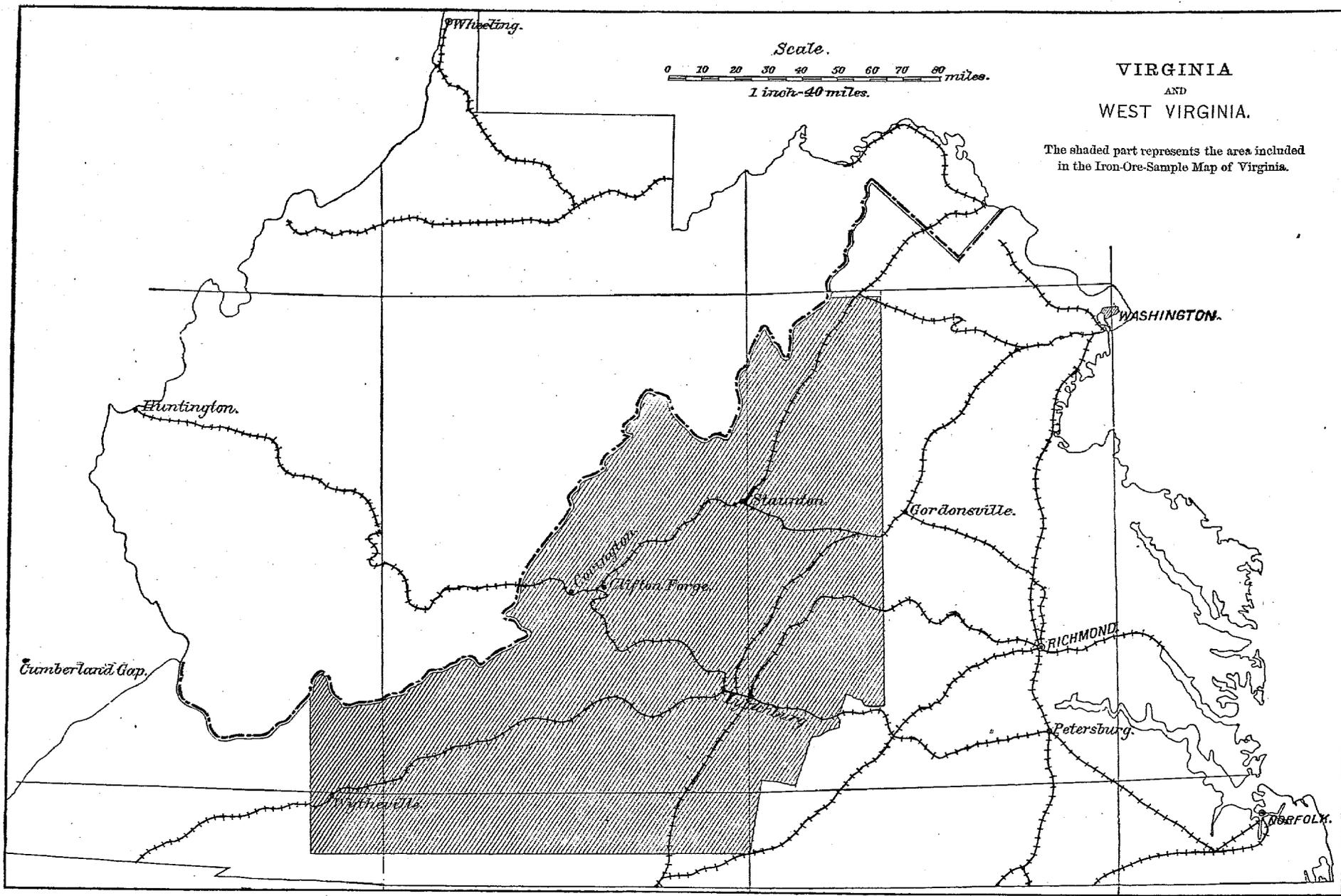


FIG. 76.

Index to the sample numbers.

a

[For finding on the map the location of the samples, and for finding description of same in the report.]

Sample No.	Page No.	County.	Map No.	Sample No.	Page No.	County.	Map No.	Sample No.	Page No.	County.	Map No.
001	208	Amherst.....	12	035	273	Wythe.....	31	069	288	Shenandoah.....	84
002	208	..do.....	13	036	273	..do.....	31	070	287	..do.....	78
003	208	..do.....	12, 13	037	274	..do.....	32	071	288	..do.....	82
004	207	..do.....	11	038	274	..do.....	32	072	288	..do.....	83
005	206	..do.....	9	039	274	..do.....	33	073	286	Rockingham.....	74
006	206	..do.....	8	040	274	..do.....	34	074	286	..do.....	75
007	207	..do.....	10	041	274	..do.....	35	075	286	..do.....	70
008	206	..do.....	6	042	274	..do.....	36	097	205	Amherst.....	7
009	205	..do.....	7	043	277	Botetourt.....	47	098	205	..do.....	7
010	264	Nelson.....	2	044	277	..do.....	46	099	200	Appomattox.....	14
011	270	Campbell.....	24	045	277	..do.....	45	700	270	Botetourt.....	53
012	270	Pittsylvania.....	25	046	278	..do.....	49	1001	270	..do.....	53
013	270	..do.....	26	047	279	..do.....	50	1002	284	Alleghany.....	67
014	270	..do.....	27	048	279	..do.....	51	1003	284	..do.....	68
015	271	Franklin.....	28	049	279	..do.....	54	1004	285	..do.....	70
016	271	..do.....	29	050	278	..do.....	48	1005	285	..do.....	71
017	263	Albemarle.....	1	051	279	..do.....	52	1006	285	..do.....	71
018	270	Campbell.....	23	052	279	Alleghany.....	55	1007	284	..do.....	68
019	269	..do.....	22	053	279	..do.....	50	1008	285	..do.....	60
020	269	Appomattox.....	21	054	279	..do.....	57	1009	283	..do.....	63
021	269	..do.....	20	055	281	Botetourt.....	59	1010	284	..do.....	64
022	269	..do.....	19	056	281	..do.....	60	1011	284	..do.....	65
023	269	..do.....	18	057	280	Alleghany.....	58	1012	208	Amherst.....	13
024	277	Wythe.....	44	058	281	..do.....	62	1013	208	..do.....	13
025	275	..do.....	38	059	281	..do.....	61	1014	204	Nelson.....	3
026	275	..do.....	40	060	288	Augusta.....	81	1015	204	Amherst.....	4
027	275	..do.....	39	061	288	..do.....	79	1016	204	..do.....	4
028	275	Pulaski.....	40	062	288	..do.....	80	1017	205	..do.....	5
029	278	..do.....	41	063	289	..do.....	73	1018	207	..do.....	11
030	274	Wythe.....	37	064	286	..do.....	73	1019	260	Appomattox.....	16
031	277	..do.....	43	065	287	Rockingham.....	77	1020	260	Campbell.....	17
032	270	Smyth.....	42	066	287	..do.....	77	1021	260	Appomattox.....	15
033	270	..do.....	42	067	287	..do.....	77				
034	273	Wythe.....	30	068	287	..do.....	77				

b

c

d

A.—EAST OF THE BLUE RIDGE.

The iron-ore deposits of this division are, as a rule, interstratified with metamorphic schists and quartzites, or sandstones, which have a nearly vertical dip and a nearly northeast and southwest trend, and which are commonly considered by geologists to be of Archæan age.

e

The former mine was worked in May, 1880, by Mr. Appelby, and 30 to 40 tons of ore were raised from an open cut 15 feet deep, at the time it was sampled. The latter mine ("Betty Martin", on Mrs. Martin's land) has been abandoned for some time. Some ore is said to have been shipped from it. Open cut, 20 to 30 feet deep.

These two small mines are near each other and contain, apparently, precisely similar ore. They were sampled as one, from 30 to 40 tons of ore in piles at each place.

617. *North Garden.* Magnetite and limonite (intimate mixture). One-half mile north of railroad station, at North Garden, Albemarle county, on Mrs. Betts' land; also, one-quarter mile northwest of station, on Mrs. Martin's land.

617. Analysis: Iron, 46.69 per cent.; phosphorus, 0.055 per cent. titanic acid, present; manganese, present; phosphorus ratio, 0.118.

JAMES RIVER ORE-BELT.

f

This is the principal iron-mining region east of the Blue Ridge. It is situated along that part of the James river which forms the boundary between the counties Nelson and Amherst on the northwest and Buckingham, Appomattox, and Campbell on the southeast. The southwestern extremity of the region is about 5 or 6 miles south-southeast of Lynchburg (down the James river), and the region where mining has gone on extends for about 30 miles to the northeast. Measuring across the belt, the greatest distance between any two mines is about 3 miles.

a 610. *Greenway*. Specular (micaceous, soft). Two and one-half miles nearly west of Greenway post-office, which is on James river, and about 2½ miles north of Allen's Creek post-office, which is also on James river. Colonel Thomas Dunlap (who lives at Stapleton) manages the mine for Naylor & Co., Philadelphia. J. Lee Warne has charge at the mine.

This mine is worked by two shafts; it is said to have been opened for 500 feet along the deposit (northeast and southwest), and to a depth of 205 feet. The chief miner, who had charge of the mine, stated that the machinery was unsafe, and that the lower part of the mine was flooded; also that the deposit was 12 feet thick at the bottom of the mine. A small steam-engine is used for hoisting. Hand-specimen 610*a* is from the southwestern shaft, and is rather better in appearance than the average of the ore from that shaft. Hand-specimen 610*b* is from the northeastern shaft, and in order to obtain a specimen that would hold together, it was taken a little better than the average. The hand-specimens represent very well the different structure of the ore in the two shafts.

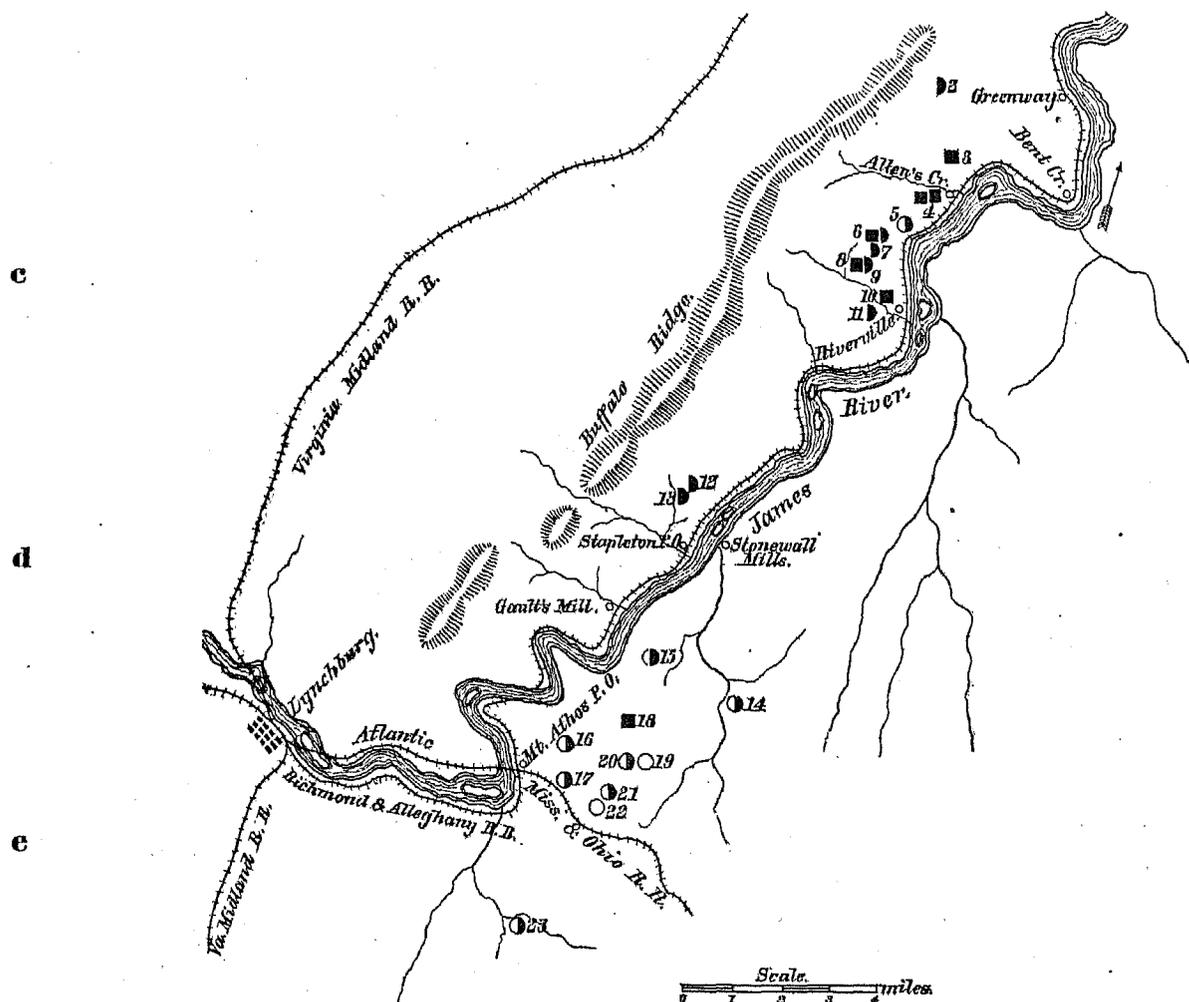


FIG. 77.—MAP OF THE JAMES RIVER IRON-ORE BELT. The numbers refer to the key to the iron-ore sample map of Virginia (p. 261).

610. Analysis: Iron, 53.02 per cent.; phosphorus, 0.049 per cent.; titanio acid, none; phosphorus ratio, 0.092. Sample taken from piles of ore ready for shipment at the two shafts; about equal amount at each. In shipping the two kinds go in together.

f 1014. *Slippery Gut Deposit*. Ferruginous schist. Three-fourths of a mile west of Dr. Megginson's house (which is 1 mile down James river from Allen's Creek post-office), along top of a ridge on Dr. Mundy's land. Lease or mineral right held by Mumford, Grubb & Co., Lynchburg Iron, Steel and Mining Company.

No mining has been done. The schist affects the magnetic needle slightly, but it has not the appearance of being a workable ore.

1014. Analysis: Iron, 24.67 per cent.; phosphorus, 0.121 per cent.; titanio acid, none; phosphorus ratio, 0.490. Sample taken across the 60-foot thickness of the formation on the outcrop.

1016. "*First Vein*" east of "*Old Furnace Vein*." "Specular," with magnetite. Near Old Elk Creek furnace, Amherst county, about three-fourths of a mile north of Dr. Mundy's house, on his land. Leased by Mumford, Grubb & Co., Lynchburg Iron, Steel and Mining Company. Mr. Grant has charge of this mine.

The ore-bed dips 70° southeast, and runs northeast and southwest. (It lies a few rods east of the old "Furnace vein", mined many years ago to supply Elk Creek furnace, near by. The workings of this old "vein" are now

inaccessible.) The mine is entered by a shaft 60 feet deep. Drift to northeast 125 feet long from bottom of shaft. **a** Deposit said (by miners) to be ordinarily 3 feet thick, but at end of drift was only 1 foot 3 inches thick. It was, however, somewhat richer than the ordinary run of the deposit, even when compared with picked ore from the rest of the deposit. This thin but rich part of the seam is represented by hand-specimen 1016*a*, while the ore ordinarily mined is represented by 1016. Ore will be used in the furnace of the Lynchburg Iron, Steel and Mining Company, Lynchburg.

1016. Analysis: Iron, 38.43 per cent.; phosphorus, 0.113 per cent.; titanio acid, small amount; phosphorus ratio, 0.307. Sample represents the output of the mine, from pile of picked ore at the mouth of the shaft.

1015. "Second Vein" east of "Old Furnace Vein." "Blue ore." Magnetite and martite. Near Old Elk Creek furnace, Amherst county, about three-fourths of a mile north of Dr. Mundy's house, on his land. Leased by **b** Mumford, Grubb & Co., Lynchburg Iron, Steel and Mining Company. Mr. Grant has charge of this mine.

Ore-bed dips 60° to 70° southeast; runs northeast and southwest (it lies a few rods east of 1016); is entered by tunnel at foot of hill about on level with the drift in 1016. Foot-wall is "slate"; the hanging-wall is sandstone or quartzite. A drift has been run southwest about 50 feet along the deposit from the point where the tunnel strikes the deposit. At the head of the drift the bed is about 1 foot thick. (All ore.) The ore is finely granular, and consists of martite, with some magnetite dispersed through it. This ore will be used in the furnace of the Lynchburg Iron, Steel and Mining Company, Lynchburg.

1015. Analysis: Iron, 46.63 per cent.; phosphorus, 0.057 per cent.; titanio acid, none; phosphorus ratio, 0.122. Sample taken across the 1-foot thickness of the deposit, head of drift, 50 feet southwest of tunnel, 20 to 30 feet from surface. **c**

1017. *Brown Hematite Mine.* Limonite. One-half of a mile west of Dr. Mundy's house, on his farm, and about one-quarter of a mile from James river. Leased by Mumford, Grubb & Co., Lynchburg Iron, Steel and Mining Company. Mr. Grant has charge of the mine. This ore is used in the furnace of the Lynchburg Iron, Steel and Mining Company, Lynchburg.

This mine was started as an open cut, but is now worked by a shaft 40 feet deep. The deposit stands vertical, and the walls are soft decomposed slate or schist. The ore is fragmental, apparently from crushing. A drift about 100 feet long has been run from the bottom of the shaft toward the southwest, and a tunnel is being run in from the hillside to connect with it.

1017. Analysis: Iron, 44.54 per cent.; phosphorus, 0.850 per cent.; titanio acid, small amount; phosphorus ratio, 1.908. Sample taken close to shaft in stope, about 20 feet from top of shaft. Thickness at point where sample was taken, 8 feet. **d**

609 and 697. *Adams, Scott & Co. No. 10½.* Specular (soft). One and one-half miles north of Riverville post-office, which is on the James river. Leased by Adams, Scott & Co. Dr. Scott has charge at the mine. Ore used in the furnace at Lynchburg.

Shaft 105 feet deep. Deposit stands vertical. Walls, slate and sandstone. Strike of bed northeast and southwest. Drift to southwest about 150 feet long from bottom of shaft. At this point (*i. e.*, head of drift) the thickness of the head is 14 to 15 feet. Of this thickness about half is solid, and the other half is fine, loose ore. A large amount of ore has been mined from the stopes above this drift. **e**

609. Analysis: Iron, 40.51 per cent.; phosphorus, 0.095 per cent.; titanio acid, none; phosphorus ratio, 0.235. Sample taken across the 14- to 15-foot thickness of the deposit at the head of the drift, and across the 16½-foot thickness of the deposit at the bottom of the shaft, sampling the two kinds of ore together at both points.

697. Analysis: Iron, 41.55 per cent.; phosphorus, 0.044 per cent.; titanio acid, small amount; manganese, trace; phosphorus ratio, 0.106. Sample taken at bottom of shaft across a layer of fine, loose ore 6½ feet thick, on the southeast wall of the deposit. Whole thickness at this point, 17½ feet.

698. *Adams, Scott & Co. No. 11.* "Specular" (soft). One and one-half miles north of Riverville post-office, which is on the James river, a few rods west of No. 10½. Leased by Adams, Scott & Co. Dr. Scott has charge at the mine. Ore used in the furnace at Lynchburg. **f**

This ore-seam runs parallel with No. 10½. It stands vertically, and is entered by shaft 120 feet deep. From the bottom of the shaft a drift runs to the southwest 65 feet. Near the head of the drift the ore-deposit is 4 feet thick. At the bottom of the shaft the ore is wanting, its place being supplied by "black dirt". It was found in sinking the shaft, that one edge of the body of ore ran obliquely across it with an almost vertical pitch to the southwest. At a distance of 64 feet from the shaft, in the drift, it is seen that the ore is replaced by "black dirt", and the boundary between ore and black dirt turns obliquely upward, parallel with the boundary noticed in the shaft; between the two boundaries is the ore-body, and on each side is "black dirt". It was found by measurements taken in the mine and at the surface that this "shoot" of ore had a pitch to the southwest of 85° (see Fig. 78).

698. Analysis: Iron, 39.75 per cent.; phosphorus, 0.126 per cent.; titanio acid, small amount; phosphorus ratio, 0.317. Sample taken from pile of ore ready for shipment at mouth of shaft, which came from near the head of the drift. Thickness, 4 feet.

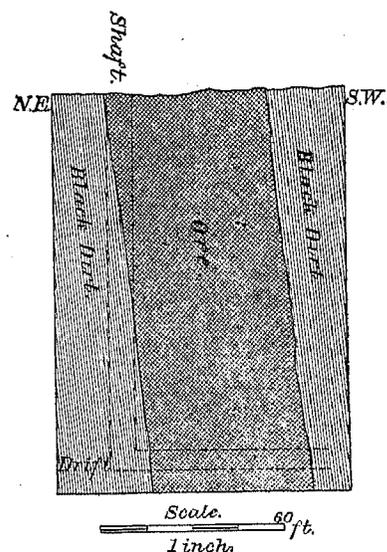


FIG. 78. — LONGITUDINAL SECTION, ADAMS, SCOTT & COMPANY'S MINE ON No. 11. JAMES RIVER, VIRGINIA.

a 608. *Adams, Scott & Co. No. 13.* Specular (fine, loose), magnetite intermingled. One and one-half miles north of Riverville post-office, which is on the James river, and a few rods west of No. 11. Leased by Adams, Scott & Co. Dr. Scott has charge at the mine.

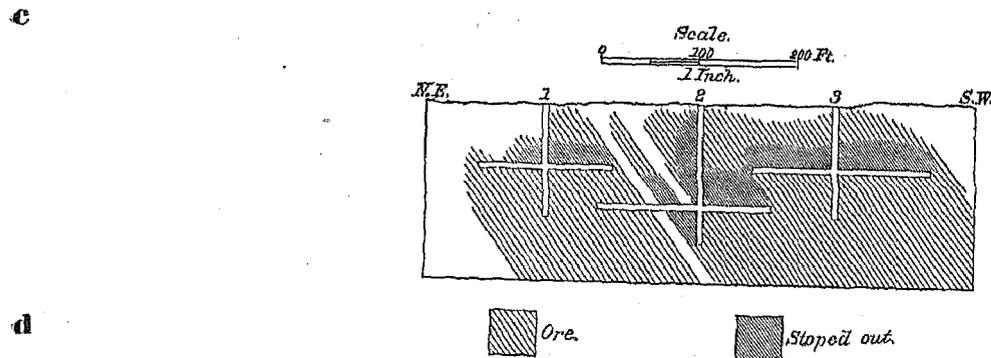
The greater part of the ore and rock in this mine is in a soft pulverulent state, so that the extent and shape of the deposit could not be determined. There was apparently no distinct foot-wall or hanging-wall. The hand-specimen 608 represents a small deposit of solid ore which was found some time since in the mine. Shaft 100 feet deep. Drifts both ways have been begun. The ore is a sand made up of grains of hematite and magnetic ore.

608. *Analysis:* Iron, 44.96 per cent.; phosphorus, 0.051 per cent.; titanic acid, small amount; phosphorus ratio, 0.113. Sample taken from ore-pile at top of shaft. The ore came from the bottom of the shaft, at depth of 100 feet.

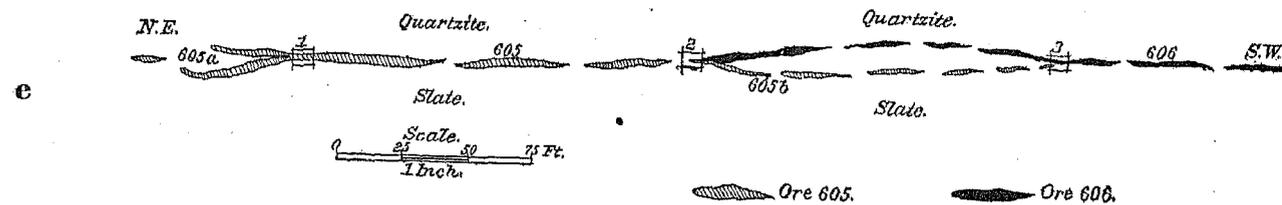
b 605 and 606. *Dover Company No. 11.* Specular and hard hematite (martite). One and one-half miles northwest of Riverville post-office. Leased by Dover Mining Company, of New York. A tramway was built by the company from the mine to the canal wharf at Riverville. Ore used in the furnace at Lynchburg.

This mine was worked by three shafts (numbered 1, 2, and 3 on the sections, Fig. 79). They are sunk on the "vein" at an inclination of about 70° southeast. The hanging-wall is a quartzite or sandstone, usually much decomposed in the neighborhood of the ore. The foot-wall is a talcose or hydromica-slate or schist—very soft near the ore.

LONGITUDINAL SECTION OF THE WORKINGS.



HORIZONTAL SECTION OF THE DEPOSIT ON THE LEVEL OF THE DRIFTS.



CROSS-SECTION BETWEEN SHAFTS 2 & 3.

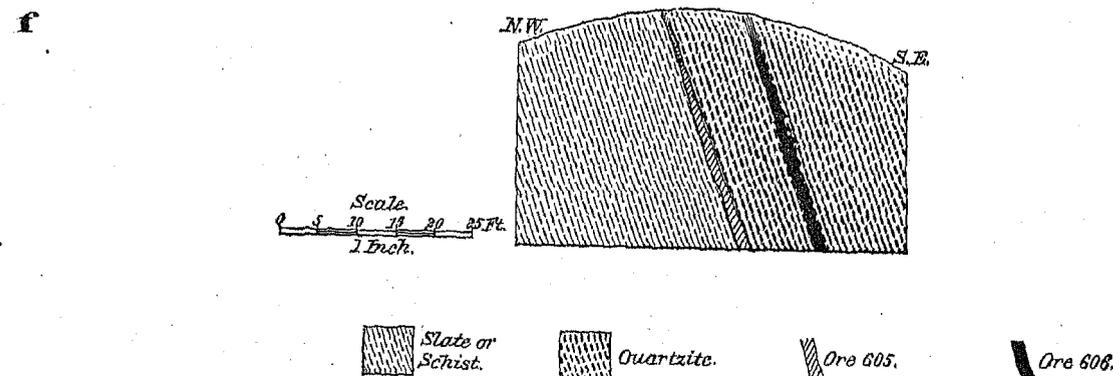


FIG. 79—SECTIONS OF THE DOVER COMPANY'S MINE ON NO. 11. JAMES RIVER, VIRGINIA.

Shaft No. 1 is down 88 feet; at depth of 60 feet is a drift running both ways—to northeast 60 feet and to a southwest 50 feet. Here the deposit varies in thickness from 3 feet down to 0. At the bottom of the shaft the ore is exposed with a thickness of 3 to 4 feet.

At Shaft No. 2 the main deposit is met by another, which is a different kind of ore, called, locally, "steel-ore" (hand-specimen 606). For most of its length it runs parallel with the other, and at a distance of about 10 feet in the hanging-wall (*i. e.*, on the southeast side of the main deposit). Shaft No. 2 is 115 feet in depth; at depth of 82 feet is a drift running both ways—100 feet to the northeast and 45 to 50 feet to the southwest. Both "veins" are exposed in this part of the mine, both in the southwest drift and in the bottom of the shaft. Thickness of each deposit about 1½ feet.

Shaft No. 3 is 105 feet deep; at depth of 60 feet is a drift running both ways—to northeast 80 feet and to southwest nearly 100 feet. The main deposit seems not to continue to the southwest beyond this shaft, but the "steel vein" continues the length of the drift. Neither of the deposits in this mine is quite continuous, but they seem to run out and then come in again.

In the main deposit the ore in the northeastern part (represented by hand-specimen 605*a*) is almost entirely micaceous specular, whereas in the southwestern part the ore, though largely specular, contains many fine crystals of magnetic iron dispersed through it. This sort is represented by hand-specimen 605*b*. The two varieties are mined and shipped irrespective of the difference in composition, while the ore of the "steel vein" is kept separate. Some barite occurs in connection with this latter sort.

605. Analysis: Iron, 48.47 per cent.; phosphorus, 0.103 per cent.; titanic acid, small amount; phosphorus ratio, 0.212 per cent. Sample taken at heads of drifts in shafts No. 1 and No. 2. Thickness, 1½ to 3 feet. Sample represents the specular ore with some little magnetite intermingled.

606. Analysis: Iron, 54.88 per cent.; phosphorus, 0.061 per cent.; titanic acid, small amount; phosphorus ratio, 0.111 per cent. Sample represents the hard hematite ore, and was taken at the heads of the two drifts in Shaft No. 3, on the "steel vein".

Following are the complete analyses of samples 605 and 606:

	605.	606.		605.	606.
	<i>Per cent.</i>	<i>Per cent.</i>		<i>Per cent.</i>	<i>Per cent.</i>
Sulphur	0.352	0.579	Hygroscopic water	0.07	0.07
Phosphorus	0.103	0.061	Water of composition	0.85	0.52
Iron, metallic.....	48.47	54.88	Total	100.000	100.001
Silica	21.58	14.00	Per cent. of insoluble silicious matter	28.53	20.71
Iron, protoxide	0.03	13.67	Silica	21.58	14.00
Iron, peroxide	62.35	63.01	Alumina (with trace of oxide of iron).....	4.12	2.92
Alumina.....	4.94	2.93	Lime	0.01	0.05
Lime	0.28	0.73	Magnesia	0.31	0.21
Magnesia	0.37	0.26	Potassa.....	0.01	0.46
Iron, disulphide	0.320	0.300	Soda	0.11	0.06
Barium oxide.....	1.18	2.11	Phosphoric acid.....	0.028	0.002
Potassa.....	0.99	0.54	Barium sulphate	1.32	3.04
Soda.....	0.14	0.10	Titanic acid	0.07	0.00
Carbonic acid.....	0.21	0.54	Total	28.458	20.742
Sulphuric acid.....	0.45	1.04			
Phosphoric acid	0.239	0.141			
Titanic acid	0.07	Trace.			

607. *Dover Company, No. 6.* Hard hematite (martite). One-half mile northwest of Riverville, on Captain J. Dillard's land.

Short open cut from which 20 to 30 tons of ore have been taken. The ore sampled came from within 7 to 10 feet of the surface. The deposit stands vertical, and the walls are of soft slate; thickness, 3 to 4 feet.

607. Analysis: Iron, 36.10 per cent.; phosphorus, 0.131 per cent.; titanic acid, none; phosphorus ratio, 0.363 per cent. Sample taken from pile of ore at the cut.

604 and 1018. *Naylor & Co., No. 6½.* Specular. Three-quarters mile west of Riverville post-office. Owned and managed by Naylor & Co., Philadelphia. Mr. Carlis has charge of the mine. Ore goes to northern markets.

The northeast shaft is about 41 feet deep on the slant of 60° toward the southeast. The shaft goes down upon the ore-bed. At the bottom is a drift toward the northeast 25 feet long at the head of which the deposit is 3 to 4 feet thick.

The southwest shaft, about 200 feet from the other, is 15 feet above it at the top, and is 45 feet deep. At the bottom of this shaft the deposit is 1 foot thick. The ore is soft specular, and contains occasional thin bands of hard, fine granular hematite. In the hand-specimen 604 the hard hematite predominates, but the great part of the ore in this mine is in appearance precisely similar to hand-specimen 610*a*.

a 604. Analysis: Iron, 48.92 per cent.; phosphorus, 0.033 per cent.; titanic acid, none; phosphorus ratio, 0.067 per cent. Sample taken from stope close to bottom of northeast shaft, thickness 3 feet; and from bottom of southwest shaft thickness 1 foot; depth, 40 feet. Not to be picked over before shipment.

The above sample and notes were taken in April, 1880. In December, 1880, the northeast shaft had been sunk to a depth of 115 feet, and a drift run at that level to the northeast 25 feet. Walls of this mine are soft slate. The ore in this part of the mine contains scarce any of the hard hematite, and is precisely similar in appearance to hand-specimen 610a.

1018. Analysis: Iron, 51.14 per cent.; phosphorus, 0.012 per cent.; titanic acid, none; phosphorus ratio, 0.023 per cent. Sample taken in drift a few feet northeast of northeast shaft, across the 1-foot thickness of ore, and at a depth of 115 feet. Not to be picked over before shipment.

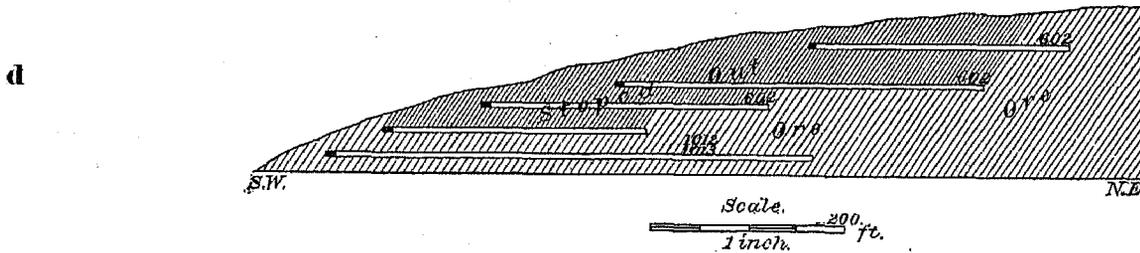
b 601, 602, 603, 1012, 1013. *Maud vein, Stapleton.* Specular. One and one-quarter mile north of Stapleton, which is on the James river. Naylor & Co. Colonel Thomas Dunlap, manager at mine.

This deposit runs nearly north-northeast and south-southwest, stands nearly vertical, has for a foot-wall (on the west) a talcose or hydromica slate, and for a hanging-wall (on the east) a coarse "quartzite", which has an imperfectly stratified structure. On each side of the deposit is a layer of clayey substance between the ore and the inclosing rock. This substance is light to dark-yellowish brown. On the west wall it is only a few inches thick, while on the east wall it varies from 6 inches to 1½ feet thick.

The deposit is essentially a ferriferous slate (or schist) and "quartzite", approaching in character in some parts of the mine pure specular ore. Thin layers of schist and "quartzite" are found interlaminated with the ore. The deposit consists, in an imperfect way, of two different layers placed vertically side by side, that on the west being darker colored, less slaty in structure, and apparently richer in iron; this kind of ore forms about one-half of the deposit, and is represented by hand-specimen 603. The other kind of ore, called locally "slate ore", forms the rest of the deposit, and is represented by hand specimen 602. (See cross-section, fig. 80.)

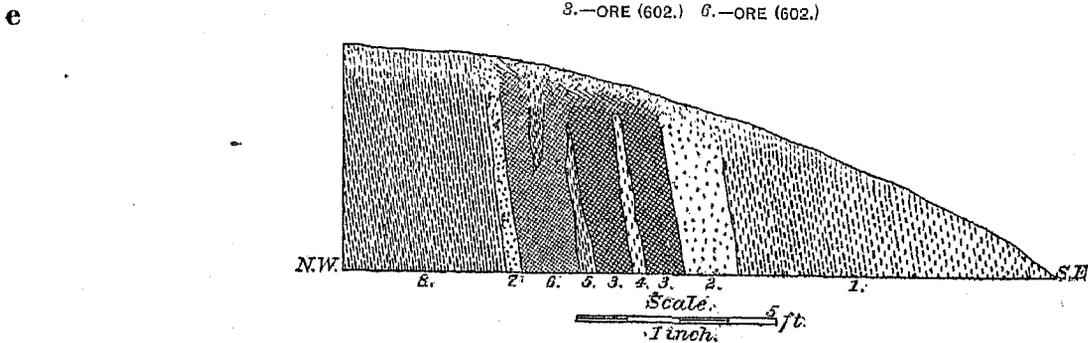
This deposit has been opened about 800 to 900 feet of its length; greatest depth below surface, 80 feet. (See longitudinal section.)

LONGITUDINAL SECTION OF WORKINGS.



DIAGRAMMATIC CROSS-SECTION:

1 and 4—Quartzite. 5 and 8—Slate. 2 and 7—Clay.
3.—ORE (602.) 6.—ORE (602.)



f FIG. 80.—SECTIONS OF THE MAUD VEIN, JAMES RIVER, VIRGINIA.

A narrow-gauge railroad is in process of construction from the mine to the canal-wharf at Stapleton. The intention is to run all the ore out of the mine through the "tunnel" which has been started below (about 25 feet below) the present four levels. The railroad now building is to connect with this tunnel.

02. Analysis: Iron, 49.89 per cent.; phosphorus, 0.139 per cent.; titanic acid, none; phosphorus ratio, 0.279. Sample taken across the 2 to 4 feet thickness of the deposit, in the stopes near heads of the upper three drifts. Average thickness, about 3 feet.

The above sample was taken in April, 1880, and was taken without regard to the two varieties of ore mentioned above. The occurrence of these two varieties was noticed especially in the upper two levels. The mine was visited again in December, 1880, for the purpose of sampling the two varieties separately. The particular spots where they were seen in April were not accessible, and all the good exposures across the deposit failed to present the

varieties before noted. These good exposures were 40 to 80 feet below the levels where the varieties were seen in **a** April. Two slightly different varieties were, however, found in the "tunnel" below the four drifts. This "tunnel" is merely a drift, connecting with the tramway by a tunnel through about 80 feet of "quartzite" and "slate".

1012. Analysis: Iron, 50.33 per cent.; phosphorus, 0.136 per cent.; titanic acid, none; phosphorus ratio, 0.270. Sample taken across a thickness of 6 inches of ore on the west wall of the deposit, in stope just above the lowest drift, *i. e.*, the one connected with the tramway, 500 feet from the mouth of the tunnel.

1013. Analysis: Iron, 48.16 per cent.; phosphorus, 0.120 per cent.; titanic acid, none; phosphorus ratio, 0.428. Sample taken across the thickness of 2 feet 6 inches of ore on the east wall of the deposit, at same point as sample 1012.

About 20 feet east of the northeast end of the workings on the main deposit a shaft had been sunk (April, 1880) 30 feet, upon a "shoot" of rather pure specular ore, having a slaty structure. From the bottom of the shaft the excavation goes down about 30 feet, toward the southwest on the shoot, at an angle of about 45°. Thickness of deposit, 4 to 5 feet. Hand-specimen 601 shows its character. **b**

601. Analysis: Iron, 51.21 per cent.; phosphorus, 0.096 per cent.; titanic acid, small amount; phosphorus ratio, 0.187. Sample taken near bottom of shaft on "shoot" of specular ore described above. Thickness, 4 to 5 feet.

603. Analysis: Iron, 56.50 per cent.; phosphorus, 0.129 per cent.; titanic acid, small amount; phosphorus ratio, 0.228. Sample taken to show output of mine from about 250 tons of ore on the canal wharf at Stapleton, ready for shipment and consisting chiefly of 602, but containing some of 601. This sample was taken in April, 1880.

699. *Stonewall*. Limonite. Near Stonewall creek, about 3 miles south of Stonewall (ferry), which is on the James river. Stonewall is about one half mile down the river (northeast) from Stapleton. The mine is managed by Colonel Thomas Duulap. **c**

The mine consists of an open cut about 225 feet long, running up the hillside each way from a small valley which cuts through it. At no part is the excavation more than 20 feet below the surface. The ore dips 70° to 75° to the southeast; runs in a northeast and southwest direction, and has a thickness of about 3 feet. It is all lump-ore. The walls are decomposed schist, with thin seams of chert. Several hundred tons have been shipped from this mine. This ore has an imperfectly lamellar structure.

699. Analysis: Iron, 42.81 per cent.; phosphorus, 0.478 per cent.; titanic acid, small amount; manganese, small amount; phosphorus ratio, 1.116. Sample taken from three large piles of ore at the mine, containing all the ore that is taken out of the cut.

1021. *Chestnut Mountain*. Specular. Chestnut mountain, 3 miles northeast of Judge Williams' house, and on the land of the Birmingham Coal and Iron Company. Some little ore has been shipped from this mine.

Two shafts 125 feet apart, neither of them accessible. Shafts 100 feet deep, and connected at bottom by a drift, from which the ore represented by the sample was taken. **d**

1021. Analysis: Iron, 42.94; phosphorus, 0.012 per cent.; titanic acid, none; manganese, trace; phosphorus ratio, 0.028. Sample taken from a pile of 200 to 300 tons of ore ready for shipment at the mine. Mr. Logan, who has charge of the mining on the Birmingham property, stated that the ore came from the drift at depth of 100 feet, and that the deposit was 3 to 4 feet thick.

1019. *Red Belt*. Limonite. On the land of the Birmingham Coal and Iron Company, three-quarters of a mile southeast from Judge Williams' house, which is near the James river.

This mine was not in operation at the time it was visited, but mining had been done there a short time before, and it was expected to be resumed again in the spring. This ore, like that of 699, has an imperfectly lamellar structure, and is called "Red Belt", from containing occasional thin bands of red hematite. There is one shaft, which was not accessible. The ore-deposit stands vertical, and is said to be quite variable in thickness, but to attain in places a thickness of 8 feet. Mr. Logan stated that there were two drifts, each 60 feet long, at the depth of 60 feet, one running northeast, the other southwest; and that there were also similar drifts at the depth of 40 feet.

1019. Analysis: Iron, 40.65 per cent.; phosphorus, 0.250 per cent.; titanic acid, small amount; phosphorus ratio, 0.615. Sample taken from pile containing 75 to 100 tons of ore at the mine (ready for shipment). Mr. Logan stated that it came from the 60-foot level.

1020. *Railroad*. Limonite. Land of Birmingham Coal and Iron Company, close to Atlantic, Mississippi and Ohio railroad, about 1 mile east of Mount Athos post-office.

Open cut, 25 feet long, and 10 to 15 feet deep. This ore is in a crushed state in the mine; it is screened, and about one-third is saved as good ore. The bed containing the ore stands vertical, and is about 20 feet thick. It consists, however, of alternating layers of sand and clay, so that about one-third only of the thickness is ore. The walls are decomposed schist and sandstone. **f**

1020. Analysis: Iron, 36.27 per cent.; phosphorus, 0.535 per cent.; titanic acid, small amount; manganese, small amount; phosphorus ratio, 1.476. Sample taken across the 20-foot thickness of the deposit, on face of ore in open cut, avoiding the intermingled clay and sand. It represents a thickness of 6 to 8 feet of good ore.

623. *Cross-cut, Archer's Creek property*. Hematite (martite). On Mr. Stone's land.

623. Analysis: Iron, 41.69 per cent.; phosphorus, 0.527 per cent.; titanic acid, none; manganese, small amount; phosphorus ratio, 1.264. Sample across the 30-foot thickness of the deposit in cross-cut.

622. *Cross-cut, Archer's Creek property*. Hematite. Three-quarters mile northeast of Mr. Pettigrew's house, on his land.

A soft schistose ore.

a 622. Analysis: Iron, 32.31 per cent.; phosphorus, 0.357 per cent.; titanic acid, none; phosphorus ratio, 1.102. Sample taken in cross-cut, across the 3-foot thickness of the deposit.

621. *Cross cut, Archer's Creek property.* Limonite. Three-quarters mile northeast of Mr. Pettigrew's house, on Mr. Neighbor's land, 100 yards west of 622.

An imperfectly lamellar ore, resembling 699 and 1019.

621. Analysis: Iron, 44.40 per cent.; phosphorus, 0.630 per cent.; titanic acid, none; manganese, small amount; phosphorus ratio, 1.419. Sample taken from ore-pile at cross-cut. The cut had been partially filled in again, so that the thickness could not be ascertained.

620. *Cross-cut, Archer's Creek property.* Limonite. Three-quarters mile northeast of Wright's mill, on Mr. Williams' land.

A compact, hard ore.

620. Analysis: Iron, 53.79 per cent.; phosphorus, 0.253 per cent.; titanic acid, none; phosphorus ratio, 0.470. Sample taken in cross-cut, across the 4-foot thickness of the deposit.

619. *Cross-cut, Archer's Creek property.* Hematite. One-half mile northeast of Wright's mill, on Mr. Williams' land. A soft schistose ore.

619. Analysis: Iron, 34.12 per cent.; phosphorus, 0.120 per cent.; titanic acid, none; phosphorus ratio, 0.244. Sample taken in cross-cut, across the 2- to 3-foot thickness of the deposit.

618. *Near Oxford furnace.* Limonite (roasted). One-quarter to one-half mile southwest of the old Oxford furnace, which is about 3 miles south of Mount Athos post-office.

The furnace was abandoned some years since and is now dilapidated. Various cuts in the neighborhood, from which the furnace had been supplied, were visited, but no ore fit for a sample was found at the cuts, as the few fragments found were quite soft and greatly decomposed through long exposure. The ore-deposit extends northeast and southwest, and stands nearly vertical; said to be 1 to 3 feet thick.

618. Analysis: Iron, 50.73 per cent.; phosphorus, 0.577 per cent.; titanic acid, none; phosphorus ratio, 1.137. Sample taken from pile of ore at Oxford furnace. Mr. Banks, who formerly worked the furnace, stated that this ore had been roasted.

611. *Otter river.* Limonite. One mile and a half east of Otter river, a station on the Virginia Midland railroad, about 30 miles south of Lynchburg, on Mr. H. M. Oliver's land, one-quarter mile from his house, first ridge east.

This ridge has many blocks and fragments of limonite scattered over it. Many test-pits have been dug, but usually without striking the ore. Shaft (inaccessible) sunk by L. D. Solomon, prospector and miner for the Pig River Mining Company. Mr. Oliver, the owner of the land, stated that the shaft was about 90 feet deep; that at the depth of 50 feet a drift had been run in toward the southeast without passing out of the ore; thickness not stated. No ore had been shipped from the mine.

611. Analysis: Iron, 34.19 per cent.; phosphorus, 0.613 per cent.; titanic acid, none; manganese, considerable amount; phosphorus ratio, 1.793. Sample from about 50 tons of ore at the shaft, said by Mr. Oliver to have come from the drift 50 feet below the surface. Thickness unknown.

612, 613, and 614. *Pittsville.* Magnetite and manganiferous magnetite. One-half mile from Pittsville junction of the Pittsylvania and Franklin Narrow Gauge railroad, 9 miles from Franklin junction of the Virginia Midland railroad.

The rock in the vicinity of the ore is decomposed and disintegrated to a considerable depth, so that in no part of the mine are solid walls to be observed. A bright-red to reddish-brown clayey or sandy substance is the result of the decomposition. Here and there parts of the rock have escaped entire disintegration, and it is seen that these parts were a fine-grained schist with magnetic grains disseminated through it. In many parts the structure of the rock is preserved, though the rock is ready to fall to pieces on being disturbed. In most of the places where this occurs it is seen that the dip of the ore-seam is coincident with that of the foliation of the rock.

In five shafts in the northern part of the mine (marked 612 on the plan) the dip of the ore-seam is toward the west and northwest; in three more widely-separated shafts south of these the deposit stands nearly vertical, while in the shaft still farther south (marked 613 and 614 on the plan) the dip is to the east and southeast. The dip varies in this mine from vertical to almost horizontal. The ore-deposit has been explored in this mine to a depth of 150 feet, and for about 2,500 feet of its length. On the sketch only those shafts are indicated from which ore is being or has been taken, though between 40 and 50 shafts and test-pits have been sunk, in most of which some ore has been found. The ore in the more northerly part of the mine is a hard, steel-gray, coarsely granular magnetite.

612. Analysis: Iron, 60.87 per cent.; phosphorus, 0.072 per cent.; titanic acid, none; manganese, trace; phosphorus ratio, 0.118. Sample taken from ore on cars (3) ready for shipment. This ore came from the five shafts in the northern part, marked 612 on the plan. Thickness, 1 to 3 feet; depth, 40 to 60 feet.

In the central and also in the more southerly part of the mine the ore contains more impurities, is more decomposed, and in general softer.

613. Analysis: Iron, 59.83 per cent.; phosphorus, 0.086 per cent.; titanic acid, trace; some manganese; phosphorus ratio, 0.144. Sample taken across the thickness of the deposit in short drifts at the bottom of the five shafts marked 613 on the plan. Ordinary thickness, 3 feet; varies from 2 to 5 feet; depth, 100 to 125 feet.

In two shafts in the central part of the mine (two of those from which 613 was taken), marked 614 on the plan, a band of black, massive ore occurs alongside of the other ore. It is about 1 foot thick, and contains a large percentage of manganese. On each side of this band, and in places continuous with it, is a black pulverulent substance, said to consist largely of manganese.

614. Analysis: Iron, 26.13 per cent.; phosphorus, 0.117 per cent.; titanac acid, none; mauganese, considerable amount; phosphorus ratio, 0.448. Sample taken in two shafts in central part of mine, marked 614 on plan. Thickness, 1 foot.

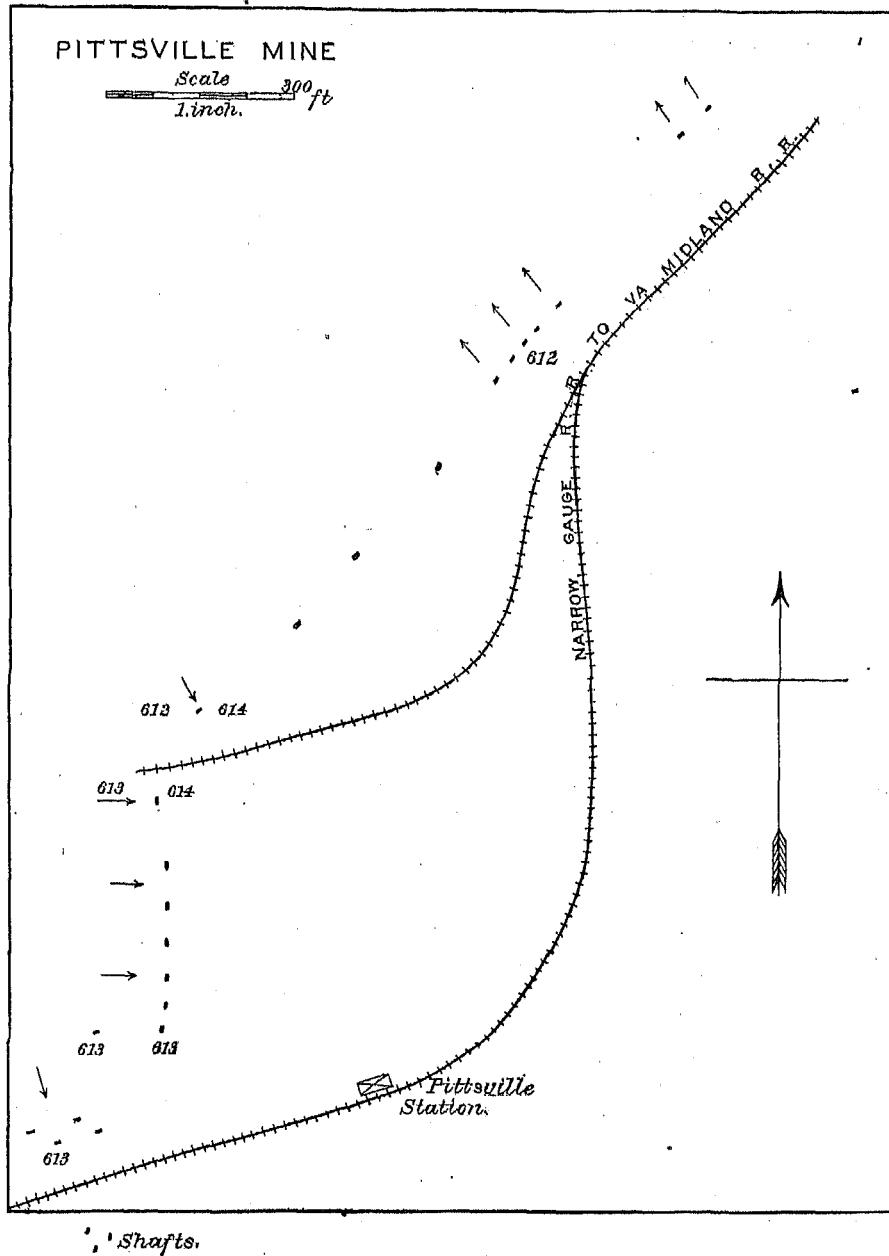
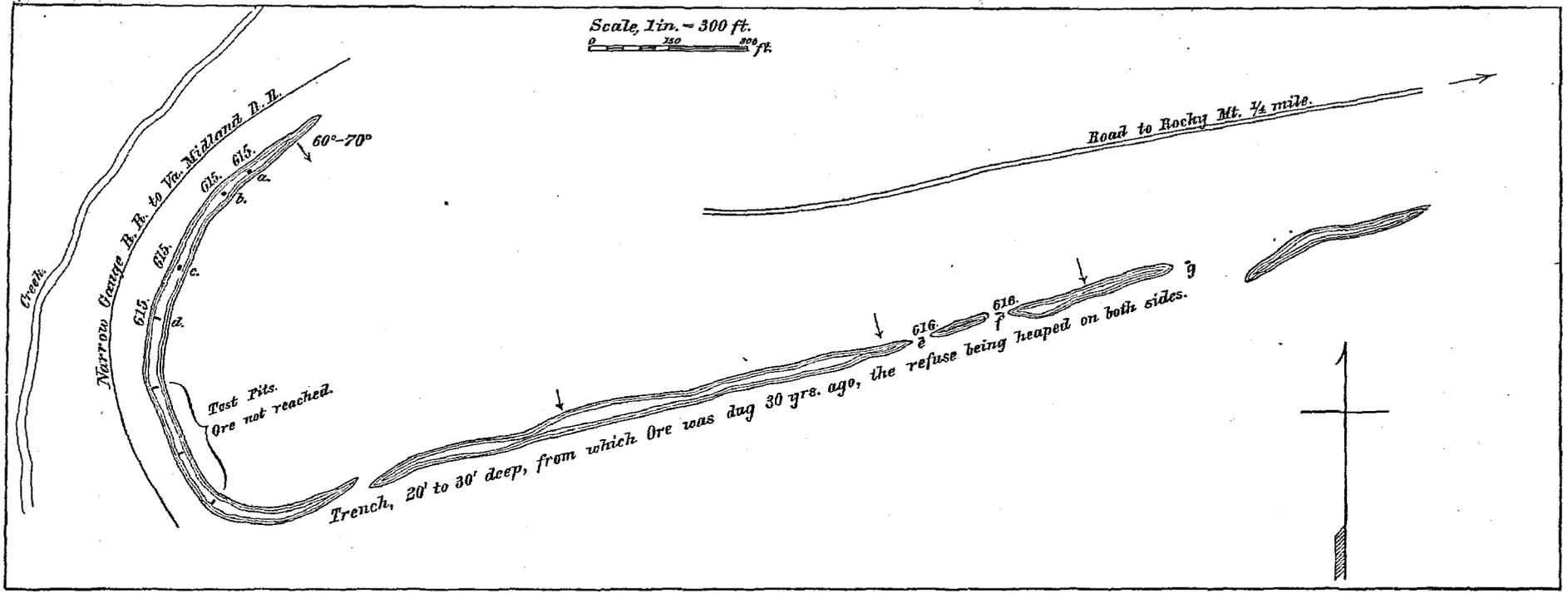


FIG. 81.

This mine has been worked about two years, and, according to the superintendent, 50,000 to 60,000 tons of ore f shipped to Pennsylvania Steel Company's furnace at Steelton, Pennsylvania. The land is leased, and the mine worked by the Pig River Mining Company, at the head of which is Major George Mason. Mr. Blackwell, ore agent of the Pennsylvania Steel Company, has had charge of the mine.

615 and 616. *Rocky Mount (Franklin)*. Magnetite. One-half mile west of Rocky mountain (Franklin Court-House). Leased and worked by Pig River Mining Company. Ore goes to Pennsylvania Steel Company, Steelton, Pennsylvania.

The deposit is composed of two parts, which are supposed by those working the mine to be continuous. The western is the part now being worked (see Fig. 82). It runs nearly northeast and southwest, dipping 60° to 70° southeast. The rock in the immediate vicinity of the ore is very much decomposed, iron-stained, and broken up by fissures. As yet no solid walls are found adjoining the ore. The present company began work about three years



- a Working shaft, 20 feet deep; ore 10 to 12 feet thick.
- b Working shaft, 20 feet deep; ore 8 to 10 feet thick.
- c Working shaft, 12 feet deep; ore 8 feet thick.
- d Test-pits with ore in sight.

- e Test-shaft with ore; sunk two years ago; depth 25 feet.
- f Test-shaft with ore; sunk two years ago; depth 20 feet.
- g Test-shaft with ore; sunk two years ago; depth 25 feet.

The numbers indicate the location of the samples; the arrows indicate the dip of the ore bed.

FIG. 82.—SKETCH OF THE OLD AND THE NEW WORKINGS ON THE IRON ORE DEPOSITS AT ROCKY POINT, VIRGINIA.

ago. They are working three shafts on the westerly deposit where the ore is 8 to 12 feet thick. Besides these *a* there is one test-pit with ore exposed, and three others in which ore had not been found at the time the mine was visited. The ore in the part worked is a very hard fine granular magnetite, quite uniform in appearance, with little rock intermingled.

615. Analysis: Iron, 53.59 per cent.; phosphorus, 0.018 per cent.; titanio acid, none; phosphorus ratio, 0.034. Sample taken across the 9-foot (average) thickness of the deposit in three shafts on the western part of the deposit; depth, 20 feet.

Following is the complete analysis of sample 615:

615.		615.	
	Per cent.		Per cent.
Sulphur.....	0.304	Carbon in carbonaceous matter.....	0.01
Phosphorus.....	0.018	Hygroscopic water.....	0.13
Iron, metallic.....	53.59	Water of composition.....	0.87
		Total.....	100.433
Silica.....	14.07	Per cent. of insoluble silicious matter.....	26.53
Iron, protoxide.....	26.79	Silica.....	14.07
Iron, peroxide.....	40.33	Alumina (with a trace of oxide of iron).....	2.46
Alumina.....	2.77	Lime.....	2.79
Manganese, protoxide.....	0.12	Magnesia.....	2.20
Lime.....	4.21	Ferrous oxide.....	4.28
Magnesia.....	2.80	Total.....	26.40
Iron, disulphide.....	0.681		
Carbonic acid.....	1.01		
Phosphoric acid.....	0.042		

b

c

d

e

The more easterly deposit runs nearly east and west, and dips, as nearly as could be ascertained, at an angle of 45° to 50° to the southward. A large amount of ore was taken from this deposit about thirty years ago by open-cut workings. There are two test-shafts 30 feet deep (inaccessible) on this deposit, and the ore from them is softer and less magnetic than that of the westerly deposit.

616. Analysis: Iron, 43.00 per cent.; phosphorus, 0.203 per cent.; titanio acid, none; phosphorus ratio, 0.472. Sample taken from piles of weathered ore at the two test-shafts on the eastern deposit. Thickness not known.

B.—SOUTHWESTERN VIRGINIA.

The principal mining region of this division lies along the southeastern portion of Wythe county, at the northwestern base of that portion of the continuation of the Blue Ridge which is known as Poplar Camp mountain toward the northeast, and as Coal ridge in its more southwesterly portion. The region extends along a part of New river, and its tributary, Cripple creek, in an east-northeast and west-southwest direction. This may be called the Cripple Creek and New River belt. In this division of the state there are several mines which lie beyond the limits of the Cripple Creek and New River belt.

CRIPPLE CREEK AND NEW RIVER BELT.

WESTERN BASE OF THE BLUE RIDGE.

These iron-ore deposits occur in connection with calcareous shales, calcareous sandstones, and impure limestones, which Professor William B. Rogers regarded as of Canadian age (*See The Virginias*, November, 1880, p. 170, where quotation from *Roger's Report on Geology of Virginia*, 1838, p. 16, is cited). Section 25, by W. B. & H. D. Rogers, gives these rocks as belonging to No. II of Rogers (the Canadian of Dana), (*The Virginias*, June, 1880, opp. p. 93).

634. *Speedwell*. Limonite. One mile south of Speedwell furnace. Owned and managed by David James & Co.

Ore disseminated in lumps and small fragments through the soil. It is roasted and washed, and used in *f* Speedwell furnace for making "neutral iron".

634. Analysis: Iron, 46.26 per cent.; phosphorus, 0.160 per cent.; titanio acid, trace; some manganese; phosphorus ratio, 0.346. Sample taken from a pile of washed ore at Speedwell furnace.

635 and 636. *Ravenscliffe*. Limonite. One-quarter mile south of Sayers & Oglesby, or Wythe furnace. Bank managed by Crockett, Tate & Co.

Small open cut. Rock in the neighborhood, limestone. Ore occurs in a fragmental state in the soil, and in the soft, crushed beds of brown, yellow, and white calcareous shale. This ore is washed and used in Ravenscliffe furnace for making "neutral iron".

636. Analysis: Iron, 42.23 per cent.; phosphorus, 0.165 per cent.; titanio acid, small amount; phosphorus ratio, 0.390. Sample taken from unwashed ore at the Ravenscliffe ore-bank.

- a 635. Analysis: Iron, 56.29 per cent.; phosphorus, 0.156 per cent.; titanitic acid, none; phosphorus ratio, 0.277. Sample taken from pile of washed ore at the washer.

Following are the complete analyses of the above samples:

	635.	636.		635.	636.
	<i>Per cent.</i>	<i>Per cent.</i>		<i>Per cent.</i>	<i>Per cent.</i>
Sulphur	0.094	0.063	Carbon in carbonaceous matter	0.06	0.03
Phosphorus	0.156	0.165	Hygroscopic water	1.17	1.23
Iron, metallic	56.29	42.23	Water of composition	11.07	10.44
			Total	99.954	100.192
Silica	4.70	17.04			
Iron, protoxide	0.44	0.96	Per cent. of insoluble silicious matter	5.28	23.92
Iron, peroxide	79.73	59.79			
Alumina	1.24	7.88	Silica	4.70	17.04
Manganese, protoxide	0.28	0.57	Alumina (with trace of oxide of iron)	0.62	5.20
Lime	0.10	0.13	Lime	0.06	0.11
Magnesia	0.63	0.82	Magnesia		0.33
Iron, disulphide	0.176	0.118	Potassa		0.54
Potassa		0.54	Soda		0.13
Soda		0.13	Phosphoric acid		0.008
Carbonic acid	0.10	0.14	Titanic acid		Trace.
Phosphoric acid	0.358	0.374	Total	5.28	23.958
Titanic acid		Trace.			

- b 637 and 638. *Sayers & Oglesby*. Limonite. One-half mile south of Sayers & Oglesby, or Wythe furnace. Bank managed by Sayers & Oglesby.

This ore is mined by an open cut, and occurs as fragments disseminated through the soil, and through the crushed and softened strata of clay and shale, the principal rock in the neighborhood being limestone. This ore is washed at Sayers & Oglesby furnace, and used there for making "neutral iron".

Two slightly different varieties of ore occur. In external characters they differ only in color, the one being yellowish brown, the other reddish brown. These are separated in mining, and used in the proportion of half-and-half in the furnace.

- c 637. Analysis: Iron, 54.21 per cent.; phosphorus, 0.179 per cent.; titanitic acid, none; manganese, small amount; phosphorus ratio, 0.330. Sample taken from piles of "yellow ore", washed at Sayers & Oglesby furnace.

638. Analysis: Iron, 53.14 per cent.; phosphorus, 0.117 per cent.; TiO_2 , none; Mn, small amount; phosphorus ratio, 0.220. Sample taken from piles of "red ore", washed at Sayers & Oglesby furnace.

639. *Sampson's, Cripple Creek*. Limonite. One-half mile south of Mr. Sampson's house, on his land.

Mining was carried on near by many years ago, and the ore used in Pierce's forge, Cripple creek; those banks are caved in, and nothing is to be seen.

639. Analysis: Iron, 51.15 per cent.; phosphorus, 0.086 per cent.; titanitic acid, none; manganese, small amount; phosphorus ratio, 0.163. Sample taken from small piles of ore at two small test-pits on Mr. Sampson's land.

- 640 and 641. *Chadwell Farm*. Limonite, and manganiferous limonite. One mile southwest of Brown Hill furnace, on Chadwell farm.

Test-pit. Between Pierce's mill and Sampson's house (both on Cripple creek) a road turns south from the Cripple Creek road. About half a mile to the south along this road, is a road through bars (to right) into the woods. This leads to a small test-pit, with a little manganiferous limonite exposed. No ore has been mined.

640. Analysis: Iron, 34.84 per cent.; phosphorus, 0.068 per cent.; titanitic acid, none; manganese, large amount; phosphorus ratio, 0.195. Sample taken from small pile of ore at test-pit.

On the same farm (Chadwell), and on the road mentioned as leading south from the Cripple Creek road, and about one-quarter mile from that road, is an abandoned tunnel, from which ore was formerly obtained. This ore was smelted in Brown Hill furnace.

641. Analysis: Iron, 54.63 per cent.; phosphorus, 0.150 per cent.; titanitic acid, none; phosphorus ratio, 0.275. Sample taken from piles of ore at mouth of tunnel.

642. *Noble*. Limonite. Two miles south of Brown Hill furnace.

This bank was not visited. The ore is used to supply Brown Hill furnace; belonging to the Lobdell Car-Wheel Company.

642. Analysis: Iron, 54.56 per cent.; phosphorus, 0.053 per cent.; titanitic acid, none; phosphorus ratio, 0.097. Sample taken from pile of washed ore at Brown Hill furnace.

630. *Walton*. Limonite. One-half mile northeast of Walton furnace. Managed by Lobdell Car-Wheel Company.

Here the ore occurs disseminated in lumps and particles through the surface soil. It is worked by simply shoveling up the soil and washing it. It is used in Walton furnace for making "neutral iron".

630. Analysis: Iron, 58.58 per cent.; phosphorus, 0.051 per cent.; titanitic acid, none; manganese, small amount; phosphorus ratio, 0.087. Sample taken from piles of washed ore at Walton furnace.

625. *Carter*. Limonite. One mile northeast of Graham's old furnace, on Reed creek. Managed by Graham & a Robinson.

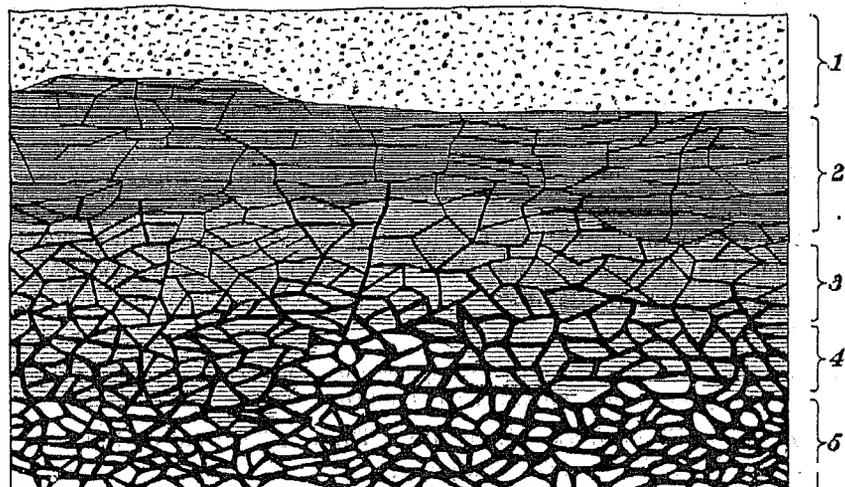
This deposit (or group of deposits) has supplied Cedar run, or Graham's old furnace, since 1839. The old workings, consisting of wholly irregular excavations, are fallen in so that nothing of them can be seen. The present workings consist of several test-pits and shafts, in only one of which, a shaft, has a workable amount of ore been found, and that is the present source of supply for the furnace.

This ore occurs in lumps of various sizes and in a finely-disseminated state, disseminated through a good deal of waste matter, which is chiefly yellow clay. The lumps are easily broken up after roasting, and the finely-divided ore is washed before being used in the furnace. The deposit forms irregular masses, inclosed in and mingled with the soil. At a short distance (50 to 100 feet) below the surface these masses narrow and run out. The rock in the vicinity is limestone. The product from this ore, "neutral iron." The iron has to be hauled 9 to 10 miles to Max Meadows station, on the Atlantic, Mississippi and Ohio railroad.

625. Analysis: Iron, 55.04 per cent.; phosphorus, 0.113 per cent.; titanac acid, none; phosphorus ratio, 0.205. Sample taken from piles of washed ore at Cedar run, or Graham's old furnace.

627. *Hurst*. Limonite. West side of Little Reed Island creek, three-quarters mile from its junction with New river. Bank owned by David Forney.

This ore was dug from the steep bank of the creek. An exposure of it in this position appears to illustrate the manner in which this and other cavernous limonites from this region were formed. Under the few inches of soil is seen a horizontally-bedded limestone, the beds being one-half inch to 2 or 3 inches thick. A portion of this rock near the top has the bedding undisturbed, but toward the side and in going downward this regularity disappears, the laminæ being broken into small pieces and lying in every possible direction. In the regular part of the rock the crevices between the beds or laminæ and the fissures running across the same are filled to some extent with seams of limonite, their maximum thickness being one-quarter of an inch. Toward the more broken part of the rock the fissures are still more filled with limonite, and the inclosed bits of limestone are somewhat softened and discolored. Farther downward the thickness of these reticulating seams is greater, and the inclosed bits are composed of soft, fine sand or brown, yellow or drab ocher. In certain parts the inclosed portions have disappeared, and the result is a cavernous mass of limonite nearly pure. (See Fig. 83.)



1. Soil.
 2. Limestone, with crevices filled with limonite.
 3. Limestone, softened and decomposed, and containing in the crevices more ore than the above.
 4. Meshwork of limonite, inclosing ocher and fine sand.
 5. Ore, with cavities (cavernous or honey-comb ore).
- Below the soil the irregular lines represent limonite; the horizontal lines, limestone.

Fig.—83. HURST BANK, Wythe county, Virginia. Vertical section, to show the relation of the ore to the limestone. Scale, $\frac{1}{16}$ nature.

About 6 feet of thickness are exposed, the lower three-fourths being limonite ore. This deposit is exposed along the bank in a horizontal direction about 75 feet, but the openings made are not sufficient to show its extent. This ore has been used in Forney's forge for making bar-iron; makes "neutral iron".

627. Analysis: Iron, 56.43 per cent.; phosphorus, 0.023 per cent.; titanac acid, none; phosphorus ratio, 0.041. Sample taken across the 4-foot thickness of ore from top to bottom.

626 and 628. *Johnson*. Limonite. West side of Little Reed Island creek, one-half mile in a southerly direction from the junction with New river.

This bank has been worked for some years to supply Forney's forge and Graham's new furnace. Irregular open cuts and excavations have been made. The ore is very cavernous limonite, requiring washing, on account of the intermingled ocher, clay, and sand, but not requiring roasting, as it is easily broken up. In places this ore forms a skeleton work running through the impure decomposed limestone; in general, however, all traces of the limestone, as such, have disappeared, and only the cavernous ore with the inclosed ocher remains. The case is similar to that described in connection with 627. Makes "neutral iron".

626. Analysis: Iron, 56.29 per cent.; phosphorus, 0.063 per cent.; titanac acid, none; phosphorus ratio, 0.148. Sample taken from piles of ore ready for shipment at the open cut in that part of the mine which has been worked for some years.

a Following is the complete analysis of sample 626:

		626.			626.
		<i>Per cent.</i>			<i>Per cent.</i>
Sulphur.....		0.062	Titanic acid		None.
Phosphorus.....		0.083	Carbon in carbonaceous matter		0.09
Iron, metallic.....		56.29	Hygroscopic water.....		2.04
			Water of composition.....		9.41
			Total.....		100.187
Silica.....		4.94	Per cent. of insoluble silicious matter.....		5.80
Iron, protoxide.....		0.43			
Iron, peroxide.....		79.85	Silica.....		4.04
Alumina.....		1.69	Alumina (with a trace of oxide of iron).....		0.72
Manganese, protoxide.....		0.15	Magnesia.....		0.05
Lime.....		0.20	Potassa.....		0.07
Magnesia.....		0.60	Soda.....		0.03
Iron, disulphide.....		0.116	Total.....		5.81
Potassa.....		0.07			
Soda.....		0.03			
Carbonic acid.....		0.39			
Phosphoric acid.....		0.191			

b To the north of the old part of the mine one-eighth of a mile a new excavation has been made to a depth of 10 to 12 feet. Here the ore occurs disseminated through crushed strata of manganiferous ochreous clay. Most of it is in small fragments, but some lump-ore occurs, and this has a structure similar to that of 626 and 627. The ore from this excavation is used to supply Graham's new furnace.

628. Analysis: Iron, 56.43 per cent.; phosphorus, 0.033 per cent.; titanic acid, none; phosphorus ratio, 0.058. Sample taken from piles of screened ore ready for washing at the new excavation.

629. *Rich Hill.* Limonite. Three-fourths of a mile southwest of mouth of Little Reed Island creek. Owned by David Forney.

Two old excavations; abandoned and caved in; no ore in place to be seen. In a tunnel, without ore, near by, it is seen that the rock along the belt containing the ore-deposits is calcareous and ferruginous shale of various colors. A part of this ore is "potty", the rest is cavernous, and similar in structure to 626, 627, and 628. Makes "neutral iron" for car-wheels, etc.

629. Analysis: Iron, 56.22 per cent.; phosphorus, 0.034 per cent.; titanic acid, none; phosphorus ratio, 0.060. Sample taken from a pile of lump-ore at the more easterly of the two pits.

632. *Panic or White Rock.* Limonite. Three miles west of Panic or White Rock furnace, on furnace property. Lobdell Car-Wheel Company.

Here a cut 6 feet wide and 15 feet deep has been made, following the ore in an approximately east and west direction for some 50 feet. Another cut 15 feet deep has been made just west of the first and at right-angles to it, without, however, striking any ore. The rock passed through is a decomposed brown, white, yellow, and gray shale. Dip nearly vertical. The ore appears to occur in an irregular mass or pocket. No solid rock is encountered in this mine.

632. Analysis: Iron, 46.61 per cent.; phosphorus, 0.125 per cent.; titanic acid, small amount; phosphorus ratio, 0.267. Sample taken across 6-foot thickness of ore in the open cut, at distance of 12 feet from the surface.

Following is the complete analysis of sample 632:

		632.			632.
		<i>Per cent.</i>			<i>Per cent.</i>
Sulphur.....		0.050	Titanic acid		0.16
Phosphorus.....		0.125	Carbon in carbonaceous matter		0.02
Iron, metallic.....		46.61	Hygroscopic water.....		1.88
			Water of composition.....		10.28
			Total.....		100.054
Silica.....		11.47	Per cent. of insoluble silicious matter.....		13.10
Iron, peroxide.....		66.52			
Alumina.....		5.42	Silica.....		11.47
Manganese, dioxide.....		3.46	Alumina (with trace of oxide of iron).....		1.50
Lime.....		0.21	Lime.....		0.05
Magnesia.....		0.11	Magnesia.....		0.06
Iron, disulphide.....		0.050	Phosphoric acid.....		0.004
Nickel, sulphide.....		0.11	Total.....		13.084
Cobalt, sulphide.....		Trace.			
Carbonic acid.....		0.08			
Phosphoric acid.....		0.284			

633. *Panic* or *White Rock*. Limonite and hematite. Two miles west of *Panic* furnace, on furnace property. **a**
Lobdell Car-Wheel Company.

Small excavation in hillside just started. The ore is disseminated in lumps and grains through the soil.

633. Analysis: Iron, 46.12 per cent.; phosphorus, 0.087 per cent.; titanitic acid, small amount; some manganese; phosphorus ratio, 0.189. Sample taken from ore-pile at the excavation. It consists of screened ore.

631. *Glade*. Limonite. Seven miles east-southeast from Wytheville.

This mine has been worked in past years, and is now being reopened to supply, in part, *Walton* furnace. Several excavations have been made, though in these the ore is not now well exposed. A tunnel has lately been run into the hillside 60 feet without striking the ore. It is seen in this locality that the rock in the immediate vicinity of the ore is a ferruginous decomposed shale. This ore has been used for making "neutral iron". **b**

631. Analysis: Iron, 49.96 per cent.; phosphorus, 0.229 per cent.; titanitic acid, none; manganese, some; phosphorus ratio, 0.458. Sample taken from pile of lump-ore just north of the mouth of the tunnel.

The deposits called *Panic* furnace and *Glade* occur on a west-southwest and east-northeast range, which lies 4 to 5 miles to the northwest of the *Cripple Creek* and *New River* range. The limestones and shales, in connection with which they occur, were regarded as of Canadian age by Professors William B. and H. D. Rogers, and were so laid down by them on section 25, *Geological Report on Virginia*. (See *The Virginias*, June, 1880, opposite page 93.)

624. *Semi-Magnetic*. Hematite and magnetite. Two miles west of Wytheville.

Two test-pits in sight of road, the deepest not over 10 feet in depth. Both contain an ore which consists of **c** a skeleton of dark steel-gray magnetic ore, the interstices of which are filled with bright-red, earthy hematite. The deposit presents no regular structure, and no true walls, as the substance adjoining the ore is the yellowish brown and reddish clay which forms the soil. The prevailing rock in the vicinity is limestone, and a bed of flint crops out a few feet to the north of the ore. This ore has never been mined, and the quantity is uncertain.

624. Analysis: Iron, 58.30 per cent.; phosphorus, 0.027 per cent.; titanitic acid, none; phosphorus ratio, 0.046. Sample taken from small piles of ore at two test-pits. Greatest thickness of ore exposed, 1½ feet.

This ore lies in a different range from either of those already mentioned as having been sampled in this division of the state. The rocks are laid down by Professors W. B. and H. D. Rogers on section 25, *Geological Survey of Virginia*, as belonging to Formation II (Canadian). (See *The Virginias*, June, 1880, opposite page 93.)

d

C.—JAMES RIVER BASIN, WEST OF THE BLUE RIDGE.

WEST SLOPE OF THE BLUE RIDGE.

The deposits under this head are distinct beds, interstratified with the heavily-bedded sandstones of the western slope of the Blue Ridge. Professor J. L. Campbell (*The Virginias*, July, 1880, page 105) discusses the geological relations of these rocks, and concludes that they are of Primordial age. He gives also a geological section to show the relations of these ore-beds to the other rocks of the Blue Ridge. **e**

645. *Wood's Property*. Hematite. Four to 5 miles a little south of west from Buchanan, old stage-road to Buford's, on Dr. Wood's land.

This deposit has never been regularly mined, but has been quite extensively opened with a view to mining. Cross-cuts have been made for several hundred feet. It is a bedded deposit with a nearly vertical dip, the adjacent rocks being stratified beds of gray, compact sandstone. At the most northeasterly opening the deposit has a thickness of 15 feet; at the others it is 5 to 7 feet thick. In external appearance the ore is a ferruginous sandstone.

645. Analysis: Iron, 42.64 per cent.; phosphorus, 0.409 per cent.; titanitic acid, none; phosphorus ratio, 0.959. Sample taken from outcrop of bed on roadside from cross-cut on ore-bed to northeast 200 feet, and from cross-cut on ore-bed to southwest 105 feet. This ore is very uniform in appearance.

644. *Arcadia Property*. Hematite (silicious). Stony creek, south-southeast from Buchanan, 3 miles (by the old **f** stage-road to Liberty) up Stony Creek valley from the James river. On the *Arcadia* Iron property.

The old stage-road to Liberty runs southward along the west bank of Stony creek, and cuts across several bedded deposits of hematitic sandstone, or "specular" ore, as it is locally called. Of these, two have been opened directly on the roadside by open cut a short distance, and then 75 to 100 feet by drift along the strike of the bed. Here the beds dip only slightly to the southeast, and have a thickness of 2 to 4 feet, with an average of about 2½ feet. The ore is charged with silicious grains. About 5,000 tons of ore (it is estimated) have been mined at this locality, but none has yet been shipped.

644. Analysis: Iron, 44.06 per cent.; phosphorus, 0.462 per cent.; titanitic acid, none; phosphorus ratio, 1.049. Sample taken across the 3-foot thickness of the bed in drift about 50 feet from road.

- a** 643. *Arcadia Property*. Hematite (silicious). South-southeast from Buchanan, up Stony Creek valley, 4 miles from James river (by old stage-road leading to Liberty). On tract of land known as the Arcadia Iron property. Here a small ravine cuts through the bed, and on each side an excavation has been started in the direction of the strike of the beds (*i. e.*, northeast and southwest). The beds of sandstone with the interbedded ore exhibit sharp, local flexures (see sketches, Fig. 84). These local flexures prevent the general dip from being learned. Professor Campbell on the section (referred to above) gives the general dip of these beds as about 65° southeast.

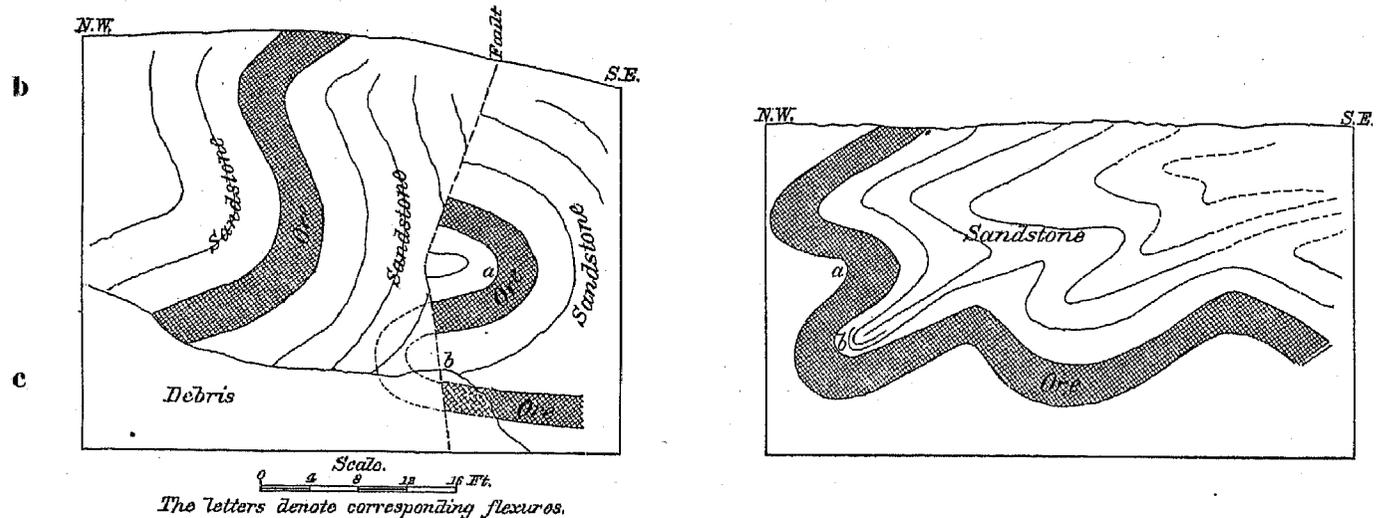


FIG. 84.—SKETCHES AT THE ARCADIA IRON PROPERTY, VIRGINIA.

By these two cuts the ore-bed has been opened for a length of about 200 feet. These excavations go about 25 feet below the surface, and are 30 to 40 feet wide. On account of the folding the amount of ore reached by this sized excavation is about 80 per cent. greater than if there had been no flexure. The thickness is 1 to 4 feet, and the average thickness about 2½ feet.

- d** 643. Analysis: Iron, 39.52 per cent.; phosphorus, 0.393 per cent.; TiO_2 , none; phosphorus ratio, 0.994. Sample taken from large pile of ore at the two cuts mentioned above. It represented ore ready for shipment, but also represents the run of the ore-bed, since the ore-bed is very homogeneous, and could not be enriched much, if any, by sorting.

To the northeast a few hundred feet is another opening on the same bed; this was not sampled, the ore looking precisely similar to that which was sampled, and the thickness was about the same.

In going along the old stage-road up Stony creek, four beds of this ore are crossed on the Arcadia Iron property. Their aggregate thickness where the road crosses them is 10 to 12 feet. Only two out of the four were sampled, *i. e.*, the second and the fourth going southeast (see Professor Campbell's section).

e WESTERN BASE OF BLUE RIDGE.

650. *Arcadia Iron Property*. Limonite. One and one-half miles northeast of Arcadia furnace, on the Arcadia Iron property.

The furnace and ore-bank were worked only a few months. The ore-pits are now fallen in, and scarce any ore is in sight at the ore-bank.

650. Analysis: Iron, 48.88 per cent.; phosphorus, 0.271 per cent.; titanac acid, small amount; Mn, small amount; phosphorus ratio, 0.554. Sample taken from small piles of ore at Arcadia furnace.

Professor J. L. Campbell (*The Virginias*, July, 1880, page 105) regards the bed of shale which contains this deposit as forming the upper member of the Potsdam. It is a common ore-bearing formation along the western **f** base of the Blue Ridge (according to Campbell, W. B. Rogers, W. M. Bowson, and Frederick Prime, jr.).

PURGATORY AND MAY'S MOUNTAINS.

The iron-ore deposits of these two mountains are regarded by Prof. J. L. Campbell (*The Virginias*, October, 1880, page 156) as occurring in connection with the shales and sandstones of the Clinton formation.

646. *Retreat*. Limonite. Purgatory mountain, 3 miles southwest of Retreat furnace. Schultz property.

This bank is situated along the top and east side, near the top, of Purgatory mountain. The workings were quite extensive in the past, the ore being used in the Etna and Retreat furnaces at the eastern base of the mountain. Nothing has been done there for twenty years, and the workings, which were open cuts, are now in ruins.

646. Analysis: Iron, 53.35 per cent.; phosphorus, 0.555 per cent.; titanac acid, none; manganese, small amount; phosphorus ratio, 1.040. Sample taken from piles of much-weathered ore at several old open cuts at the Retreat bank.

647. *Carnes*. Limonite. Purgatory mountain, 4 miles north of Buchanan. Schultz property. **a**
 Old excavation, now in ruins. No means of judging of the size of the deposit. The ore was formerly carted to the Etna furnace.
647. Analysis: Iron, 52.01 per cent.; phosphorus, 0.376 per cent.; titanio acid, none; phosphorus ratio, 0.723. Sample taken from a few lumps of weathered ore.
648. *Spengler*. Manganiferous limonite. South end of Round mountain, 4 miles north of Buchanan. Schultz property.
 Cross-cut, with a thickness of 2 to 3 feet of ore exposed.
648. Analysis: Iron, 29.59 per cent.; phosphorus, 0.031 per cent.; titanio acid, small amount; manganese, large amount; phosphorus ratio, 0.105. Sample taken from ore in cross-cut.
651. *May's*. Limonite. Five miles north of Buchanan, May's mountain west side. Schultz property. **b**
 One small excavation in hillside. Ore never shipped or used in furnace.
651. Analysis: Iron, 56.19 per cent.; phosphorus, 0.045 per cent.; titanio acid, none; manganese, trace; phosphorus ratio, 0.080. Sample taken from small pile of ore at excavation.
- 649, 700, and 1001. *Hickory Hollow* or *Salisbury Furnace*. Limonite. Foot-hills west of May's mountain, about 1 mile northeast of Mr. Pursley's house, which is 1 mile north of Saltpeter cave.
 Here a cut about 250 feet long has been made along the deposit in a nearly north and south direction, in some places to a depth of 40 feet, and the ore taken out. The ore in the upper part of the deposit, near the surface, is said to have been 20 to 25 feet thick. It is now about 8 feet thick in the bottom of the cut. The strata of buff, black, and white clay and soft shale, between which the ore body stands vertically, are very much crushed. **c**
 A tunnel extends along the deposit some 40 feet lower than the bottom of the cut. In this tunnel the ore is said to be 6 to 8 feet thick. About 500 feet to the north of this cut, and in line with it, another opening had just been started. Here the deposit is seen to be 10 to 12 feet thick.
 To the east of the main cut is a partially filled up pit 100 to 150 feet long, from which was taken in former years a large wedge shaped body of ore, which tapered downward and was 40 to 50 feet across at the top. This bank is the source of supply of Salisbury furnace, which is about 5 miles to the west-southwest.
700. Analysis: Iron, 40.17 per cent.; phosphorus, 0.287 per cent.; titanio acid, small amount; some manganese; phosphorus ratio, 0.714.
 Sample taken from ore-piles containing the lump-ore, which is taken from the main cut and the new opening. This ore is ready for the furnace. Thickness of deposit from which this came, 8 to 12 feet.
1001. Analysis: Iron, 38.64 per cent.; phosphorus, 0.273 per cent.; titanio acid, small amount; some manganese; phosphorus ratio, 0.706. **d**
 Sample represents the lump-ore from the new opening (i. e., all that is taken from it), and both the lump and the fine ore from the tunnel under the main cut; the fine ore has been washed, and thus this sample represents the output of the mine as a whole.
649. Analysis: Iron, 50.94 per cent.; phosphorus, 0.111 per cent.; titanio acid, small amount; manganese, small amount; phosphorus ratio, 0.218. Sample from small piles of weathered ore at Salisbury furnace.

BRUSHY MOUNTAIN.

The coarse sandstones, with some shaly beds, in connection with which the iron-ore deposits of this region occur, are regarded by Professor J. L. Campbell, as of Oriskany age. (See *The Virginias*, January, 1880, p. 6.)

- 652, 653, and 654. *Longdale* (Lucy Selina furnace). Limonite. Four miles northeast of Lucy Selina (Longdale) **e**
 furnace. Belongs to Fironstone, Pardee & Co.

This bank was worked 40 years ago to supply a furnace which stood near the site of the present Lucy Selina furnace. The present workings consist of four open cuts along the same line. These cuts, with the intervals, cover a distance of about 1,600 feet. The ore has been stripped but not mined in the intervals between the cuts. This deposit has every appearance of being a distinct bed of ore, though not itself stratified. Its direction is north 35° east, and south 35° west; dip about 40° southeast. It varies in thickness from 10 to 30 or 40 feet, having an average thickness of 15 to 20 feet. About one-half the ore is solid, the rest coming out in a more or less broken and finely-divided state, and the two kinds of ore are used about half-and-half in the furnace. On the upper side of the deposit lies a bed of stiff bluish-gray clay, 3 to 8 feet thick. The same formation occurs, though to a less extent, upon the foot-wall. The country rock is grayish-brown sandstone and shale; in the immediate vicinity of **f** the deposit the latter is usually much softened and broken up by fissures (see section, Fig. 85). This mine is owned by the Longdale Iron Company, who are now building another furnace next to the old one, expecting, on its completion, to make with both 500 tons of gray forge-pig per week. The old furnace makes 28 to 30 tons per day. A narrow-gauge railroad runs from Longdale station, on the Chesapeake and Ohio railroad, to the furnace (8 miles), and then on 4½ miles farther, to the ore bank.

The hand-specimens 652, 653, and 654 do not represent the ore from different parts of the mine, but different types of ore which are liable to be found in any part. Hand-specimen 652 represents best the average character of the lump-ore.

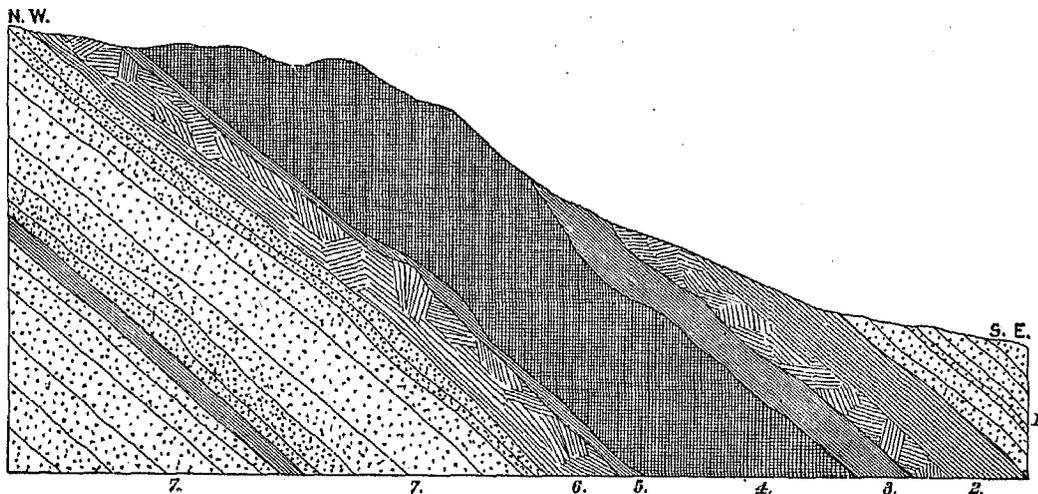
652. Analysis: Iron, 51.66 per cent.; phosphorus, 0.463 per cent.; titanio acid, none; phosphorus ratio, 0.896. Samples taken across the 15- to 30-foot thickness on ore-faces in the four cuts.

- a** 653. Analysis: Iron, 51.79 per cent. ; phosphorus, 0.224 per cent. ; titanac acid, small amount; manganese, trace; phosphorus ratio, 0.433. Samples taken from stock-pile (lump-ore), containing about 10,000 tons, near the furnace.
654. Analysis; Iron, 47.47 per cent.; phosphorus, 0.290 per cent.; titanac acid, small amount; manganese, trace; phosphorus ratio, 0.611. Sample taken from large pile of finely-divided ore near the furnace.

SECTION ACROSS THE
LONGDALE IRON-ORE DEPOSIT.

TAKEN ABOUT MIDWAY OF THE LENGTH OF THE OPENING

Scale: 1 inch to 30 feet.



- b**
- c**
1. Coarse Sandstone.
 2. Soft Shale, the beds of white, near the ore, are disturbed, and more or less crushed.
 3. Stiff, bluish-gray clay.
 4. Limonite Ore.
 5. Stiff bluish-gray clay. Absent in some parts of the deposit.
 6. Soft Shale; the beds much disturbed.
 7. Coarse Sandstone.

FIG. 85.

Following is the complete analysis of sample 652 :

	652		652
	<i>Per cent.</i>		<i>Per cent.</i>
Sulphur	0.104	Carbonic acid.....	0.07
Phosphorus.....	0.463	Phosphoric acid.....	1.060
Iron, metallic.....	51.66	Carbon in carbonaceous matter.....	0.07
		Hygroscopic water	0.91
Silica.....	9.97	Water of composition.....	10.51
Iron, protoxide.....	0.36		
Iron, peroxide.....	73.18	Total.....	100.315
Alumina.....	2.35		
Manganese, protoxide.....	0.59	Per cent. of insoluble silicious matter.....	11.64
Lime.....	0.22		
Magnesia.....	0.13	Silica.....	9.97
Iron, disulphide.....	0.205	Alumina (with trace of oxide of iron).....	1.30
Zinc, oxide.....	0.37	Lime.....	0.02
Nickel, oxide.....	0.10	Magnesia.....	0.10
Cobalt, oxide.....	0.02	Potassa.....	0.18
Potassa.....	0.18	Total.....	11.63

RICH PATCH MOUNTAIN.

For a topographical map of Rich Patch mountain, with seven geological sections across it, at intervals of 1 to 2½ miles, by Professor J. L. Campbell, see *The Virginias*, December, 1880. On these sections the geological relations of the Medina and Oriskany ore-deposits which were sampled are shown.

e 657. *Clifton Forge*. Hematite (fossil). Cliff on east side of the gorge, through which Jackson river flows.

f A drift has been run into Wilson's hill (a continuation of Rich Patch mountain), about 250 feet from the face of the cliff, in a northeast direction on the deposit, which is a stratified bed coincident with the other stratified

beds which form the anticlinal arch of this continuation of Rich Patch mountain. The drift being near the summit **a** of the arch the bed lies, at that point, nearly horizontal, though dipping a few degrees to the northwest. Along the southeast side of the drift the ore has been largely stoped out for a distance of 70 to 80 feet back from the drift, and the drift is being run still farther into the mountain. Numerous openings have been made on the outcrop of the bed along the face of the cliff, which show that the bed is pretty uniform in character. The thickness varies from 1 to 1½ feet, 2 or 3 inches of the thickness being made up of a red or brown shale-ore. (Hand-specimen, 657b.)

The ore-bed lies between heavy beds of white quartzite and sandstone above, and beds of shale or argillite below. (See Professor Campbell's geological section, next page.)

In *The Virginias*, January, 1880, p. 6, Professor Campbell states that the "red shale" and "fossil" ores mined **b** at Clifton forge are of Clinton Age; while in *The Virginias*, December, 1880, p. 188, right-hand column, 33 lines from the bottom, he quotes Professor W. B. Rogers' statement, that this ore-bed lies in the Medina sandstone, near the top, and implies that he agrees with Professor Rogers in his opinion.

The property belongs to the Charter Oak Life Insurance Company, of Hartford, Connecticut, and the ore is mined for the Quinnimont furnace.

657. Analysis: Iron, 41.71 per cent.; phosphorus, 0.444 per cent.; titanitic acid, small amount; phosphorus ratio, 1.064. Sample taken from ore ready for shipment on cars (C. and O. R. R.). Came from the drift, about 200 feet from the entrance.

655. *Callie Furnace. Old bank.* Limonite. Southeast slope of Rich Patch mountain, one-quarter mile southwest from Callie furnace. Owned and managed by D. S. Cook. **c**

The workings upon this deposit consist chiefly of an excavation about 125 feet long, 60 feet deep, and 30 feet wide, extending along the deposit in a northeast and southwest direction. About 90 feet below the bottom of the excavation a tunnel was driven in from the southeast, striking (according to a miner's statement) the same deposit. This is now fallen in. On the northwest side the ore in cut has been removed, apparently, to its limits; but on the southeast wall there is still, in nearly vertical position, a layer of ore 6 to 8 feet thick. This ore is a mixture of a blackish limonite (of massive texture and coated on the fissures with a black, varnish-like substance), with an earthy-looking, impure brown limonite. This is the ore which has supplied Callie furnace in past years.

The sandstone, in connection with which this ore-deposit occurs, is regarded by Professor Campbell (*The Virginias*, January, 1880, p. 6) as of Oriskany age. (See, also, *The Virginias*, December, 1880, between pages 185 and 186, where, on Sections II and III, Professor Campbell illustrates his view of the relations of this deposit **d** to the other formations of Rich Patch mountain.)

655. Analysis: Iron, 45.62 per cent.; phosphorus, 0.067 per cent.; titanitic acid, small amount; phosphorus ratio, 0.147. Sample taken from piles of somewhat weathered ore at the old ore-bank. Thickness of deposit probably 15 to 20 feet.

656. *Callie Furnace. New bank.* Brown shale limonite, 75 to 100 yards west of Callie furnace. D. S. Cook.

This bank is just started, and the intention is to supply the furnace with the ore which it affords. It is of the nature of an impregnation of the (nearly vertically dipping) shales and sandstones with limonite. This is apparently a lean ore. Thickness uncertain, but probably 3 to 5 feet of ore like the sample.

The intention of the furnace company is to put the furnace in blast as soon as the 5 miles of railroad which they are building, from the Chesapeake and Ohio railroad to the furnace, is completed. This railroad is already graded. The chief necessity for it is to bring coke to the furnace. **e**

656. Analysis: Iron, 25.26 per cent.; phosphorus, 0.095 per cent.; titanitic acid, small amount; manganese, trace; phosphorus ratio, 0.376. Sample taken from 1,000 to 1,500 tons of ore from the "New bank", stored in the ore-house at Callie furnace.

658 and 659. *Lowmoor.* Limonite. Two miles south of Lowmoor station and furnace, which are on the Chesapeake and Ohio railroad. Mine and furnace belong to Lowmoor Iron Company.

The workings upon these deposits were begun about five years ago, and the ore which was mined was shipped to Quinnimont and Ferrol furnaces, to the former of which it has been shipped until quite recently.

The workings consist of five nearly parallel open cuts on different folds of the same ore-beds, situated on the northeast side of Fork run, and of four tunnels or drifts, one above another, on ore-bed on the opposite side of the run. (See map, Fig. 86).

The five open cuts are 20 to 50 feet deep, and show the ore-bed to be 10 to 30 feet thick. The tunnel marked **f** 6 on the map strikes the ore-bed 83 feet below the bottom of the cut above it, while the tunnel marked 7 strikes the ore 50 feet below the cut above it. These cuts are regarded by Mr. Wickes, the superintendent of the property, as being all upon one bed, which has been folded in such a way as to make it possible to mine a great quantity of ore without going to a great depth.

Below the bed is soft, gray clay or decomposed argillite, while above is a band of clay, and a quartzite or flint-rock in a fragmentary condition. This ore is somewhat silicious.

658. Analysis: Iron, 43.84 per cent.; phosphorus, 0.636 per cent.; titanitic acid, none; phosphorus ratio, 1.451. Sample taken from pile of lump-ore, containing several thousand tons, which came from the five open cuts mentioned above. Ready for the furnace.

The four drifts (1, 2, 3, 4, on map) lie one above another all in the same bed of ore. This deposit is probably a different bed from that containing the open cuts, as it lies in a different line (though preserving the same direction).

a and the ore is of a slightly different character. The vertical distance from the lowest to the highest of these drifts is 142 feet, and the same bed outcrops at the surface of the hill above, at a height of 122 feet above the highest tunnel. The deposit is 10 to 20 feet thick. The ore is more ochreous and less silicious than that from the open cuts.

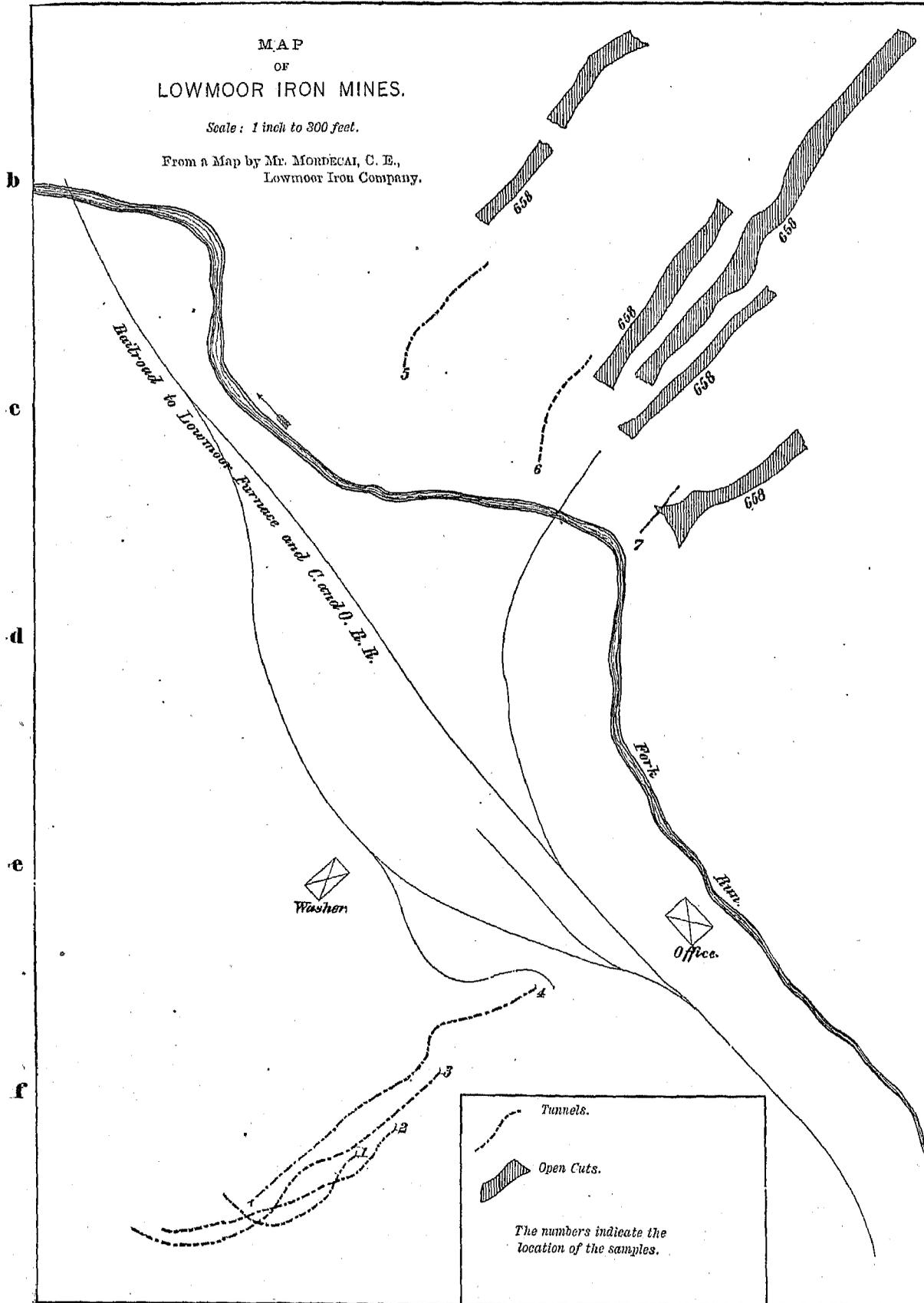


FIG. 86.

659. Analysis: Iron, 42.70 per cent.; phosphorus, 0.761 per cent.; titanio acid, none; phosphorus ratio, 1.782. Sample taken from a several piles of ore ready for the furnace, which came from the four drifts just described. Lump and a small amount of washed ore included.

Following are the complete analyses of samples 658 and 659:

	658.	659.		658.	659.
	<i>Per cent.</i>	<i>Per cent.</i>		<i>Per cent.</i>	<i>Per cent.</i>
Sulphur.....	0.007	0.007	Carbonic acid.....	0.07	0.11
Phosphorus.....	0.030	0.761	Phosphoric acid.....	1.456	1.742
Iron, metallic.....	43.84	42.70	Carbon in carbonaceous matter.....	0.06	0.00
			Hygroscopic water.....	0.03	1.46
Silica.....	22.87	21.25	Water of composition.....	9.54	9.55
Iron, protoxide.....	0.54	0.27	Total.....	99.920	99.755
Iron, peroxide.....	61.93	60.64			
Alumina.....	1.78	3.71	Per cent. of insoluble silicious matter.....	23.64	23.33
Manganese, protoxide.....	0.05	0.19	Silica.....	22.87	21.25
Lime.....	0.13	0.04	Alumina (with trace of oxide of iron).....	0.62	1.81
Magnesia.....	0.05	0.26	Lime.....	0.01	0.03
Iron, disulphide.....	0.013	0.013	Magnesia.....	0.05	0.13
Zinc, oxide.....	0.35	0.16	Potassa.....	0.14	0.00
Nickel, oxide.....	0.02	0.21	Soda.....		0.03
Potassa.....	0.14	0.06	Total.....	23.60	23.31
Soda.....		0.03			

The Lowmoor Iron Company have just built a 75-ton furnace (hot-blast, coke) at the junction of their ore railroad with the Chesapeake and Ohio railroad in order to use the ore from these deposits.

In *The Virginias*, January, 1880, page 6, Professor Campbell cites these deposits as belonging to the Oriskany formation, and in the December, 1880, number of the same journal, he shows (on Section No. IV, between pages 188 and 189) the relation of these beds to the other formations.

POTTS' CREEK.

Only outcrops observed. No mining has ever been done on this creek, or, so far as could be ascertained, within the area which it drains.

1009. *Outcrop on A. Given's land.* Limonite, silicious. Southeast side of Potts' creek, and about one-quarter mile east of A. Given's house, 20 miles southwest of Covington:

It is a ferruginous sandstone, the beds standing vertically and projecting above the other sandstones, which join it on each side. This outcrop is 12 to 15 feet thick, but only 5 to 6 feet of the thickness (so far as can be seen on the surface) is rich enough in iron to be called ore. This outcrop was traced with continuous thickness 200 to 250 feet up the hillside.

1009. Analysis: Iron, 31.97 per cent.; phosphorus, 0.164 per cent.; titanio acid, none; phosphorus ratio, 0.513. Sample taken across the outcrop, sampling only about 6 feet of the thickness, i. e., the best of the ore.

1009a and 1009b are hand-specimens from quite small outcrops on the farms of Mr. Robeson and Mr. Hamilton, Potts' creek, about 16 miles southwest from Covington.

WARM SPRINGS MOUNTAIN.

Professor J. L. Campbell (*The Virginias*, April, 1880, p. 55) gives a geological section of Warm Springs mountain through Warm Springs, Bath county, by which it appears that the Lower Helderberg limestone occurs along the southeast slope of that mountain near the base, dipping to the southeast. This formation is overlaid by the Oriskany sandstone, and this in turn by the Hamilton shales. A section observed near Covington, at the southeast base of Warm Springs mountain, agrees with the supposition that this mountain, at least along its southeast base, contains the same succession of formations at this part as it does near Warm Springs, 20 miles to the northeast at the point where Professor Campbell's section crosses. (See section, Fig. 87.)

This section runs northwest and southeast; it is taken near Mr. Dickson's house, near the Chesapeake and Ohio railroad, west of Covington, in valley leading northeast. The bottom of the valley contains gray and black shales (Hamilton). Up the mountain side next to the shales, and dipping under them to the southeast, lies strata of coarse gray and brown sandstone, containing casts of *Renssalaria ovoides* (Oriskany). Above the exposures of sandstone and dipping under them come heavy beds of fossiliferous limestone (Lower Helderberg). The sandstone formation contains, interbedded, two deposits of rather lean iron ore, one 4 feet the other 5 feet thick.

a 1010. *Dolly Ann*. Limonite. Pounding Mill run, about 3 miles above (*i. e.*, northeast of) Dolly Ann furnace, which is at the southeast base of Warm Springs mountain, about 3 miles east-northeast of Covington.

Very little mining has been done at this locality, and that was many years ago. The ore and its accompanying sandstone make a cliff along the southeast side of the valley. On account of the *débris*, it cannot be seen exactly how the ore-bed dips, but it appears to dip about 50° to the southeast, that is, away from the axial line of the valley; thus it is difficult to estimate the thickness of the bed, but there appears to be a thickness of at least 12 to 15 feet of good ore. This outcrop extends at least 800 to 900 feet in length.

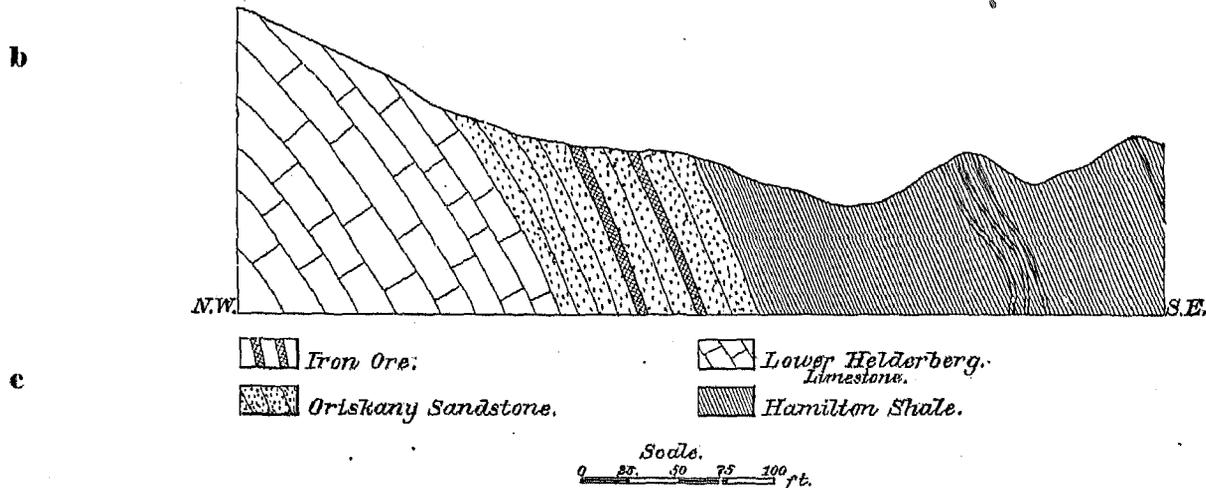


FIG. 87.—SECTION ON SOUTHEAST BASE OF WARM SPRINGS MOUNTAIN, IN VALLEY LEADING NORTHEAST FROM MR. DICKSON'S HOUSE ON THE CHESAPEAKE AND OHIO RAILROAD, WEST OF COVINGTON, VIRGINIA.

Judging from the position at the base of Warm Springs mountain and the lithological character of this ore, and the sandstone occurring with it, which are the same as those at the locality near Mr. Dickson's, the geological position is probably Oriskany.

d 1010. Analysis: Iron, 51.77 per cent.; phosphorus, 0.428 per cent.; titanio acid, trace; phosphorus ratio, 0.827. Sample taken across the 12-foot thickness of the deposit at about the middle of the exposure.

1011. *Wills'*. Limonite. One half mile southeast of the railroad station, Covington, on Mr. Wills' land.

At this mine is a loose deposit of limonite resting on and against the Upper Silurian limestone. No signs of stratification appear in it. It consists of fragments of ore scattered through a mass of sand and clay. The amount of lump-ore is inconsiderable. To obtain the fine ore all the material mined has to be screened. Several hundred tons of such ore have been obtained here and shipped to Buffalo Gap furnace.

1011. Analysis: Iron, 37.39 per cent.; phosphorus, 0.395 per cent.; titanio acid, trace; some manganese; phosphorus ratio, 1.056. Sample taken from 30 to 40 tons of screened ore at the ore-bank.

1003. *Smith-McAlister*. Limonite. One mile southeast of Covington, on Mr. McAlister's land. Leased and mined **e** by Mr. Smith.

The only workings consist of a circular excavation on the top of the deposit, close to the surface. This excavation is about 20 feet across and 5 to 6 feet deep. Some 3-foot thickness of ore has been mined over an area of about 12 by 15 feet. The ore is being hauled $1\frac{1}{2}$ miles to Covington and shipped to Lowmoor furnace.

1003. Analysis: Iron, 51.01 per cent.; phosphorus, 1.189 per cent.; titanio acid, none. Sample taken across the 15-foot thickness of the deposit.

1002. *Dickey*. Limonite. One mile north-northeast of Covington, on Burke's lands.

A tunnel has been run into the hillside about 60 feet, in ore all the way, and in a northerly direction. The deposit is about 12 feet thick, and dips 45° to the west. Mined to 15 feet below the surface. The whole deposit **f** is in a fragmental state; hardly any lumps larger than a hand-specimen occur. The whole of the ore mined is screened, and about one-half is separated as good ore. About 200 tons of ore have been mined and shipped to Buffalo Gap furnace.

1002. Analysis: Iron, 45.24 per cent.; phosphorus, 0.216 per cent.; titanio acid, small amount; some manganese; phosphorus ratio, 0.477. Sample taken at head of tunnel across the 10 feet thickness of the bed.

PETERS' MOUNTAIN.

1007. *Gay & Lewis*. Limonite. Southeast side of Peters' mountain, about 4 miles southwest of Mud tunnel, and on the land of Mr. Hanes.

The ore deposit lies in a nearly horizontal position, dipping perhaps 10° to the southeast. It lies just at the surface, in one place being covered with 2 or 3 feet of white and buff clay.

Below it rests upon chert, and is seen to be 10 to 12 feet thick. Only a small excavation, say 20 by 30 feet, has been made, so that the extent of the deposit laterally cannot be ascertained. **a**

The ore is carted 4 miles to McDowell's switch, near Mud tunnel, on the Chesapeake and Ohio railroad, and shipped to Quinnimont furnace.

1007. Analysis: Iron, 39.96 per cent.; phosphorus, 0.436 per cent.; titanitic acid, small amount; some manganese; phosphorus ratio, 1.091. Sample taken across the 10- to 12-foot thickness of the deposit from top to bottom, avoiding some bands of very silicious ore which is not shipped, and which are together about 3 feet thick, leaving 7 to 8 feet of ore sampled.

1008. *Huddleson*. Limonite. Southeast side of Peters' mountain, about 5 miles southwest of Mud tunnel, and on Mr. Huddleson's land.

The workings consist of several irregular excavations in the hillside. The ore-mass forms the top of a knoll, and the workings do not give any clue to the shape or limits of the deposit, since they are entirely in the ore. It can only be said that it is 200 to 300 feet long, 60 to 70 feet wide, and 15 to 20 feet deep.

This, however, would not give the minimum of the amount of good ore, the mass being in general much too silicious to be considered paying ore. The good ore occurs in bunches mingled with the rest in so irregular a manner that it is impossible to estimate the proportion which the ore bears to the refuse. The whole of the ore-bearing material has to be handled in order to get at the material which will pay to ship, and it is only a small proportion which is of that quality. One-third of the ore shipped is lump and the other two-thirds fine ore.

Along the southeast side of the deposit is a belt of fine ore, which is being removed by a cut 9 feet wide, extending northwest into the hillside. The fine ore is screened, about one-third being screened out as refuse. **c**

The ore is carted 5 miles, chiefly down-grade, to McDowell's switch, near Mud tunnel, on the Chesapeake and Ohio railroad. The bank is managed by Messrs. Gay & Lewis, and the ore is sent to Quinnimont and Ferrol furnaces.

The hand-specimen 1008 represents the best of the ore.

1008. Analysis: Iron, 46.49 per cent.; phosphorus, 0.252 per cent.; titanitic acid, small amount; manganese, small amount; phosphorus ratio, 0.542. Sample taken from two piles of ore ready for shipment at the bank. One pile contains about 10 tons of lump-ore, the other about 15 tons of fine ore.

1004. *Trice*. Limonite. Northwest side of Peters' mountain, 2 miles from Trice's switch, and on the land of Mrs. Kane. **d**

The ore-bed is 6 to 8 feet thick, and dips to the southeast about 30°. It is overlaid by brown and buff shales and underlaid by chert. A few hundred tons only have been mined here. The ore is hauled to Trice's switch, 2 miles distant, and thence shipped to Quinnimont furnace.

1004. Analysis: Iron, 32.24 per cent.; phosphorus, 0.525 per cent.; titanitic acid, small amount; phosphorus ratio, 1.628. Sample taken from pile of about 50 tons of lump-ore, ready for shipment at the bank.

1005 and 1006. *Sadler or Stack*. Limonite. Northwest side of Peters' mountain, near Dunlap's creek, 2 miles from Dickson's switch, about 8 miles west of Covington, in an air line, and 11 miles by road from that place. On Mr. Stack's land.

The workings here consist of several open cuts on a northeast and southwest line. The cuts extend along the northwest slope of a hill adjoining Peters' mountain proper. They are entirely in the ore, and have cut into the deposit 40 to 60 feet laterally. The main cut is 120 feet long; then come, to the southwest, 55 feet along the deposit, where the ore has been only stripped and not mined. Then another cut 50 feet long. Two hundred and fifty feet northeast of the main cut is another 40 feet long, and about 400 feet southwest of the second cut mentioned is another 60 feet long, so that the deposit has been proved for a length of about 1,000 feet. Not more than one-third of the ore is waste, and a large part of the waste is on account of its breaking up too fine in handling. The ore is pretty uniform in quality in all the cuts, and they are all similar in section to the main cut. The outcrop of the ore shows on both sides of all the cuts, and in places extends back 75 to 100 feet on the upper edge of the main cut. This ore is hauled 2 miles to Dickson's switch, on the Chesapeake and Ohio railroad. Ore has been shipped from this bank to Buffalo Gap, Ferrol, Lowmoor, and Quinnimont furnaces, but after this will probably be shipped wholly to Lowmoor. **e**

1005. Analysis: Iron, 43.71 per cent.; phosphorus, 0.462 per cent.; titanitic acid, none; some manganese; phosphorus ratio, 1.057. Sample taken across the deposit on face of ore at end of main cut. **f**

1006. Analysis: Iron, 43.71 per cent.; phosphorus, 0.380 per cent.; titanitic acid, small amount; phosphorus ratio, 0.869. Sample taken from 300 tons of lump-ore ready for shipment at the ore-bank, from the main cut, where the work is now going on.

The four banks just described lie along the base of Peters' mountain; the Gay & Lewis and the Huddleson bank along the southeast base, and the Trice and Sadler's along the northwest base. Peters' mountain is a continuation to the southwest of Warm Springs mountain, and as these ore-deposits lie in an analogous position to those at the base of Warm Springs mountain, which were found to belong to the Oriskany formation, it seems probable that these deposits also are of that age.

a

D.—SHENANDOAH VALLEY.

WESTERN BASE OF THE BLUE RIDGE.

The iron-ore deposits of this region are described by Professor J. L. Campbell as occurring in a thick bed of shale which forms the upper member of the Potsdam formation, and which immediately underlies the valley limestone (Calciferosus). (See *The Virginias*, January, 1880, p. 4, and March, 1880, p. 43.)

663. *Kennedy*. Limonite. One-quarter mile west of Kennedy furnace site. Southeast part of Augusta county. **b** Ores not worked for many years, but formerly used to supply Kennedy and Mount Torrey furnaces. The Kennedy furnace has entirely disappeared. Banks filled in and overgrown.

663. Analysis: Iron, 52.50 per cent.; phosphorus, 0.229 per cent.; titanic acid, none; manganese, small amount; phosphorus ratio, 0.436. Sample taken from small piles of much weathered ore at the ore-bank.

664. *Mount Torrey* or *Virginia*. Limonite. One mile west of Mount Torrey (Virginia) furnace. Southeast part of Augusta county. Owned by John Wissler & Son.

Open cut running nearly east and west (the Blue Ridge having locally that trend). Length about 125 feet; depth, 30 feet. It has not been worked for two years, and has now fallen in, so that little ore is to be seen in place. The ore was used to supply Mount Torrey furnace. The decomposed shale stands here about vertical; the thickness **c** of the deposit can not be determined, though it is probable that a large amount of ore has been obtained.

654. Analysis: Iron, 45.34 per cent.; phosphorus, 0.206 per cent.; titanic acid, none; phosphorus ratio, 0.454. Sample taken from piles of ore ready for use in the furnace at the ore-bank.

673. *Miller*. Limonite. One mile south-southwest of Mount Vernon furnace. Southeast part of Rockingham county.

This bank has not been worked for several years, and has caved in to such an extent that none of the ore in place is now exposed. The ore was mined from an excavation of circular form, 150 to 200 feet across and 40 to 50 feet deep. This ore was used to supply Mount Vernon furnace.

673. Analysis: Iron, 45.41 per cent.; phosphorus, 0.274 per cent.; titanic acid, small amount; manganese, small amount; phosphorus ratio, 0.603. Sample taken from pits of fine ore at Miller ore-bank.

674. *Raines & Weaver*. Limonite.

674. Analysis: Iron, 51.30 per cent.; phosphorus, 0.103 per cent.; titanic acid, small amount; phosphorus ratio, 0.201. Sample taken from piles containing several hundred tons of lump-ore at Mount Vernon furnace. The ore is a mixture of the ore from the two banks, the two sorts of ore being just alike in appearance.

Following is the complete analysis of sample 674:

	674.		674.
	Per cent.		Per cent.
Sulphur.....	0.004	Carbon in carbonaceous matter.....	0.15
Phosphorus.....	0.103	Hygroscopic water.....	0.67
Iron, metallic.....	51.30	Water of composition.....	0.89
		Total.....	99.895
Silica.....	9.08		
Iron, peroxide.....	73.28	Per cent. of insoluble silicious matter.....	11.18
Alumina.....	2.43		
Manganese, protoxide.....	0.15	Silica.....	9.68
Manganese, dioxide.....	2.84	Alumina (with trace of oxide of iron).....	1.33
Lime.....	0.07	Lime.....	0.07
Magnesia.....	0.22	Magnesia.....	0.10
Iron, disulphide.....	0.003	Phosphoric acid.....	0.020
Nickel, oxide.....	0.14	Titanic acid.....	Trace.
Carbonic acid.....	0.07	Total.....	11.25
Phosphoric acid.....	0.237		
Titanic acid.....	Trace.		

674. *Raines*. Limonite. Four miles north-northeast of Mount Vernon furnace. Southeast part of Rockingham county. Mount Vernon Iron-Works Company, lessees.

The workings consist of an open cut 700 feet long, 20 to 50 feet wide, and 10 to 25 feet deep, running north 35° east. Ore occurs with shale, dipping only a few degrees to the northwest. Ore formerly used to supply Mount Vernon furnace. Cut caved and washed in, so that ore in place can not well be observed. The Weaver bank is a similar cut, just to the northeast of this one. It was not sampled separately, though the ore from the two was sampled together at Mount Vernon furnace.

675. Analysis: Iron, 41.15 per cent.; phosphorus, 0.231 per cent.; titanic acid, small amount; manganese, small amount; phosphorus ratio, 0.561. Sample taken from washed-ore piles at Raines' bank.

f

665, 666, 667, and 668. *For Mountain, Shenandoah Iron-Works.* Limonite. One-quarter mile southwest of a Furnace No. 2, belonging to the Shenandoah Iron-Works.

This deposit has been worked for about twenty years. The workings consist mainly of one large pit about 275 feet long, 150 feet wide, and 50 feet deep, running about north and south. At the bottom a tunnel extends from the west side in a westerly direction 175 feet. This tunnel is 10 feet wide and 10 feet high, is driven all the way in ore-bearing material, and is still being driven farther in a westerly direction. Two shorter tunnels of the same height and width extend in the same direction, one on each side of the main tunnel. The whole of the material in which these workings have been made is ore-bearing. It is a stratified deposit, the beds lying nearly horizontal, though showing local crumplings. The deposit consists of a great number of thin beds (one-quarter inch to 3 or 4 inches) of ocher and soft ferruginous shale and clay, of colors varying from light yellow to brown and black, with very thin layers of limonite interlaminated. A few layers, several inches thick, of limonite and mangiferous limonite occur, but these form a very insignificant proportion of the whole.

The whole deposit is mined, screened, and about one-half saved as good ore; of this the coarser part is roasted, and the finer is washed and roasted before being used in the furnace. The prepared ore thus obtained is all used in "Furnace No. 2" of the Shenandoah Iron-Works (William Milnes, jr., lessee), the pig being made into charcoal-blooms for boiler-plates at the forge of the iron-works, near Shenandoah Iron-Works post-office.

The hand-specimen 665 represents what little lump-ore there is in the deposit, while the samples 665, 666, 667, and 668 represent different stages of the preparation of the ore for the furnace.

- 665. Analysis: Iron, 41.17 per cent.; phosphorus, 0.215 per cent.; titanio acid, small amount; phosphorus ratio, 0.523. Sample taken from ore in the main tunnel. Raw, screened.
- 666. Analysis: Iron, 46.29 per cent.; phosphorus, 0.166 per cent.; titanio acid, small amount; phosphorus, ratio, 0.359. Sample taken from large pile of fine ore at the washer near the ore-bank. Screened and washed.
- 667. Analysis: Iron, 43.96 per cent.; phosphorus, 0.078 per cent.; titanio acid, small amount; phosphorus ratio, 0.177. Sample taken from pile of fine ore at the kiln near furnace. Screened, washed, and roasted.
- 668. Analysis: Iron, 49.25 per cent.; phosphorus, 0.224 per cent.; titanio acid, small amount; phosphorus ratio, 0.455. Sample taken from a pile of the coarser ore in the ore-house near the furnace. Screened and roasted.

Following is the complete analysis of sample 665:

	665.		665.
	<i>Per cent.</i>		<i>Per cent.</i>
Sulphur	0.010	Titanic acid	Trace.
Phosphorus.....	0.215	Hygroscopic water	1.27
Iron, metallic.....	41.17	Water of composition.....	11.28
		Total	99.837
Silica	20.03	Per cent. of insoluble silicious matter.....	25.15
Iron, peroxide	58.00	Silica	20.03
Alumina	0.71	Alumina (with trace of oxide of iron).....	5.05
Manganese, protoxide	0.02	Lime	0.10
Manganese, dioxide	0.32	Magnesia.....	0.02
Lime	0.17	Total	25.20
Magnesia	0.00		
Iron, disulphide	0.019		
Carbonic acid.....	0.14		
Phosphoric acid	0.498		

MASSANUTTON MOUNTAIN.

In *The Virginias*, March, 1880, p. 35, Frederick Prime, jr., states that the iron-ore deposits of Massanutton mountain are contained in the slates and shales of the Clinton formation.

670. *Three Top Mountain.* Limonite. Two miles north of Mine run, or Boyer's furnace, Massanutton mountain.

This bank, as well as the furnace, has been abandoned for several years, and the workings are fallen in. A large quantity has been mined and brought to Mine Run furnace.

670. Analysis: Iron, 43.78 per cent.; phosphorus, 0.153 per cent.; titanio acid, small amount; some manganese; phosphorus ratio, 0.349. Sample taken from two large piles of lump-ore at Mine Run furnace.

NORTH MOUNTAIN.

This mountain lies along the northwestern part of Augusta and Rockbridge counties, but east of Mill mountain, which is a continuation (to the northeast) of Rich Patch mountain. The deposits which were sampled belong, according to Professor J. L. Campbell, to the Oriskany formation (see *The Virginias*, January, 1880, p. 6).

a 661 and 662. *Grace*, formerly *Ferrol*. Limonite and hematite. Three-quarters mile southeast of Elizabeth, Ferrol, or Grace furnace, which is on the Chesapeake and Ohio railroad. Belongs to Pennsylvania and Virginia Iron and Coal Company.

Mining was begun here eighteen years ago by the Confederate government. The workings consist of an excavation running for about one-quarter mile in a northeast and southwest direction along the northwest side of a hill at the northwest base of North mountain. The rocks (soft slate and soft sandstone) dip 40° to the southeast, and the ore-bed appears to be coincident with the other stratified beds. It outcrops along the hillside with a variable thickness, averaging 10 to 12 feet. The ore is largely in a soft, fragmental state, but contains bands of hard limonite from 1 to 2 feet thick, and also a bed of soft red shale or earthy hematite ore, 2 to 3 feet thick, at certain parts of the outcrop. A tunnel is being driven in to strike the ore-bed 100 feet below the outcrop.

661. Analysis: Iron, 46.19 per cent.; phosphorus, 0.289 per cent.; titanic acid, small amount; phosphorus ratio, 0.626. Sample taken to show the output of the mine from two car-loads of limonite ore ready for shipment to Quinimont, the Grace furnace not being in blast at the time.

662. Analysis: Iron, 29.87 per cent.; phosphorus, 0.246 per cent.; titanic acid, small amount; some manganese; phosphorus ratio, 0.824. Sample taken from 15 to 20 tons of the red-shale ore at the furnace, ready for use in the furnace. The bed of this ore was not well exposed at the time.

660. *Buffalo Gap*. Limonite. One-half mile north-northeast from Buffalo Gap furnace, which is on the Chesapeake and Ohio railroad. Belongs to the New York and Virginia Iron and Coal Company.

c The workings consist of an open cut, 75 feet long, running in a northeast and southwest direction, from the northeast end of which a tunnel runs northeasterly without yet striking any more ore. Some thousands of tons of ore have been taken from the cut, but the ore-deposit seems to come to an end near the mouth of the tunnel.

660. Analysis: Iron, 41.51 per cent.; phosphorus, 0.310 per cent.; titanic acid, none; manganese, small amount; phosphorus ratio, 0.747. Sample taken from pile of lump-ore, ready for use in furnace, at the ore-bank, as the thickness of the deposit is not well exposed.

GREAT NORTH MOUNTAIN.

This mountain runs along the northwest border of Shenandoah county, in a north-northeast and south-southwest direction. Professor J. L. Campbell gives a section showing the structure of the southern continuation of this mountain and the relations of its ore-beds, 12 miles to the southeast of Liberty Furnace bank (one of those sampled), by which it appears that the ores of this mountain are of Upper Silurian age (*The Virginias*, September, 1880, p. 140).

671. *Old Bank, Liberty Furnace*. Limonite. One-half mile north of Liberty furnace. Belongs to John Wissler & Son.

First worked fifty years ago. Present workings begun five years ago. They consist of an open cut about 400 feet long, 10 to 50 feet wide, and 10 to 60 feet deep. Direction, north 15° east and south 15° west.

The deposit consists of a succession of ferruginous shales and clays of various colors, standing vertical with a number of intercalated beds of hard limonite and a little red-shale ore. The proportion of good ore in the deposit is very variable. Thickness of the part mined varies from 10 to 20 feet, and it is said that about two-thirds is good ore. This ore is used, in connection with 672, to supply both Liberty and Columbia furnaces.

671. Analysis: Iron, 41.71 per cent.; phosphorus, 0.114 per cent.; titanic acid, small amount; phosphorus ratio, 0.273. Sample taken from pile of several hundred tons of lump-ore ready for use at the furnace.

672. *Hollow Bank, Liberty Furnace*. Limonite. One-half mile north-northeast from Liberty furnace. Owned by John Wissler & Son.

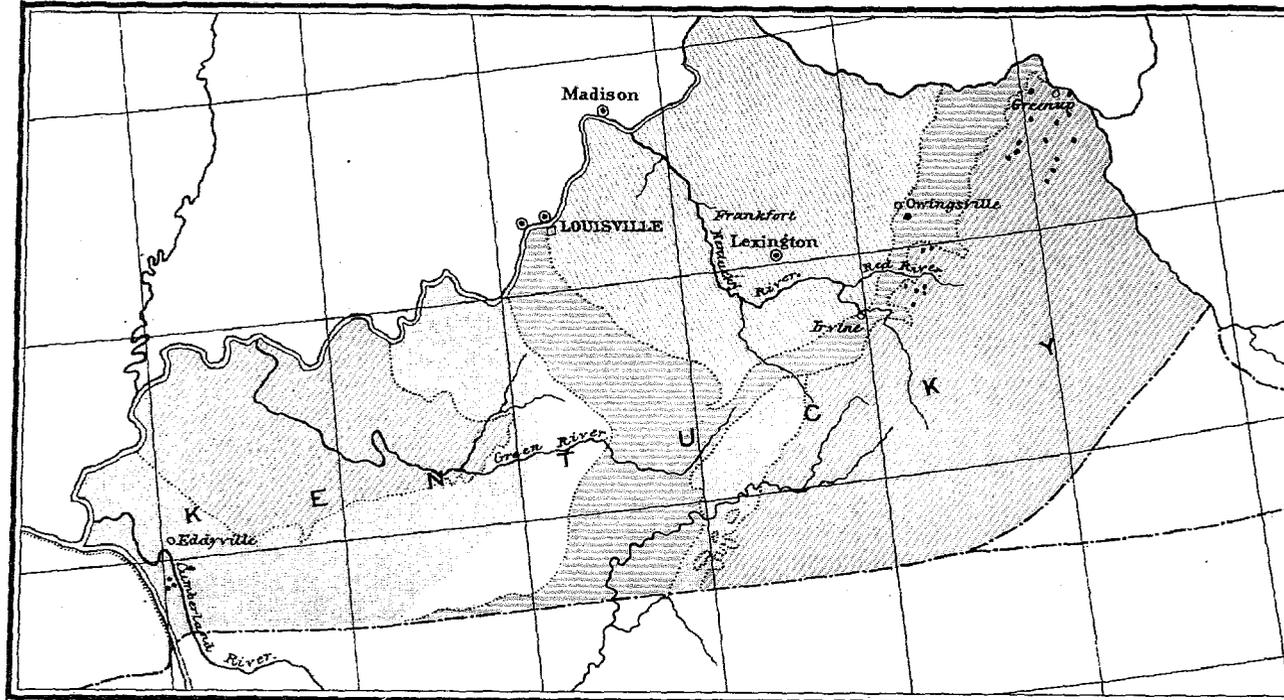
Open cut, about 175 feet long and 5 to 10 feet deep, running north 20° to 30° east. In same line, to north-northeast, three shafts have been sunk, 30 feet, 75 feet, and 45 feet, respectively, in depth. The structure of the deposit is similar to that of 671, though there is a larger proportion of hard ore. The deposit here is 3 to 5 feet thick. This ore is used, in connection with 671, to supply Columbia and Liberty furnaces.

672. Analysis: Iron, 43.90 per cent.; phosphorus, 0.076 per cent.; titanic acid, small amount; phosphorus ratio, 0.173. Sample taken from piles of lump-ore at Liberty furnace from Hollow bank.

669. *West Bank, Van Buren Furnace*. Limonite. One and one half mile southwest of Van Buren furnace, on the southeast slope of Paddy mountain, an offshoot from Great North mountain. Belong to Frank King.

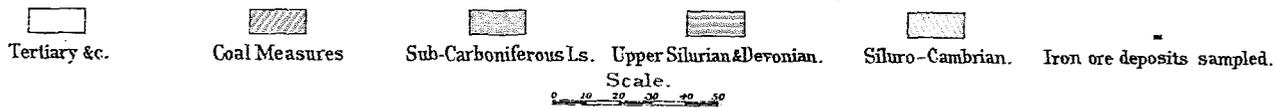
Mining was begun here eleven years ago, but none has been done in the last seven years until six months ago. The present workings consist of a tunnel, 300 to 400 feet long, running into the hillside in a westerly direction. The deposit consists of a great number of crumpled strata of softened ferruginous shales, white, pink, yellow, and brown, with numerous thin layers of limonite intercalated. Dip very variable, but the strike is about north-northeast and south-southwest. The ore is used for supplying Van Buren furnace. Thickness very variable; from 2 to 5 feet of good ore.

669. Analysis: Iron, 35.26 per cent.; phosphorus, 0.066 per cent.; titanic acid, small amount; some manganese; phosphorus ratio, 0.187. Sample taken from pile of lump-ore ready for the furnace, at the ore bank.



IRON ORE SAMPLE MAP OF KENTUCKY.

Geology generalized from a preliminary Map of the Kentucky Geological Survey.



John Ross & Co. Lith.

The ores of the Clinton group, in Kentucky, are represented at only one locality, the Old Slate Furnace bank, **a** in Bath county. (See the map of the region, Fig. 90).

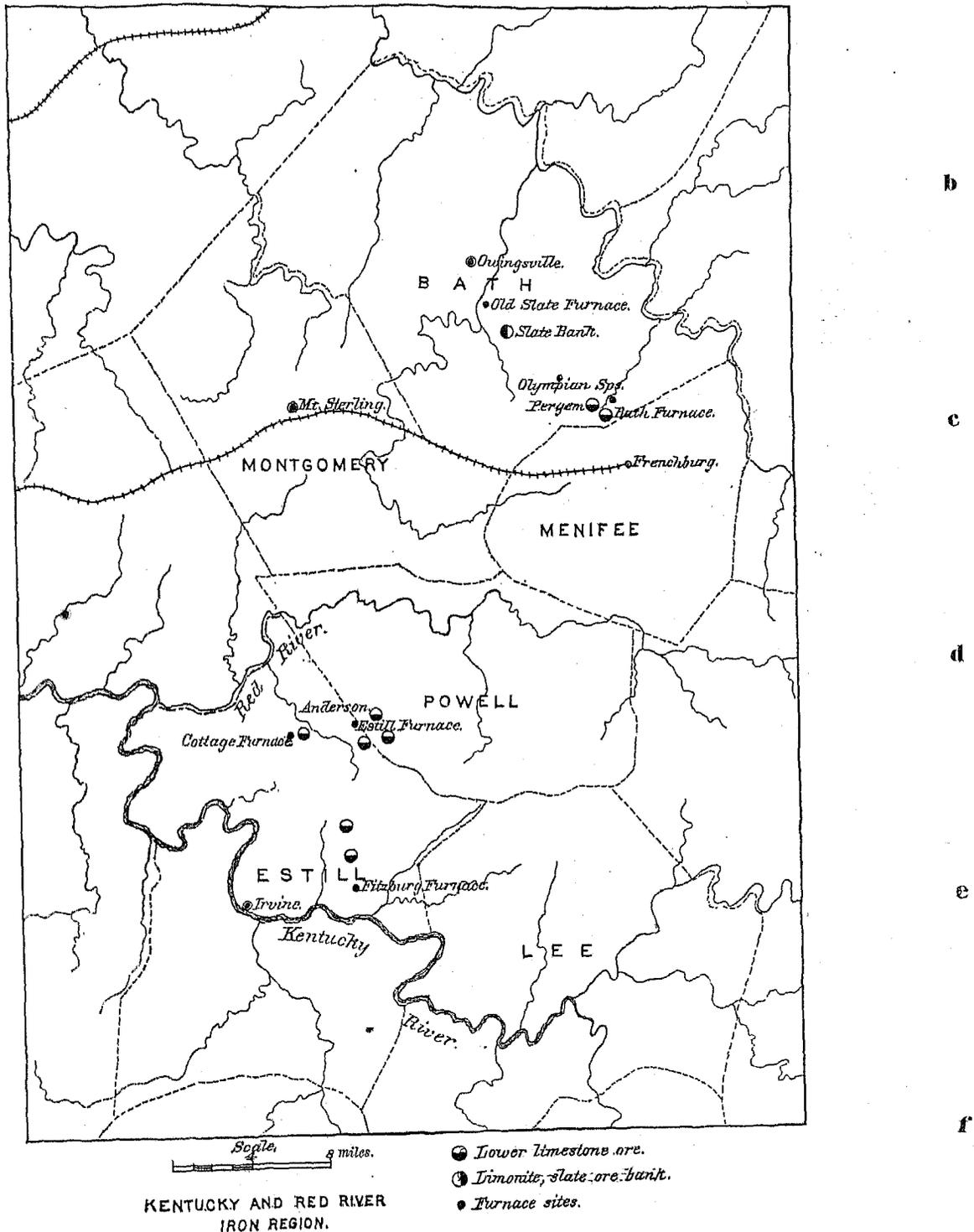


FIG. 90.

The Old Slate furnace was the first in the state, and was built in 1791. It is situated on Slate creek, 5 miles south of Owingsville, on the road to Olympian Springs. That portion of the bank from which the ore was taken is known as the *Block house* bank, and is $1\frac{1}{2}$ mile south of the furnace on the same road. The bank covers two or three low hills, and, though now abandoned, the pits and diggings from which the ore was formerly taken are seen on either side of the road and in the adjoining fields. The ore is an altered red hematite which, in its general appearance, seems related to the Dyestone group. It is a limonite, at times quite hard and compact, at times porous and fossiliferous, and of a reddish brown color. It is similar in texture and occurrence to the ore found near the Marion furnace, in Wayne county, Tennessee.

a The sample was drawn from lumps of ore scattered through the fields and from old dump-piles near the diggings, and gives, upon analysis—

	585.
	<i>Per cent.</i>
Metallic iron.....	51.68
Phosphorus.....	1.094
Phosphorus ratio.....	2.121

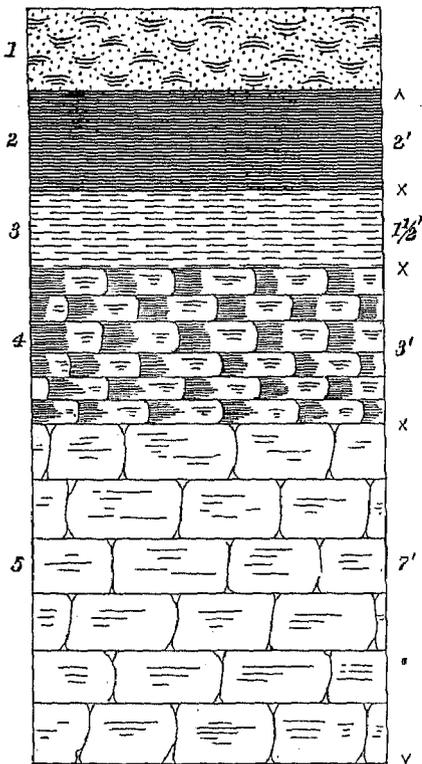
The carbonate ores occurring in the Coal Measures of eastern Kentucky are mined as far west as Bath, Powell, and Estill counties, the bed there worked, however, being only the lowest in the series, known as the lower limestone ore, and resting upon the sub-Carboniferous limestone.

Bath furnace, 6 miles southeast of Olympian Springs, in Bath county, is one of two furnaces at present in blast in this middle iron region.

The principal ore-banks are situated from 2 to 4 miles from the furnace farther up the creek. The ore is found outcropping near the crowns of the ridges on either side of the stream-bed, and is worked by benching in open cuts. The ore-bed is from 2½ to 3 feet in thickness, as seen at the *Pergem* bank, where the section shown (Fig. 91) was taken. The ore occurs in jointed layers and blocks, the interior of which is unaltered carbonate, while the outer layers are much changed to limonite.

Two samples were here taken, No. 583 from the Pergem bank, No. 584, an average sample, from the stock-pile at the furnace. These samples show, upon analysis—

	583.	584.
	<i>Per cent.</i>	<i>Per cent.</i>
Metallic iron.....	50.65	44.51
Phosphorus.....	0.183	0.262
Phosphorus ratio.....	0.361	0.634



1. Clay.
2. Black slate.
3. White shale.
4. Limestone ore.
5. Sub-Carb. limestone.

FIG. 91.

The *Anderson* bank is half a mile northeast of the furnace. The ore is a carbonate in all stages of alteration, from a blue ferruginous limestone, deep upon the bed, to a true limonite on exposed and weathered surfaces. The accompanying section (Fig. 92) was taken at the only opening on the *f* Anderson bank, and represents the working-face at the head of a short tunnel upon the ore-bed. The tunnel had reached a depth of 20 feet from the outcrop, and at this distance the ore-mass had much the appearance of an unaltered limestone, having a pale-blue fracture and streak. Its thickness is variable, and the upper portion of the bed more altered than that resting directly upon the underlying limestone. The cavities in the ore-mass, marked *a, a, a* in the cut, were filled with yellow and gray clay; those marked *c, c, c* were lenticular in shape, and surrounded by a somewhat altered liver-colored ore.

The sample taken at the point above described comes from the whole thickness of the bed at the head of the tunnel, and is known as the "blue ore".

d This result shows the advantage to be gained by careful selection of ores. The Red River iron-works include Estill, Fitzburg, and Cottage furnaces, all situated between the Red and Kentucky rivers, in Estill county. The preceding map shows their location.

Of these, Estill furnace alone was in blast when the region was visited. The ore bed from which the furnace is supplied is the same as that described in Bath county, namely, the lower limestone bed of the carbonate ores. The furnace is situated in the northern part of Estill county near the Powell county line.

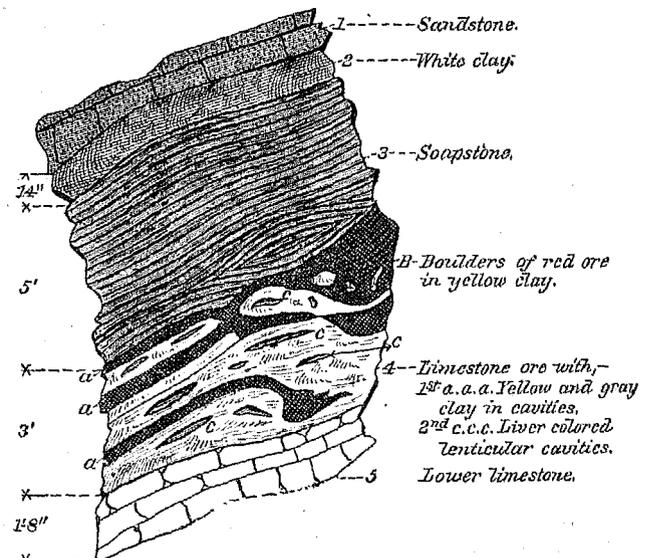


FIG. 92.

A second sample was taken from a small prospecting pit, sunk upon a shoulder of ore some hundred feet a southeast of the above opening.

This pit exposes a much altered portion of the bed, and shows a limonite in hollow concretions, the cavities often filled with a scoriaceous sandy material, resembling the silicious porous cinder from a charcoal furnace.

The sandstone shown in Fig. 92 here dips directly upon the ore-bed, accounting partly for its greater alteration. This ore is known as the "red ore", and is compared with the blue ore above mentioned in the following analysis:

	586.	587.
	<i>Per cent.</i>	<i>Per cent.</i>
Metallic iron	34.94	47.51
Phosphorus.....	0.273	0.181
Phosphorus ratio	0.781	0.381

No. 586 is the "blue ore". No. 587 is the "red ore".

The result exposed well the nature of the unaltered ore deep upon the bed.

A third sample, taken from the stock-piles at the furnace, and representing ore from many pits, shows, upon analysis—

	588.
	<i>Per cent.</i>
Metallic iron	45.50
Phosphorus.....	0.528
Phosphorus ratio	1.100

These ores are but poorly worked, the farmers of the neighborhood bringing it at will to the furnace and selling it by the ton. The management does not attempt to control the miners, either as to time of work or methods of mining. The banks of the Fitzburg and Cottage furnaces, which were opened in the same irregular manner, offered no opportunity for proper sampling, having been long abandoned.

The Hanging Rock region of Kentucky includes Carter, Boyd, and Greenup counties, and a portion of Lawrence.

The ores are carbonates and limonites, altered from carbonates, occurring in horizontal beds at well-defined horizons.

The division of these ores adopted by Mr. P. N. Moore, in the *Geological Survey of Kentucky*, (Vol. 1, p. 69), is as follows:

- (a) The limestone ores.
- (b) The block ores.
- (c) The kidney ores.

The limestone ores are so called because they rest upon limestones.

The block ores are so called from their peculiarity of cleaving into square-cornered blocks.

The kidney ores are named from the shape which they usually assume.

Many names are given by the miners to the different varieties under each of these groups, among which are the following:

Big block, little block, big blue block, little blue block, big yellow kidney, little yellow kidney, black kidney, red kidney, lime kidney, roll kidney, upper limestone, lower limestone, slate ore, flag ore, china ore, gray lime.

The terms "big" and "little" block have reference to the thickness of the ore-bed, while the same terms applied to the kidney ores refer to the size of the individual kidneys, regardless of the thickness of the bed through which they may be scattered.

The terms yellow, black, and red are applied to the kidney ores according to the color of the ore, though reference is sometimes had, as in the case of the yellow kidney ores, to the color of the adhering clay.

Roll kidney is a peculiar rough ore, sometimes forming a continuous layer across a bed of kidney ore.

The limestone ores take their names from the horizons at which they occur, the upper ones lying above what is known as the ferriferous limestone, the other occurring above the lower or sub-Carboniferous limestone, as above described.

Flag and slate ore are names given to certain local ores which occur in thin slabs or flags.

The term china ore is given to a coarse, sandy variety, of irregular occurrence, while the name of gray lime is applied to certain portions of the limestone ore, which is little altered and of a clear unspotted gray.

The limestone ores vary from unaltered carbonates or siderites to limonites.

The block ores show unaltered carbonate in the center of the blocks, surrounded by layers completely changed to limonite, while the kidney ores are cores of carbonate, inclosed by concentric layers of limonite, which at times constitute the entire kidney.

a The accompanying map of the Hanging Rock region, Fig. 93, shows the location of the various furnaces and the principal mining localities.

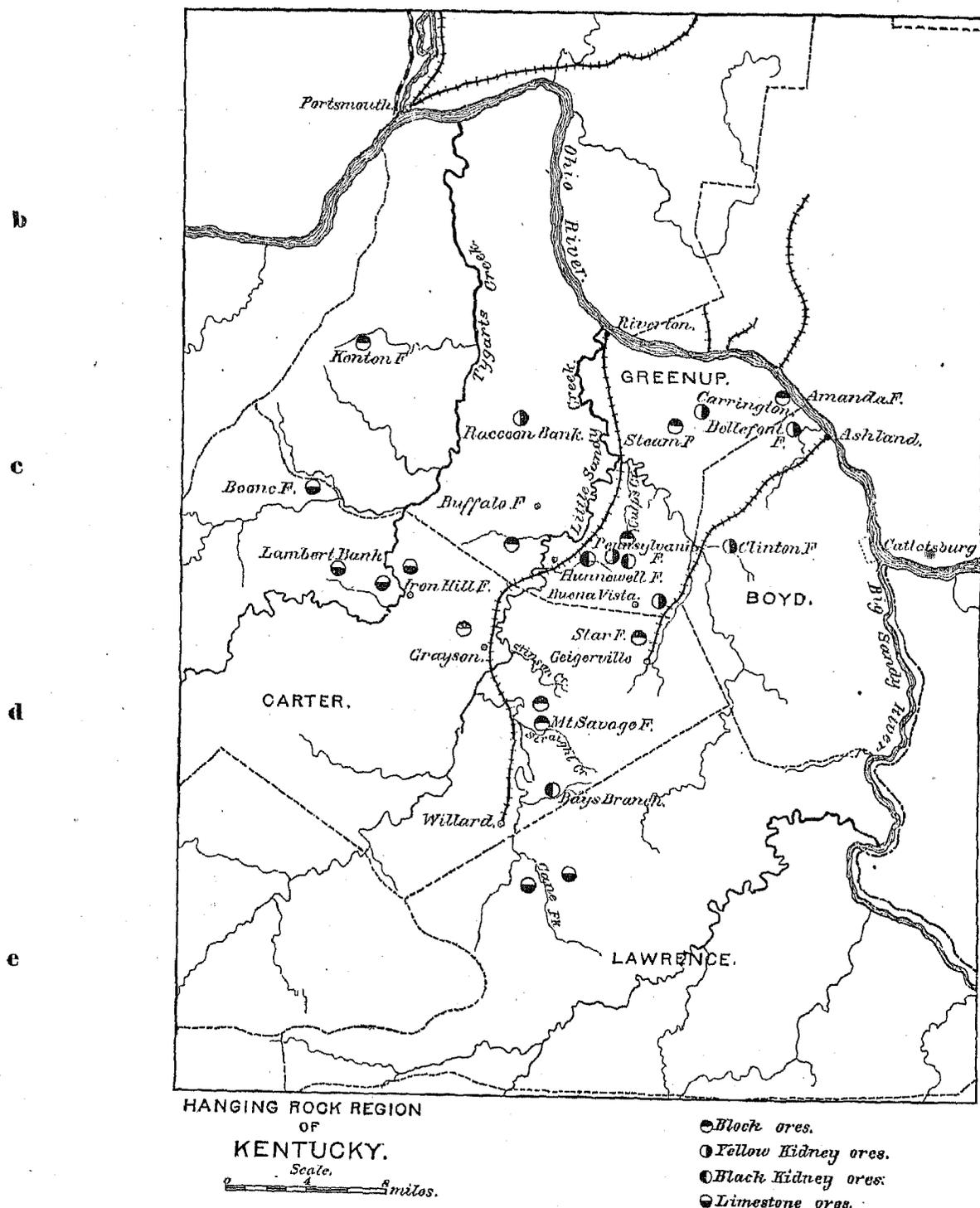


FIG. 93.

Samples were taken from none but working-pits, as all abandoned diggings were covered and fallen, and it was therefore impossible to secure average samples of the ore.

The ore in this region is almost invariably mined by stripping and benching, though in one or two instances short tunnels were run upon the bed.

On *Reuben's branch* of East Fork, north of Pennsylvania furnace, in Greenup county, the little block ore has been quite largely worked.

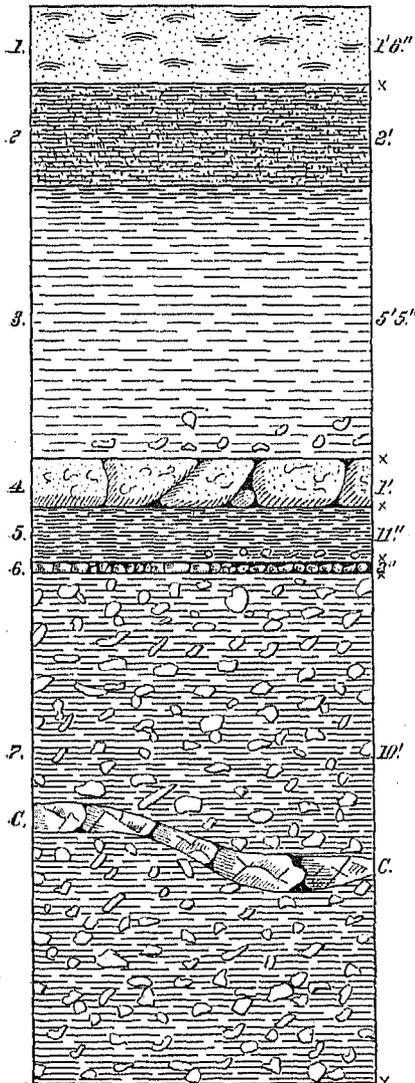
The accompanying cut (Fig. 94) shows the ore-bed as opened west of the branch near the crown of the main ridge.

The ore was exposed by stripping, and was opened along 100 feet on the horizontal bed at this point. The kidney ore lying above the slate was not being worked, the quantity being very small. It is almost entirely altered to limonite, and the kidneys are much softened.

The block ore below the slate showed little unaltered carbonate. The blocks were often hollow or contained cavities filled with sandy clay, surrounded by a dense hard limonite. The analysis of two samples, the first of the kidney ore, the second of the block ore below the slate, yield results as follows:

	593.	594.
Metallic iron.....	54.39	32.02
Phosphorus.....	0.167	0.227
Phosphorus ratio.....	0.306	0.700

The kidney ores are largely worked for Pennsylvania furnace.



- 1. Clay.
- 2. Micaceous Shale.
- 3. Olive Shale.
- 4. China Ore.
- 5. Black Shale.
- 6. Black Kidney.
- 7. Olive Shale with Yellow Kidney Ore.

FIG. 95.

Fig. 95 shows a section taken at the *Blancet mine*, on Pea Ridge, 1 mile south of the furnace.

The main ore-bed is that bearing the big yellow kidney, marked 7 in the cut. These kidneys, which occur irregularly scattered through the shale, vary in size from small grains to 6 inches in diameter. The cores are of dense unaltered carbonate, often crossed by fine veins of calcite. About this inner unaltered carbonate are concentric layers of limonite, which are, however, much folded and contorted, and are covered on the outermost surface with soft yellow ocher. This bed is divided at C by a rough layer of purplish ore, of irregular thickness, which is called "roll kidney". The bed of black kidney ore at 6, though only 2 inches in thickness, shows kidneys changed to limonite throughout. The bed is not thick enough to work alone, but the ore is separated in the process of benching for the yellow kidney which lies below it.

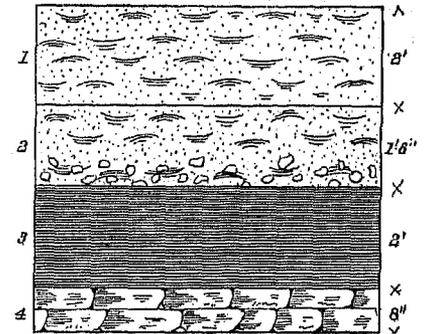
At 4 is a well-defined bed of coarse ore, with brown concentric rings, alternating with sandy layers. The outer coating is a dark-brown, sandy limonite, called china ore, and rejected at the furnace.

The ores from these four beds are compared in the following analyses:

	595.	596.	597.	598.
	Per ct.	Per ct.	Per ct.	Per ct.
Metallic iron.....	54.65	32.27	32.01	31.49
Phosphorus.....	0.698	0.423	0.513	0.139
Phosphorus ratio.....	1.278	1.311	1.603	0.441

No. 595 is the black kidney ore from 6. No. 596 is yellow kidney ore at 7. No. 597 is the roll kidney ore at C. No. 598 is the china ore from 4.

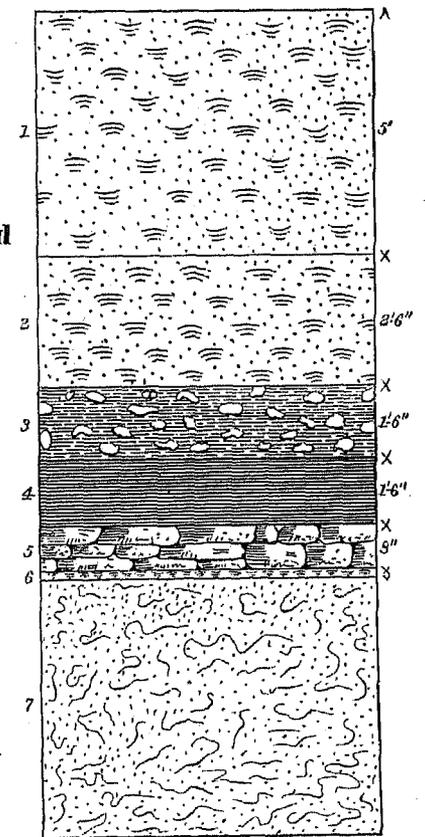
It will be seen from the above that the black kidney ore, though it contains the highest per cent. of iron, has also the



- 1. Yellow Clay.
- 2. White Clay with Kidney Ore.
- 3. Gray and Black Slate.
- 4. Block Ore.

FIG. 94.

The main ore-bed is that bearing the big yellow kidney, marked 7 in the cut. These kidneys, which occur irregularly scattered through the shale, vary in size from small grains to 6 inches in diameter. The cores are of dense unaltered carbonate, often crossed by fine veins of calcite. About this inner unaltered carbonate are concentric layers of limonite, which are, however, much folded and contorted, and are covered on the outermost surface with soft yellow ocher. This bed is divided at C by a rough layer of purplish ore, of irregular thickness, which is called "roll kidney". The bed of black kidney ore at 6, though only 2 inches in thickness, shows kidneys changed to limonite throughout. The bed is not thick enough to work alone, but the ore is separated in the process of benching for the yellow kidney which lies below it.



- 1. Yellow clay.
- 2. Fire clay.
- 3. Micaceous shale with Kidneys.
- 4. Gray slate.
- 5. Block ore.
- 6. Clay.
- 7. Sandstone.

FIG. 96.

greatest amount of phosphorus of the four, while the china ore, rejected at the furnace, compares quite favorably with the kidney ores, its low phosphorus giving it even a greater value, though apparently the silica is much higher.

a Hunnewell furnace, on the line of the East Kentucky railroad, in Greenup county, is controlled, together with the Pennsylvania furnace above-mentioned, by the railroad company. It uses a variety of ores from many sources, some of them coming from beyond Willard, in Lawrence county. Figure 96 shows a section on *Turkey lick*, 1 mile east of the furnace. The kidneys occurring above the block ore are here but thinly scattered, though at time of large size. The block ore here shown is a dense ore, altered as usual to limonite on the surface, and showing ocher and fine veins of calcite when broken through the core. The analyses of this ore, together with an average sample from the stock-pile at Hunnewell furnace, are as follows:

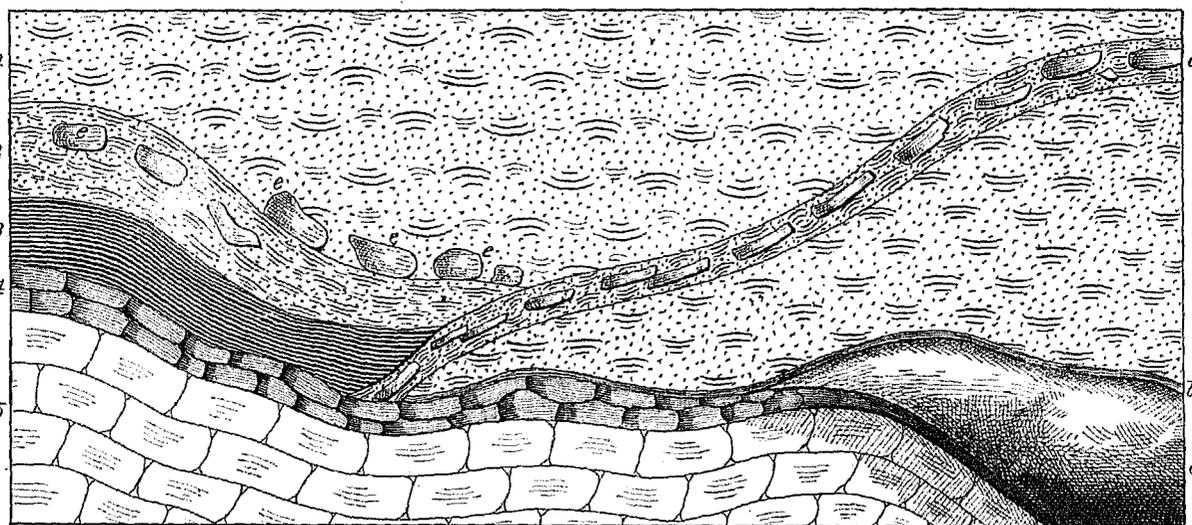
	590.	801.
	<i>Per cent.</i>	<i>Per cent.</i>
Metallic iron.....	51.101	36.18
Phosphorus.....	0.173	0.341
Phosphorus ratio.....	0.339	0.943

Sample 599 represents the block ore above described. Sample 801 is from the stock pile at the furnace.

Other ores in use at Hunnewell furnace will be mentioned under the description of the banks from which they come.

The Iron Hill furnace, on Tygart's creek, in Carter county, is run almost exclusively from the limestone ores.

c A section taken at the *Duzan* bank, 1½ mile northeast of the furnace, is shown in Fig. 97. The ore-bed, which conforms to the irregularities in the underlying limestone, is shown spreading over a bulge at *c*; the thickness of



- e**
1. Red clay, 2 ft.
 2. Gray clay, 18 in.
 3. Gray slate, 16 in.
 4. Limestone ore, 8 in.
 5. Lower limestone, 4 ft.

- e.e.e. Sandstone in broken pieces.*
a. Olive and red clay with line of sand boulders, 7 in.
b. Yellow clay above ore, 2 in.
c. Ore bed spreading over limestone bulge.

FIG. 97.

the bed, however, is still the same. The ore is soft, and much decomposed, and of a yellowish-gray color, coming from the bed in shaly flakes and thin plates, and is much contaminated by the clay-bed above it. The sample was taken along the whole surface of the bed exposed in the figure, marked 4, the bed being very wet at the time. The analysis shows—

f

	802.
	<i>Per cent.</i>
Metallic iron.....	37.32
Phosphorus.....	0.224
Phosphorus ratio.....	0.600

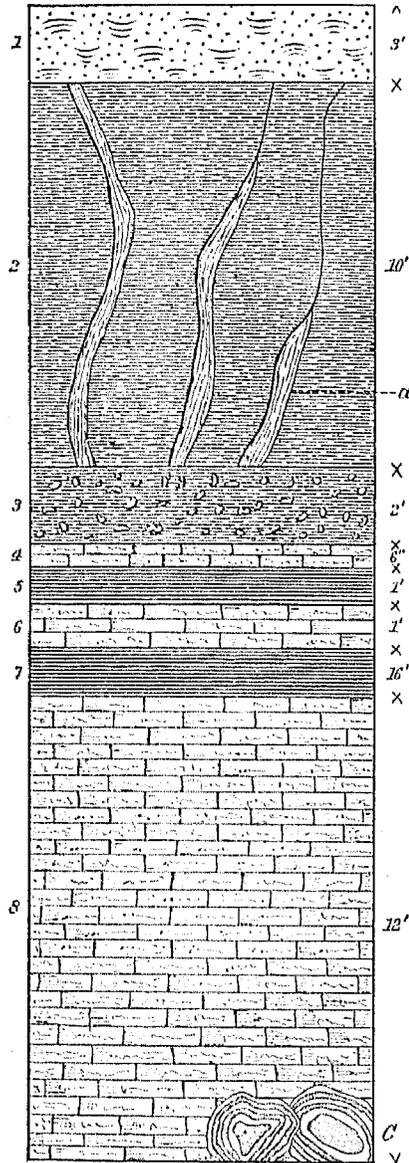
The *Lambert* bank, a section at which is shown in Fig. 98, is situated on the ridge between Clark's branch of Tygart's creek and Buffalo creek. This is an occurrence of ore peculiar to this locality, the deposit, according to Mr. P. N. Moore, lying 73 feet above the sub-Carboniferous limestone. The ore is an ochreous limestone ore, having a lean, earthy appearance, and a somewhat shaly texture. The great thickness of the bed here—over 14 feet, all

included—alone distinguishes this deposit from others of the region. Above the main ore-bed is a layer of micaceous a shale, thickly scattered with a peculiar fine kidney ore. These kidneys are quite small and round, consisting of a dark-brown limonite. At C is a distinct layer of what appears to be a silicious limestone, of a blue and often greenish color, decomposing to a soft, yellow powder upon exposure. The individual blocks are covered with concentric layers of sandy limonite. The formation is not persistent, and was here exposed only along 15 feet at the right and bottom of the accompanying section.

The following are the three analyses of samples taken from the Lambert bank:

	803.	804.	805.
	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>
Metallic iron	35.36	34.82	40.48
Phosphorus.....	0.260	2.479	0.737
Phosphorus ratio	0.735	7.119	1.821

No. 803, from kidney ore at 3; No. 804, from the main bed 8, including the portions (4 and 7) above the slate-seams; No. 805 is the ore from the bed at C, taken from all portions of the exposed lumps.

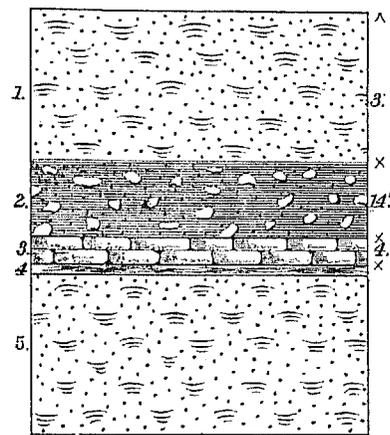


1. Clay.
2. Olive shale.
3. Kidney ore in shale.
- 4, 5, 6, 7. Lime ore.
8. Slate and mica'd clay.
- C. Rough limonite.
- a. Clay seams.

FIG. 98.

Fig. 99 shows a section at the *Ferguson* bank, an opening upon the lower limestone ore, 2½ miles northwest of Iron Hill furnace. Here the sandstone overlying the ore-bed is well defined and unusually thick. The figure shows the face of ore from which the sample was taken, illustrating a bulge in the underlying limestone. The ore is here exposed by a small cut on the outcropping bed, from which none had been taken. The sample here taken shows upon analysis the following result:

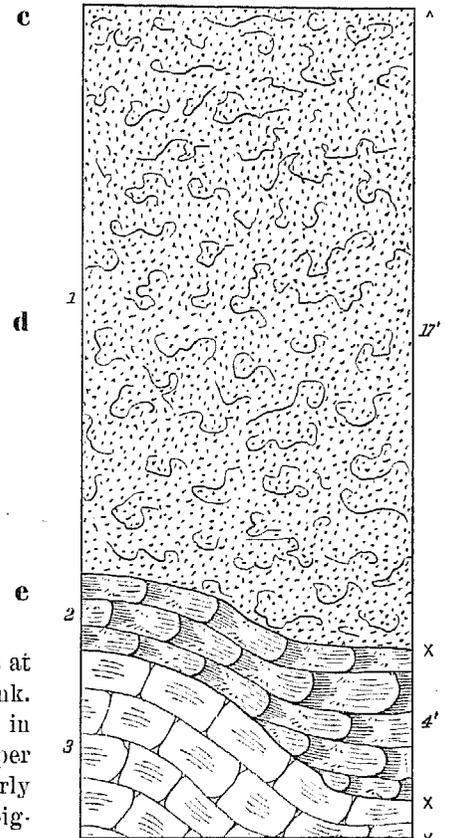
	806.
	<i>Per cent.</i>
Metallic iron	34.55
Phosphorus.....	2.51
Phosphorus ratio	7.265



1. Yellow clay.
2. Kidney ore in micaceous sand
3. Little block ore. [stone.]
4. White and gray clay.
5. Yellow clay.

FIG. 100.

These results show the kidney ore at 3 to be the only available ore at this bank. The very high per cent. of phosphorus in the other beds, regardless of the low per cent. of iron present, renders them utterly unfit for the manufacture of good pigment, and recourse must be had to other ores.



1. Sandstone.
2. Limestone ore.
3. Lower limestone.

FIG. 99.

The ore is here exposed by a small cut on the outcropping bed, from which none had been taken. The sample here taken shows upon analysis the following result:

a The bed was here very little altered, and consisted of a dense blue carbonate, changed slightly to limonite on the most exposed edges. The high phosphorus will render the ore useless at this particular point.

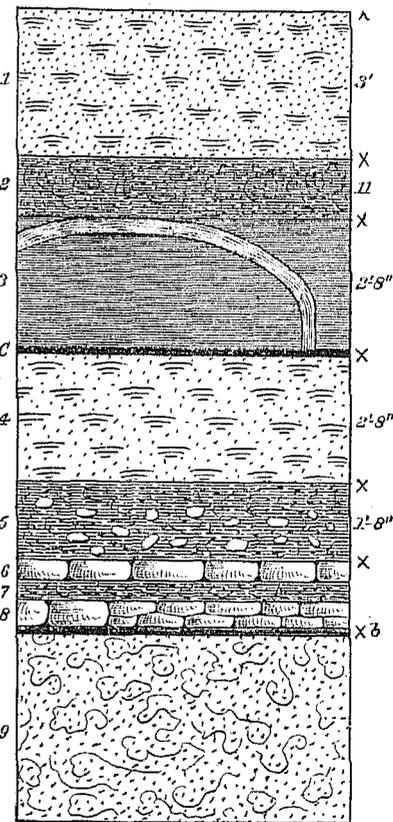
The difference between the soft decomposed ore, shown in Fig. 97, above which the thick sandstone is wanting, and the unchanged ore under the sandstone, shown in Fig. 99, is very striking, and whether due to the weathering or not must be determined by other samples offering similar comparisons.

The ores of *Robin's run*, a branch of Sandy creek, in Carter county, are largely mined for Mount Savage furnace. Fig. 100 shows a section taken above No. 3 coal at the Stewart bank. The opening is a small one, on the side of the ridge, half a mile north of Mr. Stewart's house. Two samples were taken from this opening, which upon analysis gave results **b** as follows:

	807.	808.
	<i>Per cent.</i>	<i>Per cent.</i>
Metallic iron	31.20	35.63
Phosphorus	0.187	0.170
Phosphorus ratio	0.599	0.477

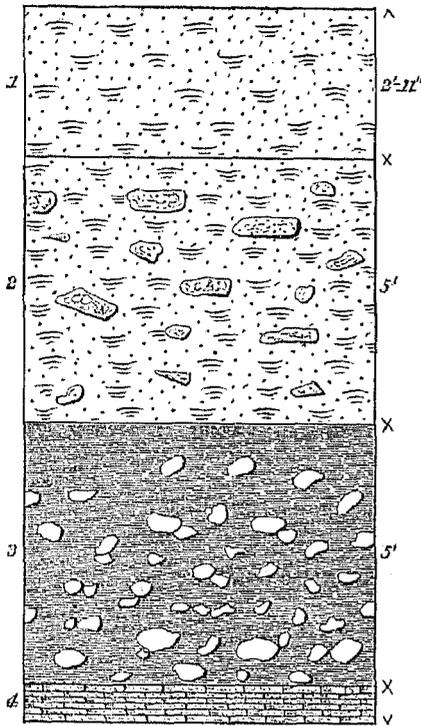
No. 807 is kidney ore, from the seam at 2; No. 808 is the block ore **c** from 3. Above this ore, near the crown of the hill, an old entry exposes No. 4 coal. Continuing eastward on the north side of Robin's run, the ridges, which rise some hundred feet above the stream-bed, are lined and terraced to the crowns with the trenches and their accompanying dump-piles, left where the ore has **d** been stripped along the outcrops of the beds.

These old diggings afford no opportunity for sampling. On the south side of Robin's run, 2 miles



1. Surface clay.
 2. Micaceous sandstone.
 3. Gray shale.
 4. Gray clay.
 5. Micaceous sandstone.
 6. Little block ore
 7. Micaceous sandstone.
 8. Little block ore.
 9. Sandstone over No. 3 coal.
- C. Coal seam, $\frac{4}{8}$ '.
b. Fire clay, $\frac{1}{2}$ '.

Fig. 102.



1. Red clay.
2. Gray clay, with sandy boulders and sand kidneys.
3. Shale, with kidneys of lime ore, "Lime Kidneys."
4. Slate ore.

Fig. 101.

directly north of Mount Savage furnace, the ore is worked at several horizons on the side of a steep hill, rising about 200 feet. The section, at the upper opening, is shown in Fig. 101. The ore here was worked in two main benches, the bed marked 4 in the figure not being exposed when visited.

The amount of stripping and the hardness of the slate at this point renders the extraction of the kidney ore most difficult.

c This ore is known as the gray-lime kidney, and lies above No. 5 coal, wanting. The kidneys are dense cores of sandy carbonate, surrounded by very thin layers of limonite, and the ore has a lean, sandy appearance throughout, giving, upon analysis, the following result:

	811.
	<i>Per cent.</i>
Metallic iron	27.73
Phosphorus	0.927
Phosphorus ratio	3.343

d The horizon of the little block ore is here 100 feet below the above-described bed, and is exposed by a small opening upon the same hillside.

Fig. 102 shows this opening in section. The little block ore is here separated from the underlying bed, known as the little blue block, by a layer of micaceous sandstone. The ores from these two beds is not separated in mining and differ little in appearance.

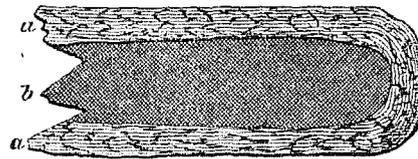
A sample was taken from each of these beds, and the ores are compared in the following analyses:

	809.	810.
	<i>Per cent.</i>	<i>Per cent.</i>
Metallic iron	37.32	34.77
Phosphorus	0.215	0.270
Phosphorus ratio	0.576	0.774

No. 809, little block ore from 6. No. 810, little blue block from 8.

Much care is exercised at Mount Savage furnace in the selection and sorting of the ores, and the result is a fairly illustrated in the above analyses.

Fig. 103 shows a section through one of the ore-blocks from the bed at 8. The center (b) is unaltered carbonate



a-a. Limonite.
b. Unaltered carbonate.

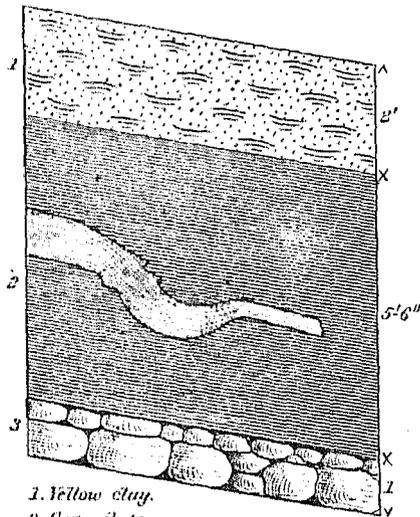
FIG. 103.

ore, of a grayish blue tint, while the outer layers are changed to a light-brown limonite (a).

Besides these, the yellow kidney ores have been worked for Mount Savage furnace, and were found mixed with other ores upon the stock-pile, from which an average sample was taken, showing upon analysis:

	812.
	Per cent.
Metallic iron.....	41.30
Phosphorus.....	0.223
Phosphorus ratio.....	0.540

Fig. 104 shows a section on *Bays branch*, 3½ miles south of Mount Savage furnace. A tunnel has here been run some 30 feet upon the bed of red kidney ore, which here dips 10° northeast.



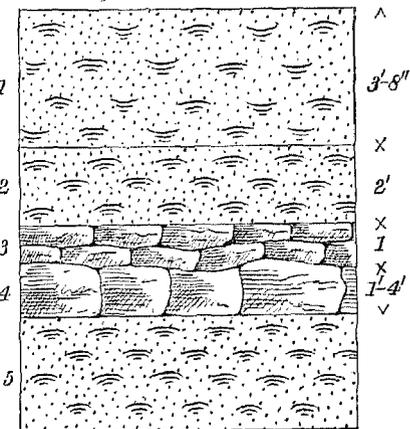
1. Yellow clay.
2. Gray slate
3. Red kidney ore.

FIG. 104.

In its general appearance the ore resembles the block ores, but comes from the bed in more rounded masses, though hardly in distinct kidney forms. It is a carbonate changed to a reddish limonite on the surfaces of the blocks. The ore was being worked for Hunnewell furnace, and lies 36 feet below the horizon of the yellow kidney ore, which was formerly worked on the hillside immediately above it.

The red kidney ore gives, upon analysis:

	813.
	Per cent.
Metallic iron.....	22.81
Phosphorus.....	0.079
Phosphorus ratio.....	0.316



1. Red clay.
2. Gray clay.
3. Lime ore (altered).
4. Lime ore (unaltered).
5. Gray clay.

FIG. 105.

South of Willard, on Dry fork, preparations were being made for extensive mining.

The limestone ores were sampled at *Shepherd's bank*, on Cane fork, in Lawrence county, where the accompanying section (Fig. 105) was taken. The ore in this instance rests upon a bed of gray clay. The upper one-foot of the bed is decomposed and partly altered to limonite, and this part is called red lime ore, to distinguish it from the unchanged gray lime ore which forms the lower portion of the bed.

The ore is shipped to Hunnewell furnace, and is taken from many other pits in the immediate neighborhood.

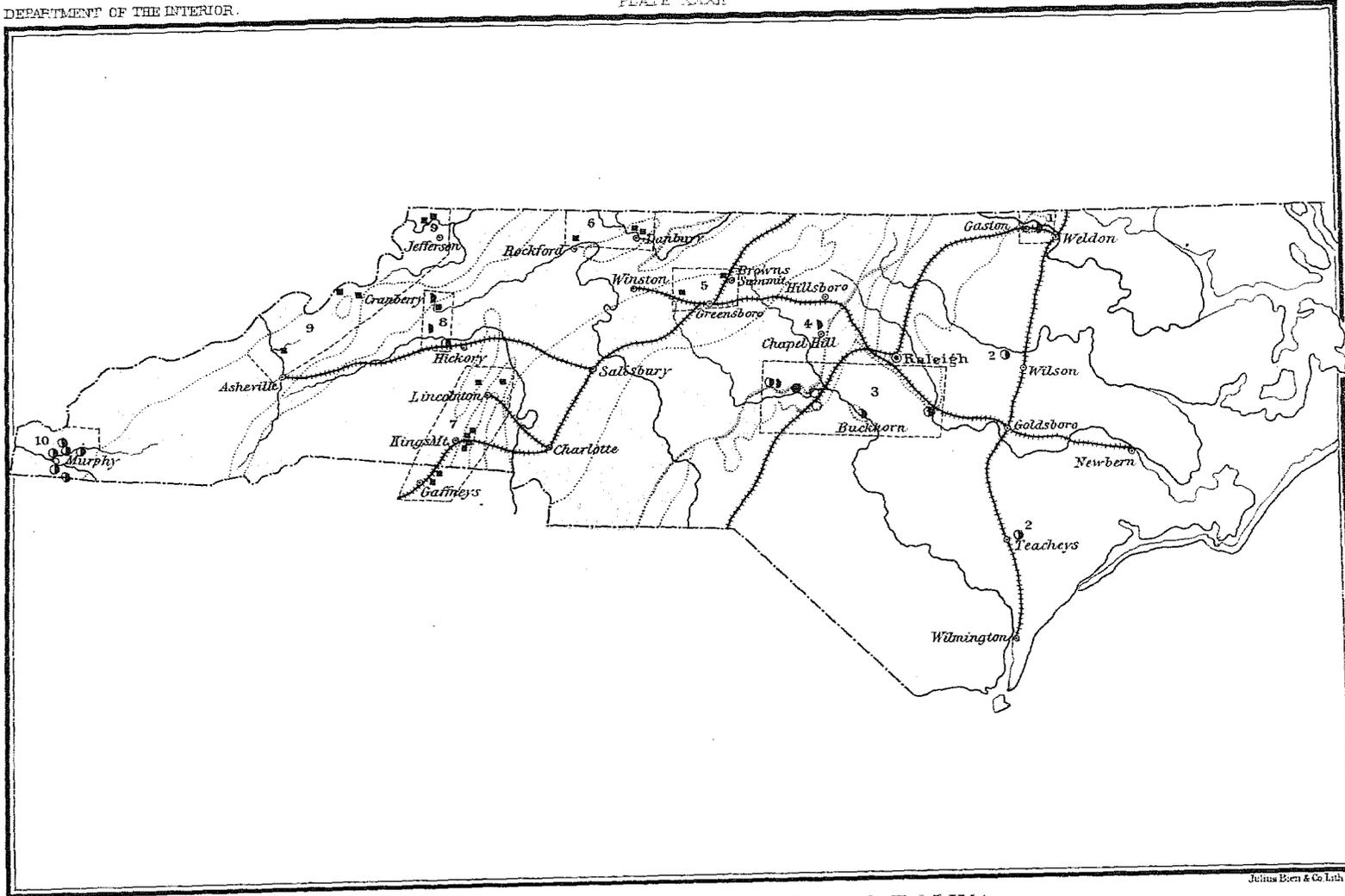
The upper and the lower portions of the bed show a marked difference in the following analyses:

	814.	815.
	Per cent.	Per cent.
Metallic iron.....	40.61	32.46
Phosphorus.....	0.126	0.141
Phosphorus ratio.....	0.313	0.434

No. 814 is the limonite from 3. No. 815 is the gray lime from 4.

a Sample 814, which seems to be a particularly rich variety of limestone ore, gives, upon full analysis, results as follows:

	814.		814.
	<i>Per cent.</i>		<i>Per cent.</i>
Sulphur	0.227	Carbonic acid	3.66
Phosphorus	0.126	Sulphuric acid	0.02
Iron, metallic	40.61	Phosphoric acid	0.290
		Carbon in carbonaceous matter	0.15
Silica	14.37	Hygroscopic water	1.40
Iron, protoxide	4.93	Water of composition	8.54
Iron, peroxide	53.93		
Alumina	9.36	Total	100.112
Manganese, protoxide	1.26		
Lime	1.03	Per cent. of insoluble silicious matter	19.43
Magnesia	0.52		
Iron, disulphide	0.072	Silica	14.37
Nickel, sulphide	0.25	Alumina	4.08
Cobalt, sulphide	0.21	Magnesia	0.07
Copper, sulphide	0.03	Total	19.42



Jelma Egan & Co. Lith.

IRON ORE SAMPLE MAP OF NORTH CAROLINA.

Geology from Geological Map of North Carolina by W. C. Kerr. 1875.

- | | | | | |
|--------------|-------------|-------------|-------------------|-------------------|
| | | | | |
| Tertiary | Triassic | Huronian. | Upper Laurentian. | Lower Laurentian. |
| ■ Magnetite. | ◐ Specular. | ○ Hematite. | ◑ Limonite. | ● Black Band. |
| | | | | Group 1. |

Scale 60 miles = 1 inch.

NOTES ON SAMPLES OF IRON ORE COLLECTED IN NORTH CAROLINA.

BY BAILEY WILLIS.

b

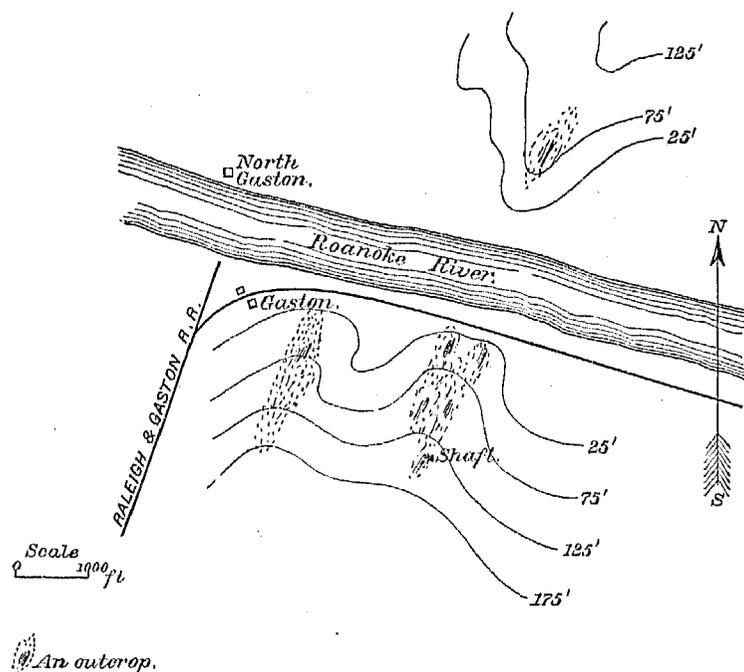
The iron ores of North Carolina may be divided geographically into ten groups, as follows:

1. Specular and magnetic ores near Gaston, Halifax county. Age: Huronian.
2. Bog-ores of the eastern counties. Age: Tertiary; recent.
3. Specular, hematite, limonite, and blackband ores of Chatham, Moore, Harnett, and Johnston counties. Age: Huronian and Triassic.
4. Chapel Hill mine, Orange county. Age: Huronian? c
5. Titaniferous magnetic ore of Guilford and Rockingham counties. Age: Lower Laurentian.
6. Magnetic ores of Stokes and Surrey counties. Age: Huronian.
7. Magnetic and limonite ores of Lincoln and Gaston counties and York county, South Carolina. Age: Huronian and Lower Laurentian.
8. Limonite of Burke and magnetic and specular ore of Caldwell county. Age: Huronian and Upper Laurentian?.
9. Magnetic ores of Ashe, Mitchell, and Madison counties. Age: Upper Laurentian.
10. Limonites of Cherokee county. Age: Huronian.

In the above division the term "age" refers to the age of the rocks in which the ores occur according to W. C. Kerr's determination, not to the period of formation of the ores, which does not enter into an economic description. d

1. Ores near Gaston, Halifax county.

On page 220 of Professor Kerr's report for 1875 is given the following sketch of the ore-beds near Gaston:



e

f

FIG. 106.—SKETCH MAP OF THE VICINITY OF GASTON, NORTH CAROLINA. From Kerr's Report, 1875, p. 220.

About 1 mile east of Gaston and one-half mile south of the river several prospecting trenches had been opened on the more easterly of the veins, and an ore-body 18 inches to 2 feet thick at the surface had been uncovered in one. A shaft had been sunk 25 feet upon this vertical vein, and it was stated that it widened as it went deeper.

a The strike of this vein is nearly due north, and it is said to show itself 8 feet thick in the bed of the Roanoke at low water; it was also said to outcrop north of the river, but a diligent search failed to reveal it. Sample 151 represents the micaceous specular ore seen in the shaft referred to.

Five miles south of Gaston, on the hills north of the Roanoke, and also 7 miles up the river above Gaston, surface pieces of a strongly magnetic trap-rock were seen; but the magnetic ore, described by Professor Kerr, was not found.

151.	
<i>Per cent.</i>	
Iron	49.83
Phosphorus	0.005
Phosphorus in 100 parts iron	0.010

b

2. Bog-ores of the eastern counties.

The alluvial beds of the eastern portion of the state contain numerous deposits of bog-ore. These lie in the form of irregular horizontal sheets and scattered nodules a little below the level surface, and are discovered by the loose pieces lying on the ground in the turpentine pine forests, or turned up by the farmer in plowing.

c A bed of this ore, on the farm of D. T. Boney, 3 miles east of Teachey's, in Duplin county, covers a curved belt about 1 mile long and one-quarter mile wide. It has been found in ditching and plowing, and is often but a few inches below the surface. The sheets are very irregular in form, and their thickness is unknown, as no attempt has been made to work the ore, which is represented by sample 153. Hand-specimens obtained here contain pieces of wood altered to limonite.

153.	
<i>Per cent.</i>	
Iron	46.70
Phosphorus	1.085
Phosphorus in 100 parts iron	2.323

d In Nash county, near Toisnot swamp, is a similar bed of ore, known as the *Bloomary* iron mine. This was worked in 1812, and again during the late war. This bed is 200 yards long, 75 yards wide, and averages about 3 feet in thickness, but thins out toward the edges. Beneath it is white sand, and above it 2 to 4 feet of brown earthy soil, containing nodules of the same ore. Portions of this ore are very sandy, but sample 154 is a fair average of the greater part of the ore seen.

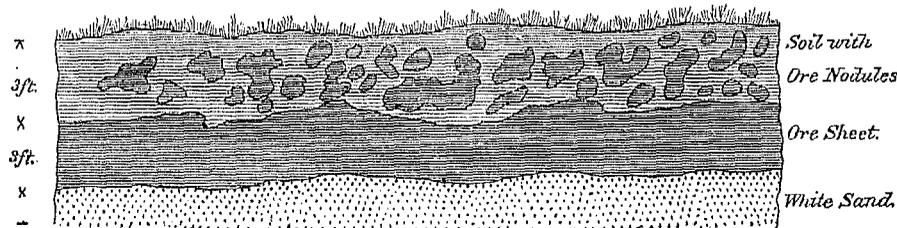


FIG. 107.

This ore is 7 miles in a direct line from the railroad, and is 8 miles northwest of Wilson.

154.	
<i>Per cent.</i>	
Iron	49.90
Phosphorus	0.040
Phosphorus in 100 parts iron	0.088

f

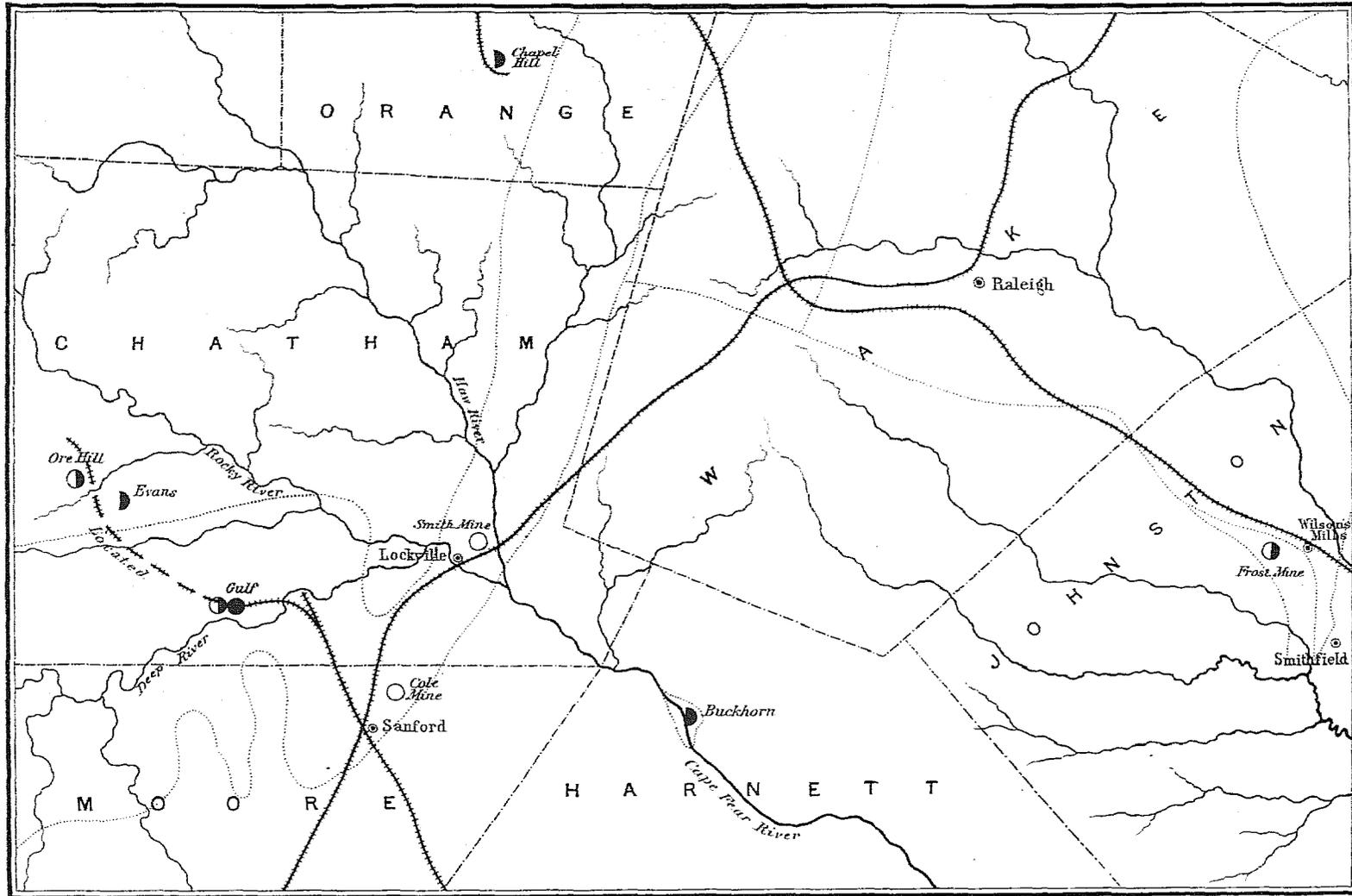
3. Specular, hematite, limonite, and black-band ores of Chatham, Moore, Harnett, and Johnston counties.

The ores included in this group differ widely in character, and there is but little geological connection between the deposits. These are:

Huronian: Limonites and specular ores; and

Triassic: Hematite, blackband, and limonite.

(a.) *Huronian limonites*.—Wilson's Mills is a small station on the North Carolina railroad, 22 miles south of Raleigh. The country is undulating, with swamps between the low hills. Two miles west of the station, near



Julius Bien & Co Lith.

IRON ORE MINES OF GROUPS THREE AND FOUR (NORTH CAROLINA).

- Tertiary.
- Triassic.
- Huronian.
- Upper Laurentian.
- Specular.
- Hematite.
- Limonite.
- Black Band.

Copied from Post Route Map and Kerr's Geological Map for 1875.

Scale: 8 miles = 1 inch.

Isaac Parish's, a small stream, named Poplar branch, flows through a thickly-wooded swamp, around the northeast, a south, and southwest sides of a ridge 50 feet high. The surface of this ridge, for the space of a quarter of a mile northwest and southeast, is covered with loose pieces of limonite, and near the eastern edge of the ridge is an old pit, 10 to 15 feet deep and 70 feet long, in which is exposed a vertical face of ore 6 feet high and 20 feet long. Outcrops of gneiss occur on the hill northwest of this ridge. Across the swamp one quarter mile northeast of the pit, surface fragments of ore are widely scattered over a gentle slope. A similar ore also occurs 1½ mile southwest of the pit on lands of Messrs. Turner and Avery. Ore was dug in the old pit described and at Mr. Avery's in 1812.

Sample 152 was taken as an average of the face of ore exposed in the pit:

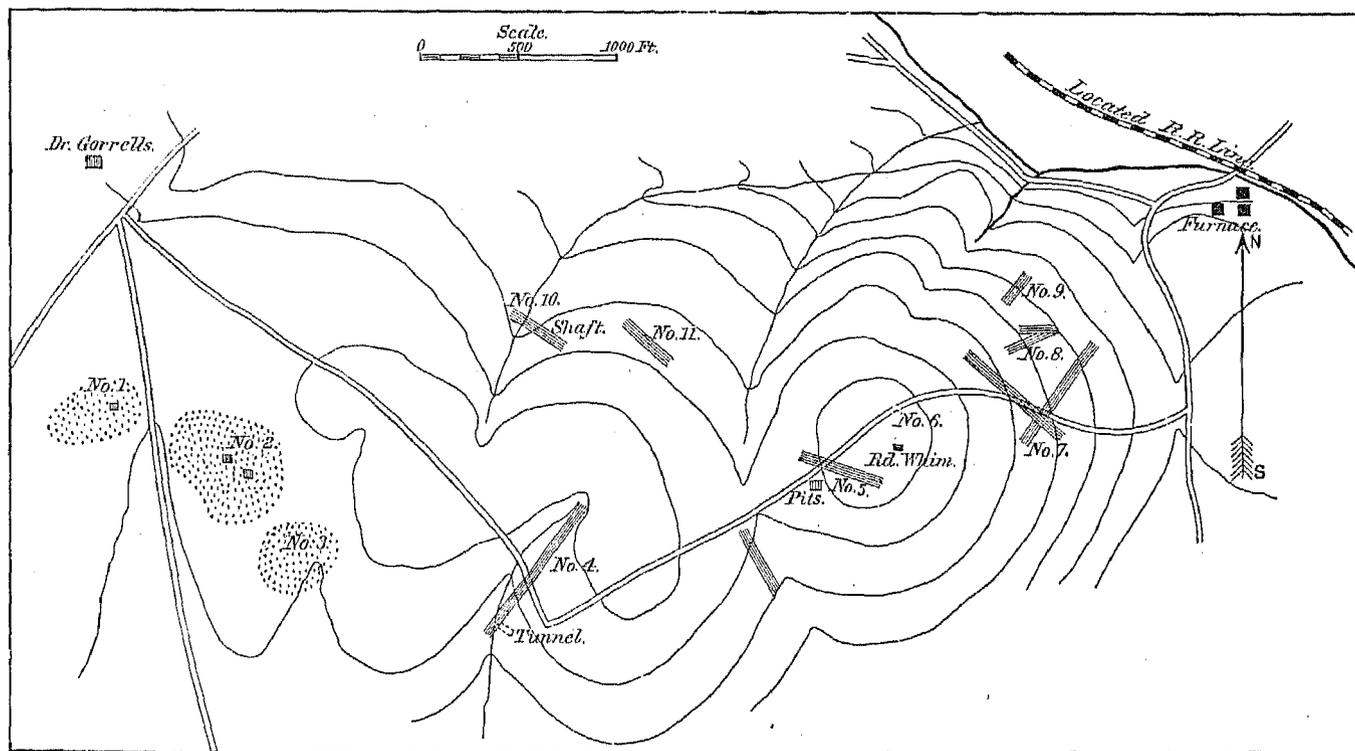
	152.
	Per cent.
Iron	47.99
Phosphorus.....	0.900
Phosphorus in 100 parts iron	1.875

b

Ore Hill is a noted locality in Chatham county. It lies upon the projected line of railroad running northwest from Fayetteville, and the road was already completed to within 12 miles of it and graded beyond it in February, 1880. There are a number of deposits of limonite and one of hematite, which have all been opened more or less for the furnace which ran here during the late war.

The accompanying map, copied from Professor Kerr's report for 1875, gives a good idea of the position of the different deposits of ore. Numbers 4, 10, and 11 were best exposed. They are represented respectively by samples 160, 159, and 158.

c



d

e

FIG. 108.—MAP OF ORE HILL, CHATHAM COUNTY, NORTH CAROLINA. From Kerr's Report, 1875.

The vein marked No. 4 on the sketch consists of hematite, accompanied by white quartz. The outcrop is not less than 1,000 feet in length in a northeast and southwest direction, and varies from 15 to 20 feet in width. Near the southern end a tunnel has been driven in from the surface across the vein; but that portion of it which had not caved in was filled with water to the roof and could not be examined. Sample 160 was selected from the face of ore exposed above the old tunnel where it had caved in, masses of quartz which could be removed by handpicking not being included.

At No. 10 a large shaft has been sunk, it is said, to a depth of 90 feet in the ore; the sides have caved in, and it is now not over 40 feet deep. The ore is well exposed in the sides of the shaft and in the bottom and sides of a pit 20 feet wide which runs off from it. It is a very porous limonite, of apparently uniform character, and free from mechanical mixtures of rock. The width of the vein is something over 20 feet, but could not be definitely ascertained.

The vein marked No. 11 had been worked in an open cut and was much obscured by the caving in of the overlying soil. Its width appeared to be 10 or 15 feet, and the ore was similar to No. 10.

a Of the other veins nothing was to be seen but small irregular outcrops, from which no safe estimate of their size and character could be made. Test-pits have apparently been opened on them all, but they are now caved in.

Analyses.

	158.	159.	160.
	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>
Iron	57.23	41.71	44.99
Phosphorus	0.390	0.232	0.248
Sulphur	0.263	.....	.....
Phosphorus in 100 parts iron ..	0.681	0.556	0.551

b

The following is the complete analysis of 158:

	158.		158.
	<i>Per cent.</i>		<i>Per cent.</i>
Silica	1.28	Titanic acid	1.04
Iron, protoxide	0.23	Carbon in carbonaceous matter	0.17
Iron, peroxide	81.19	Hygroscopic water	2.57
Alumina	2.38	Water of composition	9.32
Lime	0.14	Total	100.000
Magnesia	0.01	Per cent. of insoluble silicious matter	1.82
Iron, disulphide	0.473	Silica	1.28
Nickel, sulphide	0.02	Alumina	0.48
Copper, sulphide	0.02	Lime	0.06
Potassa	0.14	Magnesia	0.01
Soda	0.01	Total	1.83
Carbonic acid	0.18		
Phosphoric acid	0.893		

c

(b.) *Huronian specular ores.*—A vein of compact blue specular ore has been discovered on the land of Mr. Evans, d 7 miles northwest of the Gulf, and about 1 mile from the located line of railroad already referred to. There is a low ridge, which runs east and west, and the presence on it of surface pieces of ore led to the opening of the prospecting pits in which the vein is exposed. The accompanying rock is a decomposed talcose-schist, which dips with the vein about 45° north, 30° west. The thickness of the vein was stated at 7 feet; the *débris* in the bottom of the half-filled tunnel permitted only 4 feet to be seen. The greatest depth reached on the vein was 20 feet. Sample 157 was taken as an average of about 5 tons of ore lying by the side of the pits:

e

	157.
	<i>Per cent.</i>
Iron	25.75
Phosphorus	0.018
Phosphorus in 100 parts iron	0.070

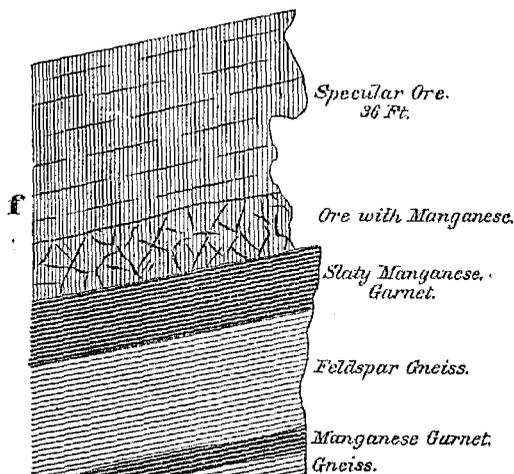


FIG. 109.

The *Buckhorn* iron mine is said to have presented before being worked a vertical face of specular ore 36 feet in height, crowning a hill whose summit is 175 feet above the Cape Fear river. When visited, in February, 1880, there remained but a few loose blocks of poor ore in a pit 80 feet long by 40 feet wide by about 15 feet deep. This pit was an approximate mold of the mass of ore, which had the same horizontal dimensions and a maximum thickness of perhaps 50 feet.

Search was made for ore in several places south and northeast; a hundred yards from the pit in the latter direction a small vein of poor ore, similar to that left in the mine, was found. Similar ore caps a hill on the right bank of the river, immediately opposite Buckhorn and half a mile from it.

All the good ore at the mine was removed and used in the Buckhorn furnace, built under the supposition that the ore-deposit was very large.

The annexed section (Fig. 109) of the original deposit is given by Professor Kerr on page 222 of his report for 1875:

This section has been completely obscured or removed by the mining operations, and there now remain only the very much decomposed gneiss and slate that form the sides of the pit.

	No. 155.
	Per cent.
Metallic iron	57.31
Phosphorus	0.016
Phosphorus in 100 parts iron	0.043

(c.) *Triassic hematite*.—An interesting form of hematite occurs in the slightly inclined stratified beds of the Trias, in the eastern part of Chatham and Moore counties. The ore consists of rounded concretions, varying in size from small grains up to half an inch in diameter, cemented by a red ocher. It lies in thin beds, conformable to the bedding of the associated clays, and covers a considerable area, the outcrops extending from Lockville to a point 9 miles southwest near Sandford.

In the following sketch and section the principal openings of the *Smith mine*, 1 mile east of Lockville, are represented. The ore was first opened in the pit marked A on the west of the branch. It gave out about 10 feet

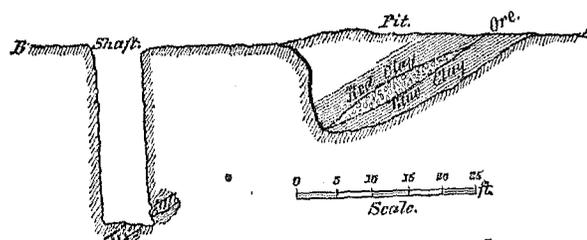
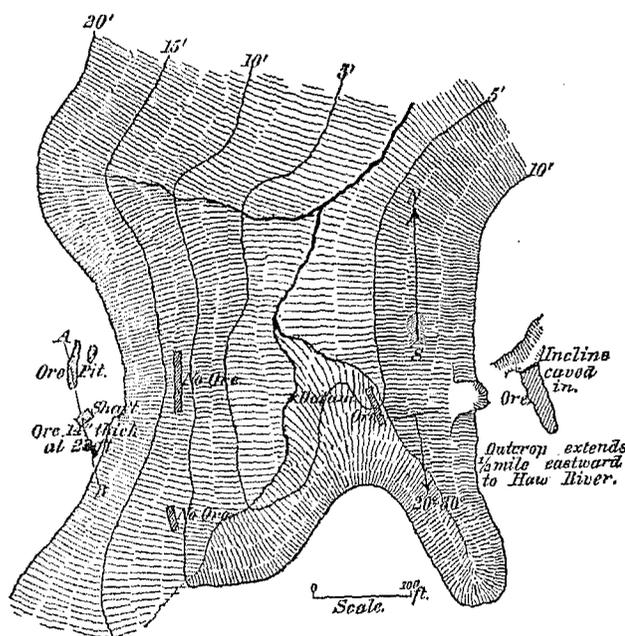


FIG. 110.—SKETCH OF THE SMITH MINE, NORTH CAROLINA.

from the surface, but was found again at a depth of 25 feet in the shaft. (See section A—B.) On the east of the branch the ore was followed in the incline about 15 feet; it then gave out and was not found again, possibly because the incline was driven over it.

Sample 164 is from the ore in the shaft and pit, west of the branch, where the maximum thickness of the bed is 14 inches.

	No. 164.
	Per cent.
Iron	43.02
Phosphorus	0.593
Phosphorus in 100 parts iron	1.380

a A very similar bed of ore occurs 2 miles northeast of Sandford and 9 miles southwest of Lockville. This is known as the *Cole mine*, and the ore was formerly marked in a blomary, but it became too hard to be dug with a pick and was abandoned. Like that at the Smith mine, this ore dips between 20° and 30° south by east, and varies in thickness from 8 to 18 inches.

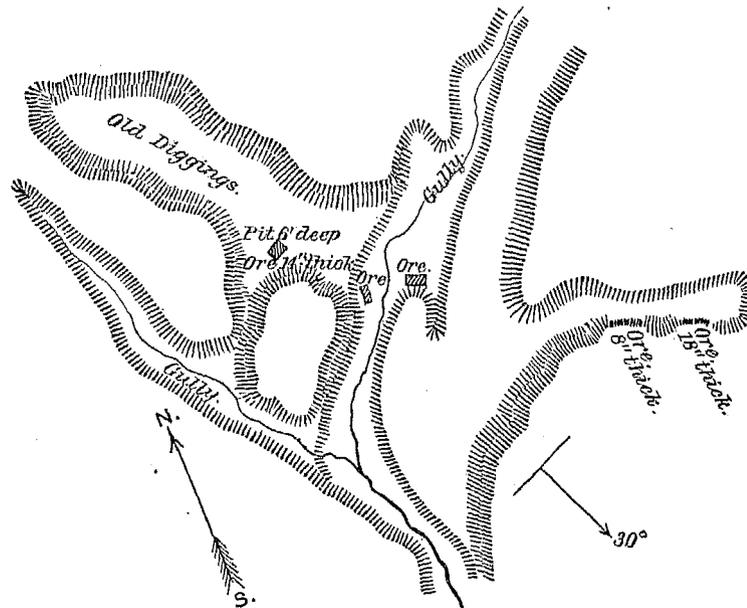
The ore is represented by sample 163.

	No. 163.
	<i>Per cent.</i>
Iron	48.67
Phosphorus.....	0.313
Phosphorus in 100 parts iron.....	0.643

b

Scale.
0 10 20 30 feet.

c



d

FIG. 111.—SKETCH OF THE COLE MINE, NORTH CAROLINA.

(d) *Blackband and ball-ore of the Trias.*—The following section (Fig. 112) (a) of the Deep River coal-beds, taken in an old shaft at the Gulf, shows the relation of these two ores to the two coal-seams.

The ball-ore occurs in rounded masses, from 4 to 8 inches in diameter, of a drab color, in a dark brown shale. It is represented by sample 156.

The blackband is compact and homogeneous. Sample 161 was taken from the bed exposed in the incline of J. L. Horton's coal mine at the Gulf, about 30 feet from the outcrop.

(e) *The Triassic limonites* are probably the weathered outcrops of the blackband or ball-ore, which accompany the coal. Half a mile west of the Gulf a small shaft had been sunk and such a bed of limonite exposed. The ore lay in rounded masses in a yellowish clay. It is represented by sample 162:

f

	Ball-ore.	Blackband.	Limonite.
	156.	161.	162.
	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>
Iron	34.96	21.25	20.33
Phosphorus.....	0.312	0.017	0.068
Phosphorus in 100 parts iron ..	0.892	0.080	0.334

4. Chapel Hill Mine.

In the southern portion of Orange county are rounded hills, 50 to 100 feet in height, the result of erosion of the decomposed Huronian rocks. Chapel hill, one of the principal of these, lies 9 miles south of University station, on the railroad between Raleigh and Greensborough. Upon its summit a true fissure-vein filled with iron-bearing quartz may be traced in a north and south course for about 1,000 feet; beyond the hill it is said to separate into a

a See page 329.

number of smaller fissures. The main vein is crossed near the southern end by another smaller vein, with a course of about north 60° east; both are well exposed by outcrops and test-pits (see accompanying sketch, Fig. 113). At the main shaft the vein has a total thickness of 10 feet. The ore at the sides is very lean, but toward the center the proportion of iron increases rapidly, and it is possible that 6 feet out of the 10 can be worked profitably; sample 402 was taken as an average of this central portion of the vein. Toward the summit of the hill the vein widens to 12 feet.

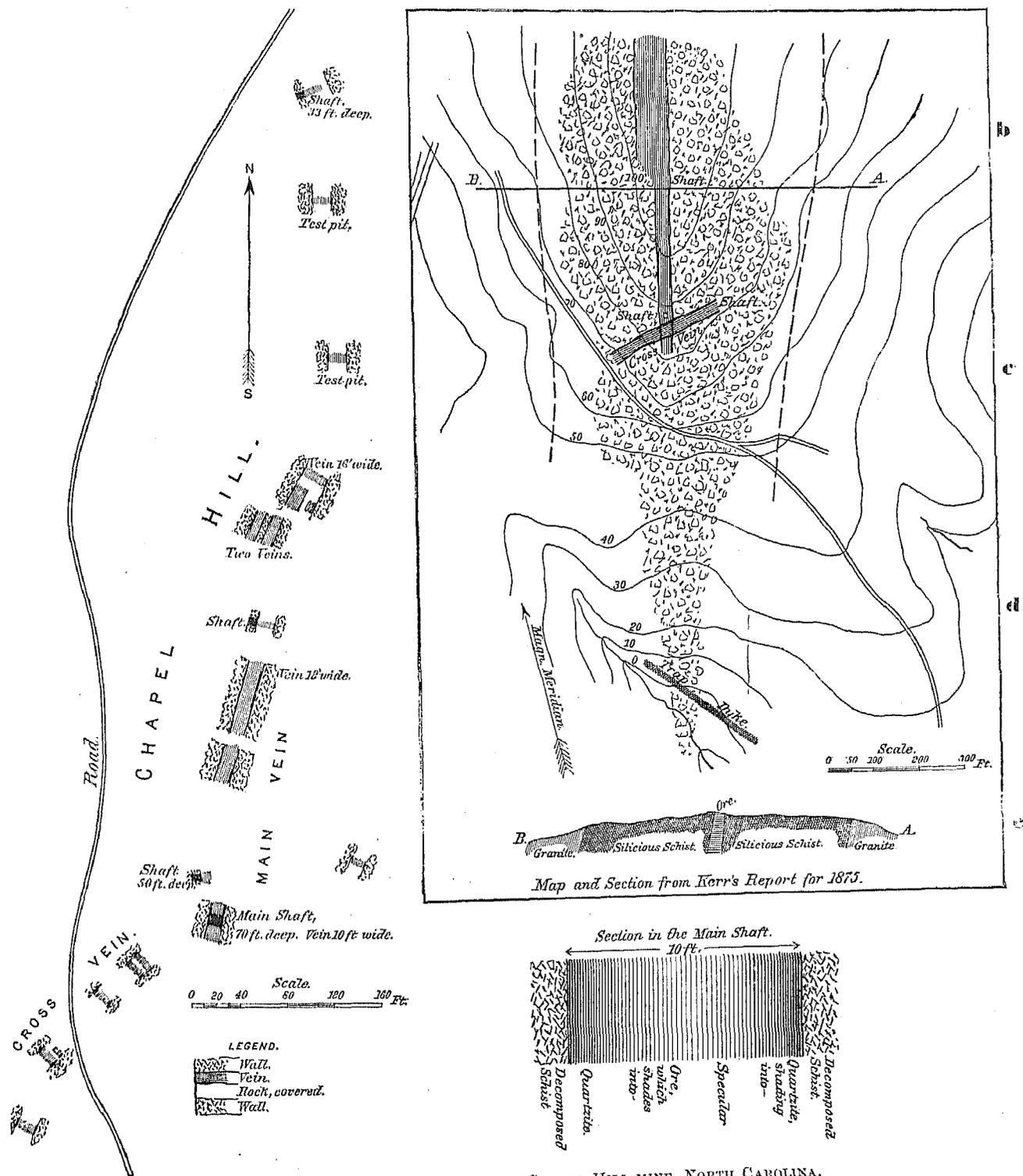


FIG. 113.—MAP AND SECTIONS OF THE CHAPEL HILL MINE, NORTH CAROLINA.

Just beyond it is faulted and separated by a horse, similar to the wall rock; 40 feet farther north there is but one vein, 18 feet wide. The quartz here carries but a very small percentage of ore. The northern end of the vein does not appear to exceed 12 feet in width. At the last opening a shaft has been sunk on the west of the vein, and some of the ore has been thrown out by a blast; sample 403 was taken as an average of this ore, which is slightly magnetic.

Analysis.

a

	No. 402.	No. 403.
	<i>Per cent.</i>	<i>Per cent.</i>
Phosphorus	0.057	0.170
Iron	37.91	42.64
Sulphur	0.153	.....
Phosphorus in 100 parts iron...	0.150	0.399

When this mine was visited in 1880, the grading of a railroad was progressing rapidly between it and University station, on the main line between Raleigh and Greensborough. Following is the complete analysis of No. 402:

b

	402.		402.
	<i>Per cent.</i>		<i>Per cent.</i>
Silica	43.00	Hygroscopic water	0.09
Iron, protoxide	1.45	Carbon in carbonaceous matter	0.01
Iron, peroxide	52.34	Water of composition.....	0.55
Alumina.....	2.07	Total.....	160.098
Manganese, protoxide	Trace.		
Lime.....	0.10	Per cent. of insoluble silicious matter.....	44.49
Magnesia.....	0.02		
Iron, disulphide	0.287	Silica	43.00
Copper, sulphide.....	Trace.	Alumina.....	1.40
Carbonic acid.....	0.05	Lime.....	0.07
Phosphoric acid	0.191	Magnesia.....	0.02
Titanic acid.....	Trace.	Total.....	44.49

c

5. Titaniferous magnetic ore of Guilford and Rockingham counties.

A range of titaniferous magnetic ore extends from Forsythe county, in a northeast direction, across Guilford and into Rockingham, a distance of about 30 miles. The right to mine on this range is leased and owned by the North Carolina Central Iron Company, which has explored the entire length of the range, and begun mining at two points—the first, a mile north of Friendship, in Guilford county; the second, 5 miles northwest of Brown's summit, in Rockingham. The former is known as the *Tuscarora Iron Works*. Forges were erected here and considerable iron made, but the works have been idle for several years. The iron range lies about a quarter of a mile south of the works and has been traced, with but little interruption, for nearly a mile in a straight line, a little north of east (see sketch, Fig. 114).

The greatest depth was reached in the Sargent shaft, which was sunk 109 feet. A tunnel, run south from the bottom, is said to have struck a vein of ore 12 feet thick. The dip on the surface is about 70° a little east of south, but it is said to change to the northwest in the tunnel. About 10 tons of ore had been left near the pits around the shaft; sample 167 was selected from these piles. (For its analysis, see page 560 b.)

Twenty miles northeast of *Tuscarora* is the other mine, worked by the company, which is now in operation. It is known as the *Dannemora*.

The following sketches (Figs. 115 and 116) show the line of outcrop, the works on the surface, and the plan and sections in the mine. The first work was done in the incline No. 1. According to the statement of the superintendent the ore gave out 10 feet from the surface, but was found again 20 feet farther down; it widened to 12 feet, which is the thickness 90 feet from the surface in the incline, 70 feet vertically. At this depth a drift has been driven along the vein and stoping has been begun. A small winze has been sunk 20 feet farther on the incline, and the ore is said to narrow to 1 foot in thickness. Before the horizontal drift reached the second incline the ore was pinched out by the granite walls.

As the ore-body thus opened gives out just beyond incline No. 1, its dimensions are pretty well ascertained. It is approximately 125 feet long, 80 feet in incline width, and 12 feet thick. The drift had been extended to another lens of the same thickness, northeast of it, and the surface outcrops and trenches indicate the existence of others to the southwest. This ore is accompanied by chlorite and mica, which are sufficiently decomposed, even at the depth of the tunnel, to be readily dug with a pick. The ore is separated on the surface, by screening, into lump and fine ore, the former being shipped for fettling, the latter for blast-furnace use. These are represented in the following analyses:

	LUMP.	FINE.
	165.	166.
	<i>Per cent.</i>	<i>Per cent.</i>
Phosphorus.....	0.023	0.001
Iron	48.21	46.89
Sulphur	0.089	.....
Phosphorus in 100 parts iron...	0.048	0.002

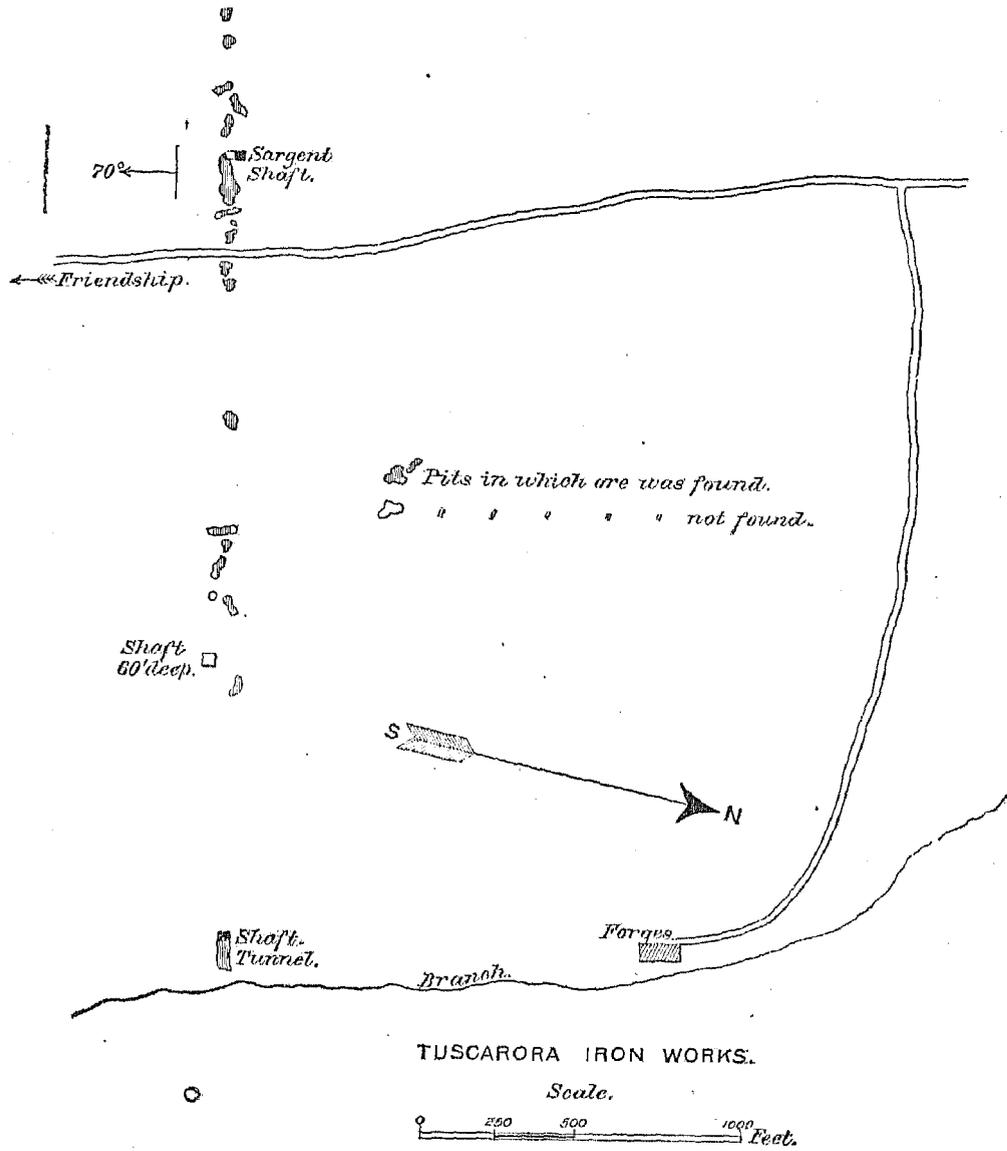


FIG. 114.

PLAN
OF THE
DANNEMORA MINE.

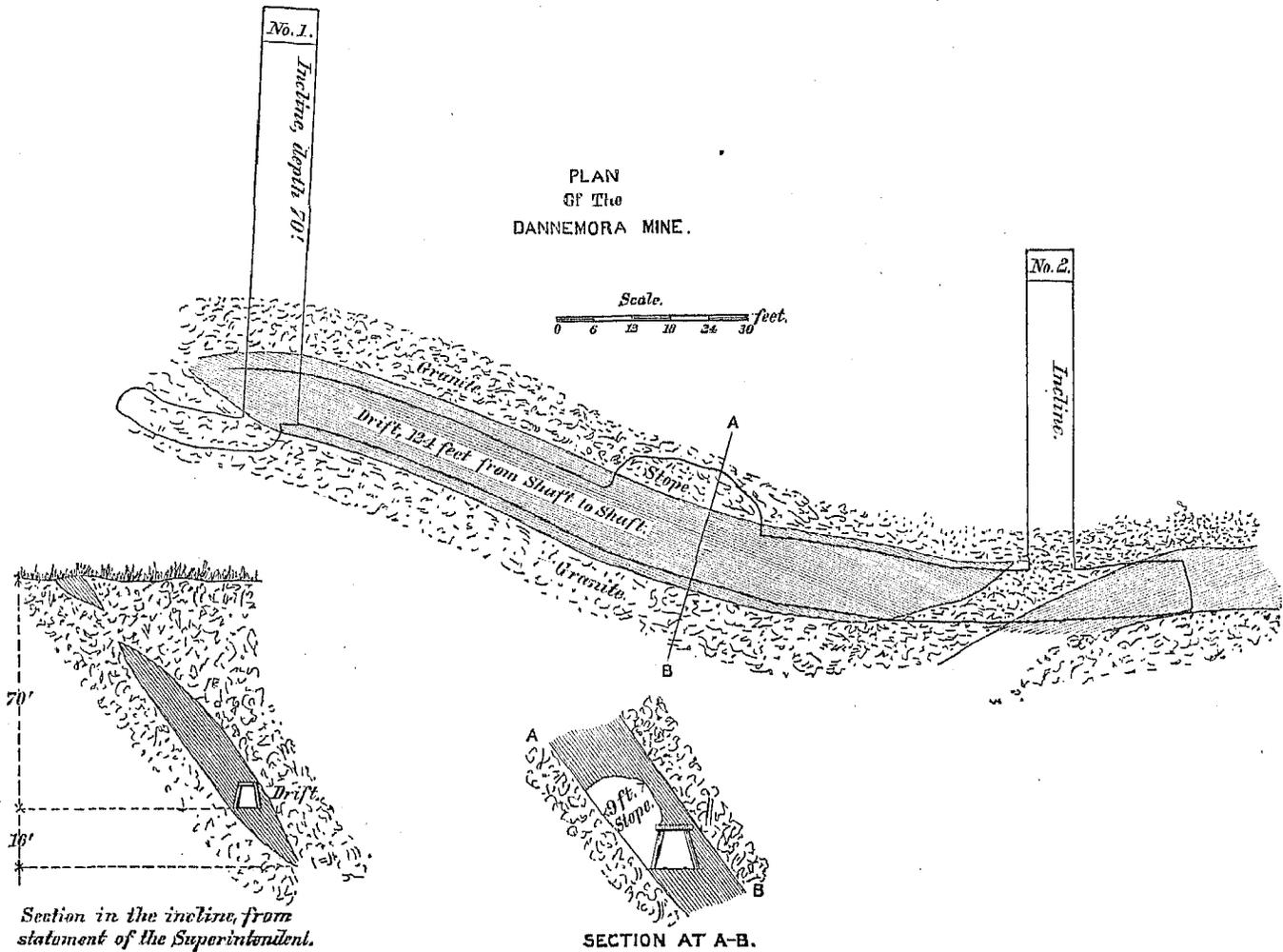


FIG. 115.

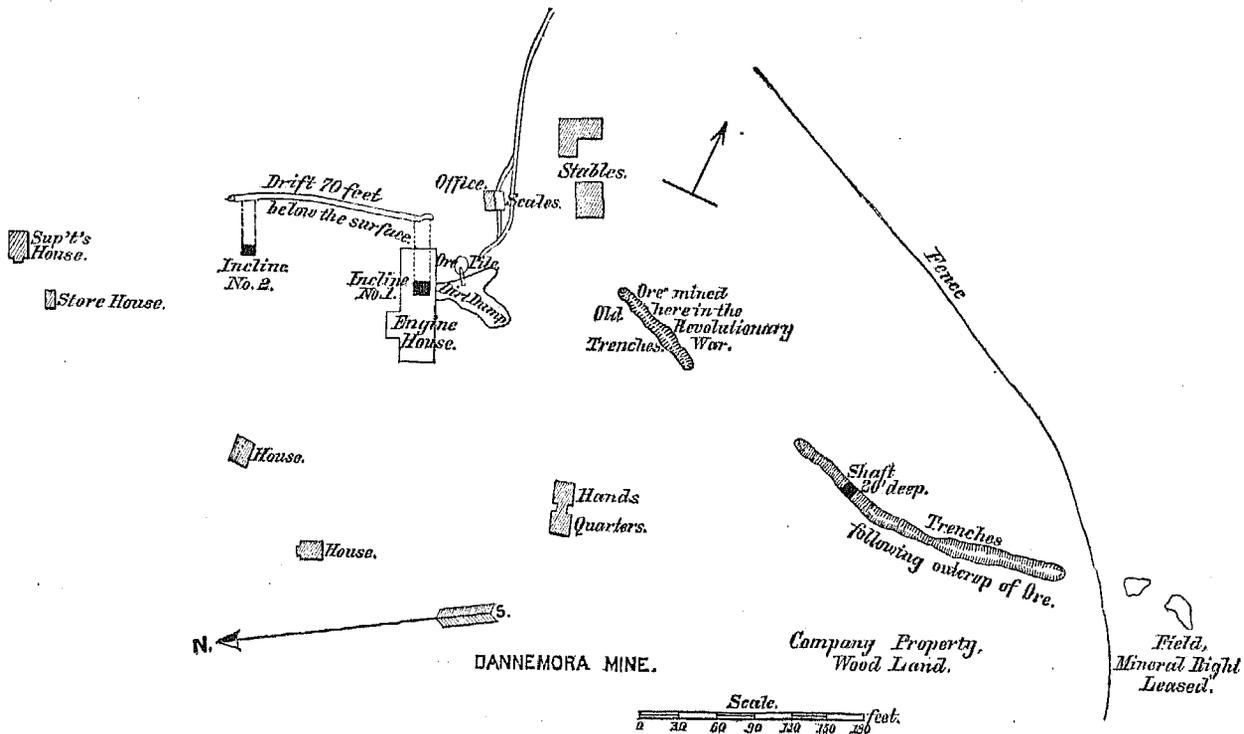


FIG. 116.

Following is the complete analysis of 165:

	165.		165.
	<i>Per cent.</i>		<i>Per cent.</i>
Silica	4.70	Carbon in carbonaceous matter.....	0.06
Iron, protoxide	23.51	Hygroscopic water	0.21
Iron, sesquioxide	43.05	Water of composition	0.98
Alumina	8.66	Total	100.00
Chromium sesquioxide	0.34		
Manganese, protoxide	0.15	Per cent. of insoluble silicious matter.....	28.00
Lime	1.42		
Magnesia	2.96	Silica	4.70
Iron, disulphide	0.133	Alumina	9.75
Nickel, sulphide	0.01	Lime	0.56
Cobalt, sulphide.....	0.03	Magnesia	0.72
Copper, sulphide	0.01	Potassa	0.03
Potassa	0.03	Soda	0.05
Soda	0.05	Phosphoric acid	0.045
Carbonic acid	0.07	Titanic acid	11.82
Phosphoric acid	0.052	Total	27.675
Titanic acid	13.71		

There are two small areas of Huronian rocks in North Carolina, which carry magnetic ores, having similar associations. The first of these is in the northern portion of the state, in Stokes county, in the neighborhood of Danbury; the second is in the southern part of the state, and extends from Catawba county, across Lincoln and Gaston, into York county, South Carolina. The ores of the former consist of mica, chlorite, and talcose schists, charged with magnetite; these are associated with silicious slates and itacolumite; talcose schist, similarly charged with magnetite, occurs throughout the entire length of the southern area, associated with silicious slates, and Professor Lieber mentions itacolumite as one of the members of the series in South Carolina (*Report for 1856*, p. 89). The strike of the rocks of the southern area is about north 10° to 15° east, dipping to the westward at a high angle. The dip in the northern area, which lies in the prolongation of the strike of the other, is toward the northwest and east at angles of 20° to 40°.

6. *Magnetic ores of Stokes and Surry counties.*

This includes the ores of the Huronian, in Stokes county, already referred to, and similar magnetic ores, assigned by Professor Kerr to the Upper Laurentian, in Surry county.

The sketch (Fig. 117), drawn with the assistance of a gentleman well acquainted with the region, shows the location of the ore-beds in the neighborhood of Danbury, Stokes county. The question mark placed against several outcrops indicates that they were not visited by the writer, but are located from statements of others.

All the known beds lie north of the Dan river, with strikes ranging from northwest among the western deposits through north to north by east among the extreme eastern.

The *Hard-Ore* bank, so named on account of the hardness of the ore and associated hornblende schist, lies 4½ miles northwest of Danbury, on a small branch of Buck Island creek.

The ore has been mined at different times on both sides of the branch at two points about 700 feet apart. The dip is about 40° north-northeast, and the bed therefore pitches with the hill on the south side of the branch; the ore was thus very easily obtained at this place, and there are extensive shallow pits now overgrown with trees twenty or thirty years old. The opening on the north side of the branch is a deep trench 50 or 60 feet long which extends under the overhanging bluff of hornblende schist; the vein is said to be 3 to 4 feet thick. It was followed downward until the influx of water and the hardness of the ore made it unprofitable to continue mining. The last work was done in this trench twenty-four years ago; no ore was to be seen in place, and sample 168 was taken from little pieces that were found near the trench, some of these contained pyrite.

	168.
	<i>Per cent.</i>
Iron	56.04
Phosphorus.....	None.

A small brook enters the Dan river just below the mouth of Buck Island creek; the hills on the east of this brook contain several beds of ore, known as the *Nelson* banks, and a shaft sunk on the ridge between the two streams is also said to have struck an ore-deposit.

Two out of the four leads of ore, said to have been found on Mr. Nelson's land east of the branch, are sufficiently well exposed to admit of no doubt as to their character; these are marked 179 and 180 on the sketch, the numbers

a representing the samples taken from them. Near the branch, in the fork of the roads toward the river, is a small pit from which ore is said to have been taken, and on the other side of the road, between the house and the barn, is a shaft of which the same statement is made. This pit and shaft represent, respectively, Mr. Nelson's western and eastern leads of ore.

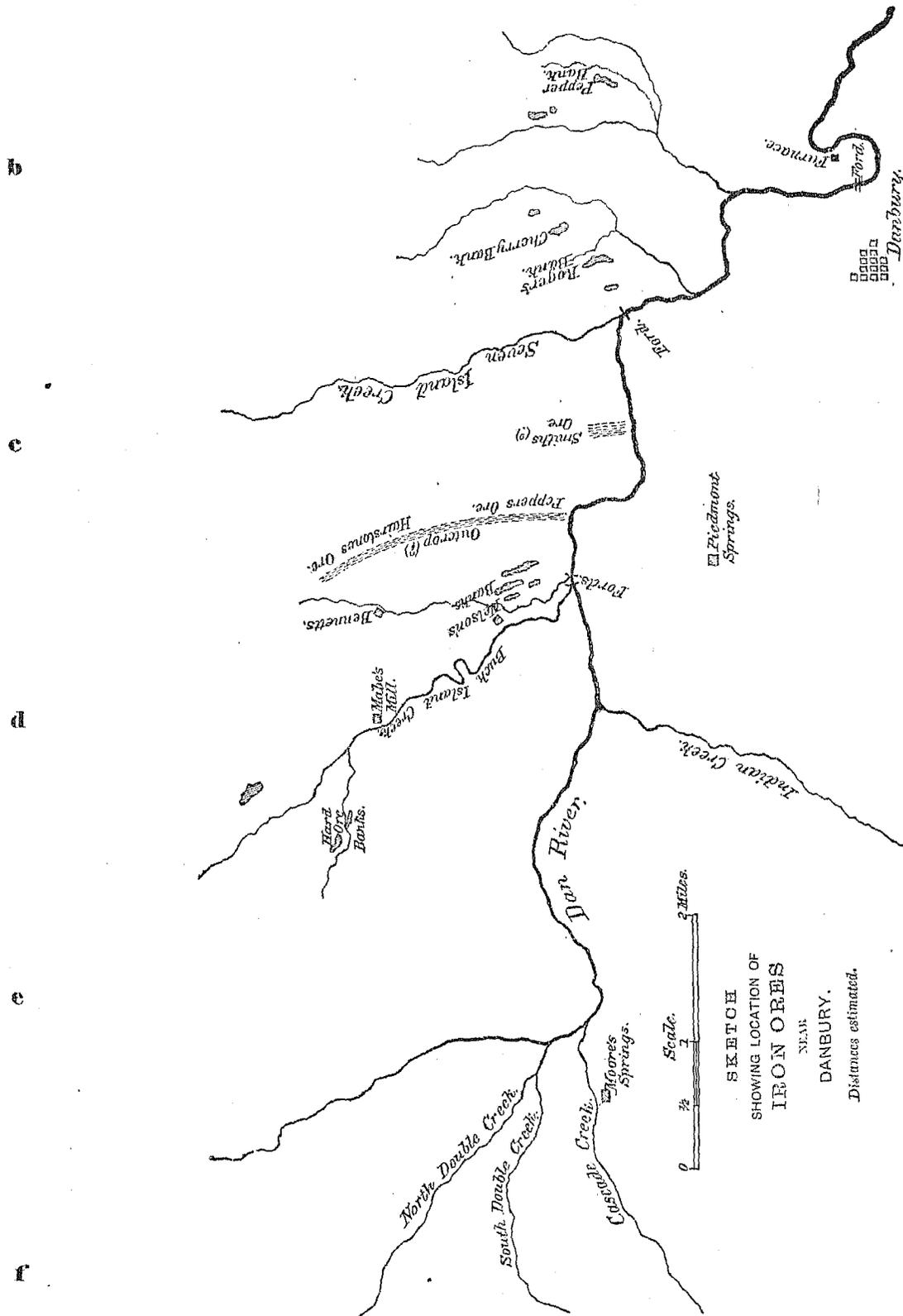


FIG. 117.

The range marked 179 consists of a soft talcose schist, which contains crystals of magnetite irregularly distributed through it. Nothing is known of its extent beyond the three openings shown in the sketch; the most northerly of these was specially cleaned out to get a sample of the ore, and the following section (Fig. 120) was thus exposed:

The sample is an average of the upper and lower beds :

	179.
	<i>Per cent.</i>
Iron	39.70
Phosphorus	0.040
Phosphorus in 100 parts iron	0.101

Nothing was to be seen in the five southern pits on the lead marked 180. The two northern ones were not so much fallen in, and pieces of ore were found near them from which sample 180 was taken. This range consists of hornblende or chlorite schist charged with magnetic ore. It is said it can be followed 2½ miles northwest by surface fragments.

	180.
	<i>Per cent.</i>
Iron	44.45
Phosphorus	0.015
Phosphorus in 100 parts iron	0.034

Both these ores are accompanied by pyrite which occurs in cubical crystals in the talcose schist just overlying. The strata dip about 40° east-northeast. Just east of Nelson's ores is the outcrop of the *Pepper* ore, and half a mile farther eastward lies *Smith's* ore. These deposits were not seen by the writer.

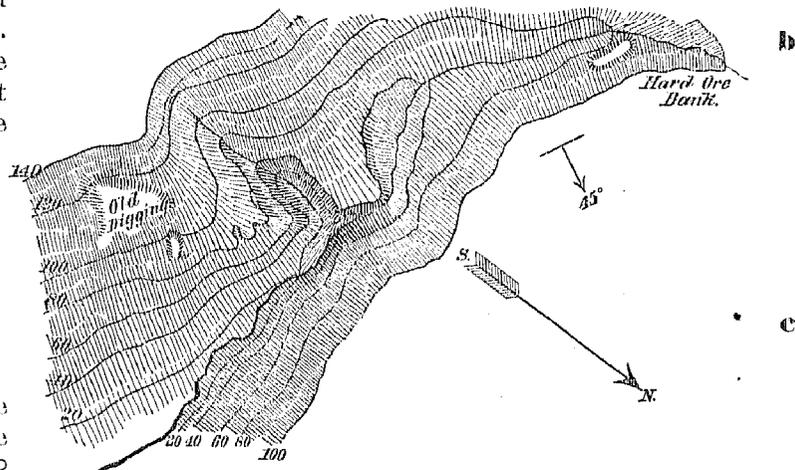


FIG. 118.

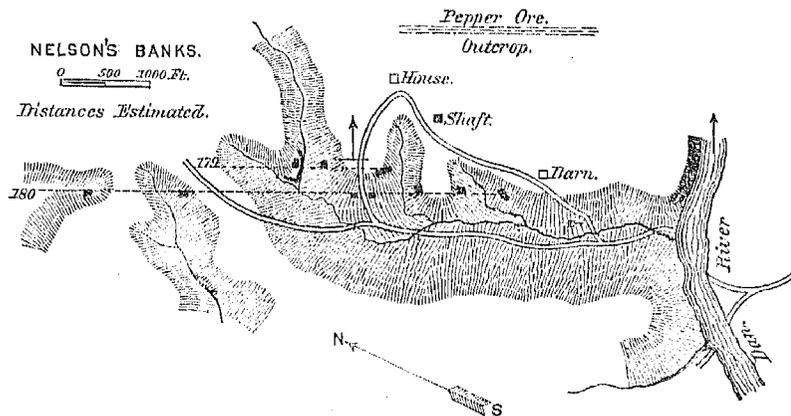


FIG. 119.

Next in order toward the east is the *Roger's* bank which lies near Seven Island ford, about 2½ miles north of Danbury. More work has been done at this bank than at any other; many years ago the outcrops and all the ore, to such depth as the rude pumps and other appliances permitted, were removed.

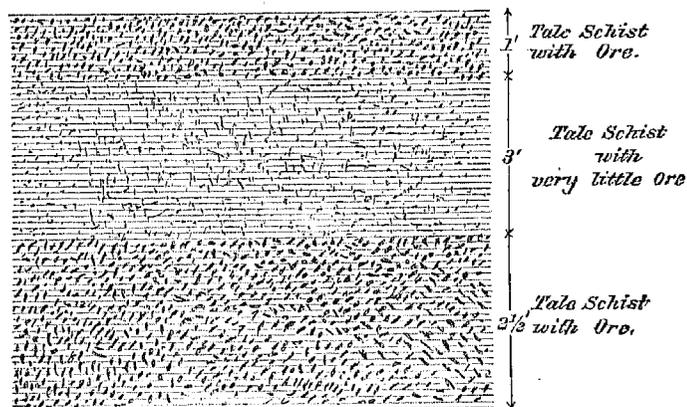


FIG. 120.—SECTION AT THE NELSON BANK, NORTH CAROLINA.

a During the late war the vein was followed in a tunnel at a depth of 60 feet; this tunnel is 150 feet long, and, as will be seen from the sketch, the thickness of the vein varies from 18 inches to 8 feet, the thinnest point being near the bottom of the main shaft; the dip is about 40° east by north. About 2 tons of ore were left near the main shaft in 1865; these had weathered down to an earthy pile, but by digging into it pieces of firm ore were

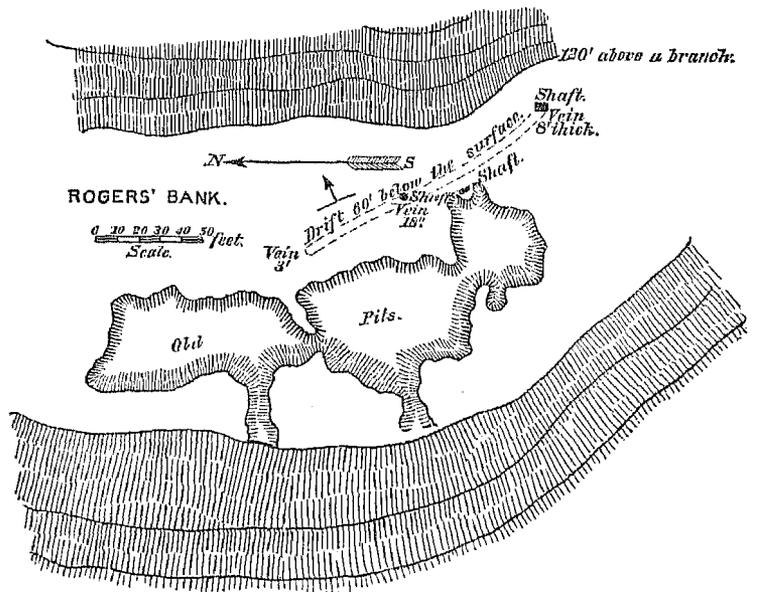


FIG. 121.

found, and the sample was taken from these. It is probable that this sample is richer in iron than the average, since the accompanying chlorite and mica would be the first to decompose. This ore also contains pyrite. The following is the analysis :

	No. 170.
	Per cent.
Iron	58.26
Phosphorus.....	0.001
Phosphorus in 100 parts iron.....	0.002

The complete analysis of No. 170 is as follows :

	170.		170.
	Per cent.		Per cent.
Sulphur.....	0.179	Carbon in carbonaceous matter.....	0.01
Phosphorus.....	0.001	Hygroscopic water	0.07
Iron, metallic.....	58.26	Water of composition.....	0.38
		Total	100.168
Silica	12.29	Per cent. of insoluble silicious matter.....	21.15
Iron, protoxide.....	16.88		
Iron, peroxide.....	64.24	Silica	12.29
Alumina.....	0.58	Alumina.....	4.34
Lime.....	1.99	Lime.....	1.69
Magnesia.....	3.31	Magnesia.....	2.92
Iron, disulphide.....	0.336	Total	21.24
Carbonic acid.....	0.08		
Phosphoric acid.....	0.002		

There are several test-pits in the neighborhood of the Roger's bank, in which parallel beds of ore are said to have been found; and the *Cherry* bank, which lies half a mile northeast, was quite extensively worked fifty years ago.

The *Pepper* ore-bank lies 2½ northeast of Danbury and about 1½ mile east of the Rogers bank. The ore, a granular magnetite, occurs disseminated irregularly through a mica-schist; the beds are conformable to the stratification of the schist, and are a portion of the original stratified deposit. The dip is about 40° southeast. It will be noticed that the dip and associations of this ore differ from those of the other deposits north of Danbury. The dip agrees with that of the Upper Laurentian rocks east of Danbury, as given by Professor Kerr (page 128 of *Geological Report* for 1875), and the ore is very like that of Surry county assigned by him to that age. The old works at this bank consist of several shafts and tunnels, now in a dangerous condition, and a trench about 150

yards long, which extends in a northeast and southwest direction. The thickness of the ore-bed 50 feet below a the surface is stated at 12 feet. Sample 169 was taken from a stratum 1 foot thick, seen in one of the old tunnels. The following is the analysis :

	No. 169.
	<i>Per cent.</i>
Iron	43.92
Phosphorus.....	0.033
Phosphorus in 100 parts iron.....	0.075

The Upper Laurentian ores of Surry county are grouped with those just described in the arbitrary division **b** adopted in this report. It has already been stated that the Pepper bank probably belongs to the same age as these ores, and what is said on page 314 of the occurrence of the magnetite at that bank applies equally well to the deposits of Surry county. The first of these deposits is the *Ferris* bank, near Hyatt's forge, on Tom creek, about 2 miles north of Pilot Mountain post-office. The irregular beds of ore dip with the stratified mica-schist, in which they occur about 30° to the north. A large quantity of ore has been taken out in small shafts and tunnels sunk to the water-level, about 20 feet. At this depth the ore becomes charged with pyrite and can no longer be worked in the forge. Two beds of ore, each about 2 feet thick, were seen in the shaft, which was open at the time the bank was visited; they were separated by about 1 foot of mica-schist. The upper bed is represented by sample 171, the lower by 172; the latter was taken out near the water-level. Sample 173 represents the mingled ore from these **c** two beds after it has been stamped and washed in a rude trough, which only partially removes the associated minerals. Sample 174 was taken from the bottom of a shaft sunk below the water-level, about 100 feet from that in which 171 and 172 were seen. The following are the analyses :-

	171.	172.	173.	174.
	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>
Iron	48.02	60.41	67.10	60.16
Phosphorus.....	0.094	0.073	0.056	0.051
Sulphur	0.106	0.112	0.133	1.956
Phosphorus in 100 parts iron...	0.196	0.121	0.083	0.085

Similar ore is obtained about 200 yards southeast of this bank, and also 1 mile southeast at the *Bullington* bank, but none was to be seen when the locality was visited.

About 7 miles west of Pilot Mountain post-office, across the Ararat river, beds of magnetic ore occur in a sandy mica-schist, dipping about 20° a little west of north. These beds have been mined along a distance of about 1,000 feet in three parallel rows of shafts, sunk 15 or 20 feet apart, to a maximum depth of about 20 feet. One lenticular mass of ore, having a greatest thickness of 6 to 8 feet, has been entirely removed. The southern line of shafts seems to have struck a layer of ore which has not been reached in those north of it.

The following sketch shows the bed of ore from which sample 175 was taken :

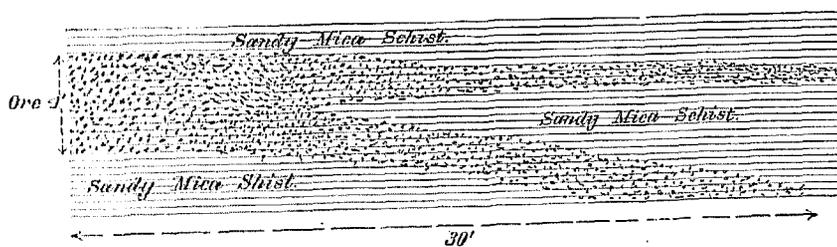


FIG. 122.

Sample 176 represents the same ore when stamped and washed for use in the forge.

	No. 175.	No. 176.
	<i>Per cent.</i>	<i>Per cent.</i>
Iron	38.76	63.30
Phosphorus.....	0.049	0.033
Phosphorus in 100 parts iron ..	0.126	0.052

On the plantation of Mr. Jackson Williams, on the Fisher Gap road from Rockford to Mount Airy, about 3 miles north of Rockford, magnetic ore has been mined over an area of about 12 acres.

a The following are the dimensions of the principal ore-bodies, as given by Mr. Williams:

No.	Thickness perpendicular to strike and dip.	Length along the strike.	Remarks.
	<i>Feet.</i>	<i>Feet.</i>	
1	1	6	Removed to water-level.
2	3	5	Removed to water-level; underlies No. 1.
3	2	6	
4	8	17	Exhausted.

b

Similar deposits of ore occur in the ridges, which extend $1\frac{1}{2}$ mile southwest and $2\frac{1}{2}$ miles northeast of Williams's bank. There are six distinct banks along this line of 4 miles, of which the most northeasterly is the Poplar branch. Another lead of ore comes in half a mile west of Williams's at *Crowder's* and *Stanley's* banks.

Sample 177 is from a bed of ore at *Williams's* bank 3 inches thick, which was being followed as a lead. Sample 178 is from a body of ore at the *Poplar Branch* bank about 2 feet thick and 8 feet long.

The following are the analyses of the ore as mined:

	No. 177.	No. 178.
	<i>Per cent.</i>	<i>Per cent.</i>
Iron	45.28	56.08
Phosphorus.....	0.022	0.029
Phosphorus in 100 parts iron...	0.049	0.052

c

Professor Kerr describes (page 257 of *Geological Report* for 1875) beds of ore in Yadkin and Davis counties which closely resemble the above. The mode of occurrence of these ores indicates that they formed a portion of the original sediments, which, after alteration, produced the micaceous sandstones; a form of deposit similar to that now making on the shores of Long island and in the "Black Sand" beach of Block island.

Limonite near Danbury.—The road, which leads west from Danbury along the northern slope of the Sauratown mountains, crosses several localities where scattered surface fragments indicate the presence of limonite. At one of these places, 8 miles west of Danbury, there are several old trenches, near one of which is a small pile of ore. Sample 181 was taken from this pile and numerous surface pieces on both sides of the road.(a)

	No. 181.
	<i>Per cent.</i>
Iron	47.76
Phosphorus.....	0.690
Phosphorus in 100 parts iron	1.442

e 7. *Magnetic and limonite ores of Lincoln and Gaston counties, North Carolina, and York county, South Carolina.*

The first ores to be mentioned in this group are those of the Killian and Forney mines. These lie in Kerr's "syenitic" belt, assigned by him to the Lower Laurentian, about 5 miles north of Lincolnton, the Forney bank being about 2 miles east of Killian's.

The ore at these banks occurs in irregular pockets, a few inches to 3 or 4 feet thick, and of very uncertain length and depth. The strata stand nearly vertically. No work has been done at either mine below 20 feet.

At the *Forney* bank the line of shafts extends about 400 yards in a direction a little west of north.

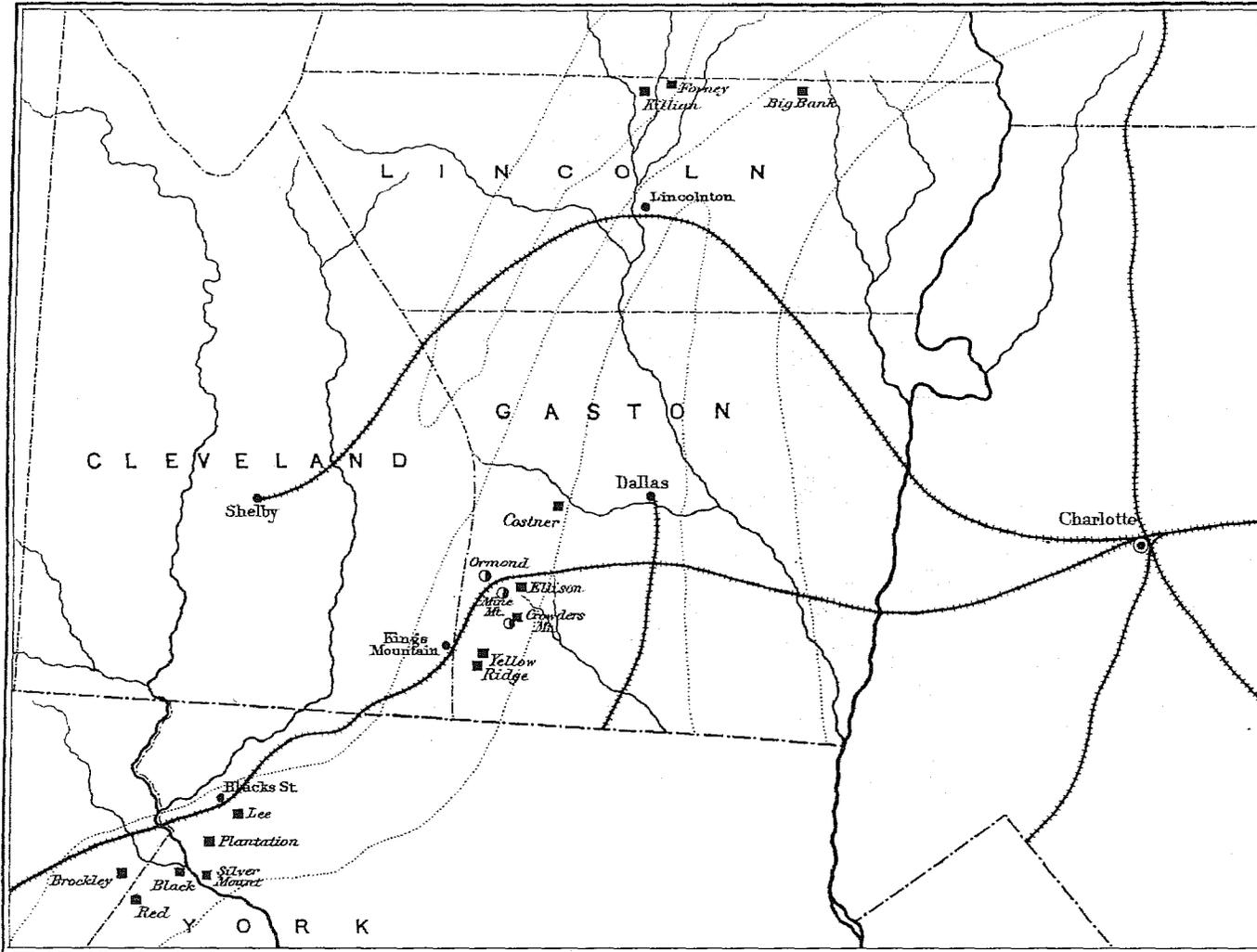
Sample 182 is from about four tons of ore freshly mined at the *Killian* bank at a depth of 20 feet, and sample 183 is from a pocket 3 feet thick at the *Forney* bank.

f

	No. 182.	No. 183.
	<i>Per cent.</i>	<i>Per cent.</i>
Iron	64.92	64.96
Phosphorus.....	0.023	0.009
Phosphorus in 100 parts iron...	0.055	0.014

Huronian (?) magnetites.—These ores and their associated rocks are compared on page 311 with those in the neighborhood of Danbury, in Stokes county. The belt of Huronian strata in which the ores occur extends from Catawba county, North Carolina, to York county, South Carolina, and the distance between the extreme northern ore-bank, in Lincoln county, North Carolina, to the most southern, in South Carolina, is about 50 miles.

a The analysis shows that the ore contains a trace of titanium.



Julius Ben & Co. Lith.

IRON MINES OF GROUP SEVEN (NORTH AND SOUTH CAROLINA).

- Huronian
- Upper Laurentian
- Lower Laurentian
- Magnetite
- Limonite

Drawn from Post Route Map and Kerr's Geological Map for 1873.

Scale, 8 miles = 1 inch.



The *Big Ore* bank lies on a broad ridge 9 miles north of Lincolnton, in Lincoln county. There are a large a number of shafts and trenches scattered in a very irregular manner along a distance of about 1 mile, in a general direction of north 15° to 20° east.

The accompanying sketch (Fig. 123) gives the approximate location of these various diggings, but it is difficult to form an idea of the manner of occurrence of the ore from such irregular workings. The mine was owned by a number of persons, any one of whom dug ore at pleasure, as water is drawn from a well, without keeping any record of it. When the ore found in one shaft was so far removed that it could no longer be shoveled into the bucket suspended from the windlass it was considered easier to sink a new shaft near the old one than to timber up a tunnel and transport the ore underground. These two facts account for the large number of little pits usually seen at an old ore-bank in the south, which often give rise to the idea that the amount of ore is very small and irregular in occurrence, an idea that may sometimes be erroneous. b

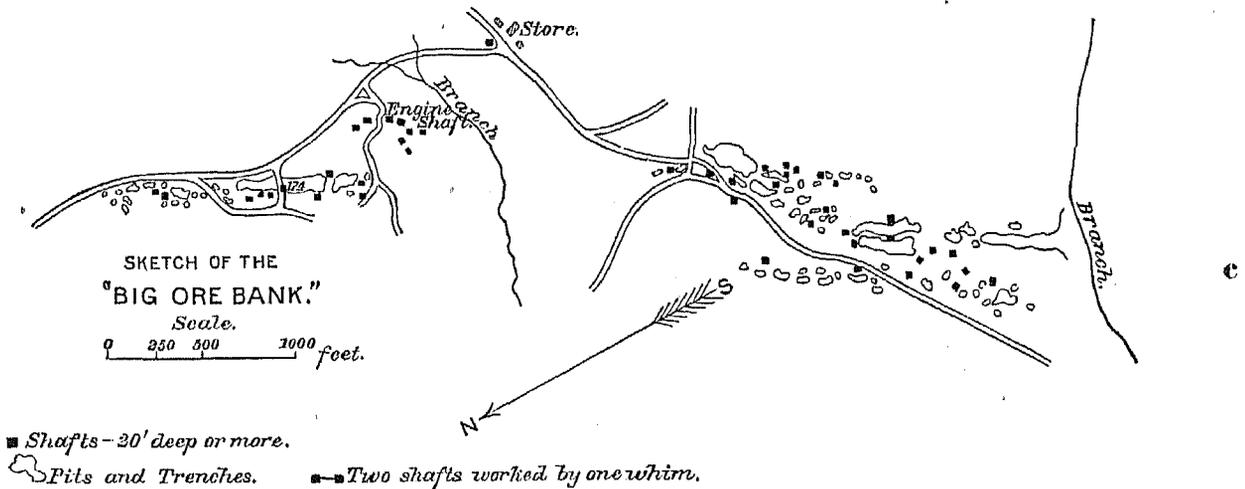


FIG. 123.

According to the statement of an old miner, the ore at the Big bank lies in lenticular masses, which overlap d each other, the southern end of one lying west of the northern end of the next. These ore-bodies consist of alternate layers of magnetic ore and talcose schist, and have a thickness of 8 to 20 feet, with a maximum length stated at 80 feet. The greatest thickness of any one stratum of clean ore is perhaps 2 feet; but such a layer is usually between two thinner ones of talcose schist impregnated with ore, so that the entire thickness would be mined out at once. As the strata stand nearly vertical there are apparently several parallel lines of ore-bodies. No ore was to be seen at the southern end of this bank, but some work had been done north of the little branch, and sample 184 was taken from about one ton, mined at a depth of 40 feet in the shaft so numbered. The analysis gives:

	184.
	Per cent.
Iron	58.38
Phosphorus	0.013
Phosphorus in 100 parts iron	0.022

The complete analysis of No. 184 is as follows:

	184.		184.
	Per cent.		Per cent.
Sulphur	0.086	Phosphoric acid	0.030
Phosphorus	0.013	Carbon in carbonaceous matter	0.01
Iron, metallic	58.38	Hygroscopic water	0.30
		Water of composition	1.01
Silica	9.14	Total	100.250
Iron, protoxide	8.68		
Iron, peroxido	73.67	Per cent. of insoluble silicious matter	14.32
Alumina	2.45		
Manganese, protoxide	0.06	Silica	9.14
Lime	0.27	Alumina	1.83
Magnesia	4.32	Lime	0.20
Iron, disulphide	0.140	Magnesia	3.17
Copper, sulphide	0.05	Total	14.34
Carbonic acid	0.06		

The engine shaft had been sunk during the late war to a depth of 80 feet. The thickness of the mass of ore thus opened was stated at 16 feet. When the bank was visited preparations were being made for pumping out and

a working this shaft, and the census schedules show that this has been accomplished and the mining of ore is now going on for the supply of a small charcoal furnace.

There are several openings of greater or less extent on the strike of the ore north of the Big bank. From the southern end of the latter to the most northerly of these is about $2\frac{1}{2}$ miles, and such is the proximity of the different banks that the range of ore may be considered to be nearly continuous for this distance. A portion of the ore of the Big bank is changed to martite.

About 22 miles from the Big Ore bank, in a general direction of south 25° or 30° west, is the *Costner* bank, the most northerly of a series of beds in Gaston county whose characteristics are the same as those of the range just described. A shaft was sunk during the late war at the Costner bank to a depth of 115 feet, and the thickness of the vein thus opened was stated at 7 feet. Several piles of ore, left near this shaft 15 years ago, had weathered down into earthy mounds, within which were found a few lumps of ore which still retained their form. Sample 185 is from these lumps. A small quantity of a very different ore, called "flint" by the workmen, was taken out in sinking the deep shaft. This is represented by sample 186.

	185.	186.
	<i>Per cent.</i>	<i>Per cent.</i>
Iron	51.75	44.82
Phosphorus.....	0.002	0.004
Phosphorus in 100 parts iron.....	0.004	0.009

The relation existing between these two ores could not be ascertained.

The *Ellison* bank is about 4 miles south by west from the Costner, and is similar in its ore and associations. It lies half a mile from the railroad, between Charlotte and Atlanta, within 50 feet of the road from King's mountain to Dallas. The greatest depth reached at this bank is 112 feet, and the vein varied from 5 to 12 feet in thickness, with an average of 7 or 8. The outcrop has been removed for about 100 yards. Sample 187 is from small pieces of ore, picked up around the old trenches and pits.

	187.
	<i>Per cent.</i>
Iron	54.61
Phosphorus.....	0.016
Phosphorus in 100 parts iron.....	0.029

The same range of magnetic ores, disseminated through talcose schist, has been quite extensively worked on the *Yellow Ridge*, 4 miles south by west from the Ellison bank, and $2\frac{1}{2}$ miles east of King's Mountain Station. There are two groups of pits and trenches on the ridge, about one-quarter of a mile apart. At the northern workings the bed is said to be 6 to 10 feet thick, at a depth of about 30 feet. Sample 193 is from a few pieces of ore found near the old whim-shaft.

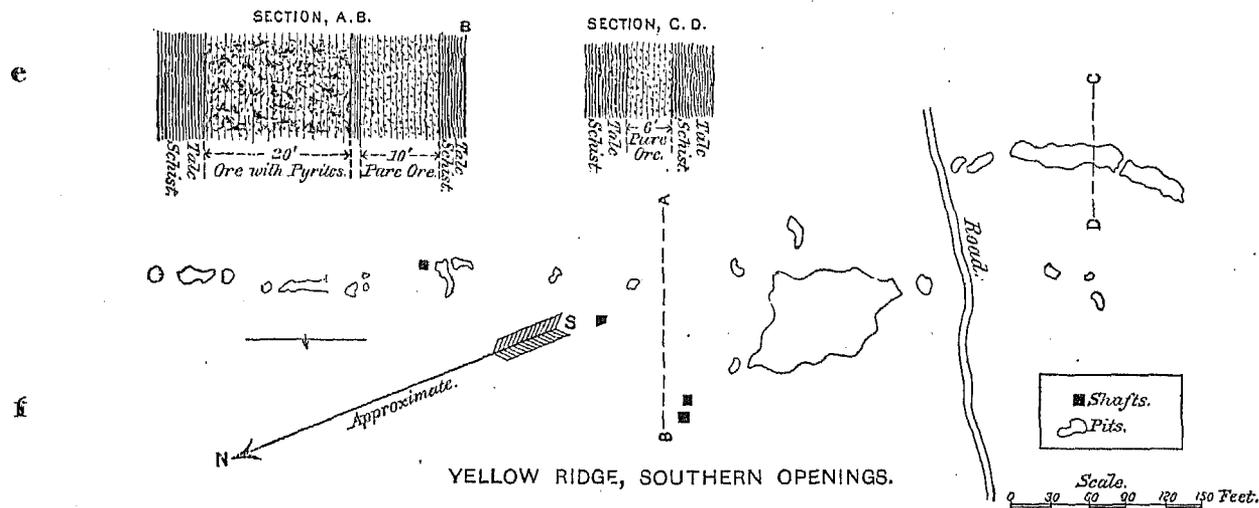


FIG. 124.

The deposit, opened in the southern end of the ridge, consists of two parts, separated by a layer of talcose schist, containing no ore. The western side of the bed is said to be 20 feet thick, and contains a large amount of pyrite. The eastern side is 10 feet thick, and is free from pyrite. A hundred yards farther south the ore narrows to 6 feet, and the portion of the bed that is contaminated with sulphur has disappeared. This is shown in the sketch and sections on Fig. 124.

Sample 191 is from a pile of the ore containing pyrite; 192 is from a few large pieces of pure ore found near the shaft; and 193 is from the northern openings.

	191.	192.	193.
	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>
Iron	57.64	57.43	59.24
Phosphorus.....	0.009	0.010	0.030
Sulphur	0.441	0.101	.....
Phosphorus in 100 parts iron...	0.016	0.017	0.051

Twelve miles southwest of the Yellow ridge, in York county, South Carolina, are the northeastern openings of the King's Mountain Iron Company's mines, which, together with those of the Cherokee Company, open up this same range of ores for about 6 miles.

Passing from northeast to southwest the principal banks are the *Lee*, *Plantation*, and *Stewart*, east of Broad river, and the *Brockley*, west of it. The strata dip about 40° southeast, and the strike is northeast and southwest.

The Lee bank has been very extensively worked along a line of about 6,000 feet, to a greatest depth of 45 feet. The deepest shaft is one-half mile southeast of Black's station, on the railroad between Charlotte and Atlanta. The bed exposed in this shaft is said to widen from 3 or 4 inches at the top to 8 feet at the bottom.

Sample 199 is from a large number of pieces of ore picked up near the old trenches of the southern 1,500 feet of the bank.

It is about 3 miles from the southern end of the Lee bank to the Plantation, of which the Stewart is merely a continuation. The ore-beds are said to be smaller and not as rich as those of the Lee bank, and the openings are not so extensive.

Sample 200 is from about 2 tons of ore mined at the Plantation bank several years ago. The analyses are:

	199.	200.
	<i>Per cent.</i>	<i>Per cent.</i>
Iron	52.16	54.65
Phosphorus.....	0.014	0.002
Phosphorus in 100 parts iron...	0.027	0.004

The openings at the Brockley bank, of which the following is a sketch (Fig. 125), appear to indicate the

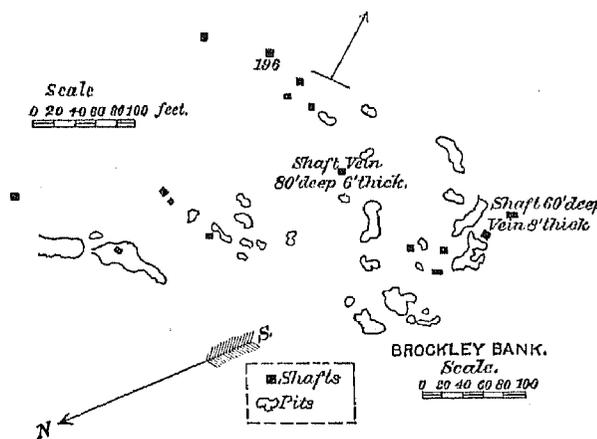


FIG. 125.

existence of several parallel beds of ore.

This bank lies about 2 miles from the railroad.

Sample 196 is from about 1 ton of ore, mined several months before at a depth of 60 feet, in the shaft marked with that number.

	196.
	<i>Per cent.</i>
Metallic iron.....	58.34
Phosphorus.....	0.011
Phosphorus in 100 parts iron.....	0.019

The above description includes all the principal banks on the range of the so-called "gray ores". There are several others in close proximity to these, which differ from them in their general character.

a Two of these banks lie west of Broad river; one $1\frac{1}{2}$ mile south of the Brockley bank, the other at Cherokee ford, 2 miles east of the same point. The former is known as the "red ore", the latter as the "black". The "red ore" consists of magnetite or martite, impregnating a silicious schist. There are three openings upon it, two of them close together, the other half a mile off to the northeast. Sample 197 was taken at the latter opening from about 3 tons of ore mined there some years ago. Nothing could be learned concerning the thickness or general character of the ore-beds.

The ore at the *Black* bank, near Cherokee ford, consists of magnetite, in lenticular masses a few inches to 2 or 3 feet thick, or impregnating the accompanying chlorite schist. The dip of the ore and schist is about 40° to the southeast, and the openings extend about 400 yards along the strike. No work has been done beyond 15 feet below the surface. No satisfactory sample of this ore could be obtained. A pile of very poor ore was all that could be found, and from this sample 198 was selected.

The following is the analysis of the sample 197:

	197.
	<i>Per cent.</i>
Iron	37.79
Phosphorus.....	0.172
Phosphorus in 100 parts iron.....	0.453

c Sample 198 not analyzed.

The *Silver Mountain* bank is opened on a friable bluish-gray ore, consisting of martite in a silicious schist, about 1 mile south of the Plantation bank. The diggings extend for about half a mile in a northeast and southwest direction across the summits of two hills, which border on the Broad river. Sample 401 is from a bed of ore about 3 feet thick, which dips toward the southeast. The analysis gives:

	401.
	<i>Per cent.</i>
Iron	39.24
Phosphorus.....	0.180
Silica	36.67
Phosphorus in 100 parts iron.....	0.450

The Costner, Ellison, and Yellow Ridge banks, near King's mountain, in Gaston county, North Carolina, have already been described. East of this range, on the summit of *Crowder's* mountain, is an outcrop of coarsely granular martite, and somewhat lower down is a bed of limonite. *Crowder's* mountain rises about 1,000 feet above the surrounding country, and is crowned by a bold ridge 50 to 100 paces wide, limited on the east and west by precipices. The northern spur is particularly wild and rugged. The southwestern slope from the summit, though very steep, is less broken, and it is on this that the martite crops out, as shown on the sketch (Fig. 126). The principal

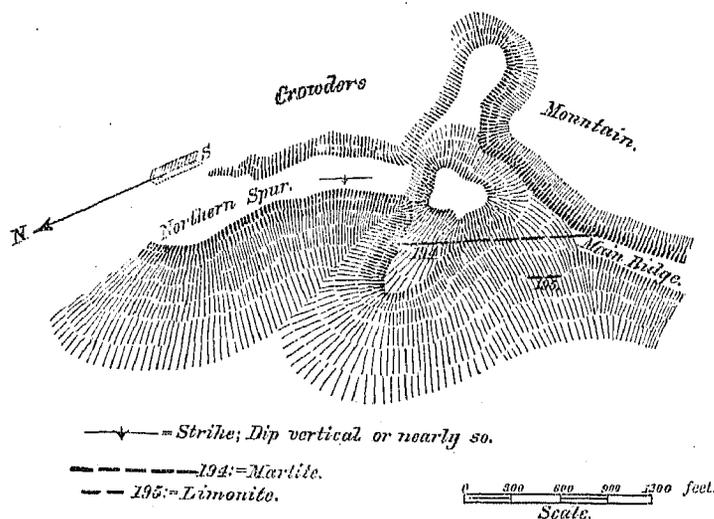


FIG. 126.

exposure is under the roots of a pine tree near the point marked 194. Here the bed of ore is $2\frac{1}{2}$ feet thick. Sample 194 is from this point.

The only other outcrop is on the main ridge and is very small; but surface fragments were found along the **a** hillside across the entire 1,200 feet between the two.

The associated rocks are highly silicious slates, which stand vertically, with a strike of north 15° or 20° east. But little could be learned concerning the limonite represented by sample 195.

About a ton of the ore was piled up near an old trench, at the place designated by that number on the sketch, and the sample was taken from that. Nothing was seen in place.

It is said that there are three other beds of ore on the northern spur of the mountain, but their exact location was not known to any one seen by the writer.

	MARTITE.	LIMONITE.
	194.	195.
	<i>Per cent.</i>	<i>Per cent.</i>
Metallic iron	50.30	55.17
Phosphorus	0.020	0.604
Phosphorus in 100 parts iron...	0.040	1.095

b

Four and a half and 5 miles northeast of King's Mountain Station, near the Piedmont Air-Line railroad, are two interesting deposits of ore, which do not appear to belong to the regular formations hitherto considered. **c**

The first of these is the *Ormond bank*, which lies about 500 yards west of the railroad. The openings at the bank extend about 1,500 feet in a direction of about north 20° east; the greatest depth, 80 feet, was reached in the engine-shaft.



FIG. 127.

d

The ore was said by an old miner to lie in lenticular masses 3 to 8 feet in thickness, the southern end of one, lying east of the northern end of the one beyond it.

About two tons of ore were found near the shaft marked 190 on the sketch, and the sample of that number was taken from them. This pile contained two kinds of ore intimately associated in the same pieces; the first is very dense, hard enough to scratch glass, has a brown streak like limonite, and is distinctly magnetic; it is not at all granular, and in appearance closely resembles many of the dense homogeneous limonites. The other is dark **e** colored, fine grained, and slightly friable; it shows lamination, has a very dark almost black, slightly reddish streak, and is also magnetic. The two occur in such intimate association, that but one sample was taken from the pile.

The analysis of this gives :

	190.
	<i>Per cent.</i>
Iron	65.82
Phosphorus	0.002
Phosphorus in 100 parts iron	0.140

The second deposit is known as the *Mine Mountain*. It lies about half a mile east of the railroad on a spur of Whetstone mountain, three-quarters of a mile from the Ormond bank. **f**

The ore is limonite altered from siderite or calcite; portions of it are mamillary and stalactitic, but the greater number of specimens show pseudomorphs after rhombohedra. It incloses large crystals of quartz, sometimes 3 inches through, whose surfaces bear the impressions of rhombic crystals. Associated with this limonite is an earthy friable ore, which also shows pseudomorphs after rhombohedra, but has a dark-reddish streak, and is apparently manganiferous.

These ores occur in a vein, 8 to 10 feet wide, with vertical walls of silicious slate. An open cut 20 feet deep and trenches extending to a distance of 100 feet are the only workings. The strike is about north 30° east.

Samples 188 and 189 represent the limonite and manganiferous ore, respectively; they were taken from two piles of about 10 tons each at the bank.

a Besides the quartz crystals which the ore contains, there are others of apatite of such size that they could be separated by hand-picking and they were not included in the samples.

	188.	189.
	<i>Per cent.</i>	<i>Per cent.</i>
Metallic iron	61.00	58.37
Phosphorus	0.009	0.005
Phosphorus in 100 parts iron ..	0.015	0.009

Following are the complete analyses :

	No. 188.		No. 189.			No. 188.		No. 189.	
	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>		<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>
Sulphur	0.090	0.112	Carbonic acid	0.15	0.14	Phosphoric acid	0.023	0.017	
Phosphorus	0.009	0.005	Carbon in carbonaceous matter	0.06	0.03	Hygroscopic water	0.33	0.62	
Iron, metallic	61.00	58.37	Water of composition	0.30	4.24	Total	100.272	99.868	
Silica	1.63	5.28	Per cent. of insoluble silicious matter ..	1.63	5.50	Silica	1.63	5.28	
Iron, protoxide	0.24	0.29	Silica	1.63	5.28	Alumina	Trace.	0.26	
Iron, peroxide	86.75	82.92	Lime	Trace.	0.14	Total	1.63	5.68	
Alumina	0.25	1.33	Nickel, sulphide	Trace.					
Manganese, protoxide	1.00	4.11	Cobalt, sulphide	Trace.					
Lime	0.24	0.52	Copper, sulphide	Trace.					
Magnesia	0.13	0.16							
Iron, disulphide	0.169	0.211							
Nickel, sulphide	Trace.	Trace.							
Cobalt, sulphide	Trace.	Trace.							
Copper, sulphide	Trace.	Trace.							

8. *Limonite near Hickory, and magnetite and specular ores of Caldwell county, on the Upper Yadkin river.*

These ores are grouped together simply for convenience of enumeration; they possess no characteristics in common, and have different geological relations.

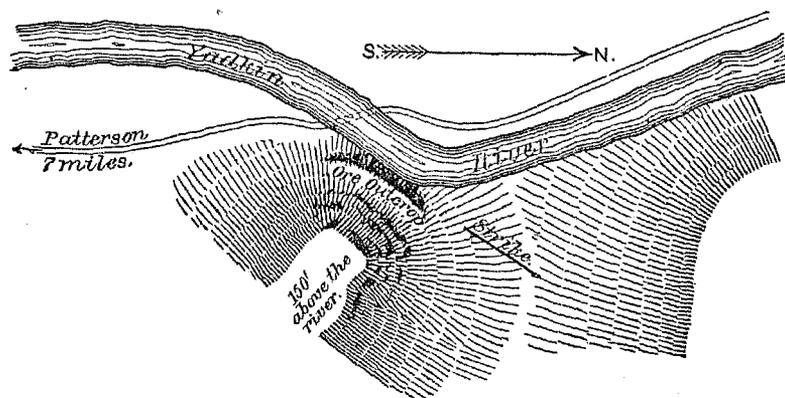


FIG. 128.—SKETCH OF THE OUTCROP OF TITANIFEROUS MAGNETITE ON THE UPPER YADKIN RIVER, NORTH CAROLINA.

The farm of Mr. N. Propst lies a quarter of a mile north of the Western North Carolina railroad, very near the eastern boundary of Burke county. A bed of limonite was opened many years ago in a field close by his house, and the ore is said to have been quite extensively used. All the old pits are now filled up, and sample 404 was taken from scattered pieces of ore found in the field. Surface pieces indicate the extension of the bed of ore in a northeast and southwest direction for about half a mile, the line crossing the railroad; and about 4 miles southwest of Propst's similar ore used to be dug, at Mrs. Townsend's. The analysis of sample 404 gives—

	404.
	<i>Per cent.</i>
Iron	54.84
Phosphorus	1.357
Phosphorus in 100 parts iron	2.474

The age of this ore, according to Kerr, is Upper Laurentian.

The Yadkin river above Patterson is a clear mountain stream, sometimes closely hemmed in among the spurs of the Blue Ridge, sometimes bordered by a narrow strip of bottom-land.

The farm of Mr. Curtis is on the river about 7 miles from Patterson, where the valley, a quarter of a mile in width, is bounded by wooded hills 150 to 200 feet high. The road crosses the river at a bend close to a bluff of chlorite schist about 20 feet high. This schist contains grains of a titaniferous mineral that has a black streak, a metallic luster, and is very slightly magnetic.

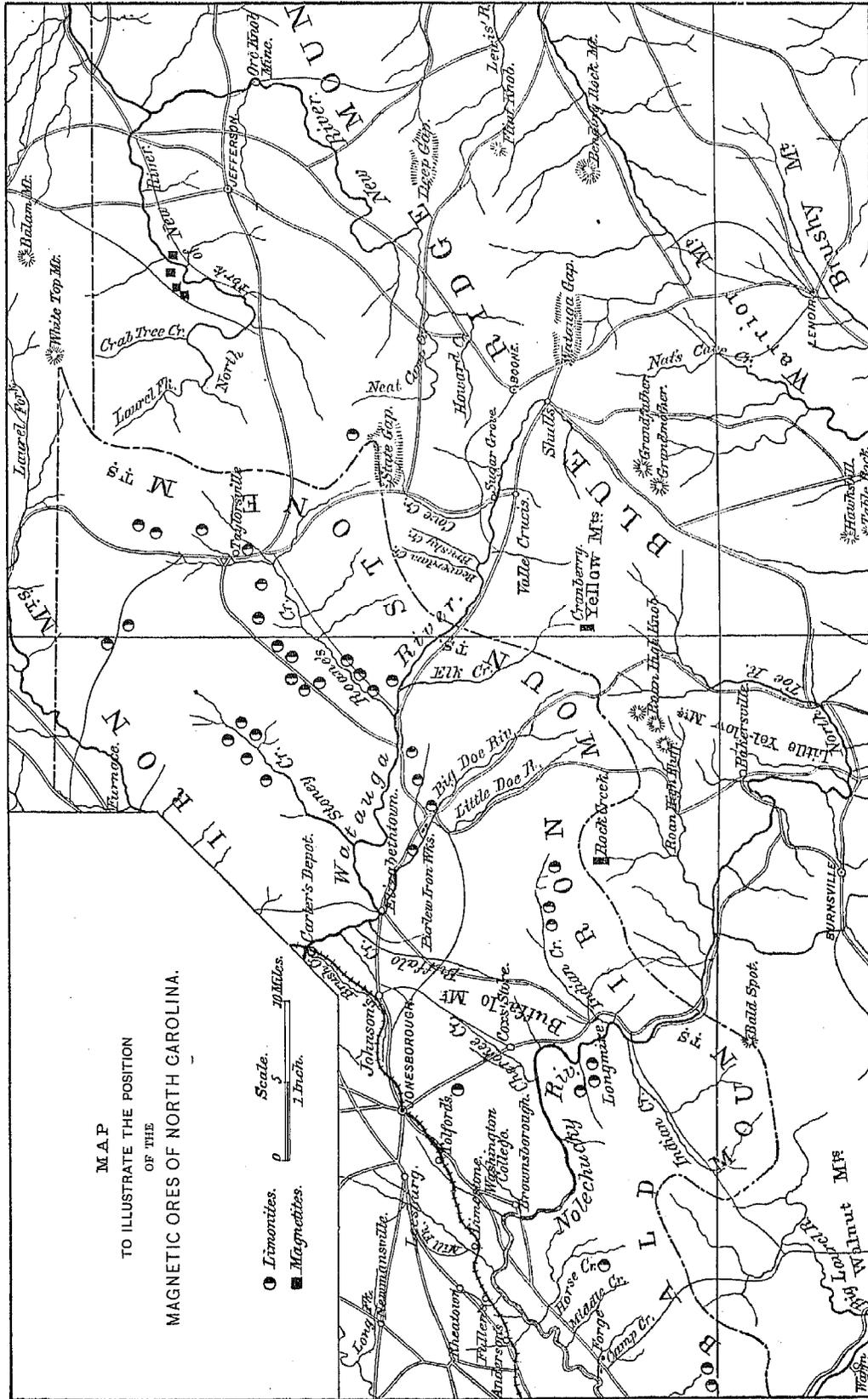


FIG. 129.

Surface fragments of the rock, which is distinguished by its specific gravity and granular appearance, are said to have been traced several miles toward the northeast. The stratum is something over 50 feet in thickness.

a Dennis creek, one of the small streams running into the Yadkin river near its source, flows through a narrow valley called the "Richlands", which comes to an end among the high spurs of the Blue Ridge, near the Watauga and Caldwell county line. Near the head of the creek, just over the line in Watauga county, are several open cuts in a very steep hillside, which were dug in search of specular ore. The rock is principally a light-gray slate, which is thickly sprinkled with crystals of magnetite, and is accompanied by layers of specular schist one-fourth to 1 inch thick.

At Bull Ruffin, 4 miles northeast of this point, the same ore is said to crop out in a bed 1 foot thick, and it is also stated that it can be traced nearly continuously from the one locality to the other.

Sample 406 was taken at the head of the Richlands; it was not easy to separate the thin layers of ore entirely from the associated schist, and it is possible that a larger bed, if found, would yield a higher percentage of iron.

b The analysis gives—

		406.
		Per cent.
Iron		44.45
Phosphorus		0.012
Phosphorus in 100 parts iron		0.027

9. Magnetic ores of Ashe, Mitchell, and Madison counties.

Ashe county.—The location of the ores sampled in Ashe county is shown on the accompanying sketch (Fig. 130):

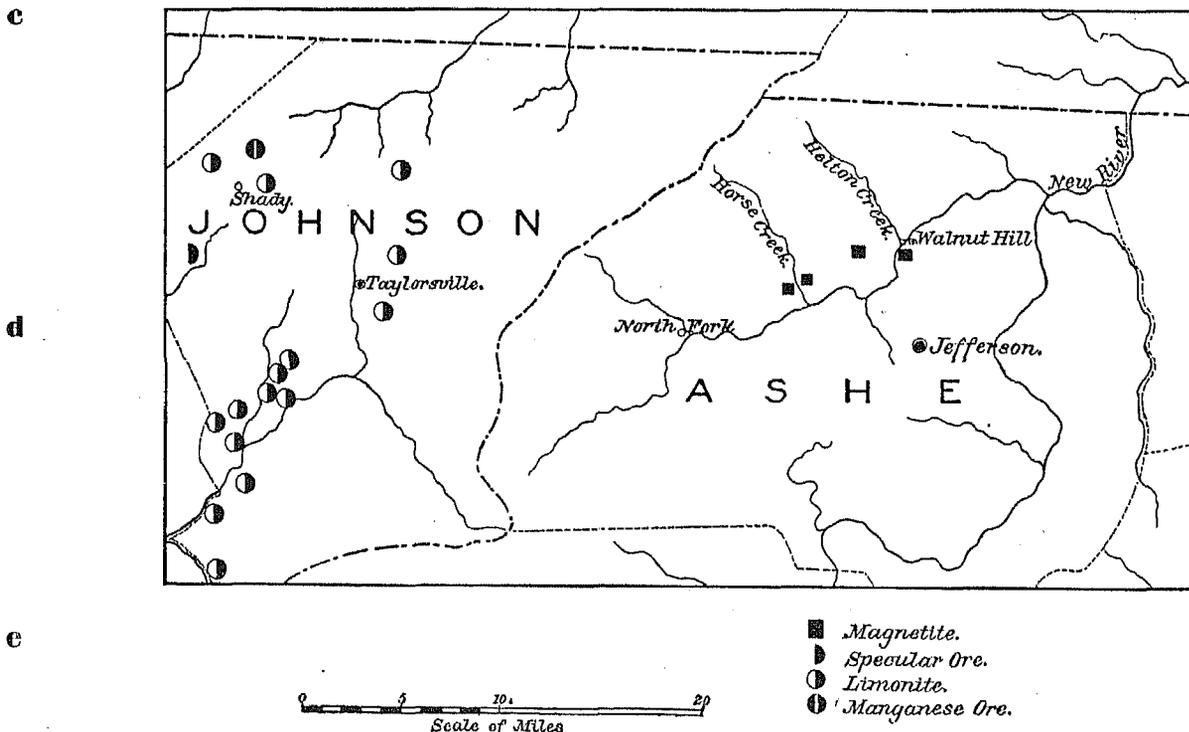


FIG. 130.—MAP OF PARTS OF JOHNSTON AND ASHE COUNTIES, NORTH CAROLINA, SHOWING LOCALITIES OF IRON ORES.

The first deposit seen is that on *Horse creek*, half a mile above its mouth, on the lands of J. and C. Graybeal and F. S. Hampton. The ore is a magnetite, which occurs in coarse crystals, associated with hornblende and mica. Thirty years ago it was mined on the farm of Mr. Joseph Graybeal and worked in a forge near by; but the old pits are now filled up, and only weathered surface-pieces of ore are to be seen. These present a peculiar honeycombed appearance, on account of the removal of the accompanying minerals, which have left a nearly pure magnetite behind. Sample 942 was taken from a large number of such pieces which were scattered over a steep hillside. It is possible that some portions of the ore may be as rich as this sample, for the proportions of foreign minerals vary very much in all similar ores of this region; but it is probable that sample 941, taken from ore dug in a small pit on Hampton's land, 1 mile northeast of Graybeal's, represents more nearly the average yield of the bed. Nothing could be seen or learned concerning the thickness of the bed or its general character. It was not definitely ascertained that the ores at Hampton's and Graybeal's belong to the same bed; it is possible there may be two parallel belts. The above samples contained—

		941.	942.
		Per cent.	Per cent.
Iron		51.66	63.80
Phosphorus		0.019	0.009
Phosphorus in 100 parts iron ..		0.037	0.014

The *Poison Branch* bank lies about 1 mile from New river and 2 miles from the mouth of Helton creek, 3 or 4 a miles east of Graybeal's. The bed, exposed in an open cut, consists of two parts. The upper is 1 foot thick, and consists of mica-schist, which incloses large crystals of magnetite; it is much decomposed and is quite soft. Immediately beneath it is a hard, fine hornblende schist 2 feet thick, which is also impregnated with magnetite.

Sample 943 represents the upper and 944 the lower part of the bed, both taken at the bank from the ore in place. The following are the analyses:

	943.	944.
	<i>Per cent.</i>	<i>Per cent.</i>
Metallie iron	62.78	50.63
Phosphorus	0.041	0.010
Sulphur	1.000	0.070
Phosphorus in 100 parts iron ..	0.005	0.032

b

Another deposit of magnetic ore, associated with hornblende, has been opened on the land of Mr. N. B. Ballow, on the south side of New river, a mile above the mouth of Helton creek. No mining has been done, but the bed has been uncovered, exposing 12 feet of ore, with a thin parting of hornblende and quartz in the middle. On the other side of the river, a quarter of a mile from this exposure, the bed crops out about 1 foot thick, on much lower ground, and on another hill a little farther southwest it is 3 or 4 feet thick.

c

Sample 945 was taken from the bed on the south side of the river. The analysis gives:

	945.
	<i>Per cent.</i>
Iron	48.92
Phosphorus.....	0.018
Phosphorus in 100 parts iron	0.037

Southeast of the iron ore, close to the river, Mr. Ballow has uncovered a bed of peculiar graphitic gneiss, 2½ to d 3 feet thick.

The *Cranberry* ore-bank is the best known and most typical of the deposits of magnetic ore in western North Carolina. It lies on one of the northern spurs of the Big Yellow mountain just west of Cranberry creek.

The following sketch, taken from *Kerr's Report* for 1875 (p. 264), gives the general outlines of the deposit and the contours of the steep ridges, upon which are located the shallow diggings that have furnished ore for the Cranberry forge. No mining has ever been done and all the old pits, except those on the southeastern pitch, marked 407, 408, and 409, are caved in; in the absence of outcrops the limits of the bed have therefore to be determined by the distribution of surface fragments. These are found, as shown by Professor Kerr, on the highest ridge, and are more or less thickly scattered over the hillside down to the creek. (a)

At the time the bank was visited, April, 1880, there were several cuts extending around the hill at about the e 60- to 75-foot contour line from the road on the southwest to the little brook; there were also several openings on the other side of the brook in which the ore was exposed.

In the section thus formed the mass of ore south of the brook consists of pyroxene, accompanied by magnetite; contained in this mass are small pockets or veins of very pure, dense, coarsely crystalline magnetite 1 to 2 feet thick. There are also very similar pockets of pyroxene, which breaks out in sharply angular pieces. North of the brook the pyroxene is largely replaced by epidote. At the opening marked 409 pure ore, pyroxene with ore, and epidote with ore may be seen in close contact in irregular bunches, having no well-defined limits.

Samples 407, 408, 409, and 410 represent respectively the pure magnetite, the pyroxene with magnetite which forms the mass of the ore, the epidote and magnetite, and the pure pyroxene. They were each taken as averages of the exposed rock at the points designated by their respective numbers on the sketch: f

	407.	408.	409.	410.
	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>
Sulphur	0.115	0.128	0.128	.....
Phosphorus.....	0.004	0.007	0.010	0.009
Metallie iron	64.64	44.08	32.37	24.01
Phosphorus in 100 parts iron...	0.006	0.016	0.031	0.037

aSince this locality was visited a railroad has been completed to Cranberry, and extensive mining operations are now in progress.

a Following are the complete analyses of 407 and 409:

	No. 407.	No. 409.		No. 407.	No. 409.
	<i>Per cent.</i>	<i>Per cent.</i>		<i>Per cent.</i>	<i>Per cent.</i>
Silica	5.27	29.99	Per cent. of insoluble silicious matter	7.20	43.69
Iron, protoxide	26.68	18.93		Silica	5.27	29.99
Iron, peroxide	62.57	25.05	Alumina	1.41	4.63
Alumina	1.18	16.07	Lime	0.52	4.62
Manganese, protoxide	0.22	0.76	Magnesia	0.26	0.56
Lime	1.40	11.33	Ferrous oxide		3.78
Magnesia	0.55	1.78	Potassa		0.10
Iron, disulphide	0.200	0.180	Soda		0.07
Nickel, sulphide	0.04	0.09	Total	7.46	43.75
Carbonic acid	0.08	0.07			
Phosphoric acid	0.007	0.024			
Titanic acid	0.95				
Hygroscopic water	0.35	0.37			
Water of composition	0.49	1.49			
Total	100.047	100.134			

b

c

d

e

f

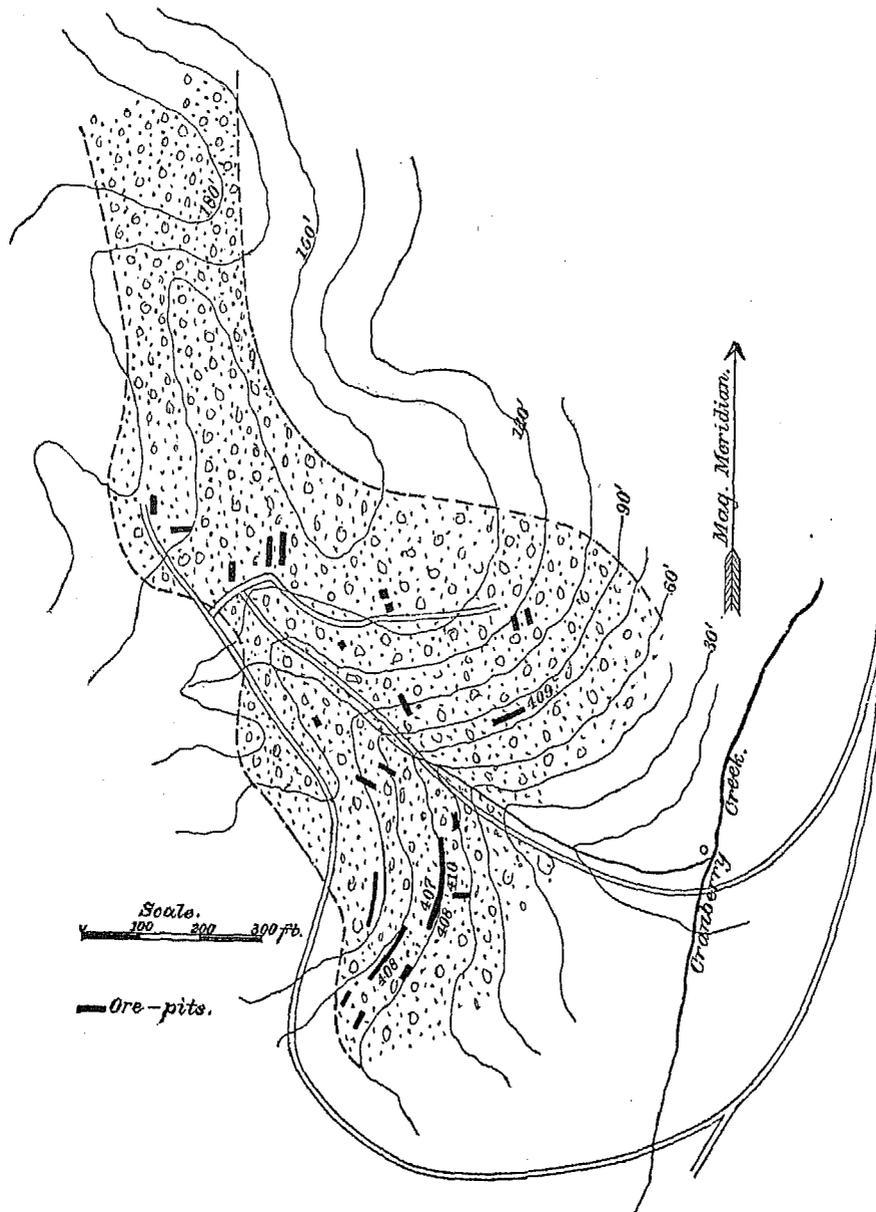


FIG. 131.—SKETCH OF THE CRANBERRY ORE-BANK, NORTH CAROLINA. From Kerr's Report for 1875.

Big Rock creek, one of the tributaries of Toe river, in Mitchell county, gathers its waters from the western slopes of the Great Roan and the southern and eastern sides of Iron mountain. These ranges, together with their

bold spurs, that rise from 1,000 to 3,000 feet above the creek, form a number of converging mountain valleys, a several of which meet near Cloudland post-office. Three miles north of this point, on the steep hillside west of Greasy creek, there is a small open cut, in which a bed of very pure, rich magnetite is exposed. The ore is very similar in appearance to the pure ore of Cranberry, and has a thickness of 5 to 8 feet. The ridge, upon which it is found, extends in a course of about south 15° west to Cloudland, where it is cut through by the most western of the streams that meet there, and then continues in about the same direction for some miles. It is said that this ore has been traced by surface-pieces to a distance of 15 miles along this ridge from the open cut first described. Widely-scattered fragments of epidote, which cover the hillside, indicate that here, as at Cranberry, it is one of the associates of the magnetite, though none of it was seen in the ore itself.

Sample 411 was taken from about 1 ton of the ore at the pit above Greasy creek. The following is the analysis:

	411.
	<i>Per cent.</i>
Iron	63.36
Phosphorus	0.012
Phosphorus in 100 parts iron	0.019

Another bed of magnetic ore, whose associations and character prove it to be closely related to those just described, has been opened on Big Ivy creek, in Madison county, 3 miles from the French Broad and 12 miles from Asheville. This opening **c** is on the land of Mr. Ellers, on a steep hillside, within 200 yards of the creek. It is a trench, about 15 feet deep and 35 feet long, dug at right-angles to the ore-bed, which strikes about northeast. The following is the section thus exposed (Fig. 132):

In this section the proportions of magnetite and pyroxene vary considerably, and the belts, indicated on the sketch, are not separated by sharply-defined lines. But the preponderance of pyroxene at the sides, for the widths given, is such as to warrant the statement that the ore, rich enough to bear transportation, has not a greater thickness than 10 feet.

Sample 412 was taken from the central 10 feet of the bed in the trench. The following is the analysis:

	412.
	<i>Per cent.</i>
Iron	42.95
Phosphorus	0.005
Phosphorus in 100 parts iron	0.012

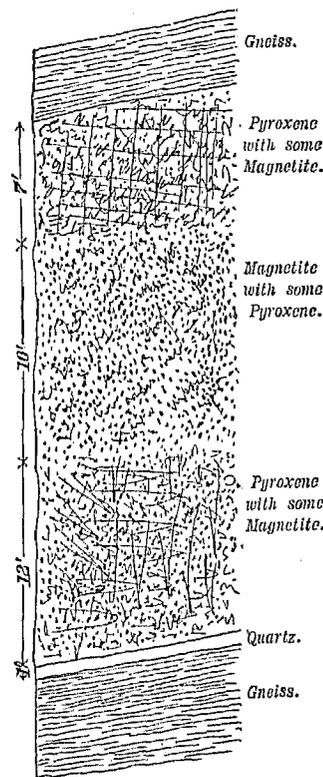


FIG. 132.—SECTION OF ORE DEPOSIT AT BIG IVY CREEK, NORTH CAROLINA.

10. Limonite of Cherokee county.

Professor Kerr gives, on pages 269 and 270 of his report for 1875, a somewhat detailed description of the three **e** parallel limonite belts on Valley river and southeast of it, and of their associates, marble, steatite, quartzite, mica-schist, and gneiss. The writer was unable to follow out the details of the section given by him, but he visited and sampled the five most important mines, including all three ranges. The location of these points is given on the accompanying sketch (Fig. 133), each one being indicated by the number of the sample taken there:

The first place visited is on the property of Mr. Morse, in the valley of Valley river, 10 miles northeast of Murphy. The bed seen at this point was about 8 feet wide, with a strike nearly east and west, at an angle with the general strike of the range. The ore is compact and hard, with nodules filled with clay and some softer, more earthy portions.

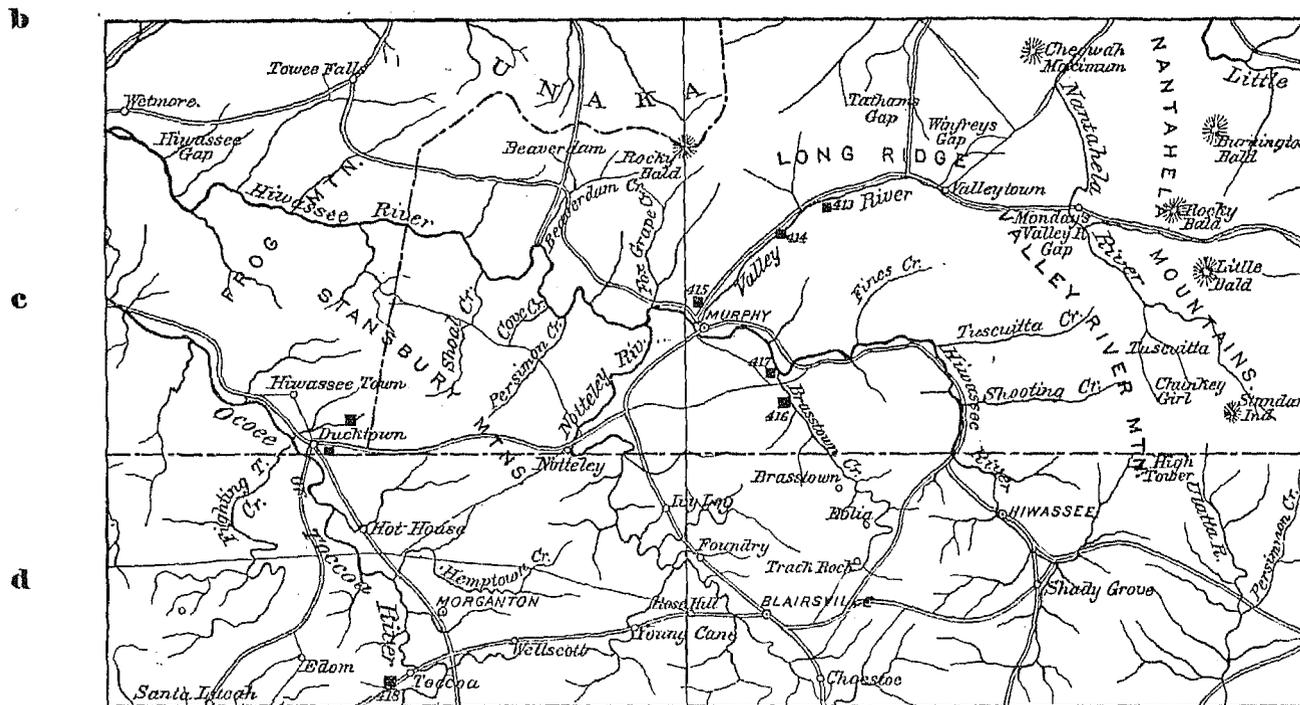
Sample 413 is an average of the entire face of ore exposed, which was 8 feet wide by 6 feet high. The analysis gives—

	413.
	<i>Per cent.</i>
Iron	57.84
Phosphorus	0.021
Phosphorus in 100 parts iron	0.036

Three miles southwest of Mr. Morse's bank, on the same general range with it, are some small pits, known as the *Tomotla* bank. The ore is but little used, as it makes a hard iron. Sample 414 was taken from a small pile of it near an old pit.

a One-quarter of a mile northeast of Tomotla there are a number of pits, from which good ore is said to be obtained. None of it was to be seen. The extent of the openings indicate that the bed is 200 feet wide at this point, if not more. The analysis of the Tomotla ore gives—

	414.
	Per cent.
Iron	55.85
Phosphorus	0.291
Phosphorus in 100 parts iron	0.521



NOTE.—Mine symbols on this map should have been the half-black circle, to indicate limonite.

FIG. 133.—MAP OF PORTIONS OF CHEROKEE COUNTY, NORTH CAROLINA, AND FANNIN COUNTY, GEORGIA, SHOWING LOCATION OF IRON MINES SAMPLED.

Another point on this range, 1 mile north of Murphy, which has been largely worked, is known as *Section Six*. The diggings are extensive, but so much caved in that but one small exposure of ore was to be seen.

e Sample 415 was taken from this ore in the pit. The analysis gives—

	415.
	Per cent.
Iron	58.25
Phosphorus	0.387
Sulphur	0.160
Phosphorus in 100 parts iron	0.664

The middle belt of ore has not been largely worked near Murphy.

f A small opening 5 miles southeast of Murphy, on the land of *Mr. Little*, furnished sample 417, of which the analysis gives—

	417.
	Per cent.
Iron	51.94
Phosphorus	0.994
Phosphorus in 100 parts iron	1.914

The third or most eastern belt has been quite largely worked at *Mr. Monteith's*, 6 miles southeast of Murphy. The ore is similar to that seen on the first range, and like that is variable in its quality. The better portions of the ore are hard and flint-like, the softer being more silicious, and grading into a brown clay.

The bed at Monteith's varies from 4 to 10 feet in thickness.

Sample 416 was taken from the ore in place, in one of the open cuts. The analysis gives—

a

	416.
	<i>Per cent.</i>
Iron	50.46
Phosphorus.....	0.601
Phosphorus in 100 parts iron	1.224

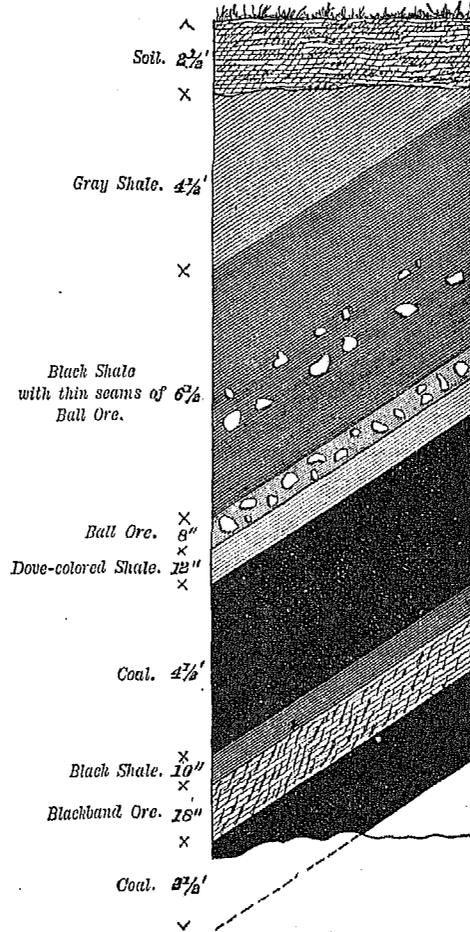
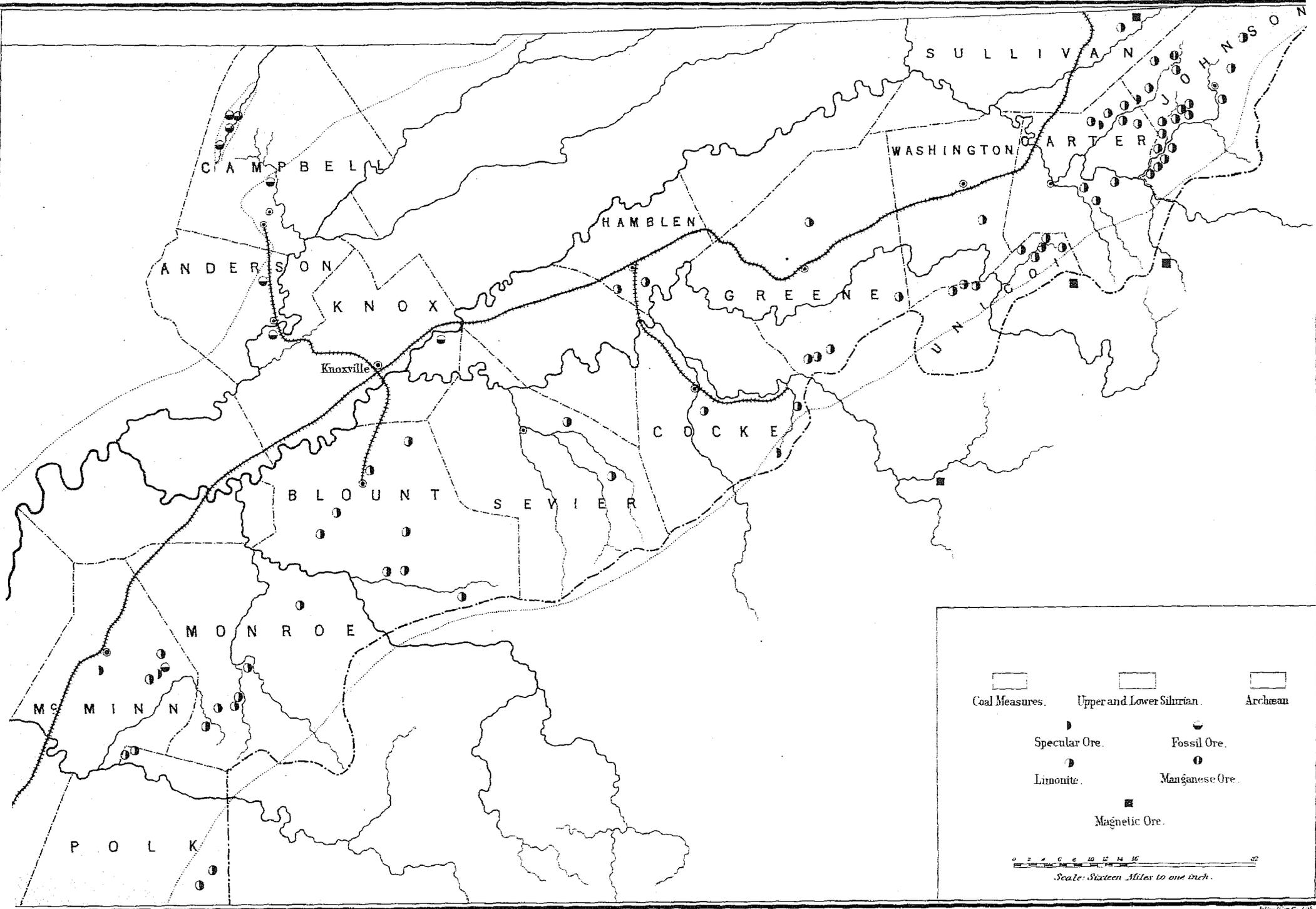


FIG. 112.—SECTION OF COAL-BEDS AT THE GULF. (See p. 306.)



IRON ORE SAMPLE MAP OF PARTS OF EAST TENNESSEE AND NORTH CAROLINA.

Julius Roth Co. LITH.

NOTES ON THE SAMPLES OF IRON ORE COLLECTED IN EAST TENNESSEE.

BY BAILEY WILLIS.

The following report contains a statement of the position of eighty-three different deposits of iron ore in fourteen counties of the valley of East Tennessee and the slopes of the Unaka chain; it does not include the deposits in Bradley, James, Hamilton, Meigs, Rhea, and Roane counties, the description of which is given in the report of Mr. William M. Chauvenet.

Ninety-two samples were taken from these eighty-three localities; they represent—

Limonites	72	
Specular ores	6	
Magnetite (Sharp's bank)	1	c
Dyestone ores	8	
Manganese ores	5	
Total.....	92	

The limonites, specular, magnetic, and manganese ores all lie in a belt between the Unaka mountains and the East Tennessee, Virginia, and Georgia railroad, extending from Georgia to Virginia. The dyestone ores are in the continuation of the ranges that enter the state from Alabama and extend northward past Chattanooga; these samples represent but a small part of the range—that lying northwest of Knoxville.

The different deposits are located on the accompanying map (Plate XXXV), which includes the entire field covered by this report. d

LIMONITES.

The limonites will first be described under the heads of counties, beginning at the south, and the much smaller groups of specular and dyestone ores will be referred to at the end.

POLK COUNTY.

Since the discovery of copper under the limonite outcrops of Ducktown much labor and some money has been uselessly expended searching for the same metal beneath the limonite deposits, so abundant in the Knox group of East Tennessee and Georgia.

In order to afford a basis for partial comparison two samples of the gossan of the *Ducktown* copper mines were selected and analyzed, with the following result: e

	OLD TENNESSEE.	LOUDON.
	479.	480.
	<i>Per cent.</i>	<i>Per cent.</i>
Metallic iron	51.94	48.96
Phosphorus.....	0.030	0.035
Copper	0.56	1.13
Phosphorus ratio	0.058	0.070

Sample 479 was taken from gossan thrown out of several shafts recently sunk for black copper ore, which was found at a depth of 15 to 20 feet. These openings were on the school property, 2 miles south of the village Hiwassee.

The other sample, 480, was taken from the gossan removed in sinking the shaft of the *Loudon* mine, where copper was found at a depth of 45 to 50 feet.

The greater percentage of copper would be looked for in the limonite of sample 479, which had been newly mined and lay nearer the copper ore; but the reverse is the case. The per cent. of copper in the gossan is therefore not a criterion for judging the proximity of the ore; and indeed its presence in small amount is no proof of the existence of copper ore below, as copper, zinc, and lead occur in the Knox group limonites. A more reliable proof of the origin of a limonite is to be found in the proportion of phosphorus contained in it. Ores of the Knox group

a derived from an organic sediment, limestone, invariably have a very considerable percentage of phosphorus, while vein-matter of chemical deposition should be expected to contain much less. A third class of limonites of the Tennessee valley, those produced by the decomposition of pyrite segregated in residual clay-beds, contains less phosphorus than the ores of the Knox group; but their occurrence as loose masses in soft clay readily distinguishes them from copper gossan.

In the report on the iron ores of Georgia, the Lower Silurian limonites were traced from where the belt enters the state from Alabama, in Polk county, northward to the Tennessee line. The last deposit described in that report is in Aliculsie valley, in the northeast corner of Murray county. The ore is very silicious, and probably lies in the Chilhowee sandstone, which rises in the long ridge of Star's mountain, in northern Polk county, Tennessee, **b** and extends across McMinn; then, breaking suddenly down, it reappears in Chilhowee mountain, and continues interruptedly to the Virginia line.

Star's mountain is cut through by Hiwassee river, and $1\frac{1}{2}$ or 2 miles farther north, on the borders of Polk and McMinn counties is a deep gorge, running east and west, known as Gee Creek gap. Two miles up the creek from the western entrance to the gap is a bed of limonite that has been partly stripped, showing a width north and south of 20 to 25 feet; half a mile farther east is another small opening on the continuation of the same bed. Two samples were taken here, 482 from the upper bed, 483 from the lower. The analyses are:

	482.	483.
	<i>Per cent.</i>	<i>Per cent.</i>
Metallie iron.....	45.47	40.40
Phosphorus.....	0.724	1.420
Phosphorus ratio.....	1.592	2.874

MCMINN COUNTY.

There are two deposits of limonite that have been opened in McMinn county which are less silicious and more porous than those in Polk and Monroe counties. They both lie in Chestnut ridge, 8 miles east of Athens, about 1 mile apart. One is on the land of Mr. R. G. Patty, near the road to White Cliff springs. Pieces of limonite may be seen scattered over the ridge by the roadside, and in a field back of Mr. Patty's barn considerable ore was thrown **d** out of a pit many years ago. Sample 974 represents this ore.

Mr. Charles Cates, living about 1 mile southwest, has recently sunk several shafts to a depth of forty odd feet, looking for copper, and was still prosecuting the search in July, 1880. The limonite which has led to this exploration bears a strong resemblance in some respects to a copper gossan. The honeycomb structure indicates, in the absence of little concretionary pots, that the ore may be derived from a sulphide; but its occurrence in concretions, which contain aggregations of the peculiar club-like crystals of pyrite, found in the ores near Maryville, Blount county, indicate that it is, like them, derived from nodular pyrite, and probably never contained any copper. Surface fragments of similar limonite are found northeast and southwest along Chestnut ridge for several miles. It is all apparently of similar character.

The analyses of samples taken at Mr. Patty's and Mr. Cates, are as follows:

	R. G. PATTY'S.	C. CATE'S.
	974.	975.
	<i>Per cent.</i>	<i>Per cent.</i>
Metallie iron.....	50.79	55.87
Phosphorus.....	0.004	0.032
Sulphur.....	0.089	0.273
Phosphorus ratio.....	0.166	0.057

f The *Hills* bank, fossil ore, and the *Stonedye* bank, a hard specular ore, are within a quarter of a mile of these limonite deposits, and another similar specular ore is found 3 miles south of Athens. (See pages 346 and 350 of this report.)

MONROE COUNTY.

Returning to the ores associated with the Chilhowee sandstone, we find them accompanying it in Guide mountain, near Jalapa, and extending southeast and northeast, with the general trend of the strata.

On the eastern slope of a very rugged ridge, part of the property of Mr. *Jerome Griffiths*, 4 miles south of Jalapa, four shafts were sunk many years ago, to depths of 40 to 100 feet, in search of copper. Nothing was found but a very sandy limonite. Half a mile farther south, near the foot of the most abrupt descent from the ridge, on the southwest quarter of section 17 of the first township of the Ocoee purchase, is a small test-pit, from which a very different ore has been thrown out. It seems probable that this belongs to one of the overlying shales or dolomites of the Knox group. This supposition is rendered more probable, as there are said to be three parallel

ranges of limonite about one-quarter of a mile apart, near Jalapa, on the property of Mr. *Curds*. But one of these, **a** which crops out on a high hill 1 mile south of Jalapa, could be sampled. It is of dark color and resinous luster, and contains small fragments of altered shale that still retain their structure.

The analyses of these ores are as follows:

	CURD'S.	GRIFFITH'S.
	484.	485.
	<i>Per cent.</i>	<i>Per cent.</i>
Metallic iron.....	52.74	53.55
Phosphorus.....	1.090	0.870
Phosphorus ratio.....	2.067	1.625

b

The ore-banks of the Tellico furnace, which have been extensively worked at intervals for many years, lie near the North Carolina turnpike, about 4 miles east of Jalapa.

The principal deposit is opened in the *Hale* bank. This is a large open cut in the western slope of one of the wooded ridges, now so much caved in that no ore is to be seen in place. It is said to lie in a large, compact body. No work has ever been done below the level of the entrance to the cut and the floor. Beneath the clay washed in upon it is said to be a solid mass of ore.

During the late war about 500 tons of ore were dug here and piled up for roasting. The approach of Federal **c** troops prevented the firing of the piles and they are still to be seen, having merely settled as the timbers rotted.

Sample 487 was taken from that portion of this pile not overgrown with weeds and bushes. The ore is dark-colored, dense, and quite homogeneous. It contains some small cavities lined with stalactites, and may be considered a type of the better class of Lower Silurian limonites.

The percentages of iron and phosphorus are given for comparison with the analyses of samples 486 and 488. The complete analysis is as follows:

	487.		487.
	<i>Per cent.</i>		<i>Per cent.</i>
Sulphur	0.147	Carbon in carbonaceous matter.....	0.10
Phosphorus	0.445	Hygroscopic water	0.79
Iron, metallic	54.78	Water of composition	10.28
		Total	100.125
Silica	0.78	Per cent. of insoluble silicious matter.....	8.14
Iron, protoxide	0.37	Silica	0.78
Iron, peroxide.....	77.65	Alumina (with trace of oxide of iron).....	0.07
Alumina	1.17	Lime	0.28
Lime.....	0.34	Magnesia.....	0.23
Magnesia	0.32	Potassa.....	0.27
Iron, disulphide	0.275	Soda	0.01
Potassa	0.41	Total	8.24
Soda	0.25		
Carbonic acid	0.13		
Phosphoric acid	1.260		

d

e

Donnelly's bank lies half a mile south of the Hale bank. It is opened on the summit of a wooded hill, but has never been much worked. Sample 486 was taken from a few pieces of ore found in the old pit.

These two banks are situated, respectively, 2½ and 3 miles south of the furnace, which was on Tellico river, where it debouches from the mountains.

A quarter of a mile from the old furnace site is a small cave, dug in the side of the hill to obtain enough ore to test it. It was never followed farther.

This limonite is totally different from that of the two banks last described. It is a very open honeycomb ore, associated with yellow clay. The analysis shows that it contains as much iron as the sample from *Donnelly's* **f** bank, but the phosphorus is double. It is represented by sample 488.

The analyses of these three ores are:

	DONNELLY.	HALE.	TELLICO.
	486.	487.	488.
	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>
Metallic iron.....	45.03	54.78	45.47
Phosphorus	0.870	0.445	1.530
Manganese, protoxide	1.03		
Phosphorus ratio	1.932	0.815	3.365

a About 11 miles north of Tellico furnace are two small openings on limonite beds, that were worked many years ago to supply a forge on Ball Play creek. Sample 489 was taken from a bold outcrop of this ore on the land of Mr. Anderson, the old pits being filled up.

The following is the result of the analysis:

	BALL PLAY.
	489.
	<i>Per cent.</i>
Metallic iron	46.56
Phosphorus	0.890
Manganese, protoxide	None.
Phosphorus ratio	1.912

BLOUNT COUNTY.

Chilhowee mountain, which extends northeast from the Tennessee river, separates Safford's Ocoee group, on the east, from the beds of the Knox group, on the west. Iron ore is not mentioned by Safford among the useful minerals of the Ocoee group, but it occurs in this county within the area occupied, according to his determination, **c** by strata of that age.

Abram's creek, rising among the Smoky mountains, flows south and west through *Cade's cove*, 6 miles in length, whence, escaping by a narrow gorge, it descends to Happy valley and runs south to the Tennessee river, which it joins just east of the gap in Chilhowee mountain.

Limonite has been worked in *Cade's cove* and Happy valley. There is also a bank 3 miles north of the latter, known as the Flat o' the Mountain bank, which has furnished ore for forges on Abram's creek and in Miller's and Tuckaleechee coves.

As it is 7 miles from Little river and 11 from Happy valley by bridle-paths to *Cade's cove*, across a mountain belt, it is not likely that the limonite will ever be extensively worked. It forms a low ridge 3 miles in length, extending in a northeast and southwest direction across the cove. A forge was worked many years ago to supply **d** the local demand of the farmers, but nothing has been done for twenty years or more. Sample 491 was taken from a few pieces of ore dug out of the leaves and clay filling an old pit on the land of William Feezelle.

There are two samples from Happy valley; one is from a test-pit half a mile from the old forge-site on *Abram's creek*, but little ore was to be seen. The other is from a new opening on the west side of Happy valley, in which *Squire J. H. Razer*, was prospecting for copper. While it is true that portions of the ore resemble gossan, the inclosure of cherty fragments proves that it belongs to the stratified group. It is represented by sample 490, while 492 is from the test-pit near the old forge.

The *Flat o' the Mountain* bank is a large deposit, judging from the area over which the old pits extend. It is said that the ore was never followed farther than 15 or 20 feet in depth, it being easier to get it near the surface. It was easy to distinguish two kinds of ore in the scattered fragments; the one of a grayish-brown color is essentially **e** sandstone cemented by limonite; it is worthless as an iron ore. The other is a dark-colored, sometimes black, ore, with brilliant luster; it is represented by sample 493. The relations of these two could not be ascertained.

The following are the analyses of these four samples:

	RAZER'S.	CADE'S COVE.	ABRAM'S CREEK.	FLAT O' THE MOUNTAIN.
	490.	491.	492.	493.
	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>
Metallic iron	55.48	55.28	50.23	53.85
Phosphorus	0.491	0.938	0.638	1.042
Manganese				0.410
Phosphorus ratio	0.885	1.098	1.270	1.935

f The strata of the Knox group, which form Chestnut ridge in McMinn county, extend northeastward to the Virginia line; they occupy a broad belt in Blount county, and there, as in McMinn, the residual clays contain deposits of limonite derived from pyrite. Similar ores are found in Hamblen county in the same belt, and they occur in another area of the same strata in Greene county.

These ores are valuable on account of the low percentage of phosphorus. As it is but five or six years since the deposits now worked in Blount and Hamblen counties have become known, it seems not unlikely that a careful survey of the areas covered by the Knox group would result in the discovery of similar ores in other localities.

These limonites do not occur in large masses; they form nodules a few inches to 2 or 3 feet in diameter, **a** imbedded in clay, through which they are irregularly distributed. The deposits thus far worked have proved to be of limited extent.

The *Seaton* bank, 8 miles northeast of Maryville, has been exhausted, after yielding from 800 to 1,000 tons of ore and being worked to a depth of 42 feet. In one part of this bank the ore was distributed approximately in the proportion of one load of ore to one of clay removed.

At the *Wilson* bank, 2 miles northeast of Maryville, the ore occurred in the proportion of one load of ore to eight loads of clay; this bank still continues to yield a large amount of ore, after being worked nine months, and does not seem likely to give out soon.

The *Carpenter* bank, 7 miles south of Maryville, was exhausted after being worked a year; sample 498 was taken from some of the last ore dug at this bank. **b**

A new bank had just been opened in June, 1880, on the land of the Widow *Kerr*, 10 miles southwest of Maryville; this yielded at the rate of one load of ore to every ten of clay, and test-pits indicate that the deposit underlies about 3 acres.

These banks are all opened on low knolls, and as the ores do not crop out they can only be discovered by the small nodules washed into the gullies, which often cut deep in the soft clays.

Samples were taken of the raw ore from each of the above-mentioned banks, pure pyrite, which still forms the central portion of all the nodules over a foot in diameter, not being included.

	WIDOW KERR'S.	SEATON.	CARPENTER.	WILSON BANK.	
				Raw ore.	Ronsted ore.
	404.	407.	408.	405.	406.
	<i>Per cent.</i>	Per cent.	Per cent.	Per cent.	Per cent.
Metallic iron.....	57.26	57.00	53.20	53.54	63.80
Phosphorus.....	0.035	0.104	0.050	0.143	0.064
Sulphur.....	0.347	0.178	0.266	0.184	0.173
Phosphorus ratio.....	0.061	0.181	0.111	0.269	0.107

Following is the complete analysis of 495:

	495.		405.
	<i>Per cent.</i>		<i>Per cent.</i>
Sulphur.....	0.184	Phosphoric acid.....	0.332
Phosphorus.....	0.143	Carbon in carbonaceous matter.....	0.06
Iron, metallic.....	53.54	Hygroscopic water.....	2.08
		Water of composition.....	10.91
Silica.....	5.01	Total.....	100.032
Iron, protoxide.....	0.34		
Iron, peroxide.....	76.10	Per cent. of insoluble siliceous matter.....	6.70
Alumina.....	4.04		
Manganese, protoxide.....	Trace.	Silica.....	5.01
Lime.....	0.02	Alumina.....	1.52
Magnesia.....	0.21	Lime.....	0.02
Zinc, sulphide.....	0.54	Magnesia.....	0.14
Nickel, sulphide.....	0.10	Total.....	6.69
Carbonic acid.....	0.32		
Sulphuric acid.....	0.02		

SEVIER COUNTY.

Two furnaces and several forges were at one time running in this county, the ore being supplied from two **f** banks.

The old shafts, from which ore for a furnace on the West fork of Little Pigeon river was obtained, may still be recognized in little circular hollows overgrown with brambles, in a wheat-field close to the road between Newport and Sevierville, 6 miles east of the latter place. A single piece of ore, of about 50 pounds weight, was all that could be found; this was carefully broken up, and sample 909 is a fair average of it. Little hollows filled with club-shaped crystals, derived from pyrite, indicate the origin of the limonite, and the writer was informed by one of the old ore-diggers that at a depth of 55 feet they came to water and the ore "turned all yellow, like gold". The field in which these shafts were sunk is now the property of Mr. G. S. Newman.

The other furnace was situated on the Little East fork of Little Pigeon, 13½ miles east of Sevierville among the outliers of the Unaka mountains. It is now a picturesque ruin overgrown with vines. Ore was obtained from

a a bed, which extends half a mile to the southwest, across several spurs of the Bear-Wallow mountain. Both limonite and manganese ore are to be seen in the old trenches; they seem in places to occur in two separate beds, with 20 to 25 feet of sandstone between them. The limonite is associated with pyrite and quartz.

Sample 910 represents the limonite, 911 the manganese:

	NEWMAN'S.	LOVES' FURNACE.	
	909.	910.	911.
	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>
Metallic iron	58.88	39.86	6.48
Phosphorus	0.060	0.108	0.097
Manganese oxide		13.835	59.73
Phosphorus ratio	0.103	0.271	.....

b

COCKE COUNTY.

Limonite occurs in Cocke county east of Newport among the strata of the Ocoee group and the Chillhowee sandstones.

A forge was run many years ago on Upper Cosby creek, among the spurs of the Unakas. Some ore is said to c have been obtained in that vicinity, but the greater amount was hauled from a bank on *Mine ridge*, 2 miles from the mouth of Sweetwater creek, 3 miles southeast of Newport. The ore, which is a light-colored, concretionary limonite, crops out on the summit of the ridge, and extends for half a mile or more along it; it is represented by sample 912, taken at the old pits:

	912.
	<i>Per cent.</i>
Metallic iron	51.68
Phosphorus	0.200
Phosphorus ratio	0.404

d The branch railroad connecting Morristown, Tennessee, with Asheville, North Carolina, passes through Newport and Wolf Creek on the French Broad river. Three miles from the latter place in the hills east of Wolf Creek is a large deposit of dark-colored, homogeneous limonite; this is the property of the "Southern States Coal, Iron, and Land Company", and has been opened but never worked. A tunnel has been driven in near the top of the ridge and passed horizontally through 68 feet of ore. About 100 tons were taken out and now remain near the mouth of the tunnel. Sample 913 was taken as an average of this pile:

	913.
	<i>Per cent.</i>
Metallic iron	50.03
Phosphorus	0.823
Phosphorus ratio	1.045

e

A deposit of specular ore, which has been lately discovered in the metamorphic rocks near the head of Wolf creek, will be described at the end of this chapter among the other ores of the kind.

HAMBLEEN COUNTY.

There are two ore-banks south of Morristown, near the line of railroad up the French Broad. Lying in the same belt of Knox strata as the deposits near Maryville, these ores are identical with those there found. The two banks worked are the *Vineyard*, 1 mile north, and the *Williams*, 2 miles west of Witt's foundery. At the former the f modules contain little or no pyrite, which is frequently found in the interior of the larger masses from the latter bank. In other respects the two ores are so much alike that there can be no doubt of their having a common origin—they have resulted through the oxidation of concretionary masses of pyrite.

Samples were taken from the ore mined for shipment to the Roane Iron Company's works. The following are the analyses:

	VINEYARD.	WILLIAMS.
	907.	908.
	<i>Per cent.</i>	<i>Per cent.</i>
Metallic iron	52.00	53.81
Phosphorus	0.068	0.020
Phosphorus ratio	0.131	0.052

GREENE COUNTY.

The range of Chilhowee sandstone which is found in eastern Cocke county extends northwestward through a Greene into Washington and Unicoi, accompanied throughout by deposits of limonite. These have been worked in five localities in Greene county; three of them for the furnaces at Hayesville, 11 miles south of Greenville; the other two, situated close together on Greene ridge, for a forge on Camp creek and for the Embreeville works, on Nolichucky river.

The former are the *Varner*, *Lamb*, and *Stephens* banks, respectively 2 miles south, 2 miles southeast, and 2½ miles east of the Hayesville furnace. The latter has been much more extensively worked than the others. Sample 917 was taken from a pile laid up for roasting six years ago. It represents a dark-colored, compact limonite, which incloses little cavities lined with binoxide of manganese.

The old workings at the Lamb and the Varner banks were so much caved in that no ore was seen in place. A few pieces were found at the latter, and are represented by sample 915. It is quite probable that this is below the **b** average, as the ore is associated with sandstone, cemented by limonite, pieces of which were thickly scattered over the dump-heap. At the Lamb bank a ton of dark-colored compact limonite had been left at the foot of the slope on which it was dug. It seems to be less silicious than the ore of the Varner bank, but this may be rather an apparent than a real difference; for specimens of ore seen at the Lamb bank inclose silicious fragments, and only a careful examination of both could determine the proportions of good and of worthless ore.

	VARNER.	LAMB.	STEPHENS.
	915.	916.	917.
	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>
Metallic iron	47.57	53.54	48.87
Phosphorus.....	1.179	1.976	1.031
Manganese			6.52
Phosphorus ratio	2.478	2.570	2.110

The *Greene Ridge* banks are about 12 miles east of Greenville, on a high spur of the Unaka chain, south of Horse creek. The South bank is about half-way up the slope; the East bank, over the ridge, nearer the top. Both consist of large open cuts, dug without system wherever the different operators preferred. There is no apparent difference in the two ores as seen in the specimens; both are compact concretionary limonites, varying in color **d** from light to dark dull brown. About a ton was found at each bank, and samples 918 and 919 were taken from these piles:

	GREENE RIDGE.	
	South Bank.	East Bank.
	918.	919.
	<i>Per cent.</i>	<i>Per cent.</i>
Metallic iron	53.88	48.12
Phosphorus.....	0.099	0.068
Phosphorus ratio	0.184	0.141

A limonite derived from pyrite occurs north and west of Greenville. One range extends from Blue Springs northeast to a point 7 miles west of Greenville; another parallel range is said to have been traced 4 or 5 miles, passing near Babb's mill, north of Greenville. These ores have never been worked to any extent, but a few loads were hauled to Camp Creek forge from a point near the public road, 5½ miles north of Greenville. Here the ore lies in small lumps thickly scattered through the yellow clay. It shows the structure of pyrite, and is essentially the same as that now mined near Maryville, in Blount county.

Sample 920, taken from a small pile of this ore, gives the following result on analysis:

	920.
	<i>Per cent.</i>
Metallic iron	57.33
Phosphorus.....	0.089
Phosphorus ratio	0.155

WASHINGTON AND UNICOI COUNTIES.

a Bompass and Greasy coves were formerly parts of Washington and Carter counties, but have now been cut off in the new county of Unicoi. They contain a larger amount of limonite in proportion to their area than any other part of Tennessee except Doe mountain, in Johnson county.

Professor J. P. Lesley made a survey of these coves in 1872, and has published his observations in a "Note on a fine Upthrow Fault at Embreeville Furnace in East Tennessee", among "Occasional Surveys of Iron, Coal, and Oil Districts of the United States". He says:

Bompass cove is an oval valley 3 or 4 miles long by $1\frac{1}{2}$ wide at its widest part, surrounded by mountains about 1,000 feet high, on the inner slopes of which rest terraces or hill spurs of decomposed limestone (Lower Silurian), holding masses of brown hematite iron ore of two varieties, the lower series (and outer or closer up to the mountain wall) being silicious and cold-short, and the upper series being argillaceous and red-short. The cove is nearly encircled by the cold-short deposits, which have been opened in a number of places, and **b** a good deal mined toward the head of the cove for an old furnace farther south. The red-short hematites are extensively spread out more in the middle of the cove, where they are capped by lead-bearing members of the limestone formation.

Greasy cove is a large and nearly level limestone plain more than 20 miles long by 5 miles wide, similarly surrounded by shale and sandstone hills nearly 1,000 feet high, and backed by the state line range of the Unaka (sub-Silurian) mountains, more than twice as high.

The ore-banks of *Bompass cove*, opened at the time of Professor Lesley's visit, are now caved in, the tramways are washed away and overgrown, and the furnace is falling in ruins. Under these circumstances no attempt was made to visit all of the old pits, which are scattered over the hill slopes and valley; three typical samples were taken. One, from an opening $4\frac{1}{2}$ miles from Embreeville furnace on the west side of the cove, represents the cold-short limonite of the under beds. Another was taken from the "Main bank" of the furnace, about 3 miles from it, on the east side of the cove. Professor Lesley says of this deposit:

c These ores are irregular masses of ochreous clays and loose sands, full of shot and balls and pipes of the hydrated sesquioxide of iron, with coatings of the black oxide of manganese, and traces of the original sulphide of iron, sulphide of lead, and sulphide of zinc, held by the limestone strata before these were dissolved and made cavernous by the drainage waters which have packed the clay-sand ore into all the holes and crevices, caves, and water-courses thus made.

Again he says:

The stripping varies from a foot or two to 20 and 30 feet. The solid ore-ground consisting of from one-half to four-fifths fine ore, the rest balls, with occasional masses of clay, and occasional masses of solid hard limestone rock (left in its original condition, but with all the edges dissolved round) has been dug into to a depth of ten, fifteen, twenty feet and more in places, without reaching bottom.

Professor Lesley's opportunities for observation were far better than those of the writer, who found no ore in place, but the masses of ore now to be seen, partly imbedded in the clay, washed into the old pits, do not agree **d** with his description. Their outer surfaces are formed of porous limonite, but the interior consists almost wholly of pyrite, and they seem to have been derived from that mineral. Sample 922 was taken as an average of these masses at this "Main bank". A third sample, No. 924, was taken from the limonite that may be seen immediately overlying the compact limestone of the "Lead mine", through which little scales of galena are thickly scattered; the limonite represented by this sample is very much like that of the "Main bank" in general appearance, but the cavities are larger and the walls thin, while in the other the cavities are small and the thick walls are very compact. The following are the analyses:

	MAIN BANK.	COLD-SHORT.	LEAD MINE.
	922.	923.	924.
	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>
Metallic iron	57.56	49.11	58.59
Phosphorus.....	0.149	0.715	0.016
Phosphorus ratio	0.259	1.456	0.027

e The ore deposits of Greasy cove were worked from 1825 to 1843 for a furnace and forge, which stood on Indian creek, in what is now the northeastern part of Unicoi county. As nothing had been done at any of the banks since that time there was no opportunity for observing the character or the mode of occurrence of the ore; the **f** principal openings were visited, however, and samples taken from such pieces as could be picked up at the old diggings. "Limonite post-office", near the "Head of the Big Lane", 10 miles south of Johnson City, is a central point, not far from which Dr. Hannum, the present owner of the principal ore-deposits, was building a forge in July, 1880.

A number of openings on a high ridge $1\frac{1}{2}$ mile west of Limonite post-office are known by the name of the *Casper bank*; this is the most western of the deposits; the ore is open and contains many little pots of more compact limonite, a texture preferred in the forges and cold-blast charcoal furnaces; but it shows dark-colored streaks, having a brilliant, resinous luster, considered by old ore-diggers to indicate a cold-short ore. Another range of ore was opened in the "Keener" and "Big" banks, and in three other small diggings within a quarter of

a mile of Dr. Hannum's house; from the Keener to the Big bank is about 1½ mile in a northeasterly direction. a This range is associated with manganese ore, which here, as in Johnson county, lies west of and parallel to the iron ore.

Three and a half miles east of Limonite post-office are several beautiful springs, which have given their name, *Blue Springs*, to an ore-bank that was opened forty years ago and abandoned soon after, as other ore was found more conveniently situated; the old diggings seem to indicate an extensive deposit, of which but little has been removed; but the *débris* accumulating through so long a period has so covered the ore, that only enough for sample 926 could be found.

A mile and a half farther south is another deposit, from which a few wagon-loads of ore were hauled fifty years ago; as the ore made a cold-short iron it was not long used. This little opening, known as the Dick's bank, has long since been lost in a dense thicket of southern laurel. b

The analyses of the samples representing these ores are given below:

	CASPER.	BLUE SPRINGS.
	925.	926.
	<i>Per cent.</i>	<i>Per cent.</i>
Metallic iron	50.31	47.71
Phosphorus	1.300	0.391
Phosphorus ratio	2.584	0.820

One other ore-bank was found in Washington county, on the road from Johnson City to Embreeville, 5 miles southeast of Jonesborough. The old pits are extensive, and much ore is said to have been removed and used in the Embreeville furnace; but only a few pieces of very open honeycomb limonite remained scattered over the surface. These are represented by sample 921, of which the following is the analysis: c

	HUFFINE'S BANK.
	921.
	<i>Per cent.</i>
Metallic iron	48.00
Phosphorus	0.308
Phosphorus ratio	0.634

CARTER AND JOHNSON COUNTIES.

These have long been the principal iron-producing counties of East Tennessee.

Holston mountain, a ridge of Chilhowee sandstone, forms the western boundary of Carter and a portion of e Johnson. Iron mountain is a similar elevation, which extends from Doe River cove, in Carter county, to the extreme northwestern corner of Johnson, where it joins Holston mountain, and the two continue as one range into Virginia. Between these ranges are the valley of Stony creek, in Carter county, and Shady valley, in Johnson county, formed by the Knox group. They are separated by a northwest-southeast ridge, Cross mountain, which extends from Iron mountain to Holston.

East of Iron mountain, in Johnson county, are the Knox group valleys of Little Doe and Roane creeks, separated by an isolated ridge of Chilhowee sandstone, Doe mountain, 12 miles long.

East of Roane creek the strata of the Knox group are again limited by Chilhowee ranges, which rise to the great mountain range, formed of Ocoee and metamorphic rocks.

The Stony Creek and Shady valleys are skirted by deposits of limonite. Doe mountain is surrounded by f them, and they extend along the eastern slope of Iron mountain from Doe River cove to Virginia. In notheastern Johnson county they are worked along the eastern Chilhowee belt.

A complete list of the ore-banks worked in these counties during the last hundred years would number considerably over one hundred; but they are generally small surface diggings, worked while the ore was easily obtained, and abandoned when for any reason, no matter how trivial, it was more easily gotten elsewhere. A few years later the old pits are filled with soft clay and overgrown with vegetation, and forgotten by all but the man who worked them.

One of the principal ore-banks on Roane creek had not been worked for a year, as the forge to which it belonged was being rebuilt. The spot from which ore had last been taken was buried under 20 feet of clay, and it

It was only with some difficulty that enough ore was found for a sample. The history of the ore-bank, which is now being opened for the new furnace in process of construction by Judge Butler, of Taylorsville, affords another instance of the loss and rediscovery of these banks. Sixty years ago this deposit was worked for a forge for a short time; other ore was found more conveniently situated and this bank was given up. Recently the property came into the hands of Judge Butler, who had information that ore had once been dug upon it; he employed a man to search for it, and the discovery and trial of the ore have led to the erection of a furnace for making car-wheel iron.

Thirty-four samples were taken in these two counties, namely :

Limonites.....	27
Specular ores.....	4
Manganese ores.....	3
Total.....	34

These ores may be divided according to localities, as follows :

CARTER COUNTY—Doe River cove; Stony creek.

JOHNSON COUNTY—Roane creek; Little Doe creek; Shady valley.

Doe River cove.—Big Doe river flows in a general northwest course from the Unaka mountains to Elizabethton, where it joins the Watauga river. Six miles east of Elizabethton the river comes out of a narrow gorge and flows

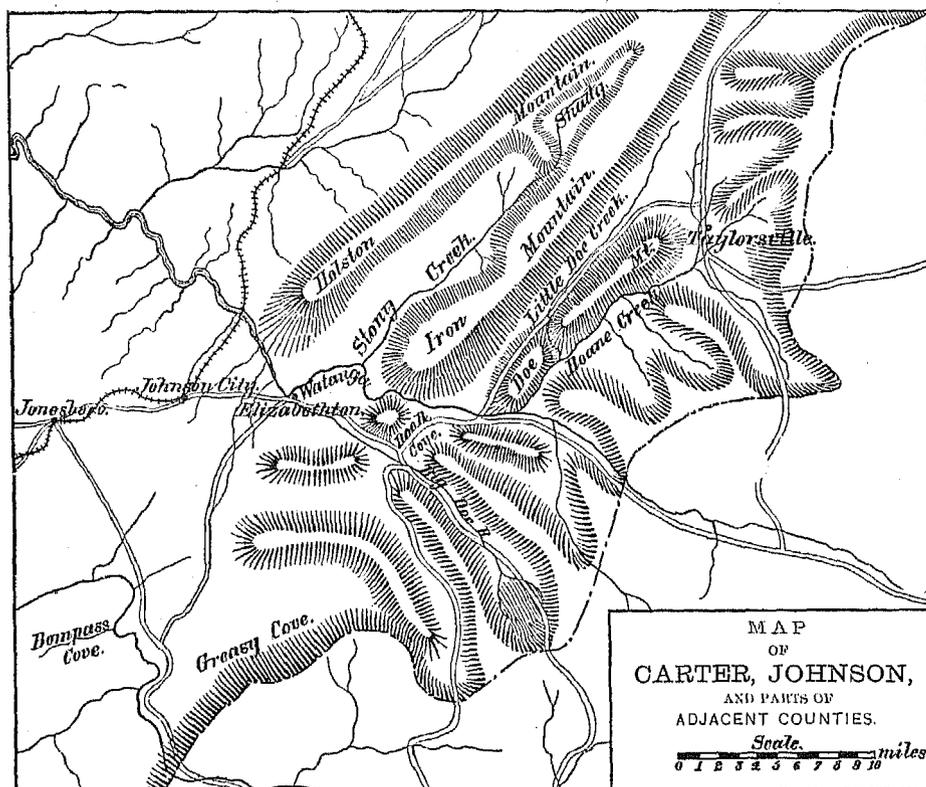


FIG. 134.

for a mile across a level valley, entering on the other side a ravine it has cut through the Chillowee sandstone of Iron mountain. This valley is formed, according to Safford, by strata of the Knox group, which extend northeastward to Virginia, and surround Doe mountain, the isolated ridge of sandstone already referred to.

f In Doe River cove this belt is about a mile wide, with Chillowee sandstone on both east and west.

Ore banks extend at intervals from Doe river to Watauga river, a distance of $2\frac{1}{2}$ miles along the eastern side, and one has been opened in Iron mountain, west of the cove; it is said these ranges of ore extend to Greasy cove, and are the continuation of those sampled near Limonite post-office.

Cedar Hill bank is on the slope just north of Doe river, on the eastern side of the cove; the *Bear Wallow* bank is another opening on the same deposit, within a hundred yards of the first. No ore could be seen in place, and samples 932 and 933 are from pieces picked up in the old diggings, which are extensive. Sample 932 represents the limonite, which is compact and partly of a light-buff color, with darker streaks. Sample 933 represents a manganese ore found in the old pits with the limonite; here, as at the Keener and Big banks, and also at Carden's, on Watauga river, the manganese ore seems to lie west of the limonite, in a parallel range. This sample was not analyzed.

Sample 931 is from the extensive openings of the *Queen's Station* bank, situated on a steep hill-slope, $4\frac{1}{2}$ miles east of *Elizabethton*, north of *Doe* river. This ore is principally a compact grayish-brown limonite, of homogeneous texture; but some portions of it have a distinctly red streak. In one specimen the mass is limonite, but the shell of a small concretion, inclosed in it, is hematite.

The following are the analyses of these samples:

	QUEEN'S STATION.	CEDAR HILL.
	931.	932.
	<i>Per cent.</i>	<i>Per cent.</i>
Metallic iron.....	57.05	55.92
Phosphorus.....	0.154	0.576
Phosphorus ratio.....	0.267	1.080

Following is the complete analysis of 931:

931.		931.	
	<i>Per cent.</i>		<i>Per cent.</i>
Sulphur.....	0.139	Phosphoric acid.....	0.352
Phosphorus.....	0.154	Carbon in carbonaceous matter.....	0.10
Iron, metallic.....	57.05	Hygroscopic water.....	1.15
		Water of composition.....	6.60
		Total.....	100.038
Silica.....	4.57	Per cent. of insoluble silicious matter.....	6.15
Iron, protoxide.....	0.38	Silica.....	4.57
Iron, peroxide.....	81.81	Alumina.....	1.22
Alumina.....	3.06	Lime.....	0.32
Manganese, protoxide.....	0.49	Magnesia.....	0.08
Lime.....	0.32	Total.....	6.19
Magnesia.....	0.25		
Iron, disulphide.....	0.256		
Carbonic acid.....	0.09		
Sulphuric acid.....	0.01		

The farm of Mr. *Wesley Carden* is on the east side of *Doe* River cove, just south of *Watauga* river. For over half a mile a range of limonite may be traced northeast and southwest, accompanied, as at *Cedar hill* and *Greasy cove*, by a parallel belt of manganese ore. This limonite is very compact and hard, with little cavities lined by quartz crystals. It was formerly worked in a forge on *Doe* river, but since that was washed away no more ore has been dug.

Sample 934 represents about one ton of ore recently taken from a test-pit southeast of Mr. *Carden's* house, near the summit of a steep ridge. The following is the analysis:

	WESLEY CARDEN'S.
	934.
	<i>Per cent.</i>
Metallic iron.....	54.03
Phosphorus.....	0.206
Phosphorus ratio.....	0.381

Little Doe creek.—The road from *Elizabethton* to *Taylorville*, *Johnson* county, passes through *Doe* River cove, crosses *Watauga* river at *Dugger's* ford, and 6 miles farther north enters the valley of *Little Doe* creek. This creek flows southwest along the western side of *Doe* mountain, and turning south at the point where the road descends to it, cuts through the mountain and enters *Roane* creek. On the west of this gorge, about a mile from the creek, is the locality known as the "Sinks", a depression surrounded by ridges, on which are five ore-banks, namely, the *Wash Place* and *Hollow* bank, 20 steps apart; the *Hill* and *Pine Bark* banks, close together, half a mile from the first, and the *Stout* bank, a half a mile still farther on. These banks are all very similar in the character of their ores, which are open honeycomb limonites, inclosing little pots or hollow concretions. The *Hollow* bank has received its name on account of the absence of the honeycomb ore and preponderance of the pots. The *Pine Bark* bank is named from the resemblance of its ore to the scaly bark of the pine. These are all small diggings, and only the *Wash Place* bank was open in July, 1880.

a Sample 935 is from about five tons of ore found piled up at it.

935.		935.	
<i>Per cent.</i>		<i>Per cent.</i>	
Sulphur.....	0.084	Carbonic acid.....	0.01
Phosphorus.....	0.214	Sulphuric acid.....	0.488
Iron, metallic.....	54.18	Carbon in carbonaceous matter.....	0.18
Phosphorus ratio.....	0.395	Hygroscopic water.....	0.97
		Water of composition.....	10.46
Silica.....	5.69	Total.....	100.061
Iron, protoxide.....	0.16		
Iron, peroxide.....	77.08	Per cent. of insoluble silicious matter.....	6.65
Alumina.....	2.38		
Manganese, protoxide.....	0.99	Silica.....	5.69
Lime.....	1.16	Alumina.....	0.71
Magnesia.....	0.01	Lime.....	0.26
Iron, disulphide.....	0.153	Total.....	6.66
Soda.....	0.39		

Limonites occur on both sides of Little Doe creek; those of the east on Doe mountain; those on the west on the foothills of Iron mountain. It is a generally-accepted opinion among the forgers that the former are not cold-short, while the latter invariably are. As a natural consequence the banks on the west are few in number, and those on the east are numerous. Two samples were taken to represent the western range: One from *Rankine's* bank, now worked for Gooden's forge, where sample 936 was obtained; the other from *Stout's* bank, which lies 2 miles northeast of Rankine's, a mile west of the creek; the latter has been but little worked, and the sample represents only what ore could be picked up in the old pit. These ores are both compact and hard, of dark color and resinous luster. The analyses are as follows:

	RANKINE'S.	STOUT'S.
	936.	937.
	<i>Per cent.</i>	<i>Per cent.</i>
Metallic iron.....	46.54	50.99
Phosphorus.....	1.507	1.273
Phosphorus ratio.....	3.238	2.406

The principal deposits on the western slope of Doe mountain are those of the Sinks and a group which extends along the northern half of the ridge from 7 to 3 miles from Taylorsville; among the latter the *Tompkins*, the *Near* and *Far Mountains*, and the *Ground-Hog* banks are the most extensively worked.

The latter was not open in July, 1880, but samples of the other three ores were obtained from stock-piles of 1 to 4 tons at Gooden's and Wagener's forges. The result of the analyses are as follows:

	TOMPKINS.	FAR MOUNTAIN.	NEAR MOUNTAIN.
	938.	939.	940.
	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>
Metallic iron.....	53.35	54.08	50.26
Phosphorus.....	0.489	0.255	0.686
Phosphorus ratio.....	0.917	0.472	1.219

Roane creek.—The northeastern spur of Doe mountain is known as Little mountain; many ore-banks have been at different times opened on it, and are said to yield an ore like that of the Near and Far Mountain group. Sample 950 was taken from the stock-pile at Brown's forge on Roane creek, 7 miles from Taylorsville; it represents the ore from the *Songa Hollow* bank of Little mountain:

	SONGA HOLLOW.
	950.
	<i>Per cent.</i>
Metallic iron.....	53.78
Phosphorus.....	0.441
Phosphorus ratio.....	0.820

Ten miles south of Taylorsville a little stream, called Mill branch, enters Roane creek from the east. Three-quarters of a mile above the mouth of this branch is Dougherty's furnace, which is supplied with ore from the *Mast* bank, a quarter of a mile south of it; sample 951 represents this limonite, which is compact, homogeneous, and light-colored.

	MAST.
	951.
	<i>Per cent.</i>
Metallic iron	54.48
Phosphorus	0.768
Phosphorus ratio	1.410

b

A low ridge extends from about 7 miles south of Taylorsville, in a southerly direction, east of Roane creek, to Watauga river. The Mast bank is opened on this ridge. Four miles farther south is another, called the *Baker* bank. Still a mile farther on are two, the John Dugger and the *Cove* banks. The latter lies 300 yards west of the former, and the ore is much like that of Carden's bank, and is similarly associated with manganese ore. It is possible this bank is on the northern end of the range of deposits which extends from Greasy cove, in Unicoi county, through Doe River cove.

The John Dugger bank is said to produce ore similar to that of the Baker bank, which is a very open honeycomb ore, with stalactitic limonite lining the interior of many of the little pots. These banks are worked for Dugger's forge, on Watauga river, 4 miles above the mouth of Roane creek; two others, the *Taylor* and Road Hollow, are opened in the southern end of this ridge, near the forge. These produce honeycomb ores similar to that of the Baker bank. Dugger's forge had, unfortunately, not been running for over a year, so that the ores were not well exposed. Three samples were obtained, however, representing the ores of the Baker, Cove, and Taylor banks. The analyses are as follows:

	BAKER'S.	COVE.	TAYLOR'S.
	952.	953.	954.
	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>
Metallic iron	57.08	46.80	52.83
Phosphorus	0.160	0.006	0.250
Phosphorus ratio	0.278	1.295	0.485

d

Following is the complete analysis of 952:

952.		952.	
	<i>Per cent.</i>		<i>Per cent.</i>
Silica	3.80	Carbon in carbonaceous matter	0.11
Iron, protoxide	0.27	Hygroscopic water	0.36
Iron, peroxide	81.94	Water of composition	10.50
Alumina	1.18	<i>Total</i>	99.951
Manganese, protoxide	0.76		
Lime	0.08	Per cent. of insoluble silicious matter	4.40
Magnesia	0.22		
Iron, disulphide	0.214	Silica	3.80
Cobalt, sulphide	Trace.	Alumina	0.65
Copper, sulphide	Trace.	Magnesia	0.05
Carbonic acid	0.14	<i>Total</i>	4.50
Sulphuric acid	0.01		
Phosphoric acid	0.367		

e

Shawn's Cross-roads is on Roane creek, 2 miles south of Taylorsville. Gentry's mountain rises north of it, on the summit of which is *Donnelly's* bank. This is worked for Rhea's forge, and produces an ore very similar to those just described. It is represented by sample 949, of which the following is the analysis:

	DONNELLY'S.
	949.
	<i>Per cent.</i>
Metallic iron	53.18
Phosphorus	0.291
Phosphorus ratio	0.547

a The ore bank belonging to *Butler's* furnace has already been mentioned. It lies $2\frac{1}{2}$ miles northeast of Taylorsville, the ore cropping out in large masses on the summit of a very steep, high ridge. It consists of dark-colored resinous limonite, which incloses many small fragments of lighter color, apparently the remains of a shale from which the ore is derived. It is represented by sample 947, taken at the bank from ore recently blasted out:

	BUTLER'S.	
	947.	
	Per cent.	
Metallic iron.....	50.74	
Phosphorus.....	1.245	
Phosphorus ratio.....	2.454	

b

Five miles northeast of Taylorsville, in the extreme northeastern corner of Johnson county, on *Laurel fork*, there are several very extensive ore-banks that have long been worked for Colonel Slimp's forge. They were not in operation when visited by the writer, who saw no ore in place. Sample 948 was taken from pieces of ore found scattered over the large diggings. It yields the following result on analysis:

	LAUREL FORK.	
	948.	
	Per cent.	
Metallic iron.....	53.05	
Phosphorus.....	0.336	
Phosphorus ratio.....	0.633	

c

This concludes the limonites of eastern Carter and Johnson counties. The eighteen samples analyzed may be considered to represent fairly the general character of these ores.

Shady valley.—As has already been stated, this is a slight depression lying in the angle between the Holston mountain on the west and Iron mountain on the east, and separated from the valley of Stony creek by Cross mountain on the south. There are two forges in the valley, on the little stream which escapes through a narrow pass around the eastern end of Cross mountain. These are supplied with ore from several banks, of which the two largest are the Armstead Blevins and the King banks. The ore at both of these is partly a dense, hard limonite, of even texture, and dull buff and brown color, partly delicately honeycomb.

At the *King* bank, which lies at the foot of Holston mountain, just north of the road to Bristol, manganese ore is associated with the limonite. *Blevins* bank is farther east, 6 miles west of Taylorsville. Half a mile northwest of the lower forge the *Silver* bank has lately been opened on a deposit of manganese, with a view to shipping the ore. The openings have not yet penetrated to any depth, and there was but little crystalline pyrolusite to be seen. The greater part of the ore taken out is dense amorphous binocide, possibly massive pyrolusite, possibly psilomelane.

Sample 956, taken from 3 tons at the lower forge, represents the Blevins ore; 957 is from about 2 tons at the *Silver* bank; and samples 958 and 959 represent, respectively, the limonite and manganese ore of the *King* bank. Samples 957 and 959 were not analyzed. The analyses of samples 956 and 958 are—

	BLEVINS.	KING.
	956.	958.
	Per cent.	Per cent.
Metallic iron.....	52.58	56.73
Phosphorus.....	0.186	0.092
Manganese.....	1.20	0.92
Phosphorus ratio.....	0.354	0.162

f *Stony creek*.—The limonite ores of Stony creek are extensively worked by the Knoxville Car-Wheel Company, which has owned the Carter furnace for a number of years, and has lately put up another, the Maxwell. The writer sampled the ores used by this company at the stock-piles of the furnaces, and did not visit the ore-banks, which are located on both sides of the valley, along northeast and southwest lines, about 10 miles long. The principal ores used in the furnaces in July, 1880, were from the Taylor, Hodge, Lips, and Ferguson banks. There were also small stock-piles at the Carter furnace of the Specular and Red Shear bank ores. In addition to these, the writer sampled the ores of the Hurley, Blevins, James Duggers, Maxwell, and Cannon banks, making eleven samples in all.

The *Taylor* bank furnishes a gravel ore, which is obtained by washing. It is a light-brown limonite, which is said to reduce easily, and has long been worked. Occasionally a larger honeycomb piece is found, but the greater part is very fine.

The ore of the *Hodge* bank is very dark-colored limonite, concretionary and stalactitic. It lies on the eastern side of the valley, 4 miles from the new furnace.

The *Lips* bank contains two qualities of ore—the one a brown limonite, mottled with almost black resinous lines; the other very much like the “ore” of the Ferguson bank, which would more properly be called a highly ferruginous sandstone; the matrix is limonite, but it is thickly set with rounded grains of pure white quartz.

The ore from the *Specular* bank is very peculiar. It is essentially a limonite, but contains many little plates of micaceous specular ore.

The name *Red Shear* bank indicates the character of the ore. It is in great part, if not entirely, derived from pyrite. Massive pyrite occur in the centers of many nodules, and is to be recognized in the club-shaped forms that stud the interior of many cavities.

The *Hurley* bank has not been worked lately, and has washed so that only enough ore was found on the surface to give a sample. It is a porous limonite, not unlike that of the Hodge bank.

The *Blevins* and the *James Duggers* banks are only recently opened and have not been worked. Duggers is the blackest limonite seen by the writer, and has the most brilliant resinous luster throughout; it is compact, and some pieces look like pitch. Blevins ore is of much lighter color, and resembles the better quality of ore in the Lips bank.

The Maxwell and the Cannon banks yield specular ores, and their description will be found under that head. The following are the analyses of the above-described ores:

	DUGGERS.	HURLEY.	BLEVINS.	MAXWELL.	LIPS.	HODGE.	TAYLOR.	FERGUSON.	SPECULAR.	RED SHEAR.	CANNON.
	962.	963.	964.	965.	966.	967.	968.	969.	970.	971.	972.
	Per cent.	Per cent.									
Metallic iron	52.24	53.95	40.88	59.19	50.09	34.28	49.73	42.97	53.96	55.67	63.84
Phosphorus	1.717	0.153	1.595	0.019	1.025	0.074	0.056	0.280	0.338	0.133	0.022
Phosphorus ratio	3.287	0.284	3.198	0.32	2.046	0.213	0.113	0.652	0.026	0.239	0.034

The following are the complete analyses of samples 967, 968, and 970:

	967.	968.	970.		967.	968.	970.
	Per cent.	Per cent.	Per cent.		Per cent.	Per cent.	Per cent.
Silica	3.38	13.68	12.04	Phosphoric acid	0.166	0.129	0.773
Iron, protoxide	0.43	0.43	0.87	Carbon in carbonaceous matter	0.04	0.02	0.03
Iron, peroxide	48.95	70.48	76.04	Hygroscopic water	1.14	1.45	0.36
Alumina	2.38	4.55	2.46	Water of composition	7.89	5.79	6.71
Manganese, protoxide	2.72	1.08	0.14	Total	100.177	100.169	99.944
Manganese, dioxide	32.20			Per cent. of insoluble silicious matter	3.67	14.80	12.73
Lime	0.56	1.56	0.23	Silica	3.38	13.68	12.04
Magnesia	0.17	0.48	0.10	Alumina	0.22	0.91	0.61
Iron, disulphide	0.041	0.110	0.111	Lime	0.20	0.14	
Nickel, sulphide	0.18			Magnesia	0.04	0.03	0.07
Cobalt, sulphide	Trace.			Total	3.66	14.81	12.72
Copper, sulphide	Trace.						
Carbonic acid	0.25	0.39	0.06				
Sulphuric acid	0.02	0.02	0.02				

SULLIVAN COUNTY.

Two samples were obtained in this county; one from the *Crockett* bank, 7 miles southeast of Bristol, the other from the *Sharp's* bank, a mile farther north.

At the *Crockett* bank, where 200 tons of limonite lie piled up, it was necessary to approach from windward on account of the sulphur contained in the ore, which was undergoing slow oxidation. This limonite is of the same character as that now mined in Blount and Hamblen counties; like that it is in the form of nodules contained in red clay. The opening is on a low mound, and but a small portion has been dug over.

The following is the analysis of the sample taken from the stock-pile referred to, not including pure pyrite:

	CROCKETT.
	961.
	Per cent.
Metallic iron	57.63
Phosphorus	0.018
Sulphur	0.196
Phosphorus ratio	0.031

a The ore of the Sharp bank is different from any other seen in East Tennessee. It has the appearance of a very compact micaceous specular ore, and is in part composed of that variety, but the greater portion is magnetite. This ore is said to lie in an irregular vein from a few inches to 7 feet thick; hand-specimens contain little veins of calcite. It is many years since the bank has been worked, and it has been so often visited that every piece of ore left on the surface has been carried off.

Mr. Thomas Cowan, of Holston Valley post-office, pointed out to the writer a steep ascent, called Gray's hill, a mile south of the bank, on the road to Bushong's furnace, where this ore was formerly used. Overloaded teams frequently threw off lumps of ore on this hill, and with Mr. Cowan's aid a sufficient amount for a sample was here dug out of the clay beds on either side of the road. The following is the analysis of this sample; it does not **b** represent an average of the ore, but it is the best sample that could be obtained under the circumstances:

	SHARP'S.		SHARP'S.
	960.		960.
	Per cent.		Per cent.
Sulphur	0.163	Sulphuric acid	0.06
Phosphorus	0.038	Phosphoric acid	0.087
Iron, metallic	56.47	Carbon in carbonaceous matter	0.01
		Hygroscopic water	0.38
		Water of composition	1.06
Silica	6.09	Total	100.117
Iron, protoxide	9.70		
Iron, peroxide	69.72	Per cent. of insoluble silicious matter	6.47
Alumina	0.88		
Manganese, protoxide	0.15	Silica	6.09
Lime	4.73	Alumina	0.38
Magnesia	2.02	Magnesia	Trace.
Iron, disulphide	0.260	Total	6.47
Nickel, sulphide	Trace.		
Carbonic acid	4.97		

d

SPECULAR ORES.

On page 452 of the *Geology of Tennessee* Professor Safford mentions, under the heading "Hard Solid ore", three localities, the Cannon, the Crockett, and the Sharp's banks. The two latter have already been described under Sullivan county; as there stated, the ore of the Crockett bank is a limonite derived from pyrite; that of the Sharp's bank is a magnetic specular ore. The lead of the Sharp's ore passes near the Crockett bank, and surface fragments of each may be found in that neighborhood.

The Cannon bank is the only opening of any extent on a very dense, hard specular ore, of steel-blue color; that has been found in several localities from McMinn county to Virginia. It is on the western side of Stony creek, 5 miles above its mouth, in Carter county. No work having been done there for many years, no ore could be seen **e** in place. Professor Safford says in regard to it: "The ore occurs here in a regular and solid bed. It rests on a thin stratum of conglomerate of pea-like quartz pebbles, while above and below the rocks are sandy slate or shale, all having a gentle dip". The sample of this ore was obtained about a quarter of a mile west of the old diggings in a field where there were numerous surface fragments.

Six miles northeast of the Cannon bank, on the west side of Stony Creek valley, is the test-pit known as the Maxwell bank, from which ore entirely like that of the Cannon bank has been dug.

Two miles farther northeast, in the same line of strike as the Cannon and Maxwell banks, similar blue specular ore was obtained on the summit of Cross mountain. Enough ore was found on the surface to furnish a sample, the pits appear to have been very shallow, and there is no reason to suppose that the ore has been exhausted.

f In Greene county the writer observed a more silicious, but otherwise similar, ore among the pebbles in the road which leads east from Greenville just after crossing the Nolichucky river, and several miles farther on, on the way to the Greene Ridge ore-banks, his negro guide pointed out an old pit in which a very sandy specular ore had once been dug for Camp Creek forge.

In McMinn county this specular ore was found in two localities, neither of which has ever been worked for the manufacture of iron. The first is the Stone Dye bank, so named because the ore has from time to time been used for dyeing purposes. The sample was obtained in a little gully on the edge of a field, $7\frac{1}{2}$ miles east of Athens, on the land of Mr. B. F. Brock. The lead of ore extends northeastward to the property of Mr. Bazzell Thomas and Mr. Robert Cochran. The other locality is 3 miles south of Athens, on the property of Sheriff William Burke; the largest pieces of this ore seen by the writer were found here, one fragment found close to a very large spring having

a thickness of 9 inches. The very deep gullies in this vicinity all contain more or less of this ore in little washed pieces. Above the spring referred to, which is on the land rented by Mr. Curtis from Sheriff Burke, are large outcrops of limestone or dolomite.

The following are the analyses of the samples taken from these banks in the order they have been described :

	CANNON.	MAXWELL.	CROSS MOUNTAIN.	McMINN COUNTY.	
				Stone Dye.	Burke's.
	972.	985.	955.	976.	481.
	<i>Per cent.</i>	Per cent.	Per cent.	Per cent.	Per cent.
Metallic iron	63.84	59.19	58.15	65.96	62.49
Phosphorus	0.022	0.019	0.015	0.024	0.044
Phosphorus ratio	0.034	0.032	0.026	0.037	0.070

It remains to mention a very different deposit of specular ore, which has recently been discovered near the head of Wolf creek, in Cocke county. It lies among the metamorphic rocks, 7 miles south of the present terminus of the railroad that branches off at Morristown from the East Tennessee, Virginia and Georgia railroad.

Major W. R. Smith, of Newport, has had the bed uncovered on his own property; it strikes northeast and southwest, and dips about 45° southeast; the entire thickness seen was 5 feet; of this 3 feet consists of blue specular ore containing some pink feldspar. In the lower 2 feet the feldspar predominates to such a degree as to render it too lean for an iron ore. Sample 914 represents the upper 3 feet of this ore, taken by clipping across that portion of the bed.

The following is the analysis:

	914.
	<i>Per cent.</i>
Metallic iron	45.68
Phosphorus	0.016
Sulphur	0.399
Phosphorus ratio	0.035

Following is the complete analysis:

	914.		914.
	<i>Per cent.</i>		<i>Per cent.</i>
Silica	26.59	Hygroscopic water	0.12
Iron protoxide	0.06	Water of composition	0.61
Iron, peroxide	63.68	Total	100.078
Alumina	5.05	Per cent. of insoluble silicious matter	32.71
Lime	0.18	Silica	26.59
Magnesia	0.06	Alumina	3.97
Iron, disulphide	0.742	Lime	0.18
Potassa	1.80	Potassa	1.80
Soda	0.17	Soda	0.17
Carbonic acid	0.04	Total	32.71
Sulphuric acid	0.01		
Phosphoric acid	0.036		
Carbon in carbonaceous matter	0.03		

DYESTONE ORES.

For the principal facts as to the dyestone or fossil ores of East Tennessee see the report of Mr. William M. Chauvenet. This report includes only the description of the beds seen in Scott, Campbell, and Anderson counties, and of the peculiar deposit known as the Hill bank, in McMinn county. A sample taken from Knox county has been added.

a The following map, copied from a report of J. B. Killibrew on the "Mineral and Agricultural Resources of the portion of Tennessee along the Cincinnati Southern and Knoxville and Ohio railroads", shows the relations of the different beds sampled in Campbell, Scott, and Anderson counties:

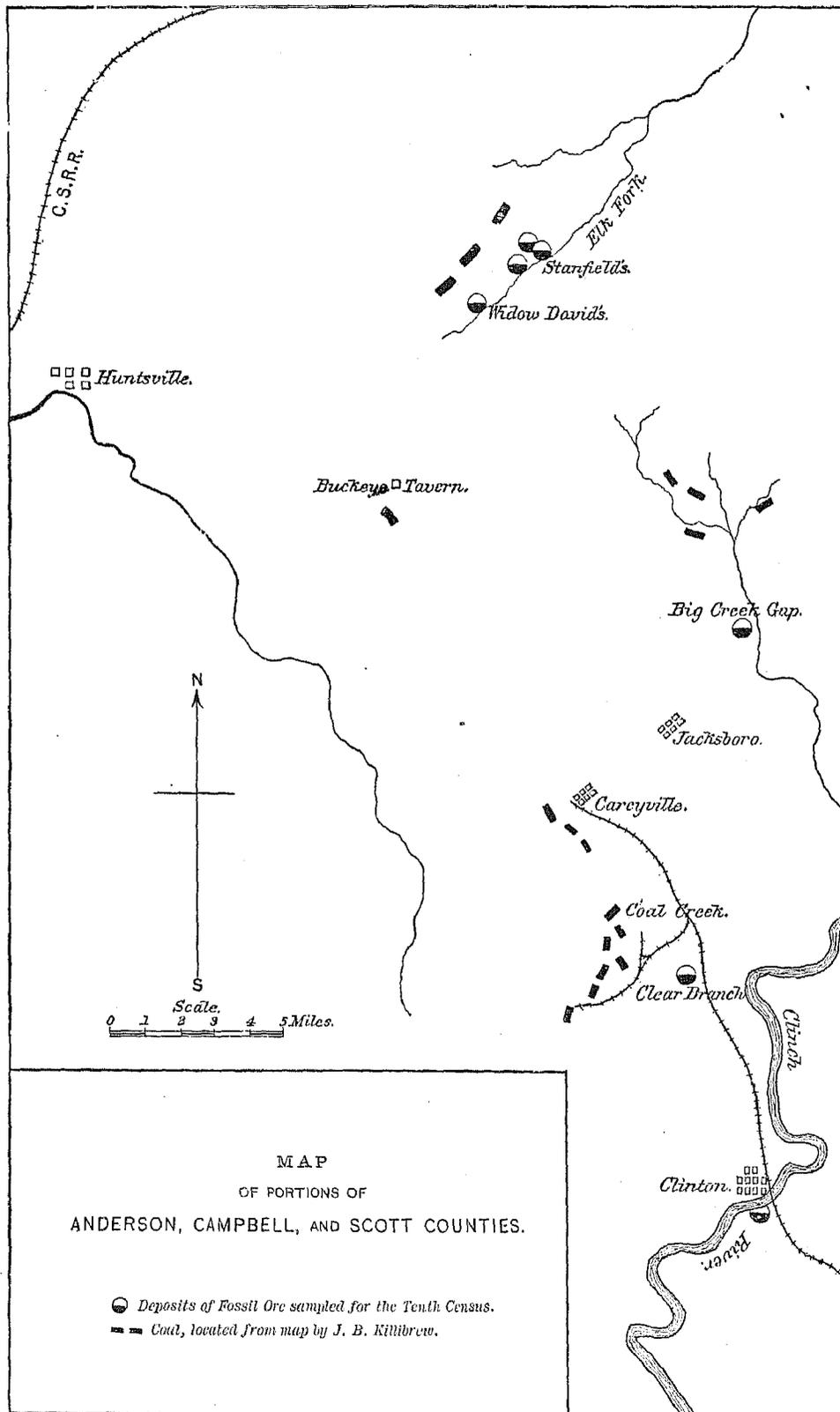


FIG. 135.

The principal range of fossil ore, which lies along the eastern side of Walden's ridge, is interrupted in northern Anderson county. It has been opened, however, on *Clear branch*, 2½ miles southeast of Coal Creek station of the Knoxville and Ohio railroad, where it has a total thickness of 2½ feet, of which the lower 1 foot is hard ore, the upper 1½ feet is soft ore.

The same ore, lying in a parallel range, has been opened in *Lone mountain*, half a mile from Clinton, on the east side of Clinch river; here it has a thickness of 1 foot, and the bed is separated into two plates by a layer of shale 1 inch thick.

What is probably a continuation of the range seen on *Clear branch* has been quite extensively worked 8 miles northeast of Caryville, south of *Big Creek* gap. Sharp's forge stood on Big creek; the ore was mined for it along a distance of 300 yards in a straight line to a depth of 10 to 20 feet; it dips 80° toward the northwest, and is said to have had a uniform thickness of 3 feet.

Samples of ore were obtained from these three deposits from ore in place; the analyses are as follows:

	LONE MOUNTAIN.	BIG CREEK.	CLEAR BRANCH.
	500.	905.	906.
	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>
Metallic iron	30.08	41.91	51.90
Phosphorus	0.522	0.559	0.698
Phosphorus ratio	1.336	1.095	1.341

It will be noticed that the soft ore from *Clear branch*, although in the specimen much lighter than the more compact ores from the other localities, is really much richer in iron. This agrees with observations of Mr. Chauvenet elsewhere.

The fossil ores of Elk Fork valley, which lie northwest of Big creek, last described, do not belong to any of the regular ranges; they have been brought to the surface by a great fault, which is described by Professor J. P. Lesley in an unpublished report, quoted in the pamphlet of Mr. Killibrew, already referred to.

The road from Caryville, after passing Morrowville, which is a single house and barn, generally known as "Buckeye tavern", crosses a ridge of Jellico mountain and descends rapidly into Elk Fork valley. At the foot of the descent is a small area of meadow-land and a house, which formerly belonged to the *widow David*. A short distance beyond the road crosses a little creek, just north of which, 50 feet west of the road, is a terrace, the face of which is a plate of fossil ore. This bed dips about 65° toward the southeast. Another parallel plate, 16 feet below the preceding, forms the face of a portion of the terrace immediately adjacent.

With the aid of Mr. Lewis Stanfield, the writer obtained the following section (Fig. 136) by stripping off the soil which concealed portions of the bed.

Three miles farther north is the property of Mr. Stanfield, on which the outcrops of four beds of ore may be seen. It is 160 paces from the outcrop of the upper bed to that of the lowest; the two intermediate ones crop out close together, 40 paces northwest of the uppermost; probably these are the continuation of the widow David's "Big bed", just described. Another outcrop of what is probably the upper plate of the same bed was seen a quarter of a mile south of Mr. Stanfield's, just where the road makes a sharp descent by a house. The following section (Fig. 137) shows the relations of these ores just north of Mr. Stanfield's:

Samples of these ores were taken at the widow David's big bed, from the upper plate (904); at the outcrop by the steep hill, one-fourth mile south of Stanfield's (902); from the outcrop of the uppermost bed, northeast of Stanfield's (901); and from surface pieces of the lowest bed, west of Stanfield's (903).

The following are the analyses:

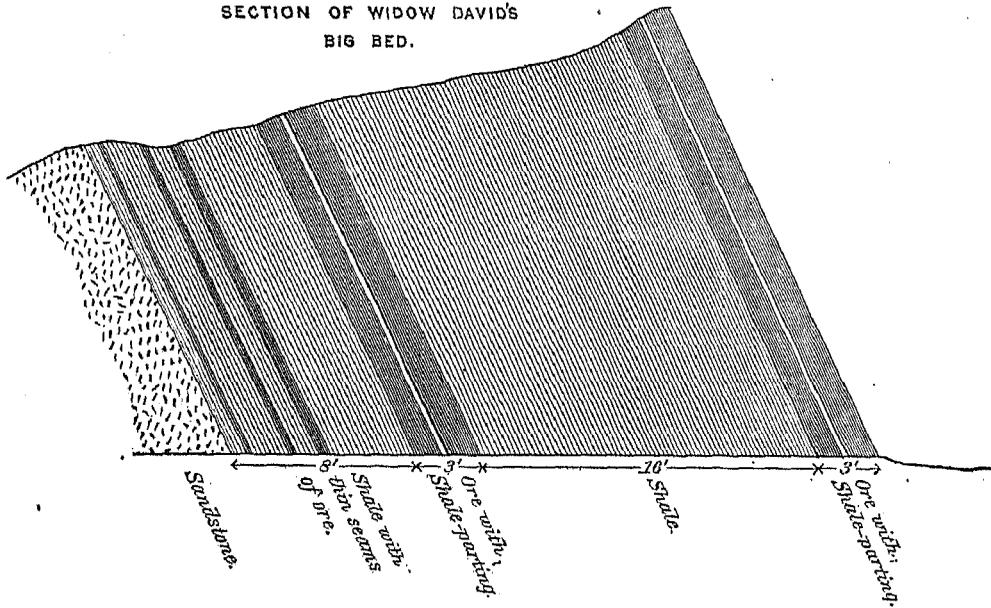
	UPPERMOST BED.	MIDDLE BED.	LOWEST BED.	WIDOW DAVID'S.
	901.	902.	903.	904.
	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>
Metallic iron	45.12	41.81	50.13	33.90
Phosphorus	0.729	0.735	0.899	0.395
Phosphorus ratio	1.624	1.757	1.793	1.163

In the region 7 to 8 miles east of Athens, in McMinn county, where limonites and dense specular ores occur on Chestnut ridge, close together, is still another peculiar deposit, a dyestone or fossil ore belonging to the Lower Silurian. It does not differ in general character from the typical fossil ore of the Upper Silurian, being composed

like that, partly of oölitic grains, partly of fossils. The principal outcrop is on a low ridge just east of the Federal road, on the property of Mr. Basil Thomas. Surface fragments extend about three-quarters of a mile northeast

a

SECTION OF WIDOW DAVID'S
BIG BED.

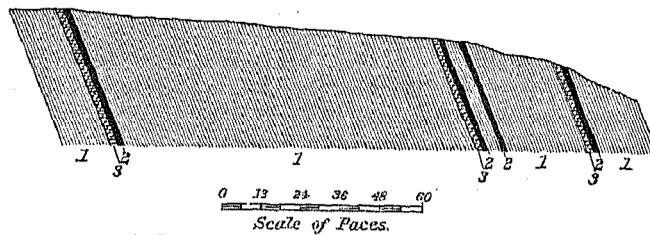


b

FIG. 136.

c and southwest, and a similar bed is said to occur 2 miles northeast of this one. The strata appear to dip 30° to 40° to the southeast. It was stated that the ore had been penetrated to a depth of 40 feet.

SECTION IN ELK FORK VALLEY.



d

- 1. Shale.
- 2. Fossil Ore.
- 3. Sandstone.

FIG. 137.

The bank is known as the *Hill* bank. The following is the analysis of the sample taken from the outcrop:

e

	HILL'S.
	973.
	<i>Per cent.</i>
Metallic iron.....	51.42
Phosphorus.....	0.822
Phosphorus ratio.....	1.599

One of the eastern outliers of the dyestone ores has been opened and worked about $S\frac{1}{2}$ miles northeast of Knoxville, Knox county, near the road to Strawberry Plains. A furnace erected here just before the war has never been put in blast.

Sample 499 was taken from a small opening from which ore, shipped for trial, had been dug. The thickness f of the bed could not be definitely measured, but it is not less than 5 feet.

	PETERS AND MOWRY.
	499.
	<i>Per cent.</i>
Metallic iron.....	49.89
Phosphorus.....	1.652
Phosphorus ratio.....	3.311

NOTES ON THE SAMPLES OF IRON ORE COLLECTED IN TENNESSEE.

By W. M. CHAUVENET.

The ores described in this report include those of James, Bradley, Hamilton, Meigs, Rhea, and Roane counties, in eastern Tennessee, and the deposits of limonite throughout the western region.

A description of the ores of the eastern iron region is in the report of Mr. Bailey Willis.

The fossil ores of the Eastern Tennessee valley occur in the Clinton group of the Upper Silurian, and belong to the great Dyestone range, of which those found along Walden's ridge and on the banks of the Tennessee river are a type.

The limonites of the western region occur, according to Dr. J. M. Safford (*Geology of Tennessee*, p. 350, § 911), in the ruins of the silicious group, and are scattered over the whole area included in the western highlands.

The fossil ores of eastern Tennessee occur in a number of distinct ranges, which cover a wide area, and present many complications in geological structure.

The main range, known as the Mountain range, extends along the east flank of Walden's ridge, an outlier of the Cumberland table-land, and can be traced almost continuously throughout the state from Lookout mountain in the south to Cumberland Gap at the Virginia line. The ore-ridges in the Tennessee valley are often duplicated.

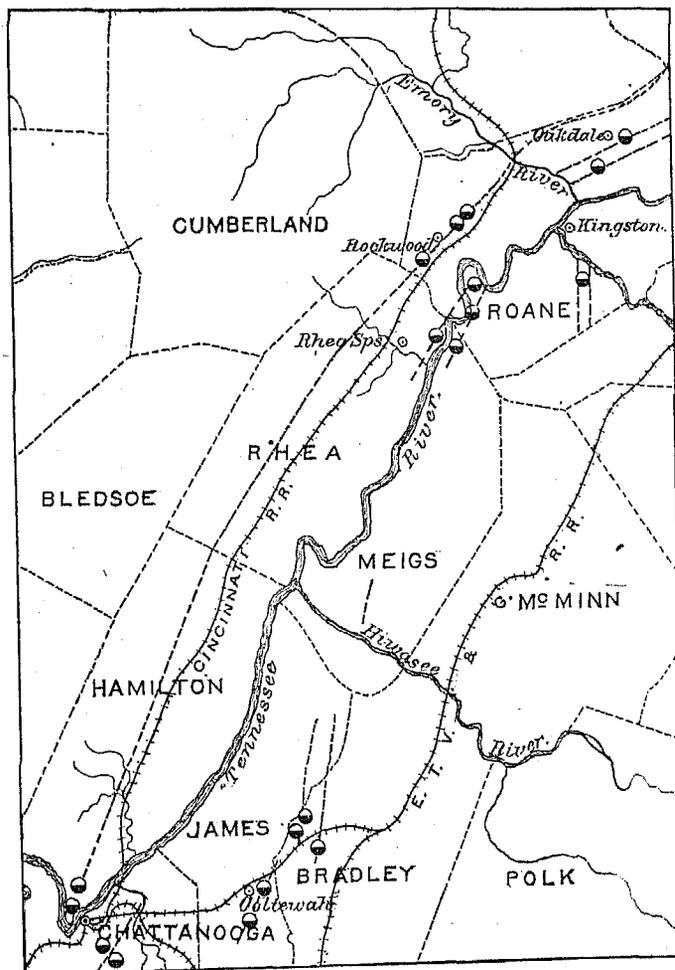
The ore from the southern portion of the ranges is similar to that found on the main Alabama range described elsewhere, of which these are but continuations. It shows well-defined fossil forms, and cleaves readily into thin slabs.

Continuing northward, the ore becomes more oolitic in nature, showing in many cases only occasional fossils, or, where the fossils are still thickly scattered, in the place of fossil shells are found impressions of corals and crinoid buttons. The accompanying map (Fig. 139) shows the principal ranges of fossil ore:

In James county, continuing north into Bradley, east of Ooltewah, the ore has been opened in two parallel ridges, which here trend north and south, known as White Oak mountain and Hinch's ridge.

Fig. 140 shows a section taken at Ragon's mine, 3 miles southeast of Ooltewah. A small pit had here been sunk upon the ore, exposing the bed, which here dips southeast at an angle of 30°. The ore is a compact variety, and an average sample taken from the three seams gives, upon analysis:

	273.
	Per cent.
Metallic iron.....	47.90
Phosphorus.....	0.128
Phosphorus ratio.....	0.267



VALLEY OF EAST TENNESSEE
SHOWING
RANGES OF FOSSIL ORES.

○ Openings on the fossil ores.
----- Ranges.

0 10 miles.

FIG. 139.

This opening is on the White Oak Mountain ridge, and a second opening upon the same is found at *Green's a* mine on the crown of the ridge south of Ooltewah gap, through which the railroad passes. A peculiar form of fossil ore, known as gravel ore, is here found in the clay above the ore-bed. The individual gravel stones are here scattered through the surface clay, most thickly at a depth of 3 feet, and have all the appearance of water-worn pebbles.

Two samples were here taken, which offer a comparison between this surface-ore and that from the defined bed below. A second sample of the gravel ore was taken from a larger quantity on the stock-pile at South Pittsburgh. The following are the analyses:

	270.	277.	272.
	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>
Metallic iron	50.60	50.03	55.30
Phosphorus	0.153	0.056	0.058
Phosphorus ratio	0.302	0.005	0.105

No. 276 is from the main bed at the mine. No. 277 is gravel ore sampled at the mine from a pile of 20 tons, taken by breaking the pebbles.

No. 272 is gravel ore from the same bed sampled at South Pittsburgh by selecting small unbroken pebbles.

North of Wolf's switch, in Bradley county, the ore has been opened at several points on White Oak mountain and Hinch's ridge. The *Smith* mine, on White Oak mountain, $1\frac{3}{4}$ miles northwest of Wolf's switch, and *Hinch's* mine, 1 mile from the switch on Hinch's ridge, were the principal working mines. The following are the analyses of the samples taken:

	274.	275.
	<i>Per cent.</i>	<i>Per cent.</i>
Metallic iron	44.88	51.35
Phosphorus	0.127	0.214
Phosphorus ratio	0.283	0.304

No. 274 is from Smith's mine, on White Oak mountain. No. 275 is from Hinch's mine, on Hinch's ridge.

This district is known as the Western Ocoll and Hiwassee district. Many farmers are digging ore in this neighborhood and hauling it in small lots to the various switches along the railroad, where it is sold to ore contractors at different prices. New pits were being opened daily, and no systematic mining was anywhere pursued. The ores sampled were therefore in all cases drawn from near the surface, and were obtained by stripping along the outcrops, no opportunity being anywhere offered for sampling deep upon the beds.

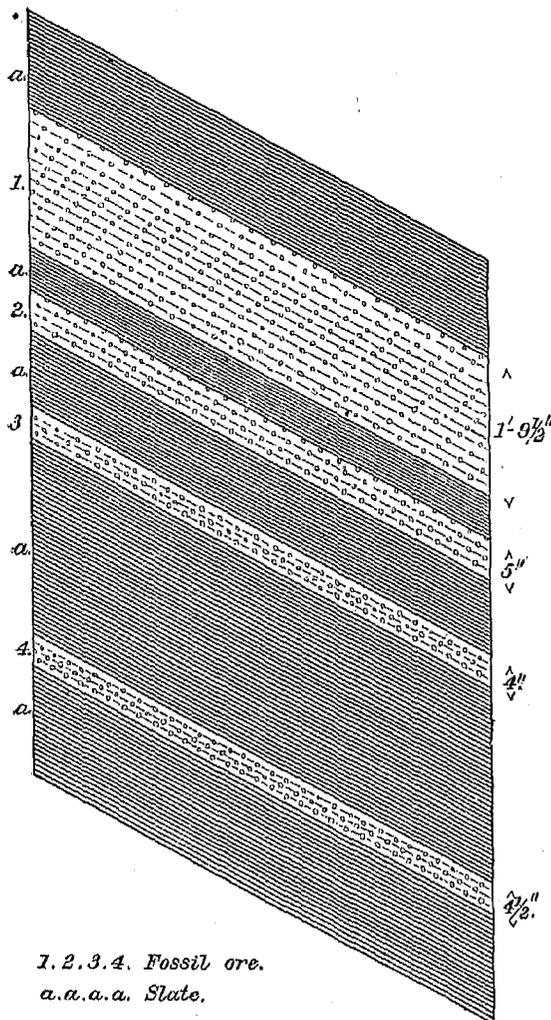


FIG. 141.—SECTION AT THE COKER MINE, TENNESSEE.

In Hamilton county, opposite Chattanooga, the fossil ore is being mined on a small scale. Fig. 141 shows a section on the property of Clift and Sawyers, where the bed was exposed by a small test-pit sunk upon the outcrop. The ore in these four seams is much decomposed, and crumbles to a fine powder in the hand.

The section shown in Fig. 141 was again exposed 100 feet below on the opposite side of the gulch. Here a tunnel had been run 10 feet upon the outcrop, the ore running quite soft to this depth; beyond this point it is hard and compact, and changes rapidly to a ferruginous limestone, the only soft portion lying near the top of the upper

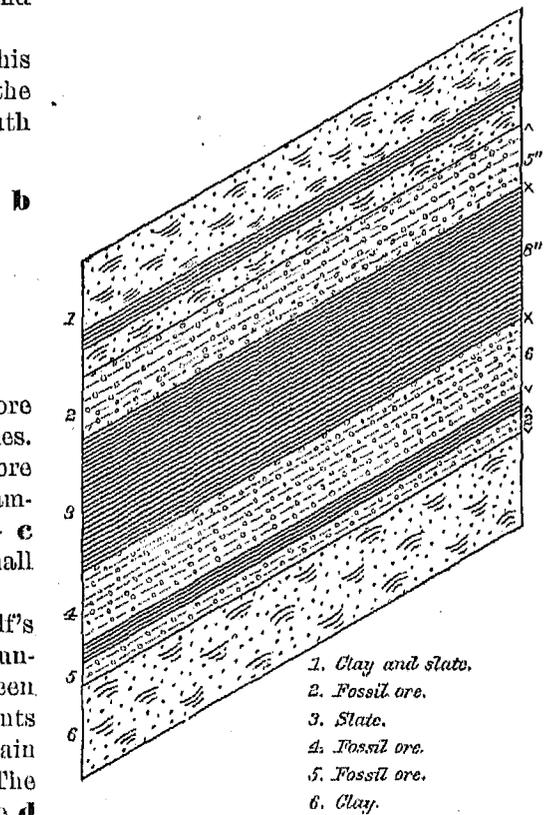


FIG. 140.—SECTION AT RAGON'S MINE, TENNESSEE.

In Hamilton county, opposite Chattanooga, the fossil ore is being mined on a small scale. Fig. 141 shows a section on the property of Clift and Sawyers, where the bed was exposed by a small test-pit sunk upon the outcrop. The ore in these four seams is much decomposed, and crumbles to a fine powder in the hand.

a bed. Two samples were here taken to illustrate the difference between the hard and the soft ore. The analyses were as follows:

	278.	279.
	<i>Per cent.</i>	<i>Per cent.</i>
Metallic iron	31.77	54.76
Phosphorus	0.430	0.753
Phosphorus ratio	1.364	1.375

No. 279 is the soft weathered ore from the exposed face of the outcrop (Fig. 141). No. 278 is the hard calcareous ore from the head of the tunnel 10 feet upon the outcrop at the lower opening. The mine is known as *Coker's mine*.

The Dyestone ridges, bearing the bed of fossil ore, are found outcropping both east and west of Lookout mountain, which rests in a synclinal trough. The beds outcropping east of the mountain have been opened in several places from 1 to 3 miles south of Chattanooga. These openings are shallow pits, from 10 to 20 feet deep, extending with the strike. The thickness of the beds, which are here much distorted, varies from 14 to 18 inches. The ore is quite soft and porous, and the seams are but poorly exposed. The analyses of two samples here taken show—

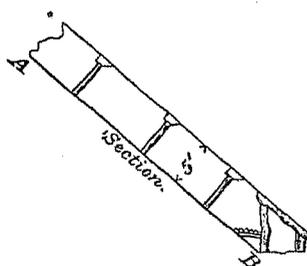
	280.	281.
	<i>Per cent.</i>	<i>Per cent.</i>
Metallic iron	47.00	48.78
Phosphorus	0.248	0.175
Phosphorus ratio	0.527	0.350

No. 280 is from a small pit 1½ mile south of Chattanooga. No. 281 is from the same lead one-quarter of a mile farther north. The pit is leased by *S. B. Lowe*.

Ascending the Tennessee river, the fossil ore is found on both sides of the stream in Rhea and Meigs counties.

Six miles above Pin Hook landing, and 7 miles northeast of Rhea Springs, in Rhea county, the ore has been largely opened at the *Iron Hill* mine, half a mile from the river. The ore-bed here averages 5 feet in thickness,

d



e

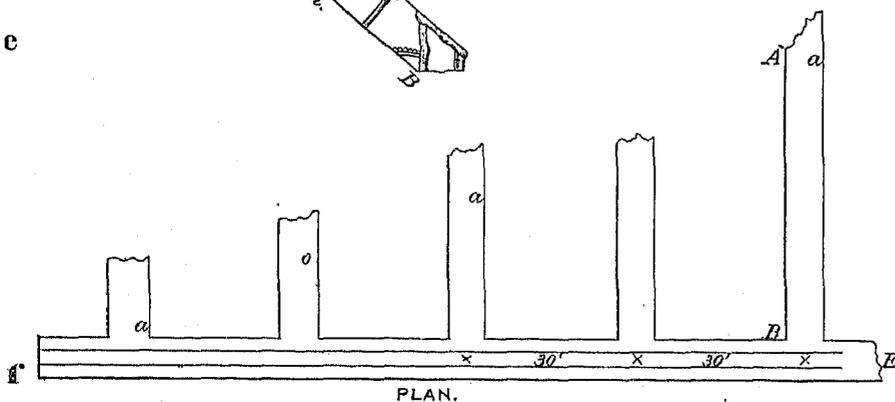
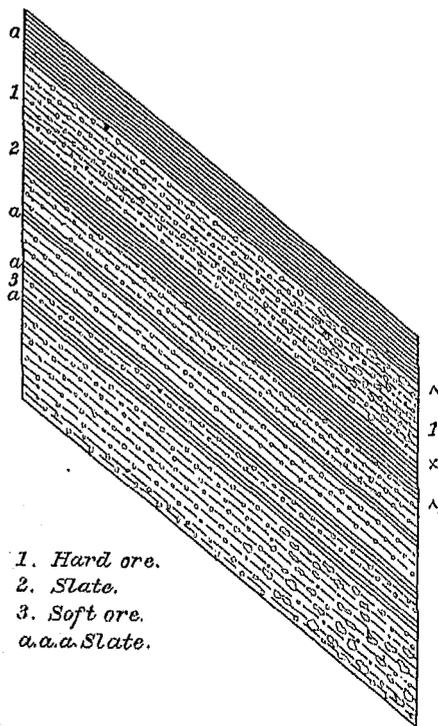


FIG. 142.—PLAN OF THE IRON HILL MINE, TENNESSEE.



- 1. Hard ore.
- 2. Slate.
- 3. Soft ore.
- a.a. Slate.

FIG. 143.—SECTION AT END OF MAIN ENTRY, IRON HILL MINE, TENNESSEE.

and is opened by an entry run with the strike at water-level, which is here 490 feet below the outcrop, measured on the dip. From this main entry stopes are run at right-angles, at intervals of 30 feet, ascending with the dip of the ore-bed. The bed outcrops on the top of a hillside facing northwest, and dips southeast at an angle of 40°. The ore above water-level, including all of that portion worked, is a soft open-grained variety, distinctly oölitic

in appearance, but showing, also, frequent fossils, cleaving readily into thin slabs, and showing fine spots of a yellow ocher when so cleft. Below water-level the ore becomes much denser, has a much more metallic luster, and no longer cleaves readily into slabs. Hill and Tarwater are the lessees of the mine.

Samples from different parts of the mine are represented in the following analyses:

	293.	294.	295.
	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>
Metallic iron.....	41.77	50.13	51.71
Phosphorus.....	0.766	0.780	0.500
Phosphorus ratio.....	1.834	1.556	0.970

b

No. 293 is from the upper 1-foot seam at the top of the main entry near the northeast end, and is the hard ore above mentioned. No. 294 is from the 4-foot seam, taken across the whole end of main entry directly below 293, from which it is separated by a thin slate seam. No. 295 is an average sample of the mine above water-level, taken at different levels on the dip, at *a, a, a* (Fig. 142).

Fig. 143 shows a section at the end of the main entry marked *B* (Fig. 142).

Sample 295 shows, upon full analysis, the following results:

	295.		295.
	<i>Per cent.</i>		<i>Per cent.</i>
Sulphur.....	0.109	Carbon in carbonaceous matter.....	0.01
Phosphorus.....	0.506	Hygroscopic water.....	0.77
Iron, metallic.....	51.71	Water of composition.....	2.94
		Total.....	99.688
Silica.....	10.88		
Iron, protoxide.....	0.60	Per cent. of insoluble silicious matter.....	13.18
Iron, peroxide.....	72.98		
Alumina.....	0.80	Silica.....	10.88
Manganese, protoxide.....	0.42	Alumina.....	1.88
Lime.....	2.26	Lime.....	0.15
Magnesia.....	0.73	Magnesia.....	0.25
Iron, disulphide.....	0.205	Total.....	13.16
Carbonic acid.....	0.07		
Phosphoric acid.....	1.158		

c

d

Directly across the Tennessee river from Iron hill, in Meigs county, the ore has been largely worked at *Kendrick's* mine. The analysis of this ore, from an average sample taken on the stock-piles of the Roane Iron Company, at Chattanooga, is as follows:

	292.
	<i>Per cent.</i>
Metallic iron.....	51.03
Phosphorus.....	0.945
Phosphorus ratio.....	0.608

e

Still ascending the river the ore is found on the south end of Half-Moon island, where it was once dug for old Eagle furnace. These diggings are now abandoned.

At *Brown's* mine, in Roane county, 4 miles above Rockwood landing, on the left bank of the river, the ore-beds are found at two horizons, and are opened by irregular trenches, extending along the outcrops, which are abandoned as soon as the soft surface-ore has been stripped, and a depth of 10 or 15 feet renders timbering necessary. Two samples were here taken, showing, upon analyses—

	291.	292.
	<i>Per cent.</i>	<i>Per cent.</i>
Metallic iron.....	52.75	48.05
Phosphorus.....	0.253	0.072
Phosphorus ratio.....	0.480	0.148

f

The ore shown in sample 292 is a flaky, dense ore, showing signs of great pressure in its many smooth, slicken-side surfaces, fracturing easily in two directions at right-angles. It comes from the bed highest in the series at this point, and was taken from a small pile of 3 tons. No. 291 is from the main 4-foot bed, and was taken along 50 feet at two points 75 yards apart in the lowest part of the diggings. This sample represents ore from 10 feet upon the bed.

a One mile from the south bank of the Tennessee river, and 5 miles above Kingston, the fossil ore outcrops largely on the southeast faces of the ridges, which here rise prominently. On the property of Mr. B. F. Welcker the ore is exposed in two beds—an upper 4-foot bed of soft ore, showing the effect of weathering, and a second bed, 2½ feet thick, of harder ore, immediately underlying this. Samples were taken from both of these beds at a point about 30 feet from the original outcrop—the beds having been stripped to this depth—and from 3 to 6 feet below the surface of the hill, which here conformed to the lay of the beds. These samples yielded, upon analyses—

	289.	290.
	<i>Per cent.</i>	<i>Per cent.</i>
Metallio iron	44.02	49.20
Phosphorus.....	0.387	0.420
Phosphorus ratio	0.879	0.865

b No. 289 is from the upper bed. No. 290 is from the lower, harder bed. J. D. Roberts is working this mine.

A tram-road was in progress from this outcrop to the river, and preparations were being made for shipping the ore to Rockwood furnaces.

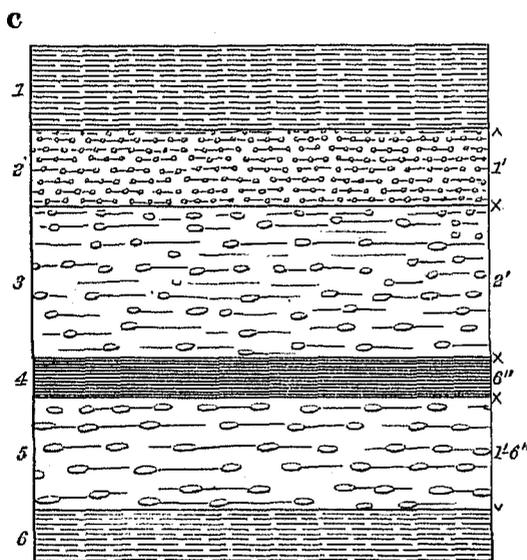
The ores mined for the Rockwood furnaces in Roane county are from the mountain-range of fossil ores above described. The ore-beds north and south of the furnaces outcrops in the crown of a number of low hills lying along

the east front of Walden's ridge, and forming what is known as Shinbone ridge. The bed, averaging nearly 4 feet in thickness, is highly inclined toward the mountain, and is much faulted and broken.

Two and a half miles northeast of Rockwood the bed lies horizontal for some distance, and is 5 feet in thickness, presenting many irregularities before it regains its upright position, sometimes inclining to the east and sometimes to the west as it continues southward. Fig. 144 shows a section taken at the horizontal portion of the bed.

Continuing southward from this point along the outcrop, the ore has been worked in many places by stripping along the exposed face.

d On *Ivy hill*, one of the Shinbone series, the ore-bed was much contorted, forming "spreads" and folds. The ore presents many varieties, from soft, porous, fossiliferous, to hard, calcareous, and compact, sometimes becoming micaceous and having a greasy feel. In places it has a steely luster and shows slicken-sided, concave plates that fracture at right-angles readily. The ore-bed is overlain by shale and underlain by a thin seam of highly ferruginous limestone, which is in places wanting; beneath this is shale again. Many almond-shaped concretions, both of the underlying limestone and the accompanying shales, are completely incrustated with a bright film of ore of a steely luster, and are easily mistaken for ore-lumps until fractured. At many places along the outcrop specimens of limonite are found in close contact with the fossil ore, often forming stalactites and hollow pots. These limonites are never in quantity sufficiently large to render them valuable at the furnaces, and are evidently due to alterations in the fossil red hematite.



1. Shale.
2. Soft fossil ore.
3. Harder fossil ore.
4. Slate.
5. Hard ore.
6. Shale.

FIG. 144.—SECTION AT PIATT'S MINE, 2½ MILES NORTHEAST OF ROCKWOOD, TENNESSEE.

The following analyses represent the ores now in use at the furnace:

	287.	288.
	<i>Per cent.</i>	<i>Per cent.</i>
Metallio iron	53.30	56.40
Phosphorus.....	0.920	0.749
Phosphorus ratio	1.726	1.952

No. 287 is from the section shown in Fig. 144, 2½ miles northeast of Rockwood, on Mr. Piatt's land, and comes from the whole face there exposed. No. 288 is from the crown of Ivy hill, on Mr. Piatt's land, 1½ mile northeast of Rockwood, taken from 50 tons of freshly-mined ore.

In the northern part of Roane county the ore-beds of the mountain range are three or more in number, and spread over an area 2 miles in width. The ores in this vicinity have been opened for Oakdale furnace, which, however, made but a short blast.

On the property of Mr. Solomon, 4 miles south of the narrow-gauge railroad to Oakdale, a vertical bed of ore **a** is exposed, from 12 to 15 inches thick. A short trench has here been run along the outcrop. The ore is a soft micaceous variety, giving, upon analysis—

	284.
	<i>Per cent.</i>
Metallic iron.....	46.31
Phosphorus.....	1.040
Phosphorus ratio.....	0.302

Half a mile southeast of the furnace was sunk a **b** shaft 60 feet deep upon the vertical bed of ore, which is here exposed on the hillside near the top of the shaft 15 inches thick. This is known as the "front vein" and contains a soft micaceous variety of fossil ore. The shaft was inaccessible, but a sample was taken from the stock-pile left at the furnace of ore from the greatest depth reached, which was 60 feet, and a second sample from the outcrop at the surface where the ore was being freshly opened. These samples offer **c** another illustration of the difference between the surface ore and that from lower levels upon the bed, giving, upon analysis—

	286.	285.
	<i>Per cent.</i>	<i>Per cent.</i>
Metallic iron.....	37.03	46.34
Phosphorus.....	0.705	0.140
Phosphorus ratio.....	1.904	0.302

No. 286 is ore from the bottom of the shaft. No. **d** 285 is from the same bed taken at the surface.

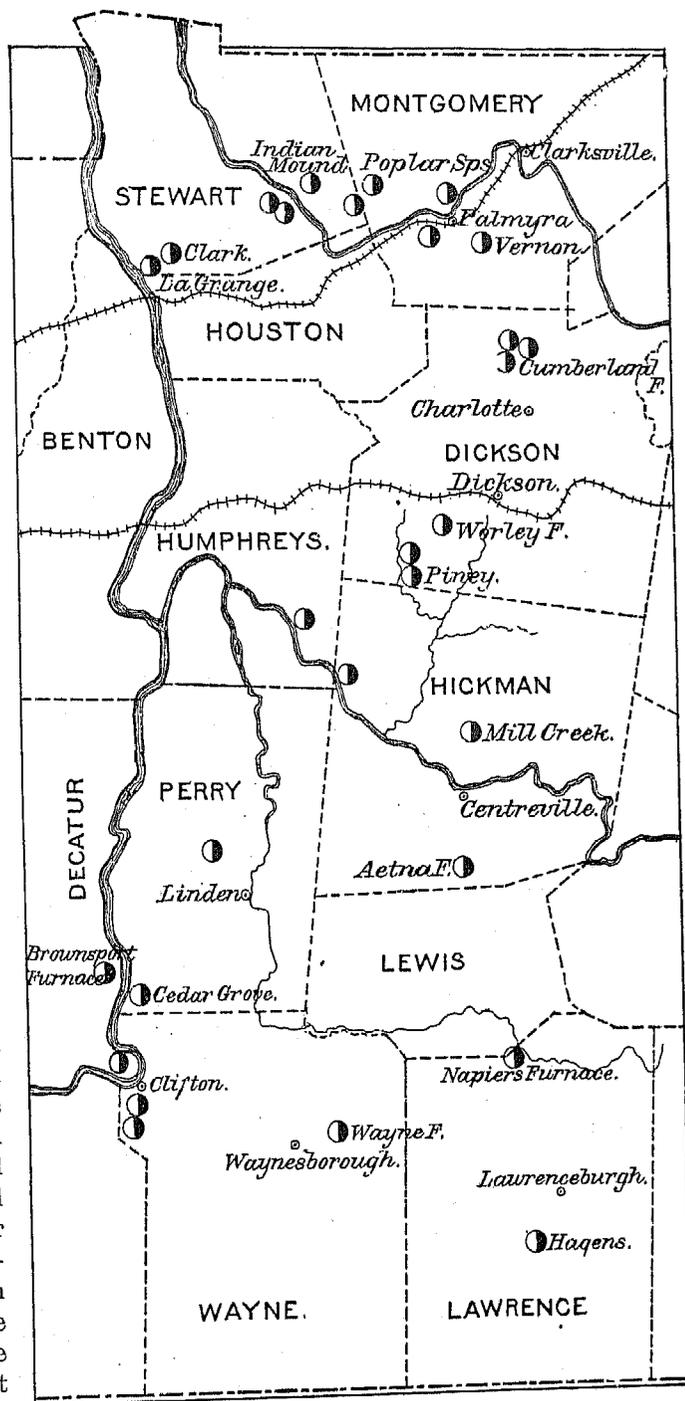
Many farmers are engaged in digging ore from Oakdale, as no systematic development of the beds is attempted.

The accompanying map (Fig. 145) of the western iron region shows the location of the ore-banks visited.

The limonites of this region occur in a well-defined belt, about 50 miles wide, beginning in northern Alabama and extending into Kentucky. The ores **e** occur in clay, associated with more or less decomposed chert in angular fragments, water-worn pebbles, and occasional lumps of coarse sandstone. The defined deposits of ore, known as ore-banks, occur at greater or less intervals over the entire region, though loosely-scattered lumps of surface limonite may be dug from almost every hillside. Throughout the region the ore is mined in open cuts, the masses being followed in the direction promising the best immediate results. At present it is a region of fallen mines and abandoned furnaces, and the samples were in most instances **f** taken from pits deserted twenty years ago.

Six miles southwest of Lawrenceburg, in Lawrence county, on both sides of the West Point road, the ore was formerly dug for *Hagen's* forge. A sample was taken from such lumps as could be found scattered through the old diggings. The ore is a dense, brittle limonite, showing, upon analysis—

	296.
	<i>Per cent.</i>
Metallic iron.....	52.43
Phosphorus.....	0.708
Phosphorus ratio.....	1.350



THE IRON REGION OF WESTERN TENNESSEE. 1 inch = 16 miles.

FIG. 145.

The ore is a dense, brittle limonite,

a Napier's furnace is situated 7 miles northwest of Henryville, in Lawrence county. Its ore-banks have been recently reopened, and show a rich limonite occurring in pots and honeycombed masses, imbedded in a deep-red clay, which shows fewer chert fragments than usual.

The two main deposits are the *Davis* and the *Pinion* banks, situated 1 mile northwest of the furnace. The Davis bank is a square open cut 50 feet across, yielding principally a porous honeycombed ore of a rich chocolate-brown color, as well as many hollow pots. The Pinion bank, one-quarter mile southwest of this, was worked 50

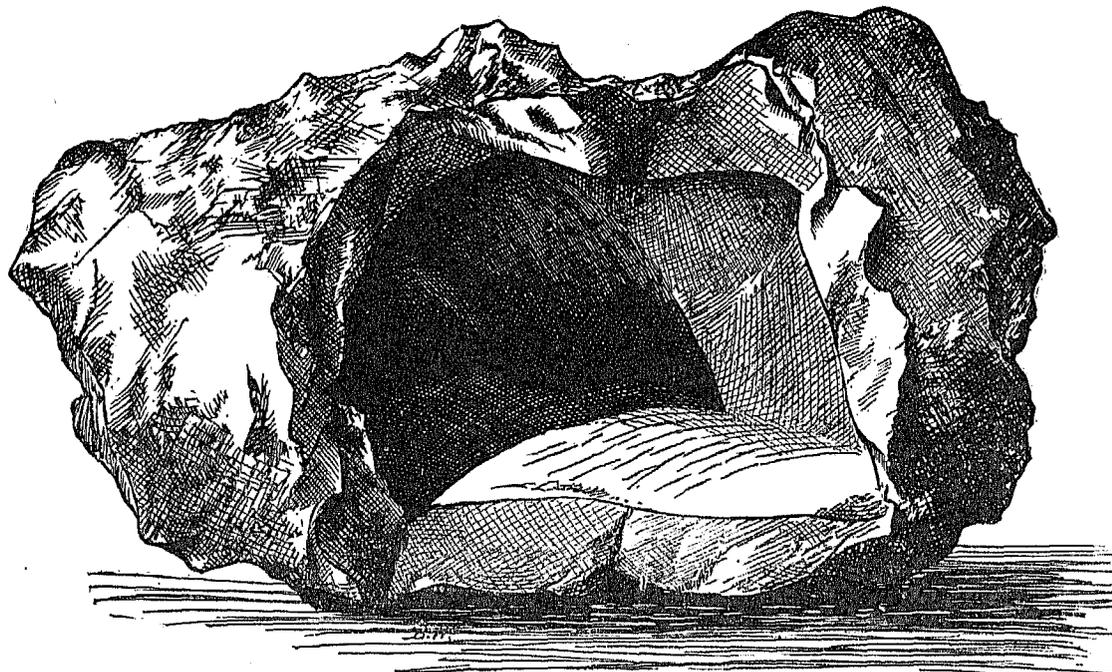


FIG. 146.—POT OF LIMONITE, FROM THE PINION BANK, TENNESSEE.

years ago for a Catalan forge, and is opened by a small circular pit. This bank is remarkable for its many hollow pots and concretionary forms which occur loosely scattered through a deep-red plastic clay. One of these hollow pots is illustrated in Fig. 146. The analysis of these ores show results as follows.

	297.	298.	299.
	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>
Metallic iron.....	53.27	40.28	52.01
Phosphorus.....	0.340	0.543	0.519
Phosphorus ratio.....	0.638	1.102	0.987

No. 297 is from the Davis bank. No. 298 is from the Pinion bank. No. 299 an average sample from the furnace stock-piles.

Following is the complete analysis of 299:

	299.		299.
	<i>Per cent.</i>		<i>Per cent.</i>
Sulphur.....	0.070	Phosphoric acid.....	1.189
Phosphorus.....	0.519	Carbon in carbonaceous matter.....	0.09
Iron, metallic.....	52.61	Hygroscopic water.....	0.43
		Water of composition.....	11.15
		Total.....	100.079
Silica.....	6.19	Per cent. of insoluble silicious matter.....	7.59
Iron, protoxide.....	0.35	Silica.....	6.19
Iron, peroxide.....	75.17	Alumina.....	1.29
Alumina.....	3.57	Lime.....	0.05
Manganese, protoxide.....	0.92	Magnesia.....	0.11
Lime.....	0.26	Total.....	7.64
Magnesia.....	0.38		
Iron, desulphide.....	0.130		
Carbonic acid.....	0.25		

Wayne furnace, now out of blast and dismantled, is situated in Wayne county, $5\frac{1}{2}$ miles northeast of a Waynesborough, on the Waynesborough pike. The ore-bank is on the crown of the hill back of the furnace, and the old diggings are fallen, covered, and overgrown. A sample was, however, taken from a small tunnel at the northwest end of the north pit from ore in place. This sample shows a dense, cherty ore, yielding, upon analysis—

	300.
	<i>Per cent.</i>
Metallic iron.....	45.78
Phosphorus.....	1.084
Phosphorus ratio	2.308

b

The white and yellow chert associated with the ore seems unusually abundant at this bank.

Two and a half miles south of Clifton, in Wayne county, the limonite ores have been largely worked for the use of Old Marion furnace, now in ruins. The *White* bank, so called to distinguish it from the "Red" bank next to be described, is one-quarter mile northeast of the furnace-site. This bank has not been worked for twenty years, and but little ore was exposed; it lies on the crown and sides of the main ridge, and the old diggings are huge pits from 50 to 100 feet deep and some acres in extent. The sample here taken gives, upon analysis—

	502.
	<i>Per cent.</i>
Metallic iron	50.57
Phosphorus.....	0.670
Phosphorus ratio	1.325

c

The *Red* bank, $1\frac{1}{2}$ miles northeast of Marion furnace, near the Waynesborough pike, is a peculiar deposit of limonite. It occurs in sheets and irregular concretions, and has much the appearance of a red hematite, owing to the coating of red oxide on the surface of the lumps. The ore is peculiar to this locality, though a much similar ore is described under the ores of Kentucky at the Old Slate bank, in Bath county. The complete analysis of this ore is as follows:

	501.		501.
	<i>Per cent.</i>		<i>Per cent.</i>
Sulphur	0.108	Phosphoric acid	0.710
Phosphorus.....	0.314	Carbon in carbonaceous matter.....	0.11
Iron, metallic.....	54.80	Hygroscopic water	1.51
Phosphorus ratio	0.573	Water of composition.....	0.17
		Total	100.342
Silica	0.03		
Iron, protoxide	0.62	Per cent. of insoluble silicious matter	7.21
Iron, peroxide	77.21		
Alumina.....	1.83	Silica	0.03
Manganese, protoxide	0.09	Alumina.....	1.11
Lime	2.21	Lime	0.10
Magnesia	0.13	Magnesia.....	0.02
Iron, disulphide	0.203		
Carbonic acid.....	0.21	Total	7.26

d

e

Decatur furnace, now in ruins, is situated on the left bank of the Tennessee river, 6 miles west of Clifton, in Decatur county. Its ore-banks are situated on the crown of the ridge, 2 miles southeast of the furnace-site. The ore is a dense, cherty limonite, associated with broken, angular chert, in yellow surface-clay, and has been irregularly dug over an area covering some acres. A sample was taken from old *détritius-piles*, from such lumps of ore as could be found, and gives upon analysis—

f

	503.
	<i>Per cent.</i>
Metallic iron	49.70
Phosphorus.....	1.466
Phosphorus ratio	2.944

Brownsport furnace is situated 3 miles west of the Tennessee river and 7 miles southeast of Decatur, in Decatur county. Its ore-bank is immediately back of the furnace and has been extensively worked. The ore is a dense

a limonite, presenting no peculiarities, much contaminated by the associated chert and the boulders of coarse sandstone thickly scattered through the clay. The bank has been opened by irregular pits upon the hillside back of the furnace. A large cut, 50 feet in depth and as many feet wide, has been run through a natural depression in the hill, exposing only walls of clay thickly scattered with fragments of white chert. The sample taken was from the diggings immediately back of the furnace, and it gives, upon analysis—

	504.
	<i>Per cent.</i>
Metallio iron	40.63
Phosphorus	0.366
Phosphorus ratio	0.901

b

Two miles east of Perryville, in Perry county, the ore was once dug for *Cedar Grove furnace*, now in ruins. A sample, taken from lumps of pot-ore from the old diggings, gives upon analysis—

	510.
	<i>Per cent.</i>
Metallio iron	50.88
Phosphorus	0.384
Phosphorus ratio	0.755

c

One of the most extensive banks of limonite in the region under discussion is the *Ætna* bank, situated between Piney and Brushy forks, tributaries of Beaver Dam creek, in Hickman county. The ore can be traced for 3 miles along the ridges, but has been opened at only one point, at the northwest end of the bank, on the sides and crown of a prominent hill, $1\frac{1}{2}$ mile southeast of the furnace and 7 miles south of Centerville. A large excavation here exposes rugged masses of honeycombed limonite imbedded in yellow clay and associated with angular fragments of chert and sandstone. Besides these irregular ledges, a finer ore is found in loose fragments and hollow concretions scattered throughout the clay. A sample was taken from the old working face at the northwest end of the pit and **d** from fragments of loosened ore, giving, upon analysis—

	505.
	<i>Per cent.</i>
Metallio iron	50.03
Phosphorus	0.279
Phosphorus ratio	0.558

Ætna furnace is now in ruins and is abandoned.

e Two and a half miles southwest of Graham station, on the Nashville and Tuscaloosa Narrow-Gauge railroad, in Hickman county, is a bank of limonite, formerly worked for *Old Mill Creek furnace*, which was situated 1 mile northeast of the bank. A large excavation has here been made upon the ore-bed, over 50 feet in depth, and covering about 2 acres. The ore is a honeycombed, porous variety of limonite, and occurs in loose masses in yellow clay, which shows less chert than usual in this region. The bottom of the pit was flooded, but a sample was collected from the lump-ore, which seemed still in abundance in the sides of the fallen banks. This sample, taken along the whole circumference of the old pit, gives the following results upon analysis:

	506.
	<i>Per cent.</i>
Metallio iron	52.95
Phosphorus	0.303
Phosphorus ratio	0.572

f

On the west branch of Piney creek, in Dickson county, are situated the ore-banks formerly worked for *Piney furnace*, on the east branch of the same creek. The body of ore, indicated by hundreds of irregular pits and diggings, extends for over a mile along the creek. No system seems to have been followed in the mining of these ores. The pits and their accompanying clay-mounds cover many acres, where the ore nearest the surface and easiest dug has been taken. Like other deposits of the region, the ore is a limonite, associated with chert in red clay. Many rough, sandy masses of ore, thickly scattered with white chert fragments, were found in many places, and had evidently been avoided by the miners.

Two samples were here taken from loose lumps and fragments of broken pots, giving, upon analysis, results as follows:

	507.	508.
	<i>Per cent.</i>	<i>Per cent.</i>
Metallic iron.....	51.88	51.00
Phosphorus.....	0.380	0.218
Phosphorus ratio.....	0.750	0.427

No. 507 is from two pits farthest west, on the land of Mr. W. B. Tatum. No. 508 is from the main bank, 500 yards farther east, on the land of R. D. Manly. These banks have not been worked for many years, but the quantity of ore that still remains is large.

Worley furnace, situated 5 miles southwest of Dickson, in Dickson county, is running upon ore from two banks upon the furnace property, one known as the "West" bank, the other as the "East" bank. The West bank has not been largely opened, and contains an ore much contaminated by included masses of angular chert. It is a dense limonite, at times concretionary and open, at times dense and cherty, and occurs in irregular patches on the crown of the west ridge. The East bank occupies the crown of the hill rising east of the furnace. Several furnaces were at one time supplied with ore from this bank, and the diggings upon the ore-mass have been very extensive. The surface of the hill is a network of pits and caverns formed by the miners in their irregular methods of work. The occurrence of the ore is uncertain, and the dead-work at times very great, though few of the pits have reached a depth of over 30 feet. The ore at times is quite free from chert, and is found in hollow pots and other concretionary forms; at other parts of the bank it is a breccia, formed by fragments of white chert firmly bedded in a matrix of dense limonite. The following are analyses of these ores:

	509.	510
	<i>Per cent.</i>	<i>Per cent.</i>
Metallic iron.....	43.31	47.14
Phosphorus.....	0.434	0.210
Phosphorus ratio.....	1.002	0.445

No. 509 is from the south side of the West bank. No. 510 is an average sample from all parts of the East bank. The old Belleview furnace, 3 miles northeast of Dickson, in Dickson county, drew ore from the *Worley* bank.

The ore-banks of the *Cumberland furnace* comprise the most extensive deposit of limonite in Dickson county. The furnace is situated 7½ miles northwest of Charlotte. Beginning at the furnace the ore is found along the crown of a prominent ridge, extending for a distance of 4 miles westward, while large deposits are also worked along a range southwest of the furnace to a distance of 4 miles. Besides these, are various other banks of minor importance. Several varieties of ore are found in these different deposits, which will be described in what follows.

The *Bell* bank, occupying the crown and sides of a prominent ridge, 3½ miles southwest of the furnace, has been worked, off and on, for a period of forty years. The ore is a light, very porous limonite, with fine and much contorted lamination, the surface of the layers being covered with bright red and yellow coatings, while their broken edges are of a dense dark brown. Frequent pebbles of white, partly decomposed chert, surrounded by a denser brown shell, are peculiar to this ore. These pebbles, much resembling broken almonds, are scattered irregularly through the ore-mass in which they are firmly bedded. Occasional masses of a dense brittle ore are also met with in the *Bell* bank.

The ores of the first-mentioned range nearest the furnace have been worked for sixty or seventy years, and the vast pits and excavations cover an area of many hundred acres in extent. The ore has been mined in some instances to a depth of 70 feet by burrowing and tunneling indiscriminately in every direction. It occurs scattered loosely through red clay in masses often hundreds of tons in weight, though the greater portion of the ore is dug with the pick in the form of small lumps.

The *Nye* bank, half a mile west of the furnace, was the first bank opened for *Cumberland furnace*, which has been in blast almost continuously for over seventy years. The body of earth removed has been immense, and the topography of the neighborhood is entirely changed by the excavations and their accompanying dump-piles. The ore in the *Nye* bank is principally a dense black limonite, fracturing like chert, and occurring in large lumps. Adjoining and directly west of this are two large excavations, known as the *Henry Drake* bank and the *Red* bank. Though in the same hillside, the ore from these two pits is quite different in quality and appearance from that of the *Nye* bank, resembling that from the *Bell* bank, above described.

The *Burton* bank is situated 3 miles west of the furnace, and much mining has here been done. The ore is principally a dense, hard limonite, of a dark color and a resinous luster, though varieties of honey-combed ores are occasionally found.

a The following analyses show the nature of these ores:

	511.	512.	513.	514.	515.
	<i>Per cent.</i>	Per cent.	Per cent.	Per cent.	Per cent.
Metallic iron	48.08	40.05	55.47	46.50	40.99
Phosphorus.....	0.213	0.404	0.180	0.341	0.150
Phosphorus ratio	0.443	0.946	0.324	0.783	0.319

No. 511 is an average sample from the furnace stock-pile, representing ores from the Bell, Dry Hollow, and Nye banks. No. 512 is from five openings on the Bell bank, of open laminated ore. No. 513 is from the Nye bank, and represents only the dense black ore. No. 514 is from both the Henry Drake and Red banks, and shows only the porous honeycombed ore. No. 515 is from all parts of the Burton bank representing the dense resinous limonite.

It will be seen from the above results that the light, porous varieties, such as that from the Bell bank, contain much more phosphorus than the dark, dense ores represented by samples 513 and 515. The two varieties may be readily separated in mining, and the advantage of such a separation is evident.

Vernon furnace now abandoned, is situated on Bud's creek, $3\frac{1}{2}$ miles southeast of Palmyra. The ore used was drawn from banks a quarter of a mile west of the furnace, in the first ravine entering the valley of the creek from that direction. At one point on the south of the ravine the ore was mined in a square pit to a depth of over 50 feet, and good ore found at that depth.

The sample here taken represents ore dug from all parts of the three main pits upon the bank, and gives, upon analysis is—

	531.
	<i>Per cent.</i>
Metallic iron	47.06
Phosphorus.....	0.059
Phosphorus ratio	1.400

d *Steel's bank*, 1 mile southeast of Sailors' Rest station, on the Louisville and Memphis railroad, at one time supplied ore for two furnaces on Yellow creek. A pile of 150 tons from this bank, mined in 1878, was found at the station, which was said to have come from the bottom of a shaft some 50 feet upon the ore-mass. The bulk of the pile was of a dense, hard limonite, though specimens of pipe-ore were found scattered throughout.

The sample taken from the whole pile yields, upon analysis—

	532.
	<i>Per cent.</i>
Metallic iron	52.88
Phosphorus.....	0.231
Phosphorus ratio	0.437

e

The old Montgomery furnace, 3 miles south of Palmyra, has lately been torn down! It used a pipe limonite from *Bryan's bank*, opposite Palmyra, a quarter of a mile from the Cumberland river, on the Clarksville road. The ore is distinctly columnar in structure, the spaces between the columns being filled with an aluminous red clay, differing in this respect from the yellow clay in which the ore occurs.

The sample was drawn from shoulders and loose lumps of ore exposed in the abandoned diggings, and yields, upon analysis—

	533.
	<i>Per cent.</i>
Metallic iron	50.07
Phosphorus.....	0.225
Phosphorus ratio	0.401

f

In Montgomery and Stewart counties alone there have been, at different times, as many as twenty blast-furnaces, all running upon limonites from the immediate vicinity.

In some cases, as at Bear Springs, three or four furnaces were supplied from one ore-bank, while others drew their supply from hundreds of small pits scattered over long distances along the ridges, from which the ore was collected by the farmers of the neighborhood. In no single instance was there a systematic mining plant, the ore being dug in irregular open pits, while the dump-piles were allowed to accumulate above valuable deposits of ore deeper upon the bed.

Poplar Springs, 2½ miles south of Oakwood, in Montgomery county, was one of these old furnaces, whose ore was collected by slave labor from surface-pickings, along the sides of the chert ridges, over a wide area.

An old stock-pile of roasted ore was found at the furnace site, from which a sample was drawn, giving, upon analysis—

		517.
		<i>Per cent.</i>
Metallie iron.....		34.68
Phosphorus.....		0.182
Phosphorus ratio.....		0.467

Rough and Ready furnace is situated in Stewart county, 3 miles north of the Cumberland river, and 20 miles directly west of Clarksville. A peculiar variety of pipe limonite was opened 1½ mile northeast of the furnace. This ore owes its origin to the decomposition and alteration of pyrite, unaltered portions of which still form a part of the columns, spreading frequently into bunches of rose-crystals. But the peculiarity of the ore rests in the clear foliated gypsum, which fills the spaces between the columns, giving to the specimens a beautiful appearance.

Were it not for the high per cent. of sulphur necessarily present, this would be a valuable ore, as may be seen from the following analysis:

		518.
		<i>Per cent.</i>
Metallie iron.....		50.74
Phosphorus.....		0.156
Phosphorus ratio.....		0.307

This bank was opened just previous to the blowing-out of the furnace, and only a few tons of ore had been taken.

The depth to which some of these limonite deposits extend is well shown at the *Mound* bank, 2¾ miles west of the furnace. A rectangular shaft, 40 by 50 feet, had here been sunk upon the ore-bed to a depth of 105 feet, without reaching the bottom of the deposit. The mouth of this shaft, which is now filled and fallen, was 60 feet above water-level on the crown of a prominent ridge, in the sides of which the ore was exposed by other open pits. It is a dense, brittle, limonite occurring in concretions and pots, and is compared, in the following analyses, with a pipe-limonite from Indian mound:

	519.	530.
	<i>Per cent.</i>	<i>Per cent.</i>
Metallie iron.....	48.87	55.15
Phosphorus.....	0.286	0.197
Phosphorus ratio.....	0.585	0.353

No. 519 is from the Mound bank above described, and represents surface-ore alone. No. 530 was taken from a small pit on the land of Mr. *E. C. Outlaw*, situated a quarter of a mile south west of Indian mound, and 3 miles northwest of *Rough and Ready* furnace, for which the ore was used. No. 530 was further subjected to full analysis, with the following result:

		530.			530.
		<i>Per cent.</i>			<i>Per cent.</i>
Sulphur.....		0.193	Phosphoric acid.....		0.452
Phosphorus.....		0.197	Carbon in carbonaceous matter.....		0.10
Iron, metallie.....		55.15	Hygroscopic water.....		6.86
			Water of composition.....		10.04
Silica.....		6.65	Total.....		100.125
Iron, protoxide.....		0.57	Per cent. of insoluble silicious matter.....		7.51
Iron, peroxide.....		77.95			
Alumina.....		2.69	Silica.....		6.65
Manganese, protoxide.....		Trace.	Alumina.....		0.65
Lime.....		0.18	Lime.....		0.12
Magnesia.....		0.17	Magnesia.....		0.04
Iron, disulphide.....		0.288	Total.....		7.46
Carbonic acid.....		0.09			
Sulphuric acid.....		0.04			

Bear Springs' furnace, on the property of the Cumberland Iron-Works, is situated on the west bank of the Cumberland river, in Stewart county, 5 miles southeast of Dover. This is an extensive property, comprising, at

a one time, four blast-furnaces—Cumberland, Dover, Bear Springs, and Bellwood—situated at different points, on a tract of land embracing 111 square miles. Bear Springs' furnace is at present in blast, and is situated in the creek bottom between the two main ore-ridges; the others have been long in ruins and are abandoned. The *Bellwood* bank, formerly mined for that furnace, is upon the crown of the ridge, one-quarter of a mile west of Bear Springs. This bank has been worked for many years, and presents a network of irregular pits and tunnels averaging 25 to 30 feet in depth, and, when visited, flooded with water. The western part of the bank is now being opened in a somewhat more systematic manner, by a trench entering the ore-bed lower upon the hillside. The ore is a dark brittle limonite occurring in hollow concretions and rounded pots, lined with a pitchy coating. The high ridge rising east of the furnace contains large deposits of limonite which have been extensively mined over a long period. The **b** *Race*, *Grave-yard*, and *East Bellwood* banks are names given to three adjoining pits upon the crown of the ridge. The ore is similar to that of the *West Bellwood* bank, the associated clay being here unusually free from fragments of chert, especially at a depth of 20 or 30 feet from the surface. A bank of pipe-ore is to be reopened 3 miles west of the furnace.

The analyses of the ores from these different banks are as follows:

	520.	521.	522.	523.
	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>
Metallie iron.....	54.85	50.30	57.55	52.111
Phosphorus.....	0.235	0.180	0.197	0.129
Phosphorus ratio.....	0.428	0.375	0.342	0.248

c

No. 520, from roof and sides of tunnels at the west end of Bellwood bank. No. 521, from north side of the hill at Bellwood bank, "new cut." No. 522, pipe-limonite from a bank 3 miles west of Bear Springs, sampled from ore at the furnace. No. 523 is from the East Bellwood, Race, and Grave-yard banks, taken from 10 to 20 feet upon the ore-beds, from loose lumps.

The furnaces of the La Grange Iron Company are two in number, situated upon Leatherwood creek, which enters the Tennessee river in the extreme south of Stewart county. *Clark furnace* is located $2\frac{1}{2}$ miles from the river. Its ore-banks occupy the slopes and crowns of the prominent ridges on both sides of the creek bottom, here **d** about one-quarter of a mile in width. The north ridge, known as Clark hill, has been largely worked, and presents a network of irregular pits and burrows, the mass of the deposit lying well upon the crown of the hill. The ore is a limonite, occurring in pots and concretions in red clay.

South of the creek the ore has been opened by a number of smaller pits lying high on the crest of the ridge, which rises precipitously from the stream-bed to a height of 150 feet. Other deposits of value are now being opened at the heads of several ravines entering the valley of Leatherwood creek from the north, 1 mile west of Clark furnace.

La Grange furnace, situated on the south side of the creek, 1 mile from the river, has been lately rebuilt, and is the first and only brick stack ever erected in western Tennessee. Its main ore-banks are the *La Grange* and *Sheridan*, the former situated one-half mile north of the furnace, the latter three-quarters of a mile northwest. **e** There are extensive and valuable deposits of limonite occupying a low position on the north side of the valley. The ore is a dense, brittle limonite, occurring in hollow concretions scattered loosely throughout the clay, and huge, honeycombed masses, which often degenerate into rough, sandy ledges. Those portions of the deposit near the surface are much contaminated by thickly-scattered fragments of white chert, which are at times included in the ore-mass, giving it the appearance of a breccia. Deeper upon the bed the chert in great measure disappears and the sandy ledges become less frequent, a fact illustrated at several of the banks above described where any depth had been reached. These banks, which had been miserably opened, are now being put in better shape, and test-pits have shown the mass of the ore-deposit to underlie the old diggings.

The following are the analyses of samples from both Clark and La Grange furnace banks:

f

	524.	525.	526.	527.	528.	529.
	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	<i>Per cent.</i>
Metallie iron.....	49.56	51.34	48.38	50.91	52.22	50.94
Phosphorus.....	0.257	0.157	0.177	0.297	0.330	0.293
Phosphorus ratio.....	0.519	0.310	0.366	0.465	0.632	0.675

No. 524 is from the *Davis*, *Peragin*, and *Pierpoint* banks, on Clark hill, and was taken from a mixed stock-pile of 900 tons, at Clark furnace. No. 525 is from the *Fig* and *Bayley* bank, on the south ridge, one-quarter of a mile west of Clark furnace, an average sample from all working-faces. No. 526 is from a small opening on the *Banagan* and *Shurlock* bank, at the head of Dry hollow. No. 527 is a sample from 400 tons at La Grange furnace, representing

an average of La Grange and Sheridan banks. No. 528 is from the La Grange bank, only from 20 to 40 feet below the surface along the whole working-face of the pit. No. 529 is from the Sheridan bank, alone representing an average. No. 527 has been further subjected to complete analysis, with the following results:

527.		527.	
	<i>Per cent.</i>		<i>Per cent.</i>
Sulphur	0.069	Phosphoric acid	0.543
Phosphorus	0.237	Carbon in carbonaceous matter.....	0.10
Iron, metallo.....	50.91	Hygroscopic water	0.57
		Water of composition.....	9.45
Silica	12.76	Total	100.119
Iron, protoxide	0.30		
Iron, peroxide	72.23	Per cent. of insoluble silicious matter ...	13.52
Alumina.....	2.33		
Manganese, protoxide	0.31	Silica	12.76
Lime	0.42	Alumina	0.58
Magnesia	0.17	Lime	0.13
Iron, disulphide	0.090	Magnesia	0.06
Carbonic acid.....	0.10	Total	13.53
Sulphuric acid.....	0.04		

The ores of the Western region just described, though they have been largely worked in certain localities, when considered in relation to their whole extent, have been scarcely touched and but partially located. The shiftless system of mining, which is confined to the portions of the ores nearest the surface, has done but little to define the probable depth of the deposits, while the surface accumulations of chert have in many instances made the banks appear of less value than they may prove to be when opened systematically. The value of the surface deposits is largely dependent upon the chert, and they become valuable or worthless as this is more or less persistent.

The continuation of the region in Kentucky will be found under the ores of that state.