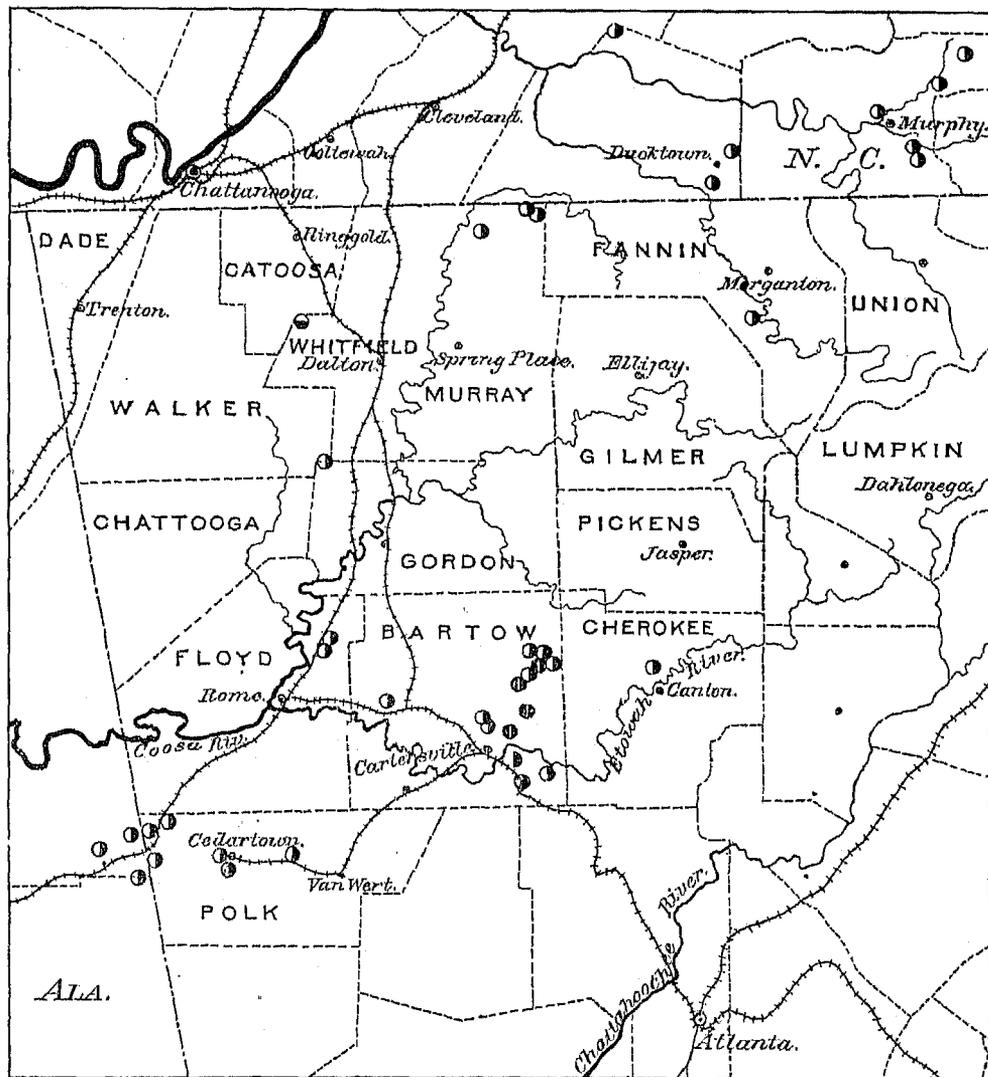


NOTES ON THE SAMPLES OF IRON ORE COLLECTED IN GEORGIA.

BY BAILEY WILLIS.

The iron ores of Georgia sampled for the Tenth census are nearly all limonites; the only exceptions are the dyestone ores of the extreme northwestern counties and a single deposit of specular ore near Cartersville, in Bartow county.



Scale.
0 5 10 20 Miles.

- ▴ Specular Ore.
- Limonite.
- ⊕ Manganese Ore.
- ⊖ Red Fossil Ore.

FIG. 147.—IRON ORE SAMPLE MAP OF NORTHWESTERN GEORGIA AND PARTS OF ALABAMA, TENNESSEE, AND NORTH CAROLINA.

In addition to the iron ores the manganese banks of the "Pyrolusite Mining Company", near Cartersville, were visited and sampled. (See the following chapter).

a The limonites of Georgia appear to belong to two different geological horizons. The three beds of Cherokee county, North Carolina, extend into Union, Fannin, and Gilmer (?) counties, and are there associated with the marble and steatite beds, assigned by Professor Kerr to the Huronian. The limonites of Polk county, in the western part of the state, are in the continuation of the range worked in Cherokee county, Alabama; this range is placed by Professor Smith in the Silurian.

According to Professor Little, in the *Handbook of Georgia*, 1876, page 47, the numerous deposits of ore near Cartersville are contained in Safford's Knox group and Chillowee sandstone (?), which would agree with Professor Smith.

As there is no published report in which the areas of the Huronian (?) and Lower Silurian are defined, and no work could be done to determine their limits, they are not mapped on the accompanying sketch (Fig. 147).

FANNIN COUNTY.—Five miles south of Morganton, near the road to Cartersville, is a deposit of limonite which has been largely worked to supply Hempton Creek forge; the opening is known as *Jarrett's bank*. This bank was not visited, but the ore is said to lie in a bed 10 to 25 feet thick, associated with a range of marble and other beds that would identify it with the limonites of Cherokee county, North Carolina. Samples 418, 419, and 420 represent this ore as brought to Hempton Creek forge; 418 is from about a ton of the raw ore; 419 is from several tons of burnt ore; and 420 is from a few shovelful of ore that had been burnt, stamped, and washed, and was ready for use in the forge. The analyses give—

	418.	419.	420.
	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>
Iron	53.41	57.83	57.40
Phosphorus	0.284	0.205	0.391
Phosphorus in 100 parts iron ...	0.532	0.458	0.577

Sample 420 is lower in iron than 419, although it has been washed as well as burned. This is explained by the fact that 420 was dug several days before 419, and was probably poorer when it started on its round of changes. It is one proof of the variable character of these ores. This range is said to continue on to Ellijay and beyond, accompanied by its characteristic associations. Large limonite outcrops are said to occur near Jasper, in Pickens county; but it may be questioned whether they do not belong to the same horizon as those near Cartersville.

An ore, which would seem by the silicious character of some portions of it to be related to the latter, is found on Judge *Donaldson's* land 3 miles northwest of Canton, in Cherokee county. It lies in concretionary masses, accompanied by a bluish earth, which is sometimes sandy and has a deep-red streak; this earth is slightly magnetic, as is also in a less degree the limonite, and yields on washing the martite (?), which is numbered *a422*, and is represented by that analysis. The width of this bed is about 50 feet, and it has been opened at several places for the supply of a furnace which was begun during the late war, but never finished.

Sample 421 represents the limonite, and 422 the bluish magnetic earth; these were taken at the bank. Sample *a422* was obtained from 422 by washing in the laboratory. The analyses give—

	421.	422.	<i>a422.</i>
	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>
Iron	52.70	48.47	67.81
Phosphorus	0.06	0.139	0.089
Phosphorus in 100 parts iron ...	1.252	0.287	0.067

BARTOW COUNTY.—Professor Little, in the *Handbook of Georgia* for 1876, page 47, states that the Etowah river cuts through the following section in crossing Bartow county from east to west. Beginning at Stamp creek, it traverses (1) Safford's Ocoee conglomerate (Acadian), (2) Safford's Chillowee sandstone (Potsdam), (3) Safford's Knox sandstone (Calciferous), (4) Safford's Knox dolomite (Quebec), (5) the Maclurea limestone, and (6) the Trenton. The second and third of these formations lie in the eastern part of the county, and appear to form the strata in which are contained the very numerous deposits of limonite and manganese that extend from the Bartow furnace; 4 miles south of Cartersville, to Wolf Pen, 9 miles north of the same place, with but slight breaks.

The following map (Fig. 148) shows the location of the principal ore-banks. There are many other small openings, but every variety of the ores is represented in the samples taken:

Bartow furnace is situated on the line of the Western and Atlantic railroad, $4\frac{1}{2}$ miles southeast of Cartersville. There are four ore-banks near the furnace, one of them within a hundred yards of it, the farthest a quarter of a mile off to the southwest. The two most western of the four are on a range of hills, about 100 feet above the valley; the ore in these is concretionary, and occurs in large nodules and irregular pockets. The other two banks are formed of pebbles and large lumps of ore imbedded in a red clay, apparently derived from the range west of

them. The largest of these banks is that which lies about one-quarter of a mile southwest of the furnace. The ore-bearing stratum is from 50 to 100 feet thick, and consists of a sandy-clay in which are imbedded irregular concretions of limonite. The strike of the range is about north 10° to 20° east, and the dip is 40° to 50° to the southeast.

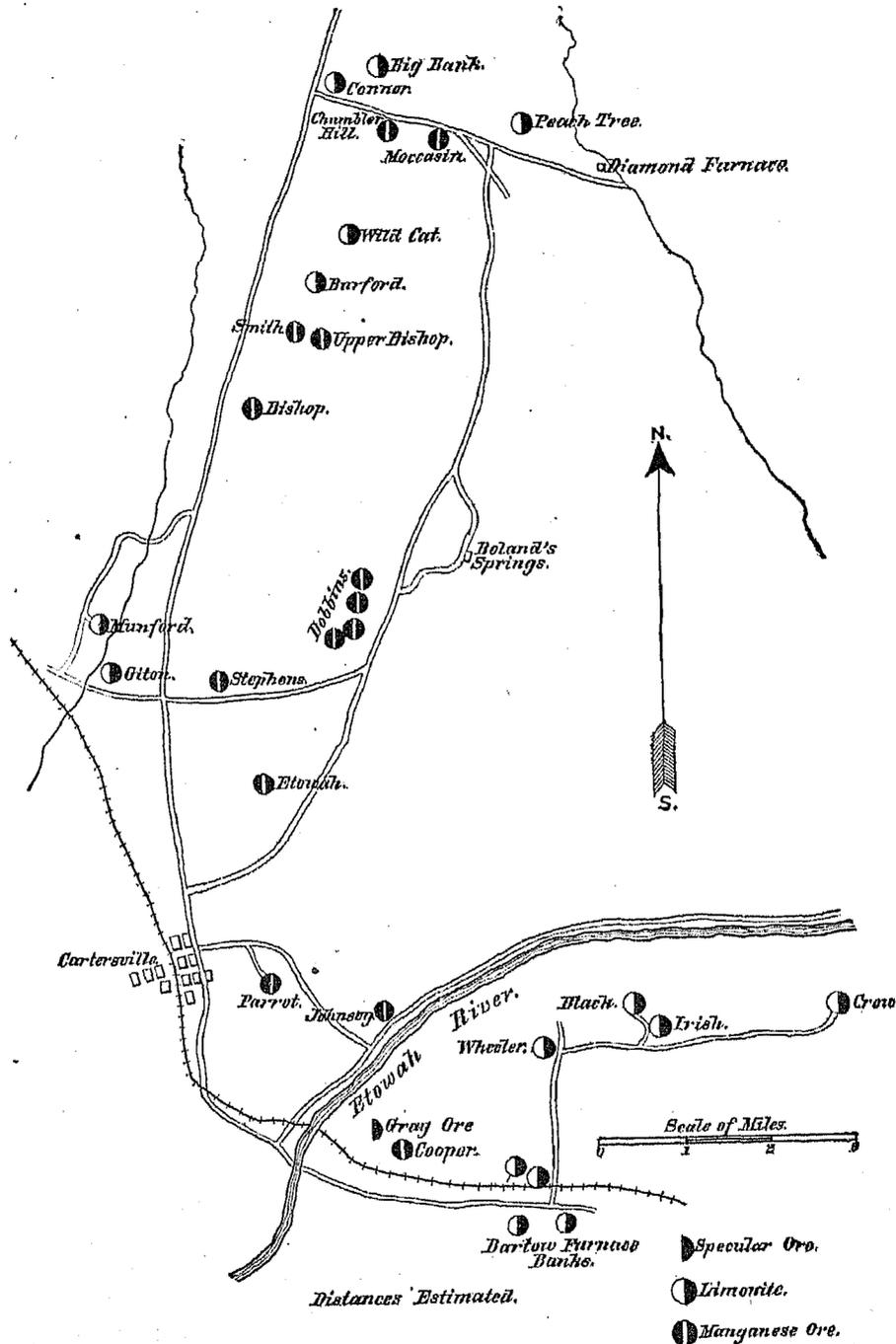


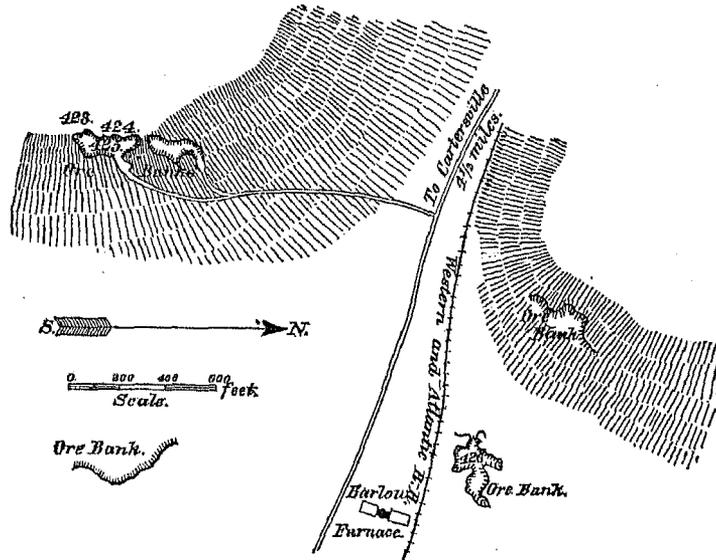
FIG. 148.—SKETCH MAP OF ORE BANKS NEAR CARTERSVILLE, BARTOW COUNTY, GEORGIA.

Samples 423, 424, and 425 were taken at this bank from three different qualities of ore. The first was being dug near the southeast corner of the pit; it is a hard limonite, and is considered the richest ore at the bank; the second is from another pocket near by, which is much softer and supposed to contain more manganese. The third is a portion of the matrix in which the ore occurs that has been penetrated by a solution of iron and contains an appreciable amount of it. The following (Figs. 150 and 151) are sketches of two specimens which accompany sample 425 and bear the record of several changes. The cemented fragments of the one and the cavity in the other, which was filled with light-yellow sandy clay, show that a rigid, unyielding rock has been fractured, has decomposed in place without loss of form, and has been subsequently indurated and cemented by deposition of limonite from solution. Where

a the fragment was of some size the iron did not entirely transform it, but left in the center a portion of the original mass, which by further decomposition formed the soft clay found within. The following are the analyses of the three samples taken from this bank:

	423.	424.	425.
	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>
Iron	50.57	53.67	40.35
Phosphorus	1.011	0.488	0.319
Manganese	2.35	5.25	.....
Phosphorus in 100 parts iron ..	3.770	0.909	0.701

b



c

d

FIG. 149.—SKETCH OF THE VICINITY OF BARTOW FURNACE, BARTOW COUNTY, GEORGIA.

Sample 426 was taken from a small pile of the pebble-ore found in the bank nearest the furnace. This ore is imbedded in a red clay, and seems to have been brought from its original position and deposited by water. The analysis gives—

	426.
	<i>Per cent.</i>
Iron	52.46
Phosphorus	0.332
Phosphorus in 100 parts iron	0.633

e

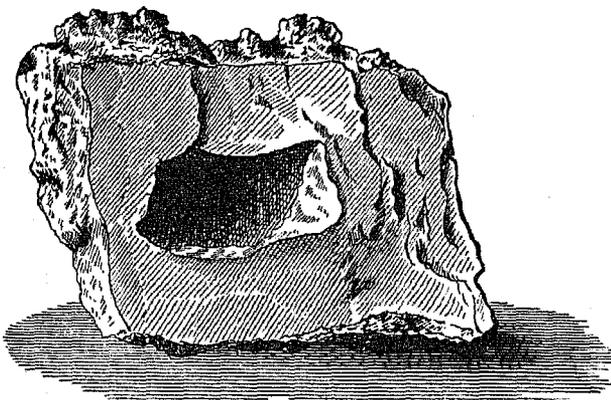


FIG. 150.

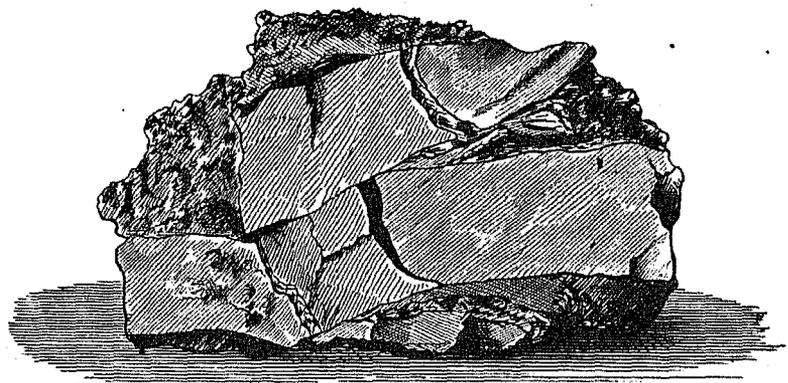


FIG. 151.

A mile and a half north of the Bartow furnace is a bed of limonite called the *Wheeler bank*. It is a solid mass of ore 25 to 30 feet in thickness, dipping about 50° from the horizontal to the east, between well-defined walls of talcose or hydromica-schist; the strike is nearly due north and south. It has been penetrated to a depth of 40 feet

in the old Etowah works, and is now being removed in several open cuts 15 to 20 feet deep. One hundred feet west of the ore-bank is a quarry in which sandstone, well adapted to lining of furnaces, is found. Samples 427 and 428 are from this bank; the latter from the ore in place in the open cut near Mr. Wheeler's house, the former from a small exposure 200 yards off to the north. The analyses give:

	427.	428.
	<i>Per cent.</i>	<i>Per cent.</i>
Iron	50.57	51.03
Phosphorus.....	0.802	1.012
Manganese	0.23	0.33
Phosphorus in 100 parts iron...	1.418	3.123

There are a number of places east of the Wheeler bank where ore has been dug in small quantities. Among these are the *Irish* and *Black* banks. They lie within a quarter of a mile of each other, 1 mile from Wheeler's. Neither has been extensively worked, and the amount of ore seen was small. The limonite of the Irish bank resembles sample 428; it is a compact brown ore. That of the Black bank has a much darker color and a brilliant luster. The following are the analyses of samples taken from the ore in place:

	IRISH.	BLACK.
	431.	432.
	<i>Per cent.</i>	<i>Per cent.</i>
Iron	57.42	54.71
Phosphorus.....	0.540	0.752
Manganese	0.15	0.40
Phosphorus in 100 parts iron...	0.940	1.374

Three miles east of Wheeler's is the *Crow* bank; this has been quite extensively worked, and presents to view a face of ore 30 feet wide and 15 feet high between well-defined walls. The ore is a dense limonite, which incloses many irregular cavities, whose dimensions vary from a few inches to several feet. One of these "ruggs" that had been opened but not destroyed was about 6 feet long vertically, and 6 inches to 3 feet wide, the interior being filled with irregular projecting masses of ore covered with a brilliant black coating of manganese(?).

Associated with the hard limonite is a softer ore which has a much darker brown streak; but a small amount of it was seen. Samples 429 and 430 represent, respectively, the hard and the soft portions of this ore:

	429.	430.
	<i>Per cent.</i>	<i>Per cent.</i>
Iron	50.24	59.20
Phosphorus.....	1.124	0.502
Manganese	0.73	4.35
Phosphorus in 100 parts iron...	1.999	•0.848

The limonites north of Cartersville occur principally in a range of low hills which lie between the Tennessee and Wolf Pen roads, and extend in a direction of north 20° east from 3 miles north of the town to the eastern boundary of the county. These hills also contain a number of deposits of manganese, and there are several banks in which the limonite and manganese ores are intimately associated in varying but approximately equal proportions. (See special report on the manganese ores.)

The nearest point to Cartersville where this range of limonites is opened is the *Giton* bank. This lies west of the Tennessee road on a steep hill about 75 feet above Pettit's creek. The ore is a compact limonite, occurring in large concretionary masses, associated with leaner portions, that consist of cemented fragments of white quartz and mica-schist(?).

The bank had not been worked for many years, when visited, but it has since been reopened, and ore for a furnace, located near the railroad, about 2 miles from Cartersville, is being drawn from it.

The following is the analysis of the sample, taken as an average, of the ore exposed in the old workings:

	440.
Iron	{ a 48.39 b 48.97
Phosphorus.....	0.457
Phosphorus in 100 parts iron	0.935

a Ignited. b Not ignited.

a While the Giton bank forms the summit of a steep hill, the *Munford* bank, which lies half a mile northwest of it, is opened in a low mound of red clay in the bottom-lands of Pettit's creek. The Giton ore is evidently in place; the *Munford* ore consists of pebbles and rounded lumps apparently deposited in their present position, with the clay, in which they are imbedded. The writer did not determine whether this ore is an alluvial deposit or is segregated from residual clays. The latter seems most probable. Ore is being shipped from the *Munford* bank to Chattanooga.

Sample 439 was taken from a pile of ore at the bank. The following is the complete analysis:

439.		439.	
	<i>Per cent.</i>		<i>Per cent.</i>
Sulphur	0.068	Carbon in carbonaceous matter	0.08
Phosphorus	0.330	Hygroscopic water	0.33
Iron, metallic	55.69	Water of composition	9.69
		Total	100.056
Silica	4.40	Per cent. of insoluble silicious matter	6.95
Iron, protoxide	0.48	Silica	4.40
Iron, peroxide	70.01	Alumina	2.17
Alumina	4.73	Lime	0.04
Manganese, protoxide	Trace.	Magnesia	0.21
Lime	0.17	Total	6.91
Magnesia	0.21		
Carbonic acid	0.06		
Sulphuric acid	0.02		
Phosphoric acid	0.756		

It is 5 miles, in a direction a little east of north, from the Giton bank to the *Burford*. There are several deposits of manganese ore between the two, but no limonite that is now known.

A large amount of ore has been taken from the *Burford* bank, which is opened on the northern slope of the hill in which it lies. It is said to be capped by sandstone, but the old pits were too much fallen in to admit of any examination of the deposit.

d Sample 438 was taken from a small amount of the ore in place; the analysis gives:

438.	
	<i>Per cent.</i>
Iron	54.36
Phosphorus	0.201
Manganese oxide	0.45
Phosphorus in 100 parts iron	0.370

A mile beyond the *Burford* bank is another, known as the *Wild Cat*. This bank was not visited, but the ore **e** was sampled at the stock-pile of the *Diamond* furnace on *Stamp* creek. The greater part of it is a compact, brown limonite, but there are some light-yellow portions that are very hard, and closely resemble flint in appearance; this variety is called "liver ore", and is considered to be very good.

Sample 433 was taken as an average of about 10 tons of the common ore. Sample *a* 433 is a special analysis of a few small pieces of "liver ore", and 434 was taken as an average of the roasted and crushed ore at the furnace. The following are the analyses.

	WILD CAT BANK.		
	Liver ore.	Raw ore.	Roasted ore.
	<i>a</i> 433.	433.	434.
	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>
Metallic iron	60.93	50.64	63.40
Phosphorus	0.441	0.668	0.755
Sulphur		0.179	
Silica	0.2		
Water of composition	10.80		
Phosphorus in 100 parts iron	0.723	1.310	1.191

The following is the complete analysis of 433.

a

433.		433.	
	Per cent.		Per cent.
Silica	8.04	Hygroscopic water	0.03
Iron, protoxide	0.34	Water of composition	0.60
Iron, peroxide	71.82	Total	100.003
Alumina	4.24	Per cent. of insoluble silicious matter	11.67
Manganese, protoxide	0.42	Silica	8.94
Lime	1.08	Alumina	2.29
Magnesia	0.03	Lime	0.19
Iron, disulphide	0.335	Magnesia	0.27
Carbonic acid	0.40	Total	11.69
Phosphoric acid	1.528		
Carbon in carbonaceous matter	0.01		

b

There are three ore-banks about 10 miles north of Cartersville, beyond the cross-road that runs westward from Wolf Pen. The first of these is the *Peach Tree* bank, about 1 mile northwest of the Diamond furnace. The openings consist of two large cuts in the southeast side of a hill near the summit, which expose a fine-grained sandstone. Through this runs an irregular deposit of limonite that dips toward the east. The total thickness is about 20 feet, but not more than 6 feet can be considered good ore, the remainder inclosing angular fragments of sandstone. A portion of this ore is stalactitic, but the greater part is a dark-brown, compact limonite.

Sample 435 was taken at the bank from the ore in place, the associated sandstone not being included. The analysis gives—

435.	
	Per cent.
Iron	59.16
Phosphorus	0.442
Phosphorus in 100 parts iron	0.747

d

Two miles west, on the other side of the range from the *Peach Tree* bank, is another of similar character, called the *Big* bank. The large irregular masses of ore to be seen in the open cuts on the summit of the very steep hill give an idea of a very large amount of ore, but even an approximate estimate would be very uncertain.

Sample 436 was taken from a pile of ore mined for the Diamond furnace. This pile contained pieces that inclosed sandstone fragments as well as pure ore. The sample was taken as an average of the total amount in the pile. The analysis gives—

436.	
	Per cent.
Iron	54.84
Phosphorus	0.649
Manganese oxide	0.12
Phosphorus in 100 parts iron	1.183

e

The *Connor* ore-bank lies but half a mile southwest of the *Big* bank, but the ore is very different. It is concretionary and partly stalactitic, like a limonite, but the streak is much too red for that ore. It appears to consist of hematite and limonite mingled, and to be derived from pyrite. It has been dug in an open cut to the depth of 10 feet in a low hill close by the roadside.

Sample 437 was taken as an average of about 3 tons mined for the Diamond furnace:

437.	
	Per cent.
Iron	60.12
Phosphorus	0.112
Phosphorus in 100 parts iron	0.180

f

There is one ore in the neighborhood of Cartersville that differs entirely from all others seen in Georgia. This is the specular ore of the *Gray* ore-bank, which is on the east side of the Etowah, about 2½ miles from the town. It lies in a very irregular bed, that varies from a few inches to 7 feet in thickness, and frequently changes its strike and dip. Its general trend is east and west. A tunnel 200 feet long had been run in to strike the ore, which had then been followed horizontally about 400 feet. This was abandoned in the autumn of 1878 (?), and had

a fallen in so as to be inaccessible when visited. Sample 441 was taken from ore found near the old Etowah workings, about 100 yards east of the tunnel. Sample 472 was afterward taken from a new opening some distance off to the west. The analyses are as follows:

	441.	472.
	<i>Per cent.</i>	<i>Per cent.</i>
Iron	53.80	57.00
Phosphorus	0.038	0.010
Sulphur	0.006	0.006
Silica	21.70	16.87
Phosphorus in 100 parts iron ..	0.071	0.018

b

The following is the complete analysis of sample 472:

	472.		472.
	<i>Per cent.</i>		<i>Per cent.</i>
Silica	16.67	Water of composition	0.31
Iron, protoxide	0.44	Total	100.054
Iron, peroxide	80.05	Per cent. of insoluble silicious matter	17.55
Alumina	1.34	Silica	16.67
Manganese, protoxide	Tracc.	Alumina	0.81
Lime	0.09	Lime	0.01
Magnesia	0.11	Magnesia	0.05
Carbonic acid	0.09	Total	17.54
Sulphuric acid	0.02		
Phosphoric acid	0.024		
Carbon in carbonaceous matter	0.01		

c

There are a number of deposits of limonite near Cedartown, in Polk county, that are worked for the large furnace of the Cherokee Iron Company. A mile west of the furnace, connected with it by a tramway, are many openings on both sides of a slight elevation. These are called the Woods bank, and their relative positions are d indicated in the following sketch (Fig. 152):

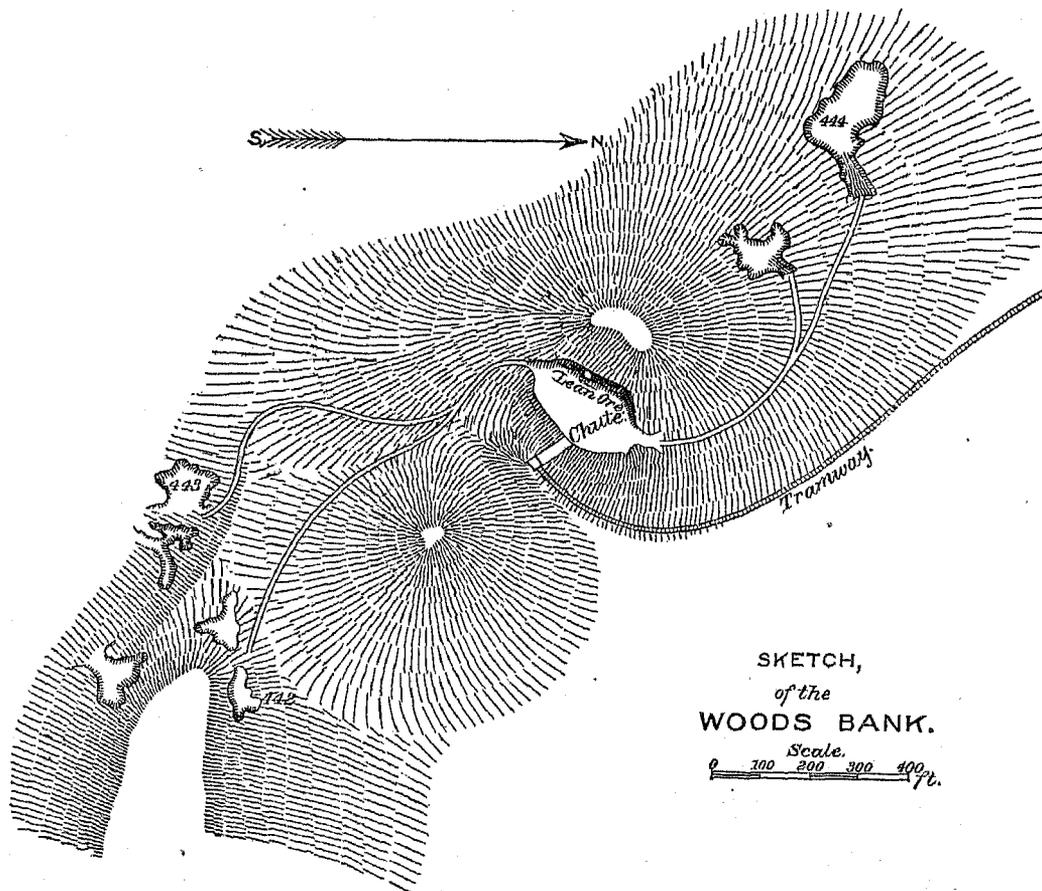


FIG. 152.

At the time this bank was visited it had been recently abandoned and the ore was well exposed in the different openings. It is a dark-brown, compact limonite, partly massive, partly concretionary, with brilliant pitchy layers, that are almost black.

Three samples were taken from the openings marked with their respective numbers on the sketch. The following are the analyses :

	442.	443.	444.
	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>
Metallie iron	47.21	54.71	40.50
Phosphorus	1.134	1.250	1.537
Manganese	0.30	0.25	1.09
Phosphorus in 100 parts iron ..	2.402	2.200	3.105

A quarter of a mile from the Woods bank, in the general direction of this ore range, namely, north 10° east, is the *Peck* bank, which was just being opened for the Cherokee furnace.

The ore at this point is darker in color and contains more of the black, pitchy variety than that at the Woods bank, but is like it in texture and hardness. The analysis of a sample taken from the ore, as broken up for transportation to the furnace, gives—

	445.
	<i>Per cent.</i>
Metallie iron	53.39
Phosphorus	1.080
Manganese	0.20
Phosphorus in 100 parts iron	2.005

The *Phillips* bank lies half a mile south of the Cherokee furnace, in a low mound that rises from the bottom-lands of a small creek. It was not visited, but sample 446 was taken from about 10 tons of the ore at the furnace. It is a compact limonite, associated with a small amount of hematite, as is apparent from the red streak obtained from some specimens. The following is the analysis :

	446.
	<i>Per cent.</i>
Metallie iron	55.64
Phosphorus	0.178
Manganese	0.20
Phosphorus in 100 parts iron	0.320

Five miles east of Cedartown an outcrop of limonite crosses the road to Van Wert; this ore, it is said, can be traced 2 miles along a ridge that trends about north 10° to 20° east. It is considered to be a very large deposit and was soon to be opened for the furnace at Cedartown. It is known as *Fisher's Creek* bank.

A sample was taken from the outcrop, north of the public road. The following is the analysis :

	447.
	<i>Per cent.</i>
Metallie iron	46.60
Phosphorus	0.570
Manganese	0.14
Phosphorus in 100 parts iron	1.223

A number of ore-banks are opened in the western part of Polk county, near the Alabama line; five samples were taken in this vicinity, on the range which extends into Alabama. (See description of sample 252, *et seq.*, report of Mr. W. M. Chauvenet.)

The *Pennington* and *Alloway* banks belong to the Etna furnace, which is situated on the Selma, Rome and Dalton railroad, a mile from the Alabama line. The former of these banks is about 200 yards south of the furnace, the latter half a mile southwest of it. The ores are both compact, dark-brown limonites. Samples 448 and 449 were taken from stock-piles at the Etna furnace; the banks themselves were not visited.

a The following are the analyses:

	PENNING- TON.	ALLOWAY.
	448.	440.
	<i>Per cent.</i>	<i>Per cent.</i>
Metallic iron	55.00	54.90
Phosphorus.....	0.936	0.413
Manganese	0.20	0.05
Phosphorus in 100 parts iron...	1.702	0.752

b There are several other banks, belonging to the Etna furnace, in the immediate vicinity of these, but they were not open when the locality was visited.

The *Folger* bank is opened $1\frac{1}{2}$ mile northwest of Prior's station. It is connected by a branch track with the Selma, Rome and Dalton railroad, and the ore has been shipped to Chattanooga. A broad ledge of ore has been stripped, exposing a very compact limonite, with dark color and brilliant luster; portions of it inclose angular fragments of chert. Sample 450 was taken from the ledge as a fair average of the ore in sight. The following is the analysis:

	450.
	<i>Per cent.</i>
Metallic iron	43.80
Phosphorus.....	0.413
Manganese	0.80
Phosphorus in 100 parts iron.....	0.939

A mile and a half north of Prior's station are several openings, known as the *Snake Pond* banks. These lie in the lowland between the public road and the railroad, and also just east of the former in the rising ground. Sample 452 is from one of the old openings near the railroad. The exposure of ore was small and possibly below the average in quality. An ore that closely resembles that of the *Folger* bank in appearance is opened on the **d** other side of the public road, but has never been worked. Sample 451 was taken from the ledge there exposed. The analyses are—

	451.	452.
	<i>Per cent.</i>	<i>Per cent.</i>
Metallic iron	42.06	35.43
Phosphorus.....	0.156	0.092
Manganese	4.05	0.40
Phosphorus in 100 parts iron...	0.347	0.200

c The ores of Bartow and Polk counties are near the southeastern and southern limits of the Lower Silurian strata in Georgia. The belt of these rocks extends from these counties northward to the Tennessee line, and deposits of limonite are found in many localities in them, though they are not as numerous as in the neighborhood of Cartersville. There is a test-pit 2 miles west of Kingston, in Bartow county, on a high ridge, by the side of which a few pieces of ore are found. Sample 473 was taken from these, and the analysis is as follows:

	CALDWELL BANK.	
	473.	
	<i>Per cent.</i>	
Metallic iron	53.04	
Phosphorus.....	0.415	
Phosphorus in 100 parts iron.....	0.782	

f This ore is a porous, concretionary limonite, the cavities of which are filled with red clay. It has never been worked.

Ridge Valley furnace is situated at the foot of the western slope of a range of hills having a northeast trend, in Floyd county, 9 miles north of Rome. It was built to work ores supposed to exist in inexhaustible quantities in these hills, but they have been worked out, and the furnace is supplied from distant banks by rail. Enough ore was found in the old pits on the ridge to show that there were several varieties. Sample 455 represents a hard,

laminated ore, which has a red streak, and more closely resembles a hematite than a limonite. Samples 453 and a 454 were taken from openings much farther up the hill; they represent a porous ore, that has the structure of a limonite, but a reddish streak. The following are the analyses:

	453.	454.	455.
	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>
Metallie iron	57.21	54.12	41.89
Phosphorus.....	0.086	0.095	0.044
Water of composition.....	8.90	13.05	5.80
Phosphorus in 100 parts iron...	0.150	0.170	0.105

b

The *Flower Branch* bank was opened a mile north of the Ridge Valley furnace. The old pits had caved in and no ore was to be seen in place; but there was a small pile, containing about half a ton, from which the sample was taken. This pile contained two varieties of ore—one a very compact limonite, apparently free from foreign matter; the other a very hard, highly silicious ore. The sample was taken as an average of the entire pile. The ore could evidently be enriched by hand-picking. The analysis gives—

	456.
	<i>Per cent.</i>
Metallie iron	51.02
Phosphorus.....	0.095
Phosphorus in 100 parts iron.....	0.184

c

Snake Creek gap is an opening through Chattooga mountain, about 13 miles south of Dalton, near the common boundaries of Gordon, Walker, and Whitfield counties. In this gap, 2 miles west of Blue Springs station, there is a large, irregular pit, opened on a bed of compact, dark-colored limonite, much of which is black, with a brilliant luster. This ore extends along the ridge, showing itself in frequent outcrops to a distance of 4 miles south, and appears north of the gap, where it has a length of about 1 mile. The width of the bed exposed in the old pit is about 150 feet. Sample 474 was taken at this opening, which is on lot 270, twenty-sixth district, third section. The following is the complete analysis:

d

474.		474.	
	<i>Per cent.</i>		<i>Per cent.</i>
Sulphur.....	0.258	Phosphoric acid	3.106
Phosphorus.....	1.359	Carbon in carbonaceous matter.....	0.06
Iron, metallie.....	51.41	Hygroscopic water	1.09
Phosphorus in 100 parts of iron	2.636	Water of composition.....	10.49
Silica	5.99	Total	100.087
Iron, protoxide	0.38	Per cent. of insoluble silicious matter.....	7.20
Iron, peroxide	72.98	Silica	5.99
Alumina	5.36	Alumina	1.14
Manganese, protoxide	Trace.	Magnesia.....	0.07
Magnesia	0.24	Total	7.20
Iron, disulphide	0.071		
Zinc, sulphide	0.21		
Carbonic acid.....	0.11		

e

The belt of Lower Silurian limonites appears to be very narrow in northern Georgia. The number of deposits is small, and they have not been worked. In Murray county, 12 miles north of Spring place, search was made for copper on the land of *J. R. Harris* at the time the Ducktown mines were opened. A shaft was sunk 60 feet and a tunnel driven 150 feet into a hill on lot 164, tenth district, third section. No copper was found, and the tunnel and the shaft are now inaccessible; but the porous limonite, which led to the exploration, still lies scattered over the surface of the hill. Sample 476 was taken from a number of such pieces. The following is the analysis:

	476.
	<i>Per cent.</i>
Metallie iron.....	55.35
Phosphorus.....	0.691
Phosphorus in 100 parts iron	1.248

Six miles beyond Mr. Harris' place, in Aliculsie valley, near the Tennessee line, there are two other deposits of limonite, which have been opened. One of these is near the road that runs through the little valley, on a wooded

a ridge. Nothing is to be seen but a few outcrops of highly silicious ore and an old shaft, said to have been sunk to a depth of 40 feet. The ore is represented by sample 477, taken from the outcrops. The other deposit referred to is called the *Calico* bank, possibly from the effect produced by the red and white clay that fills the hollows of the brown and bluish, scoriaceous limonite. Many years ago this ore was worked in a forge near by, but nearly all trace of the old diggings has disappeared. Sample 478 was taken from a small pile of the ore found near an old test-pit, on lot 238, twenty-seventh district, third section. The analyses of these two samples give the following results:

	477.	478.
	<i>Per cent.</i>	<i>Per cent.</i>
Metallic iron.....	32.17	46.78
Phosphorus.....	0.848	0.156
Phosphorus in 100 parts iron.....	2.636	0.333

b

Several outcrops of red fossil-ore occur near Ringgold and on Dick's ridge, 10 miles northwest of Dalton. A mile and a quarter north of Trickum a test-pit has been opened on lot 170, twenty-seventh district, third section, and a small amount of the ore thrown out. Sample 475 was taken from this ore. The thickness of the bed is unknown. The analysis gives:

c

	475.
	<i>Per cent.</i>
Metallic iron.....	58.36
Phosphorus.....	0.191
Phosphorus in 100 parts iron.....	0.327

NOTES ON THE SAMPLES OF MANGANESE ORE COLLECTED IN GEORGIA.

BY BAILEY WILLIS.

In the vicinity of Cartersville, Bartow county, Georgia, are numerous deposits of limonite and manganese ore; the former are described in the report on the iron ores of Georgia. It is the purpose of this paper to give some account of the ore-banks of the "Pyrolusite Manganese Mining Company" and of other small openings worked by private parties for manganese.

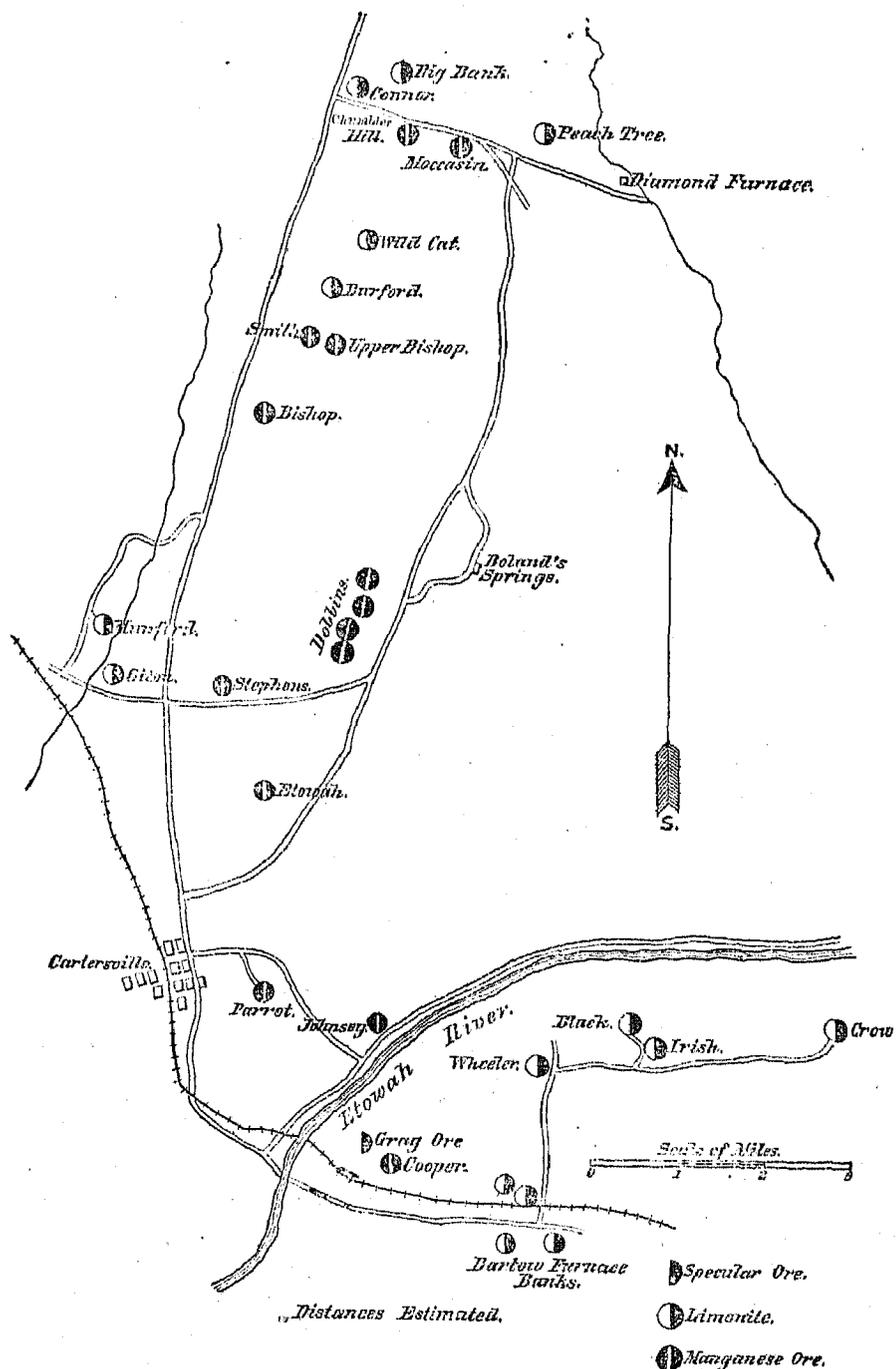
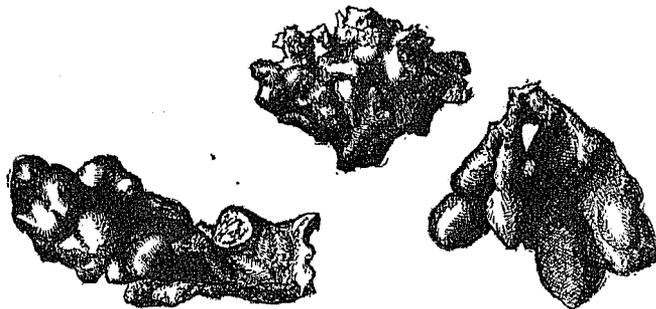


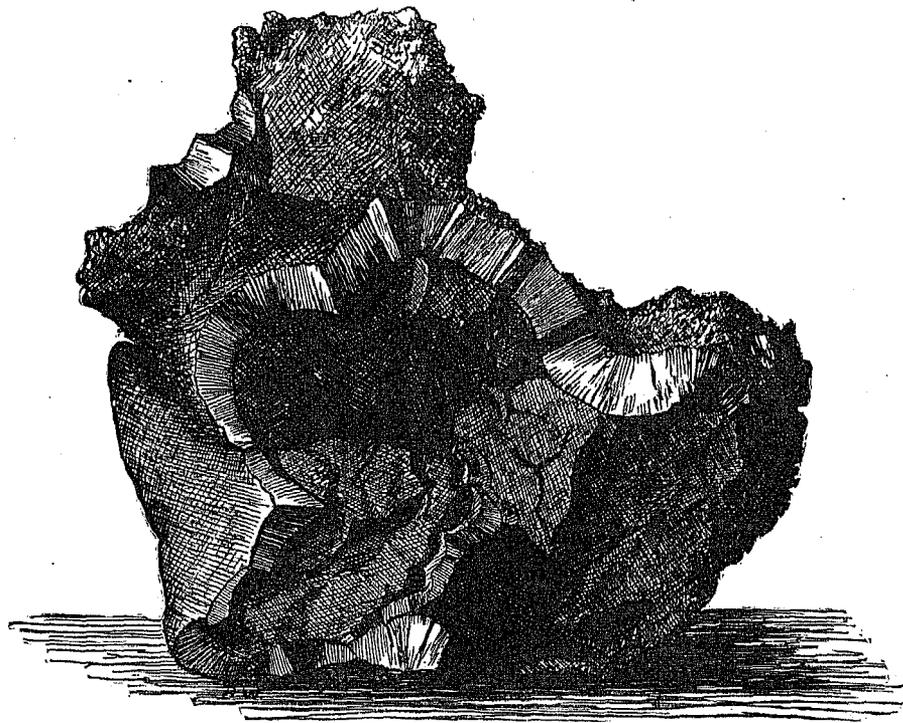
FIG. 153.—SKETCH OF ORE BANKS NEAR CARTERSVILLE, BARTOW COUNTY, GEORGIA.

a It will be seen by reference to the accompanying sketch-map that the limonites and manganese ores occur in a narrow belt running nearly north and south. From the Parrot bank northward the surface is formed of low hills, generally covered with woods, but, where cleared, often cut into deep, red gullies. It is in the clay, to which this last effect is due, that the manganese is commonly found. There are two kinds of the ore, which occur together in the same banks and sometimes in the same hand-specimens; the one is pyrolusite, in its common form of needle-like crystals, the other a hard, steel-gray, concretionary ore--psilomelane? They are found in nodules, usually but a few inches or at most a foot in diameter, enveloped in the bright-red clay, through which they are irregularly scattered. Large masses of the mingled ores occur in some banks and have the same general concretionary structure, though on a greater scale. Although deposited in the same strata the iron ores are not usually **b** intimately associated with manganese.



c FIG. 154.—PSILOMELANE. FROM THE JOHNSEY BANK, BARTOW COUNTY, GEORGIA.

At the Parrot and the Etowah banks limonite and psilomelane do occur mingled in the solid mass, but even there each mineral is distinctly separate from the other, so that the streak and other physical characteristics of each are readily recognizable. The pyrolusite is locally known as the "black" or "soft" ore; the psilomelane as "potato" ore, from its frequent resemblance to Irish potatoes; and a long, slender stalactitic form found at one locality is sometimes called "rat-tail" ore.



d
e
f FIG. 155.—PSILOMELANE? ENVELOPED IN PYROLUSITE. FROM STEPHENS BANK, BARTOW COUNTY, GEORGIA.

Cooper's bank is the only one opened south of the Etowah river; it is quite new, and the deposit could not be examined when visited. A shaft had been sunk on the summit of a ridge and a small amount of ore had been taken out; this was separated into two qualities—first and second; the former consisted of nearly pure pyrolusite, said to be most abundant near the bottom of the shaft; the latter was the psilomelane, taken from nearer the surface. A tunnel was being driven in to strike the deposit at some depth in order to obtain the greatest possible

[The analyses of the samples collected by Mr. Willis, and referred to in this report, were not made, as it was found necessary to confine laboratory work to the iron ores.]

proportion of first-class ore. Another small opening near by has furnished a third-class ore, which is associated a with limonite and red clay. These three qualities of ore are represented, respectively, by samples Nos. 457, 458, 459.

The road that leads eastward from Cartersville crosses a ridge in which the Parrot bank is opened and descends into the valley of the Etowah, here spreading into a strip of bottom-land that is bounded by the rapid river on the south and low hills on the north. On one of these gentle slopes Mr. Johnsey has made a small opening in the clay, and has obtained a considerable quantity of psilomelane; the pieces of ore are all small and disconnected; each one shows a fractured surface, indicating that it has been detached from another mass, and they are undoubtedly not in place. Sketches of several typical forms are herewith given (Fig. 154):

The Parrot bank was not visited, but a small amount of the ore was seen at the manganese works in Cartersville; it consists of psilomelane (?) and limonite mingled, and resembles that of the Etowah bank. The latter lies about 1 2 $\frac{1}{4}$ miles north of Cartersville on a ridge 75 or 100 feet above the Wolf Pen road. An irregular surface of ore has been exposed by stripping; it is massive and made up of limonite intimately associated with psilomelane (?). Each retains, however, its streak and all physical characteristics, apparent to the eye; both are concretionary and stalactitic.

Sample 461 was taken as an approximate average of the total exposure, as the two ores could only be partially separated, by even careful hand-picking.

There is a little hollow north of the Etowah bank through which a cross-road runs east and west. Quite near this road, 3 $\frac{1}{2}$ miles from Cartersville, is a small opening called the Stephen's bank. Nodules of psilomelane (?) and pyrolusite occur scattered through the clay, and a small pile of these lay by the side of the test-pit. One of them c is sketched in Fig. 155:



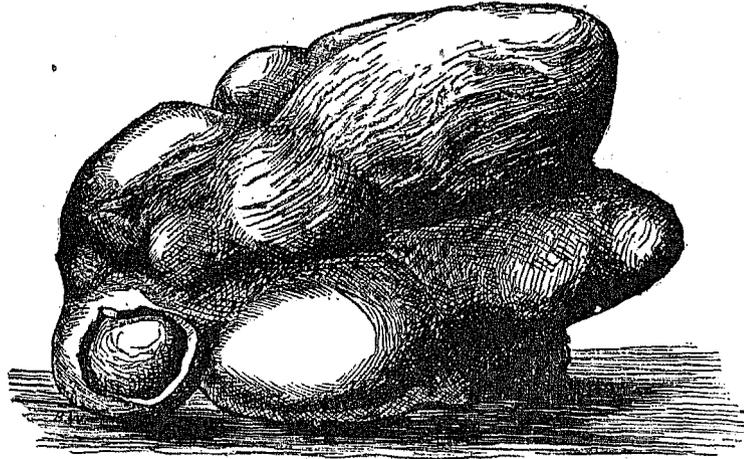
FIG. 156.—PSILOMELANE? FROM DOBBIN'S BANK, BARTOW COUNTY, GEORGIA.

Dobbins' bank, near the Wolf Pen road, 5 $\frac{1}{2}$ miles north of Cartersville, has been more extensively worked than any of the others, excepting, perhaps, the Chumbler hill. There are several openings, one of which is called the "Black" bank, because a very large proportion of the ore found there is pyrolusite. Farther north are large open cuts, which have in places been worked to a depth of 40 feet. The ore nodules lie in beds 6 to 8 feet thick, dipping $\frac{1}{2}$ to the east; they are inclosed in red clay and limited along the strike, the greatest length yet found being 120 feet. The proportion of pyrolusite in the ore is said to increase as the bed descends. The hard and soft ores are usually kept separate.

Samples 462 and 463 were taken at the northern opening and 464 from a pile of ore at the "Black mine".

The Moccasin and Chumbler Hill banks are on a cross-road that runs east and west past Wolf Pen. The former is a small open cut close by the road, in which psilomelane, forming concretions around sandstone masses, and irregular deposits of wad, are found. The ore is not considered as good, and being in large masses is more difficult to obtain than that found elsewhere; hence but little has been removed. The Chumbler Hill bank has been very extensively worked, and next to the Dobbins is the best developed. The ore lies in small concretions and also in large concretionary masses, which contain a large proportion of crystallized pyrolusite. Fig. 157 is a sketch of a specimen of psilomelane (?) from this bank.

a The fracture in the lower left-hand corner shows well the concentric formation of these nodules. Samples 465 and 466 were taken from ore in place at the Moccasin bank, and 467 was collected at the Chumbler hill.



c

FIG. 157.—PSILOMELANE? FROM CHUMBLER BANK, BARTOW COUNTY, GEORGIA.

The Smith bank, the Upper Bishop, and the Bishop are all small openings not far from the Tennessee road, between 6 and 7 miles north of Cartersville. The ore is nodular, partly crystallized pyrolusite, partly the hard amorphous ore, probably psilomelane. Sample 468 was taken from a little ore found in the old open cut of the Smith bank, not worked at present, and samples 469 and 470 are from the Bishop bank proper. No ore was seen at the Upper Bishop.

NOTES ON SAMPLES OF IRON ORE COLLECTED IN ALABAMA.

BY W. M. CHAUVENET.

The iron ores of Alabama, represented by the samples taken, may be divided into three principal groups: The limonites; the red fossil or dyestone ores; the blackbands.

The limonites of the first group are divided by Eugene A. Smith, state geologist, as follows: (1) The Silurian limonites associated with the Knox dolomite; (2) the limonites of the Carboniferous age occupying the ridges of the anticlinal valleys of middle Alabama.

The working deposits of limonite are confined to the region adjoining and extending along the Selma, Rome, and Dalton railroad from Bibb county to the eastern limit of Cherokee county at the Georgia line, and to a smaller area in Bibb and Tuscaloosa counties in the vicinity of Woodstock and Green Pond stations on the Alabama and Chattanooga railroad.

The samples taken from the second group of limonites, namely, the Carboniferous limonites, were from small abandoned pits worked for forges before 1860.

The dyestone or red fossil ores of the Red Mountain group can be traced almost continuously from the extreme south of Jefferson county northeasterly to the Georgia line in DeKalb county, a distance of 130 miles, in Alabama alone. This great range of ores had up to the fall of 1879 been opened but at two points for mining purposes—one at Eureka mine, at Oxmoor station on the South and North Alabama railroad, in Jefferson county; a second at the Irondale mine, 5 miles east of Birmingham, also in Jefferson county.

On the west of Roup's and Jones' valleys, in Jefferson county, the ore ridges are duplicated, and to this portion of the dyestone range has been given the name of Little Red mountain. On this portion of the ore no openings have yet been made for mining purposes.

An isolated group of fossil ores is found in Cherokee county, described by M. Tuomey (*Geology of Alabama* 1858, p. 27), as follows:

That part of Cherokee county between the base of Lookout mountain and the Coosa river is composed of two ridges parallel with the river from Wills creek where it crosses the valley to the Blue ponds. The ridge next to the mountain is composed, beginning at the base, of the magnesian and colored limestones, succeeded by a bed of yellow and brown sandstone, in which the bed of red "fossiliferous ore" is contained, the whole dipping northwest.

In this group are two openings for mining purposes, hereafter to be described.

The blackband ores are mined only at one locality—at the mines of The Newcastle Coal and Iron Company, at Newcastle station, Jefferson county.

The accompanying geological map of Alabama (Plate XXXVI) shows the three formations in which the ores sampled occur, while the geographical map (Fig. 158) shows the location of the banks from which samples were taken.

The sampling of the ores of Alabama will be considered, and the deposits described according to the above grouping.

SILURIAN LIMONITES.

Work was begun upon the Silurian limonites in Bibb and Tuscaloosa counties.

Sample 223 was taken from a pile of loose lumps thrown from a small prospecting pit opened in the *Strickland* bed for the use of the Edwards Iron Company, at Woodstock, in Bibb county. The bed is in Bibb county, SE. $\frac{1}{4}$, Sec. 10, T. 21, R. 6 W., and is not yet fully opened. The ore occurs in loose masses, varying in size from a small pebble to masses tons in weight, imbedded in reddish sandy clay. The ore is a dense brown limonite, with black pitch-like streaks, and shows, upon analysis—

	223.
	<i>Per cent.</i>
Metallie iron	48.10
Phosphorus	0.944
Phosphorus in 100 parts iron	1.600

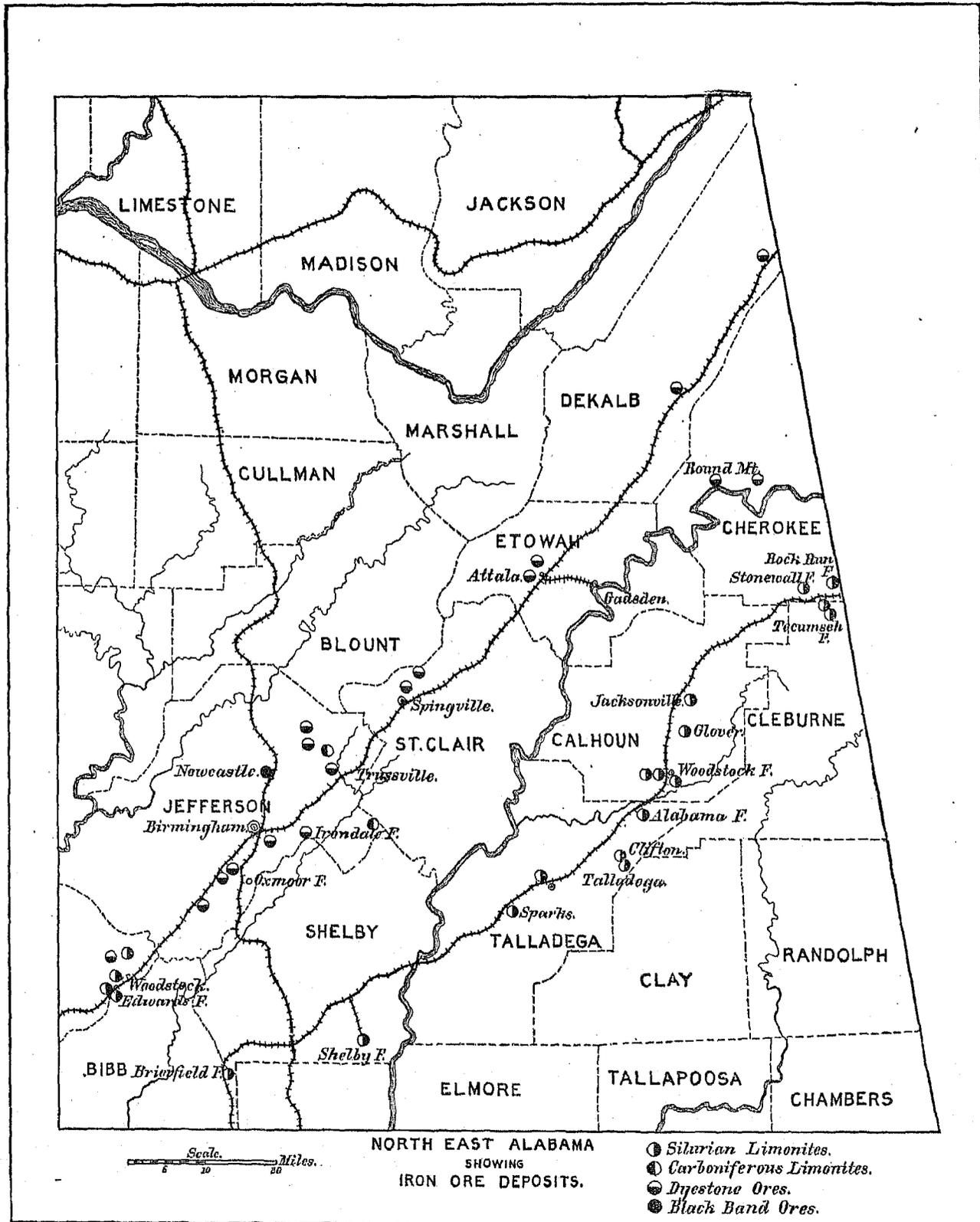


FIG. 165.

The ore from the west side of the branch which divides the Strickland bed was sampled from four small a prospecting pits. The ore differs little in appearance from that on the east side of the stream, showing, upon analysis, however, a decided difference, which may be accounted for partly by the small amount of ore from which the samples were necessarily drawn. The analysis shows—

	224.
	<i>Per cent.</i>
Metallic iron	41.48
Phosphorus.....	0.878
Phosphorus in 100 parts iron	2.117

b

The *Burns* bed, on land of Mr. Edwards, is west of the Strickland bed, and has not yet been opened. It shows a large outcropping of boulders of limonite, which were sampled on both sides of the ravine which divides the deposit. The analysis shows—

	225.
	<i>Per cent.</i>
Metallic iron	47.11
Phosphorus.....	0.764
Phosphorus in 100 parts iron	1.022

c

These deposits of limonite in yellow and red sandy clay are exceedingly irregular, both in form and extent. The hills in this vicinity show large outcropping masses of the ore, often hundreds of tons in weight, and smaller loose lumps are scattered over the surface of the hills. These pieces of loose ore do not, in all cases, indicate an underlying bed of limonite.

Crossing into Sec. 11, T. 21, R. 6 W., Bibb county, the limonite, similar in occurrence, though perhaps of lighter brown color, is found in the *De Bardeleben* bank. This ore, sampled in a pit 100 feet long, by some 40 feet wide, shows, upon analysis—

	226.
	<i>Per cent.</i>
Metallic iron	46.54
Phosphorus.....	0.221
Phosphorus in 100 parts iron	0.475

d

The bank is close beside the track of the Alabama and Chattanooga railroad. The ore was mined for the South Pittsburgh furnaces, Tennessee, and shows low phosphorus. The limonites on the property of the *Pioneer Iron Company* occur along a continuous ridge, and were sampled from three openings on the bank a quarter of a mile apart. These openings are in the SE. $\frac{1}{4}$ of Sec. 30, T. 20, R. 5 W. Sample 228 shows, upon analysis—

	228.
	<i>Per cent.</i>
Metallic iron	48.50
Phosphorus.....	0.491
Phosphorus in 100 parts iron	1.010

e

This bank was worked in 1862 and 1863 for use at Roup's Valley Iron Works, now in ruins.

One mile north of this, in Tuscaloosa county, SE. $\frac{1}{4}$ of Sec. 29, T. 20, R. 5 W., is an extensive bank belonging to the *Tuscaloosa Iron Company*. Sample 229 was here taken from three openings extending along the ridge in a northeast and southwest course and determining the strike of the bed. The ore is a dark-brown limonite, cleaving, if when struck, into thin slabs of irregular shape, and showing a black coating on the cleavage surfaces. It occurs imbedded in yellow clay, and is worked as in all other cases in the region under discussion in open cuts. The sample shows, upon analysis—

	229.
	<i>Per cent.</i>
Metallic iron	48.12
Phosphorus.....	1.021
Phosphorus in 100 parts iron.....	2.122

The ore was being shipped to the South Pittsburgh furnaces, Marion county, Tennessee.

a The bank of the *Eureka Iron Company*, held under lease, is in NE. $\frac{1}{4}$ of Sec. 2, T. 21, R. 6 W. The ore is a limonite occurring in red clay in irregular masses, as described above. It seems to be one of the best of these limonites, and shows, upon analysis—

230.	
	<i>Per cent.</i>
Metallic iron	46.59
Phosphorus	0.179
Phosphorus in 100 parts iron.....	0.385

b

The following is the complete analysis of No. 230:

230.		230.	
	<i>Per cent.</i>		<i>Per cent.</i>
Sulphur	0.318	Phosphoric acid	0.410
Phosphorus.....	0.179	Carbon in carbonaceous matter.....	0.20
Iron, metallic.....	46.59	Hygroscopic water	0.84
		Water of composition.....	9.23
		Total	100.095
		Per cent. of insoluble silicious matter.....	18.04
Silica	15.07	Silica	15.07
Iron, protoxide	0.26	Alumina.....	2.80
Iron, peroxide.....	65.89	Lime	0.10
Alumina.....	5.41	Magnesia.....	0.04
Manganese, protoxide	0.72	Total	18.10
Lime	0.65		
Magnesia.....	0.25		
Iron, disulphide	0.695		
Carbonic acid.....	0.57		

c

It is washed and shipped to Oxmoor furnace, in Jefferson county. Returning to Woodstock station limonites were found exposed in a prospecting trench on the property of Dr. *Ray*, of Woodstock.

Here, in SE. $\frac{1}{4}$, Sec. 15, T. 21, R. 6 W., Bibb county, the hill rises rapidly from the track of the Alabama and Chattanooga railroad, and sample 231 was taken on the crown of the hill, and from a second prospecting pit 400 yards east of the crown. The ore is a dense limonite showing no peculiarities. The analysis shows—

231.	
	<i>Per cent.</i>
Metallic iron	47.77
Phosphorus.....	0.023
Phosphorus in 100 parts iron.....	1.932

Sample 232 was taken on Dr. *Ray's* property in SE. $\frac{1}{4}$, Sec. 16, T. 21, R. 6 W., from a short trench from which loose lumps of ore had been thrown and which exposed large masses imbedded deeper in the yellow clay at the bottom. This ore shows, upon analysis—

232.	
	<i>Per cent.</i>
Metallic iron	54.26
Phosphorus.....	0.266
Phosphorus in 100 parts iron.....	0.490

The next sample was taken on the property of *S. H. Woodward* from outcropping bowlders of limonite. The bank located by the outcrop is in Tuscaloosa county, in W. $\frac{1}{2}$ Sec. 10, T. 21, R. 6 W. The analysis of the sample gives—

233.	
	<i>Per cent.</i>
Metallic iron	56.12
Phosphorus	0.444
Phosphorus in 100 parts iron.....	0.791

These ores are widely spread and are found in every hillside throughout the region just gone over; the ores differ little in appearance, all showing dense-brown, smooth fracture and black, mammillary, pitchy-looking surfaces, showing fewer pots and honeycombed masses than the ores next to be described, lying along the Selma, Rome, and Dalton railroad.

The limonites so extensively mined along the line of the Selma, Rome, and Dalton railroad were first sampled **a** at the *Brierfield Furnace* banks. The banks are 1½ mile northwest of the now abandoned furnace, and are much fallen and covered. The ore is a dense, cherty limonite, imbedded in yellow sandy clay, at times showing honeycombed masses, and pitchy mammillary surfaces are common. The ore was worked in open cuts which cover the low hills on the sides of the Montevallo road in SE. ¼ Sec. 21, T. 24 N., R. 11 E. No system seems to have been followed in mining these ores, the pits being very irregular in shape, and seeming to follow the richest masses of the bed. Sifters were here used to separate the finer chert lumps and the clay from the ore. This ore has been long celebrated in Alabama. The sample here taken is from many of these irregular openings from such loose lumps or outcropping masses as could be found. The analysis of this ore gives—

234.	
<i>Per cent.</i>	
Metallio iron	40.12
Phosphorus	0.265
Phosphorus in 100 parts iron.....	0.540

b

Though quite a good limonite by this showing, there is no reason why it should produce finer iron than the ores above shown from Eureka mine, in Tuscaloosa county, sample 230.

Going northeast upon the Selma, Rome, and Dalton railroad, the next working deposits of limonite visited **c** were at Shelby. Here, in SE. ¼ Sec. 13, T. 22 S., R. 1 W., in Shelby county, the *Shelby Iron Company* own and work extensive banks of limonite. The whole of the low hill northeast of the furnaces, which are two in number, is a network of irregular shallow pits and diggings. The ore occurs in small lumps scattered through red clay, and is a dense, dark-colored limonite, often in huge masses. The Shelby ore is peculiar in the many concretions lined with stalactites of a brilliant bronze hue, and in the huge pots and cavities lined upon the inner surfaces with a pitchy-black coating. Fine specimens of fibrous limonite are also found, the needles often from 6 to 8 inches in length. The finer ores dug from the clay banks with their accompanying clay are washed, and in many instances roasted, though much of this ore is also used raw. The main pit at the bank exposes a face of ore rising in a wall 45 feet in height and as many wide. This huge mass of ore shows great cavities and gnarled and twisted surfaces, varied in color from dense black to a very light brown. Three samples were taken from the *Shelby* **d** banks, all of them from such pits as are at present worked. The following are the analyses of these ores:

	235.	236.	237.
	<i>Per cent.</i>		
Metallio iron	52.82	53.92	40.64
Phosphorus.....	0.241	0.282	0.137
Phosphorus in 100 parts iron...	0.456	0.523	0.276

Sample 235 is from the washer, and shows washed ore from one pit. The ore occurs in small lumps and fragments of hollow pots loosely scattered through a yellow clay. Sample 236 is from the stock-pile at the furnaces, **e** and represents ore from many parts of new and old diggings. Sample 237 is from the face of the great wall in the main pit above described, taken across the whole face. Sample 235 has been subjected to full analysis, with the following result:

235.		235.	
<i>Per cent.</i>		<i>Per cent.</i>	
Sulphur	0.139	Carbon in carbonaceous matter.....	0.09
Phosphorus.....	0.241	Hygroscopic water	0.87
Iron, metallic	52.82	Water of composition.....	9.62
		Total	100.031
Silica	6.62	Per cent. of insoluble silicious matter.....	7.89
Iron, protoxide	0.34	Silica	6.62
Iron, peroxide	74.88	Alumina	1.17
Alumina.....	3.30	Lime	0.08
Manganese, protoxide	1.41	Magnesia	0.04
Lime	0.82	Total	7.91
Magnesia	1.02		
Iron, disulphide	0.260		
Carbonic acid.....	0.25		
Phosphoric acid	0.551		

The next furnace using the ores of this region is the *Alabama furnace*, at Alabama station, Talladega county. Its ores are drawn from a wide range of country, all of which, however, lies adjacent to the Selma, Rome, and Dalton

a railroad. The first banks visited were those on the furnace property, which are now abandoned. These banks are in Sec. 17, T. 17, R. 7 E., half a mile from the furnace. The ore presents no peculiarities, being medium brown color, with reddish surfaces at times. The mine is an irregular open cut 30 feet deep and some hundred feet across. Analysis of this ore shows—

	240.
	<i>Per cent.</i>
Metallic iron	53.45
Phosphorus	0.912
Phosphorus in 100 parts iron	1.706

b

The *Talladega* ore-bank in Sec. 20, T. 18, R. 5 E. is represented by sample 238, sampled on the cars at Alabama furnace, and is part of the furnace ore property. The ore is a dark-brown limonite with concretions composed of short, silky, fibrous ore, its cavities filled with red ocher and at times with white sandy powder. The analysis of this sample gives—

	238.
	<i>Per cent.</i>
Metallic iron	54.23
Phosphorus	0.181
Phosphorus in 100 parts iron	0.334

c

The principal banks which supply Alabama furnace are in T. 18, R. 6, Talladega county, and are known as the *Clifton* banks. These ores have but recently been opened for furnace use, and are different from any other limonites sampled in this vicinity. The bank was being worked in an open cut, known as pit No. 1, which, when visited, was 15 feet deep and 30 feet across. The ore is a spongy, honeycombed, rather light limonite, showing dark-brown and light-yellow streaks, and containing included masses of soft, white chert, usually square-cornered, often triangular in shape. At the time when sample 241 was taken this bed was showing large quantities of this white silicious matter which covered the working-face with its powder under the tools of the miner. The small pit showed a wall of ore 15 feet high which seemed to dip deeper from the surface as it went southward. The ore is imbedded in yellow d clay and is exceedingly irregular in occurrence, the small pit under consideration showing nothing but clay with white masses of chert on two sides and limonite in odd lumps and streaks on the bottom. The wall of ore on the south seemed to be a huge boulder. The analysis of this sample shows—

	241.
	<i>Per cent.</i>
Metallic iron	48.74
Phosphorus	0.011
Phosphorus in 100 parts iron	0.023

e The same ore was sampled on the pile at Alabama furnace, and shows, upon analysis—

	239.
	<i>Per cent.</i>
Metallic iron	52.40
Phosphorus	0.047
Phosphorus in 100 parts iron	0.090

This pile showed less white chert than that from which sample 241 was taken.

Bed No. 6, on the *Clifton* property, had been opened on the crown of a hill 100 feet high by two trenches. The ore thrown from this pit presented a beautiful appearance. It is a very light, spongy ore, exceedingly porous, its many cavities divided by thin, laminated walls. When freshly mined the ore, especially in the lining of its cavities, is highly colored—blue, green, and brilliant reds and yellows being most common. These colors fade upon exposure to the air. The more solid parts of the lumps are a dark-brown shade, and the whole lump assumes this shade after some weeks of exposure.

The sample taken at these two pits, from some hundred tons of ore, shows upon analysis—

	242.
	<i>Per cent.</i>
Metallic iron	52.22
Phosphorus	0.041
Phosphorus in 100 parts iron	0.078

The pits were 100 yards apart. The low per cent. of phosphorus in these ores distinguishes them from other a limonites taken on the Selma, Rome and Dalton railroad, the Skinner bank being excepted. These pits upon the Clifton bank, No. 1 and No. 6, as above, are in Sec. 26, T. 18, R. 6.

The *Leay* bed on the same property is also in Sec. 26, and was worked in 1862 for a forge on a near stream. It shows boulders in red clay, with none of the accompanying white chert. The ore is porous at times, at times argillaceous, and shows, upon analysis—

243.	
<i>Per cent.</i>	
Metallic iron.....	51.98
Phosphorus.....	0.100
Phosphorus in 100 parts iron.....	0.198

The pit is fallen and covered, and the sample was taken from such lumps as could be found exposed. The complete analysis of sample 242 is as follows :

242.		242.	
<i>Per cent.</i>		<i>Per cent.</i>	
Sulphur.....	0.109	Carbonic acid.....	0.34
Phosphorus.....	0.041	Phosphoric acid.....	0.934
Iron, metallic.....	52.22	Carbon in carbonaceous matter.....	0.26
		Hygroscopic water.....	0.55
		Water of composition.....	10.55
		Total.....	100.183
Silica.....	9.42	Per cent. of insoluble silicious matter.....	11.09
Iron, protoxide.....	0.19		
Iron, peroxide.....	74.31	Silica.....	0.42
Alumina.....	1.80	Alumina.....	1.50
Manganese, protoxide.....	1.00	Lime.....	0.07
Lime.....	0.34	Magnesia.....	0.12
Magnesia.....	0.23	Total.....	11.11
Iron, disulphide.....	0.110		
Nickel, sulphide.....	0.14		
Cobalt, sulphide.....	Trace.		
Copper, sulphide.....	Trace.		

The furnaces of the Woodstock Iron Company are situated at Anniston, on the Selma, Rome, and Dalton railroad, in Calhoun county. The ores of this company are brought from many banks located in both Talladega and Calhoun counties, along the line of the railroad. The ores sampled were from the following banks: The *Sparks* bank, in T. 19, R. 4 E., Talladega county, sampled on the cars at Woodstock furnaces. The pit is one of some importance; the ore is cherty and dense, showing, upon analysis, low phosphorus.

244.	
<i>Per cent.</i>	
Metallic iron.....	54.09
Phosphorus.....	0.118
Phosphorus in 100 parts iron.....	0.218

The *Side* bank is in the same town and range as the Sparks bank. The ore from many banks worked by the Woodstock company is brought to the furnaces by farmers, and may come from any of the hills within 10 miles. Many of these banks are nameless, and the ore brought in by ox-teams is accepted or rejected, as the inspector sees fit. The Side bank shows a soft argillaceous limonite, with occasional dense, cherty lumps, and sampled from the cars at Woodstock, gives, upon analysis—

245.	
<i>Per cent.</i>	
Metallic iron.....	47.12
Phosphorus.....	0.149
Phosphorus in 100 parts iron.....	0.316

The *Glover* bank is in Sec. 21, T. 15, R. 8 E., Calhoun county. The ore sampled at the Woodstock furnace, on the cars, from 50 tons, was a soft, clayey limonite, with occasional dense, hard lumps. This bank was opened in 1879. Analysis of the sample gives—

246.	
<i>Per cent.</i>	
Metallic iron.....	45.87
Phosphorus.....	0.048
Phosphorus in 100 parts iron.....	0.105

a The *Old Oxford* bank, near the furnaces, in Sec. 7, T. 15, R. 8 E., has been worked by the Woodstock company for eight years, and by the Oxford furnace, now abandoned, for many years previous. The sample was taken from two adjoining pits, on the top of the main hill, from a rough face of ore in one farthest west, and from a pile of loose lumps in a second, some 200 yards east. This bank is riddled by pits and trenches, and is much worked out. Analysis of this sample gives—

247.	
Per cent.	
Metallic iron.....	49.92
Phosphorus.....	0.147
Phosphorus in 100 parts iron.....	0.296

b

The ore is a dense, light-colored limonite in a very red clay which fills the cavities of the ore.

The *Skinner* bank, one-quarter mile west of the furnaces, on the west side of the ridge, is worked exclusively for the Woodstock company. The opening upon this bank is 20 feet deep and 50 feet long. The ore-masses are surrounded by a sticky, marbled clay, streaked with white, red, and yellow. The ore is worked by pulling down the bank and picking the ore from the clay. The ore is a porous, brown limonite, giving, upon analysis—

c

248.	
Per cent.	
Metallic iron.....	48.62
Phosphorus.....	0.031
Phosphorus in 100 parts iron.....	0.063

The *Washer* bank shows a very red clay, in which the ore occurs in fine lumps and shells of broken pots. The ore is put through a washer, direct from which sample 249 was taken. This bank lies half a mile west of Anniston, in Sec. 7, T. 15, R. 8 E., Calhoun county, and had been opened five years. The analysis shows—

d

249.	
Per cent.	
Metallic iron.....	52.14
Phosphorus.....	0.113
Phosphorus in 100 parts iron.....	0.217

The company work other banks in Secs. 8, 32, and 34, T. 15, R. 8 E., but these are of small importance. A few of the banks in this region show manganese in workable quantity, and the Woodstock company have used the ore from section 34 for a mix in the manufacture of spiegel iron. The pit is now exhausted, fallen, and abandoned. The per cent. of manganese in the ore was very variable.

The banks of the *Stonewall Iron Company* are two in number, situated upon the furnace property in Sec. 15, T. 12, R. 11 E., on the line of the Selma, Rome, and Dalton railroad, in Cherokee county.

The "Lower" bank, southeast of the furnace, is opened by a square pit 30 feet deep, exposing boulders of ore protruding from the bottom, and seams of ore dipping 30° in the northwest wall imbedded in yellow clay with large red masses. The ore is a dark-brown limonite with black streaks and velvety cavities, and was first worked in 1873. The sample taken from all parts of the pit shows, upon analysis—

f

250.	
Per cent.	
Metallic iron.....	41.45
Phosphorus.....	0.676
Phosphorus in 100 parts iron.....	1.631

The "Upper" bank is opened 60 feet below the crown of the high hill northwest of the furnace. The ore is associated with yellow clay and much yellow chert, and occurs in large masses. It is a very dense, brown limonite, showing little black in the cavities, and giving, upon analysis—

251.	
Per cent.	
Metallic iron.....	42.52
Phosphorus.....	0.501
Phosphorus in 100 parts iron.....	0.708

The *Tecumseh furnace*, 1 mile southeast of the Selma, Rome, and Dalton railroad, in Sec. 24, T. 12, R. 11 E., a Cherokee county, is in a region most productive of limonite ores. The hills back of the furnace both south and east covered with loose lumps, indicating the underlying beds. This ore is mined by the farmers in the vicinity, permission for such mining being obtained from the company when the ore is upon company property. In this way as many as fifty banks of limonite are opened and worked from time to time within a radius of 6 miles. These ores are dense, brown limonites.

The following banks were sampled: The *Terry bank*, Sec. 18, T. 12, R. 15 E.; the *Treadaway bank*, in Sec. 29, 12, R. 12 E.; the *Brown bank*, in section 30, same township and range. Besides these, samples were taken from the stock-piles at the furnace, made up of mixed ore from all the company's banks.

The largest exposure of limonite seen upon this range was that at the Brown bank, above mentioned. Here a pit 40 feet deep and over 200 feet long has been excavated upon the almost solid ore-mass, which is seen rising in rough masses and ledges on all sides, occupying also the bottom of the pit. The hills above the cut are covered with outcropping ledges and boulders of the ore. The ore presents many varieties, both in texture and in color, and in the southeast corner of the pit a recent blast had exposed a surface of much blackened ore, probably due to the binocide of manganese. Pots and concretions are common, the interior cavities often crossed by stalactites, showing, when broken, a radiating structure. The following analyses show the nature of these limonites: No. 252 is from the Terry bank; No. 253 from the Treadaway bank; No. 254 from the furnace stock-pile, representing many banks; and No. 255 from the Brown bank:

	252.	253.	254.	255.
	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>
Metallic iron	50.04	48.44	51.50	52.07
Phosphorus.....	0.108	0.584	0.908	0.838
Phosphorus in 100 parts iron...	0.215	1.206	1.761	1.609

Besides these banks the *Tecumseh furnace* uses ore from the *Jacksonville bank*, in Sec. 12, T. 14, R. 8 E., in Calhoun county, sampled from a stock-pile at *Tecumseh*. The bank belongs to the *Tecumseh Iron Company*, though other parties own ore-banks in the same section. The analysis of this sample shows—

	256.
	<i>Per cent.</i>
Metallic iron.....	40.04
Phosphorus.....	0.541
Phosphorus in 100 parts iron.....	1.331

This ore shows many pots lined with purple clay, and having dense brown walls; its associated clay is a bright yellow.

The ore from the *Terry bank* shows the following composition upon complete analysis—

252.		252.	
	<i>Per cent.</i>		<i>Per cent.</i>
Sulphur	0.179	Carbon in carbonaceous matter.....	0.25
Phosphorus.....	0.108	Hygroscopic water	0.42
Iron, metallic.....	50.04	Water of composition	10.20
		Total	90.93
Silica	11.23	Per cent of insoluble silicious matter	15.14
Iron, protoxide	0.22		
Iron, peroxide	71.15	Silica	11.23
Alumina.....	4.09	Alumina (with trace of oxide of iron)	3.30
Lime	0.25	Lime	0.15
Magnesia.....	0.25	Magnesia.....	0.10
Iron, disulphide	0.337	Potassa.....	0.14
Potassa.....	0.14	Soda.....	0.11
Soda.....	0.11	Total	15.09
Carbonic acid.....	0.13		
Phosphoric acid.....	0.246		

After passing *Tecumseh furnace* the Selma, Rome, and Dalton railroad crosses the Georgia line 1 mile east. The range of limonites continues into that state, and trends away in a northeast direction. Samples 448 and 449, from the Pennington and Alloway banks on the *Ætna furnace* property, in Polk county, Georgia, are described in the report on the Georgia ores, by Mr. Bailey Willis, and lie 1 mile from the Alabama state line.

a The *Rock Run* furnace, which has been idle for some years, is situated in Sec. 5, T. 12, R. 11 E., Cherokee county. The "Furnace" bank, occupying the sides and crown of the hill at the furnace, has been worked in a number of places. The old pits are much fallen, affording but a poor opportunity for sampling. Sample 258 was taken from three pits on this bank, and shows, upon analysis, the following result:

	258.
	<i>Per cent.</i>
Metallic iron	54.96
Phosphorus	0.342
Phosphorus in 100 parts iron	0.622

b

The ore is a hard, dense, brown limonite.

The *Hardin* bank, situated in Sec. 32, T. 11, R. 11 E., has been recently opened, and is one of the furnace banks. The sample was taken from a small opening showing the ore in lumps and irregular masses in red clay, not sufficiently developed to show its probable extent. Sample 257 was here taken, and gives, upon analysis—

	257.
	<i>Per cent.</i>
Metallic iron	54.15
Phosphorus	0.749
Phosphorus in 100 parts iron	1.383

c

This sample was from surface lumps, and completes the list of limonites taken on this range of ores. From these ores the celebrated car-wheel iron of Alabama is manufactured.

FOSSIL ORES.

The fossil or dyestone ore of the main Red Mountain group will next be considered. The ore is a soft red hematite of a distinctly granular structure, cleaving readily into thin slabs of varying thickness, and when so cleft **d** showing thickly bedded fossils upon the cleavage surfaces. These fossil forms are more distinct in the softer and more or less decomposed varieties of the ore. The ore stains the hand a deep red, and has an unctuous feeling when rubbed between the fingers. It lies in a well-defined bed, capped in most instances by a heavy layer of sandstone. The outcrop on that portion of the range south of Springville, in Saint Clair county, is to be found near the crown of the northeast slope of the ridges, dipping southeast. North of Springville the beds, which are three or more in number, dip northwest, and the range is much broken and divided.

The most southerly outcrop of fossil ore seen was that on the *Shamblin and Dickey* tract, in Tuscaloosa county, in the SE. $\frac{1}{4}$ Sec. 34, T. 20, R. 6 W. Here, on the crown of a low hill, a test-pit had been sunk 9 feet upon the outcrop, and from the lumps of ore thrown out the sample was taken. The pit had long since fallen in, preventing the bed **e** from being seen. This ore is to be opened for use of the Alice furnace, in Birmingham, and shows, upon analysis—

	227.
	<i>Per cent.</i>
Metallic iron	49.49
Phosphorus	0.048
Phosphorus in 100 parts iron	0.097

This bed seems isolated, though it belongs with the Red Mountain group, which it resembles both in texture and in composition.

f In the southern part of Jefferson county, in Sec. 11, T. 19, R. 4 W., the bed of fossil ore is exposed 13 feet in thickness on the property of Mr. *M. L. Potter* and Mr. *J. N. A. Griswold*, of New York. Here, in the northwestern quarter of Sec. 11, T. 19, R. 4 W., a small prospecting pit has been opened, exposing the whole thickness of the bed. Sample 260 was taken from top to bottom and across the exposed face, and gives an average of the vein. The analysis of this sample, which was taken at pit No. 1, shows—

	260.
	<i>Per cent.</i>
Metallic iron	54.15
Phosphorus	0.152
Phosphorus in 100 parts iron	0.281

Sample 261 is from SE. $\frac{1}{4}$ Sec. 2, T. 19, R. 4 W., on the same property. The whole thickness of the bed, here **a**. 13 feet 8 inches, is divided into three seams by 1 foot 8 inches of hard ore lying between the upper and lower softer portions. From this hard portion the sample in question was taken, yielding, upon analysis—

		261.
		<i>Per cent.</i>
Metallic iron		40.04
Phosphorus		0.810
Phosphorus in 100 parts iron		0.797

b

Continuing northward along the crown of Red mountain, the ore is found outcropping in a rough ledge toward the west. This outcrop is of a hard, rather dense ore, but farther back from the steep western face of the ridge an overlying softer seam can be traced. The outcropping seams, both hard and soft, were sampled along a quarter of a mile, with the strike in SE. $\frac{1}{4}$ Sec. 30, T. 18, R. 3 W. This ore is to be opened in the fall of 1880 for the use of the Alice furnace now building in Birmingham, Jefferson county. This ore shows, upon analysis—

		204.
		<i>Per cent.</i>
Metallic iron		50.09
Phosphorus		0.067
Phosphorus in 100 parts iron		0.118

c

This sample, it must be borne in mind, comes from a much weathered outcrop, and is no indication of the ore deeper upon the vein, which is apt to be lower in iron and to contain more phosphoric acid.

The *Eureka* mine is situated on the very crown of Red mountain in the NE. $\frac{1}{4}$ Sec. 21, T. 18, R. 3 W., Jefferson county. The mine is opened on the outcrop, and is worked by tunneling along the strike of the bed, which is here 7 feet thick and divided into two seams—an upper 4 feet of soft ore, and a lower 3 feet of harder ore. These two seams are mixed in mining, but a separate sample was taken from each with a view of determining their **d**. difference. The samples were both from about 20 or 30 feet from the outcropping edge of the bed at the side of the upper tunnel. The following analyses show the difference in the ores :

	202.	203.
	<i>Per cent.</i>	<i>Per cent.</i>
Metallic iron	51.25	50.40
Phosphorus	0.210	0.510
Phosphorus in 100 parts iron ...	0.426	1.080

e

This difference is very striking and shows the value of separating the upper seam from the more phosphatic-lower one (see full analysis). The bed is overlain by sandstone, and dips southeast with the formation. This ore is sent to the Oxmoor furnaces, on the line of the Alabama North and South railroad, to which it is conveyed by a narrow-gauge railway, running a small engine. The Oxmoor furnaces are situated between Secs. 33 and 34, T. 18, R. 3 W., Jefferson county. Sample 202 yields, upon full analysis—

		202.			202.
		<i>Per cent.</i>			<i>Per cent.</i>
Sulphur		0.130	Phosphoric acid		0.501
Phosphorus		0.210	Carbon in carbonaceous matter		0.02
Iron, metallic		51.25	Water of composition		2.17
			Total		100.071
Silica		16.59			
Iron, protoxide		0.19	Per cent. of insoluble silicious matter		19.28
Iron, peroxide		72.84			
Alumina		6.57	Silica		10.59
Manganese, protoxide		0.37	Alumina		2.52
Lime		0.27	Lime		0.12
Magnesia		0.22	Magnesia		0.07
Iron, disulphide		0.260			
Carbonic acid		0.07	Total		19.80

f

a The ore from the two seams at Eureka mine was sampled from the stock-pile at Oxmoor, and yields upon analysis—

	205.
	<i>Per cent.</i>
Metallic iron.....	50.89
Phosphorus.....	0.225
Phosphorus in 100 parts iron.....	0.442

The ore from Eureka mine in Tuscaloosa county, shown in sample 230, was again sampled here, and yielded
b upon analysis—

	206.
	<i>Per cent.</i>
Metallic iron.....	44.12
Phosphorus.....	0.259
Phosphorus in 100 parts iron.....	0.587

This sample was from a stock-pile of 100 tons.

c The burnt blackband ores from Newcastle were also sampled at the Oxmoor piles, but will be quoted under the description of these ores at the end of this paper.

On the crown of the ridge east of Birmingham, in Jefferson county, in the SW. $\frac{1}{4}$ Sec. 6, T. 18, R. 2 W, the dyestone ore has been opened by a small pit sunk some 20 feet upon the vein which dips southeast, and is capped by a layer of sandstone. The ore was opened for the use of the Alice furnace in Birmingham, and shows, upon analysis—

	201.
	<i>Per cent.</i>
Metallic iron.....	46.80
Phosphorus.....	0.200
Phosphorus in 100 parts iron.....	0.420

d The old *Irondale furnace*, now abandoned, is situated on the eastern side of Red mountain, 5 miles east of Birmingham, in Jefferson county. The mine is situated in a ravine on the east slope of Red mountain, 1 mile west of the furnace, and was worked by means of several tunnels running with the strike of the bed which dips southeast. The tunnel entrances are completely fallen, so as to prevent approach to the old working-faces; the sample was therefore taken from a pile of a few tons exposed for some ten years at the mouth of the opening. The ore is dense and rather sandy in character, and shows, upon analysis—

	222.
	<i>Per cent.</i>
Metallic iron.....	36.41
Phosphorus.....	0.161
Phosphorus in 100 parts iron.....	0.442

e The ore is capped by a coarse sandstone, above which, and farther up the ravine, lies a limestone once used for a flux in the furnace. This mine was one of the first openings upon Red mountain dyestone ores. In T. 16, R. 1 W., 2 miles west of Trussville, on the Alabama and Chattanooga railroad, in Jefferson county, the outcrop of fossil ore is found on the Hickman place, and this portion of the mountain has recently been purchased for mining purposes. In the NE. $\frac{1}{4}$ of SE. $\frac{1}{4}$ Sec. 10, T. 16, R. 1 W., a small opening had been made upon the ore-bed some three feet in depth and as many across. The bed is here 4 feet in thickness, dipping southeast, the upper 1 foot consisting of a softer, somewhat decomposed ore. The sample was taken from both upper and lower seams, and about 2 feet from the original outcrop face. The analysis shows—

	213.
	<i>Per cent.</i>
Metallic iron.....	59.99
Phosphorus.....	0.085
Phosphorus in 100 parts iron.....	0.142

Fifty feet below this bed is a second bed composed of highly ferruginous limestone, having the general appearance of the fossil ore, but without the defined fossil forms. It is much harder than the ore and of a more crystalline structure. It was thought possible that this bed might prove of value as a flux, but the high per cent. of phosphorus ruins it for such a purpose. The analysis shows—

	214.
	<i>Per cent.</i>
Metallio iron.....	18.18
Phosphorus.....	0.102
Phosphorus in 100 parts iron.....	0.561

b

This bed dips southeast with the ore-bed. The outcrop is largely exposed in NE. $\frac{1}{4}$ of NE. $\frac{1}{4}$, Sec. 15, T. 16, R. 1 W., where on the two sides of the Jasper road a sample was taken. This ore is also on the Hickman place, and gives, upon analysis—

	215.
	<i>Per cent.</i>
Metallio iron.....	44.16
Phosphorus.....	0.051
Phosphorus in 100 parts iron.....	0.115

c

This ore was quite hard; its thickness was not exposed.

Continuing north along Red mountain, a small opening is found in the SW. $\frac{1}{4}$ Sec. 28, T. 14, R. 2 E., Saint Clair county. A short tunnel has here been run along the strike of the ore-bed. Here the softer portion of the seam is near the bottom, the whole bed being only 36 inches thick. This pit is one of the Woodall openings, and is abandoned. The analysis of sample taken across the whole bed gives—

	216.
	<i>Per cent.</i>
Metallio iron.....	48.08
Phosphorus.....	0.292
Phosphorus in 100 parts iron.....	0.000

d

On the mountain range northwest of Springville, in Saint Clair county, on the property of Mr. A. W. Woodall, large quantities of ore are being mined. The beds outcropping on the northeast slope of the ridges are worked by stripping along the strike. This method of mining is followed with a view to securing only the softest ore, which is most easily mined. No depth upon the bed had been reached when the mines were visited. The upper seam at this point is about 50 feet below the crown of the ridge and dips northwest, about $3\frac{1}{2}$ feet of its thickness being exposed. The analysis of a sample taken along 30 feet of the outcropping bed shows—

e

	217.
	<i>Per cent.</i>
Metallio iron.....	53.28
Phosphorus.....	0.261
Phosphorus in 100 parts iron.....	0.490

One hundred and ten feet below this upper bed is a second one, also outcropping on the northeast slope. This bed is opened for some hundred feet along the outcrop. The sample here taken shows upon analysis:

	218.
	<i>Per cent.</i>
Metallio iron.....	49.49
Phosphorus.....	0.495
Phosphorus in 100 parts iron.....	0.870

f

These two samples were taken from the SW. $\frac{1}{4}$, Sec. 27, T. 14, R. 2 E., in Saint Clair county.

Four miles northeast of Springville, on the land of Mr. A. D. Aderholt, an opening has been made upon the Red Mountain ore in Sec. 23, T. 14, R. 2 E., Saint Clair county. The bed was here opened by a cut which exposes the seam dipping northwest, and varying in thickness from 30 inches to 3 feet. This bed at the outcrop, and for

a some 30 feet running with the dip, is of a dark-red color, and shows a compact, fossil ore. Thirty feet upon the dip there seems to be a slight fault, beyond which, continuing down the dip, the bed changes to a compact, bluish limestone, in which however traces of fossils can still be seen. (See Fig. 159.)

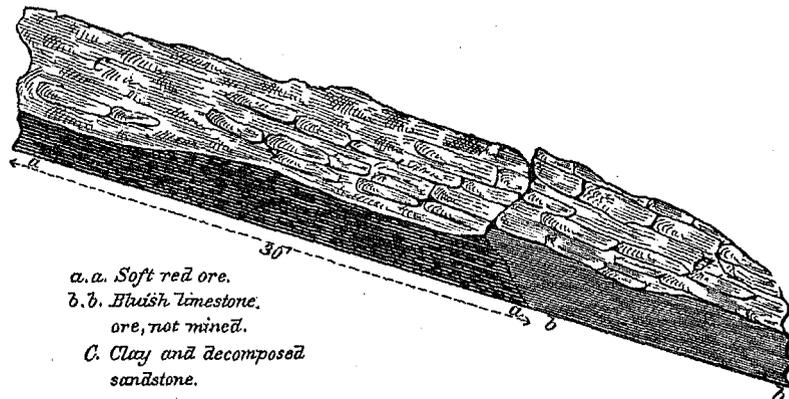


FIG. 159.—SECTION ON LAND OF A. D. ADERHOLT, ALABAMA.

c This limestone is similar to that sampled on the Hickman place, described above under sample 214. The softening of the upper part of the ore-bed is here due to the infiltration of surface-waters to which the harder limestone portion at a greater depth has not been subjected. This suggests at once the origin of the fossil ores, and points to the probable nature of the Red mountain beds when a greater depth shall have been reached, and those portions which have not been subjected to the leaching of surface-waters are exposed.

This sample was taken above the fault in the bed, and wholly from the soft part of the bed, and shows, upon analysis—

	219.
	Per cent.
Metallic iron	45.45
Phosphorus.....	0.400
Phosphorus in 100 parts iron.....	0.900

d A second sample, drawn from the same mine, was taken on the stock-pile on the Alabama and Chattanooga railroad, 1 mile from the mine, and shows, upon analysis—

	220.
	Per cent.
Metallic iron	48.40
Phosphorus.....	0.348
Phosphorus in 100 parts iron.....	0.719

e These ores, as well as the ores from Mr. Woodall's mine, were being shipped to the South Pittsburg furnaces, Marion county, Tennessee.

Other points on the Red mountain above Springville are to be opened for mining purposes. Wilson's mine, in Sec. 23, T. 14, R. 2 E.; the Thomason and Goodwin mine, in Secs. 12 and 13, T. 14, R. 2 E.

The openings on the fossil ore on the range, 1 mile west of Attala, in Etowah county, are known as the Attala mines. Here the ore is worked both by stripping along the outcrop and by tunneling.

In Sec. 34, T. 11, R. 5 E., on the property of Mr. John Moragne, a tunnel had been pushed on the crown of the f vein, and had entered across the angle of dip some 30 feet upon the bed. From this depth the sample was drawn from the working-face. The ore is soft and crumbling, and contains few hard lumps. This mine is worked for the Rising Fawn furnace, in Dade county, Georgia, and is known as the Rising Fawn mine. A second sample (268) of the same ore was taken from a stock-pile of 150 tons at Attala. These two samples give, upon analysis—

	265.	268.
	Per cent.	Per cent.
Metallic iron	54.48	56.04
Phosphorus	0.640	0.430
Phosphorus in 100 parts iron...	1.174	0.767

This shows an important difference, and is to be accounted for by the fact that the ore in the stock-pile was a taken from much nearer the outcrop, and had been some months in the pile, and, as above shown, the outcrop is likely to show lower phosphorus than ore deeper from the surface. To illustrate this further, a sample was taken from a second stock-pile at Attala, representing only the "crop-ore" taken by stripping along the exposed bed. This sample shows, upon analysis—

	266.
	<i>Per cent.</i>
Metallio iron	53.78
Phosphorus	0.487
Phosphorus in 100 parts iron	0.906

b

Farther northeast upon the mountain, in the same section, the vein has again been opened, on property leased by the South Pittsburg Iron Company, Marion county, Tennessee. An incline here enters upon the bed, and, when visited, had reached a depth of 30 to 40 feet. At this depth the mining was stopped, on account of the hardening of the ore, which changes to the same dense bluish limestone shown at the Springville mines. The sample was taken from the soft portion of the ore, and shows, upon analysis—

	267.
	<i>Per cent.</i>
Metallio iron	53.00
Phosphorus	0.041
Phosphorus in 100 parts iron	1.197

c

The bed of fossil ore at this point is much disturbed. Dipping to the northwest at the Rising Fawn mine, it then becomes vertical as it runs north along the crown of the western slope to the South Pittsburg property, where it dips to the southeast.

Two samples of ore from the property of Rathburn, Foster & Winchester, on Sec. 34, T. 11, R. 5. E., were collected at the South Pittsburg furnaces. Sample 270 represents a soft porous ore, and 271 a dense, hard, crystalline ore. The samples contained:

d

	270.	271.
	<i>Per cent.</i>	<i>Per cent.</i>
Metallio iron	45.98	81.30
Phosphorus	0.412	0.375
Phosphorus in 100 parts iron ..	0.806	1.108

Sample 267 has been subjected to complete analysis, and gives the following result:

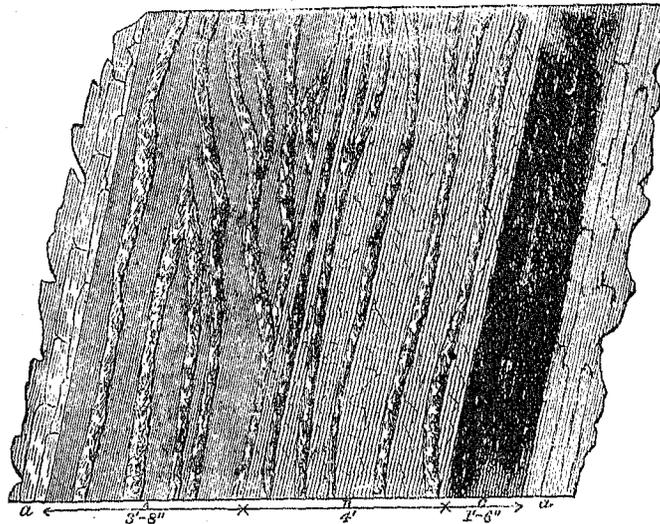
267.		267.	
	<i>Per cent.</i>		<i>Per cent.</i>
Sulphur	0.085	Phosphoric acid	1.460
Phosphorus	0.041	Carbon in carbonaceous matter	0.04
Iron, metallio	53.00	Hygroscopic water	1.02
		Water of composition	0.00
		Total	100.193
Silica	10.52	Per cent. of insoluble silicious matter	13.31
Iron, protoxide	0.40		
Iron, peroxide	75.90	Silica	10.52
Alumina	5.58	Alumina	2.35
Manganese, protoxide	0.23	Lime	0.05
Lime	2.23	Magnesia	0.20
Magnesia	0.52	Potassa	0.17
Iron, disulphide	0.124	Soda	0.01
Potassa	0.17		
Soda	0.01	Total	13.30
Carbonic acid	0.00		
Sulphuric acid	0.05		

e

f

Some few openings of small importance have been made upon the dyestone bed, between Attala and the Georgia line, on the Alabama and Chattanooga railroad, which follows the eastern base of Red mountain, but only a few tons have been taken.

a In Sec. 30, T. 15, R. 1 W., in the northern part of Jefferson county, on that portion of the dyestone range known as Little Red mountain, two outcrops of ore were sampled, the first at *Massey's mill*, on Turkey creek, where the ore-bed was exposed by the mill-race. The vein, which was here almost vertical, is shown in the accompanying cut.



- c** A. Gray slate with thin seams of fossil ore.
- B. Yellow clay with thin seams of fossil ore.
- C. Seam of fossil ore.
- D. Consolidated decomposed sandstone

FIG. 160.—SECTION NEAR MASSEY'S MILL, JEFFERSON COUNTY, ALABAMA.

The running water in the mill-race made this face inaccessible, and the measurements are only approximate. The sample was taken from lumps of ore thrown out in digging the race, and shows, upon analysis—

	210.
	<i>Per cent.</i>
Metallic iron	36.58
Phosphorus	0.324
Phosphorus in 100 parts iron	0.886

The bed was again sampled on Mr. Rodgers' land, 1 mile farther down the creek, from an outcrop 50 yards from the county-road crossing. This is a hard, lean ore, showing, upon analysis—

	211.
	<i>Per cent.</i>
Metallic iron	28.22
Phosphorus	0.061
Phosphorus in 100 parts iron	0.216

The *Round Mountain furnace* is situated in Sec. 33, T. 9, R 9 E., in Cherokee county, on the side of a steep hill, in which its ore-bed is located. The ore is a red fossil ore, occurring in a well-defined vein and mined in open pits and trenches. Three samples were here taken, which show, upon analysis—

	262.	263.	264.
	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>
Metallic iron	59.0	53.39	57.18
Phosphorus	0.084	0.104	0.098
Phosphorus in 100 parts iron ..	0.142	0.178	0.171

No. 262 is an average sample taken from the stock-pile at the furnace. No. 263 is from an old pile of some few tons of roasted ore left at the furnace top some six years previous. No. 264 was taken from four pits on the bank 50 feet apart. This ore was being piled for roasting. The furnace is now in the hands of the Round Mountain Coal and Iron Company.

CARBONIFEROUS LIMONITES.

The limonites of the Carboniferous age were sampled at only two points. The first from Jefferson county, a Sec. 25, T. 17, R. 1 W., where the ore was once dug for a Catalan forge on a near branch of Cahaba river. The crown of a small hill was covered with pits for the space of an acre, and the sample was drawn from such loose lumps as could be found, giving, upon analysis—

	221.
	<i>Per cent.</i>
Metallic iron.....	52.30
Phosphorus.....	0.057
Phosphorus in 100 parts iron.....	0.109

b

A second sample was taken from loose lumps scattered over the surface of a low hill in the SE. $\frac{1}{4}$ of Sec. 9, T. 16, R. 1 W., in Jefferson county, and yields upon analysis—

	212.
	<i>Per cent.</i>
Metallic iron.....	51.94
Phosphorus.....	0.301
Phosphorus in 100 parts iron.....	0.580

c

These ores occur in loose, sandy, light-colored clay, associated with much white and yellow chert, and are very irregular in deposit.

BLACK-BAND ORES.

The black-band iron ores, as has been stated, are mined at only one locality in the state, on the land of the Newcastle Coal and Iron Company, at Newcastle station on the North and South Alabama railroad, in the SW. $\frac{1}{4}$ of the NE. $\frac{1}{4}$ of Sec. 17, T. 16 S., R. 2 W. The ore is reached by means of a tunnel running with the strike of the bed, which dips northwest. The accompanying cut shows a section, with the strike of the beds, taken on the southeast wall of the farther end of the tunnel:



- 1. Black slate.
- 2. Gray shale.
- 3. Black slate.
- 4. Black band ore, 2 inch.
- 5. Brown shale.
- 6. Black band ore.

FIG. 161.—SECTION NEAR NEW CASTLE STATION, JEFFERSON COUNTY, ALABAMA.

Sample 209 was taken from the lower 12-inch seam, the only one worked on the ore proper, though some attempt was being made to render the dark shale above it valuable by burning. Sample 208 was taken from the 7-inch seam of brown shale. Sample 207 was taken from the stock-pile of roasted ore at Oxmoor furnace from a 12-inch seam. These three samples give, upon analysis—

	207.	208.	209.
	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>
Metallic iron	43.45	8.38	20.48
Phosphorus.....	0.228	0.115	0.104
Phosphorus in 100 parts iron...	0.524	1.372	0.658

Besides the above-enumerated ores there are many deposits, mentioned in the geological reports of Alabama which have not as yet been either located or examined with a view to mining.

NOTES ON THE SAMPLES OF IRON ORE COLLECTED IN ALABAMA.

BY BAILEY WILLIS.

c The following notes on a few of the Alabama iron ores were taken during a short visit to the state in April, 1881. The previous report by Mr. W. M. Chauvenet contains the description of all those deposits it was at first intended to take notice of. Those herein described are nearly all known only by their outcrops, and are as yet of but little commercial importance. In addition to these, there are the limonites of the sub-Carboniferous along the Coosa river, a number of outcrops of limonite in the great Lower Silurian limestone belt, and some outcrops of magnetic ore in the metamorphic rocks. These could not be examined on account of the more important work to be completed in other states.

The following are the iron ores herein reported upon: Limonite, on the farm of Mr. J. H. Pendergrass, near Davisville, Calhoun county; magnetic ore, on the farm of Mr. J. M. Kennedy, near Delta, Clay county; limonite, near Russelville, Franklin county; limonite, near Vernon, in Lamar county.

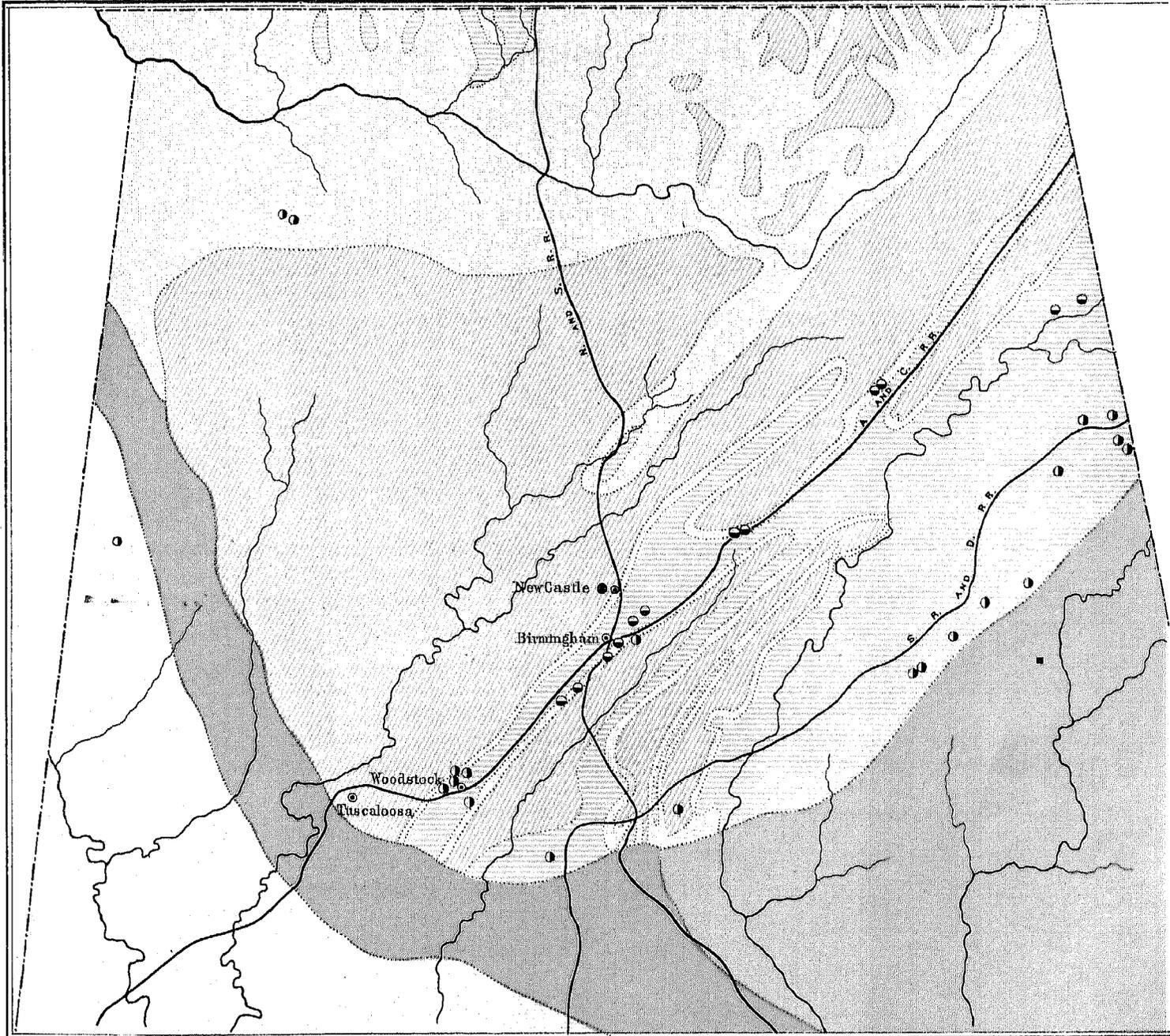
d Davisville lies in a valley of Lower Silurian limestone, between the slates of the Metamorphic group on the east and a ridge of Potsdam sandstone that rises to a height of 200 feet on the west. The little village itself stands on a limonite bed, which has been penetrated to a depth of 60 feet in wells. A mile farther north is the farm of Mr. Pendergrass. In the meadows west of his house the ore crops out in place, forming little knolls, and surface pieces are thickly scattered over the eastern slope of the ridge almost to the summit, where the Potsdam sandstone appears. Two samples were taken on Mr. Pendergrass' property—one from the pieces on the ridge, the other from the outcrops in the meadows. The analyses give—

	RIDGE.	MEADOW.
	1201.	1202.
	<i>Per cent.</i>	<i>Per cent.</i>
Metallic iron	53.29	54.86
Phosphorus.....	0.423	0.184
Phosphorus in 100 parts iron	0.720	0.335

These ores are now 12 miles from the nearest railroad at Oxford; but it is claimed that the projected railroad from Atlanta, Ga., to Birmingham will pass through Davisville, in which case they will be immediately on the line of transportation.

f There are a number of localities in eastern Alabama and central Georgia whence specimens of magnetic ore have been received. They are all granular, more or less silicious, weathered fragments. Their appearance leads to the inference, which all reports confirm, that these are small surface pieces found lying loose in the ground. So far as is known to the writer, no ore has been found in place in these localities.

Professor E. A. Smith, state geologist, pointed out the farm of Mr. J. M. Kennedy, in the northeastern corner of Clay county, as the most promising point of occurrence of this ore. It was visited by the writer. Loose pieces of a distinctly-stratified, very silicious, magnetic schist are thickly scattered in a narrow belt, having a general northeast-southwest course in a level plowed field. Layers of coarsely-granular magnetite, from one-quarter to 3 inches thick, are inclosed between similar layers of much leaner ore, or even pure-white crystalline quartz. Some of the ore is much finer-grained, and is slightly altered to martite. No specimen of pure magnetite more than 3 inches thick was found.



Julius Bien & Co. Lith.

IRON ORE SAMPLE MAP OF ALABAMA.

Geology from Geological Map of Alabama by Eugene A. Smith, 1878.



Drift.



Cretaceous.



Coal Measures.



Sub-Carboniferous.



Silurian & Devonian.



Metamorphic.

○ Limonite.

● Fossil.

● Black Band.

■ Magnetite

Scale: 25 miles = 1 inch.



The following is the analysis of the sample taken from the surface-pieces. It is probably richer than the average of the ore, if taken out in large quantities, while it would be easy to pick out individual specimens much richer than this sample :

	1203.
	<i>Per cent.</i>
Metallic iron	58.51
Phosphorus.....	0.004
Phosphorus in 100 parts iron	0.100

b

In the geological map of Alabama all the northwestern corner of the state is colored for the sub-Carboniferous limestone.

Professor Smith himself pointed out, however, that a high ridge which extends east and west and is crossed by the road from Tusculumbia to Russelville is probably formed by the sandstones and shales at the bottom of the Coal Measures. The underlying limestones form the valley in which Russelville lies, and there, as throughout western Tennessee, are associated with limonite. West of Russelville a small creek flows north and south. Upon the gentle slopes either side of this creek pieces of limonite are so thickly and so widely scattered as to give the impression of very large deposits beneath the surface. That deposits of very considerable extent exist here is certain; but they are probably very superficial, and the amount of ore to the acre is likely to be comparatively small.

c

Two samples were taken from a large number of surface-pieces, one from the lands of Mr. *T. B. Fleming*, Sec. 28, T. 6, R. 11 W.; the other from the property of Dr. *Sevier* Sec. 29, T. 6, R. 11 W:

	T. B. FLEM- ING.	DR. SEVIER.
	1204.	1205.
	<i>Per cent.</i>	<i>Per cent.</i>
Metallic iron	55.80	56.80
Phosphorus	0.590	0.527
Phosphorus in 100 parts iron ..	1.061	0.926

d

Two miles west of Vernon, in Lamar, formerly Sandford, county is an old furnace which used a limonite ore dug in the hill immediately adjacent to the furnace. This hill and one half a mile southwest of it are the highest in the neighborhood; they rise, perhaps, a hundred feet above the valley. They are formed of the red clay and pebble beds peculiar to the drift formation in the southern states. Above these is a horizontal bed of bog-iron ore 3 to 6 feet thick, and the summit is formed of red soil 8 to 10 feet in depth. The surrounding hills are all too low to catch the bed of ore, but it is said to occur in elevations 3½ miles south and 4 to 5 miles northeast on Yellow creek. The ore very closely resembles in its open texture bright luster, and in the inclosure of woody fragments the bog-ores of eastern North Carolina.

e

Two samples were taken—one from pieces of raw ore found in the old pits near the summit of the hill, the other from a mass of roasted, much-agglomerated ore.

	RAW ORE.	ROASTED ORE.
	1206.	1207.
	<i>Per cent.</i>	<i>Per cent.</i>
Metallic iron	55.04	62.65
Phosphorus	0.191	0.265
Phosphorus in 100 parts iron ..	0.347	0.428

f

NOTES ON THE SAMPLES OF IRON ORE COLLECTED IN MISSOURI.

BY W. M. CHAUVENET.

It is the purpose of this paper to describe only the opened and working deposits of ore in the state. The extensive deposits of limonite so widely scattered throughout the region as yet remain untouched for mining purposes, though for the most part located by the several geological surveys. Samples taken from surface-lumps on unopened banks of limonite are unsatisfactory, and the analyses of such samples seldom give an idea of the deposit as a whole, and are therefore only misleading. The samples taken were therefore entirely from the specular ores and the soft hematites of southeast and central Missouri, which are at present the only ores in use.

SPECULAR ORES IN PORPHYRY (ARCHÆAN).

Iron mountain, situated in Saint François county, Sec. 31, T. 35, R. 4 E., is the largest deposit of ore of any kind yet discovered in Missouri.

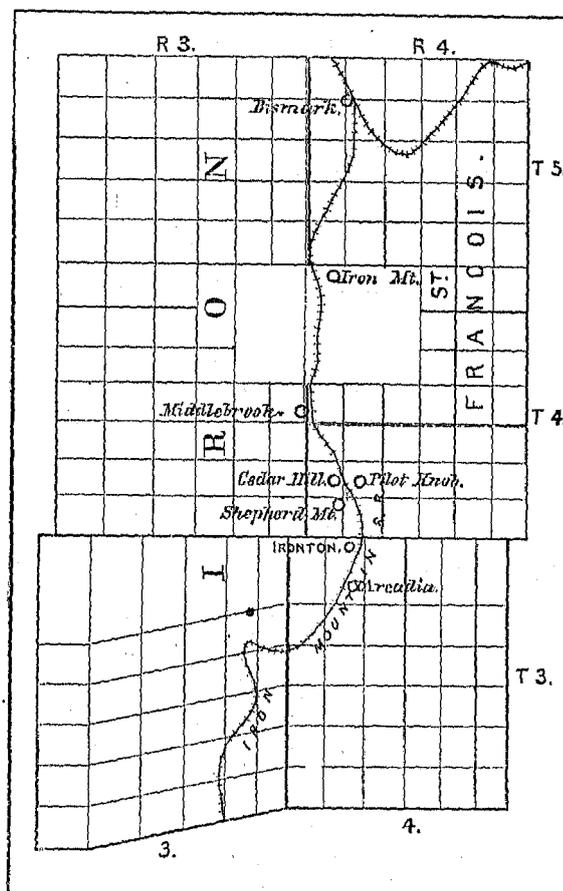
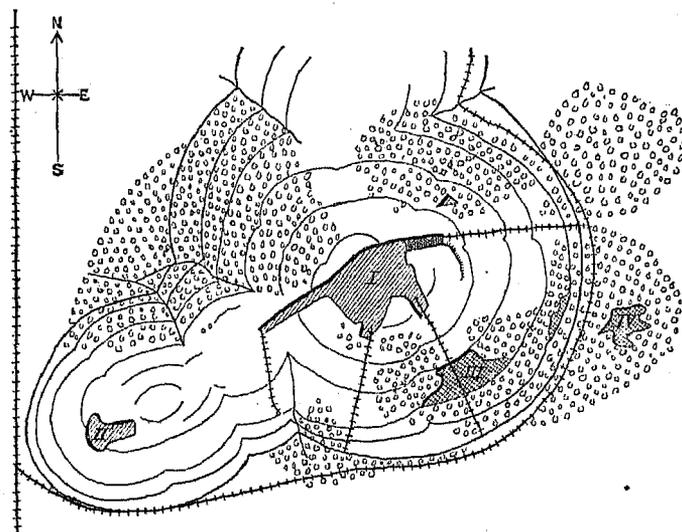


FIG. 162.—IRON MOUNTAIN, PILOT KNOB AND VICINITY.

For an external description of the mountain, see report of Dr. A. Litton (p. 75, *Second Annual Report of Missouri*, G. C. Swallow). For a geological description of the region, see *Geological Survey of Missouri*, R. Pumpelly, 1872, Part I, pp. 10 and 99.

a Fig. 163 is an outline sketch of the mountain, showing the present openings upon the ore. The cuts A, B, C, D, E, shown in the volume of 1872 (chap. V, p. 100), now constitute one large opening on the crown, shown at I (Fig. 163).



SKETCH OF IRON MOUNTAIN.

Scale. 1000 Ft.

FIG. 163.

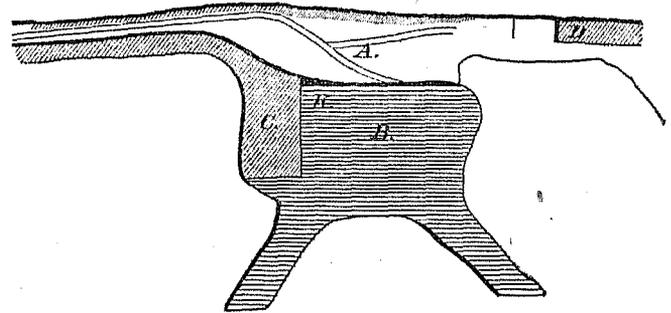


FIG. 164.—PLAN OF MAIN PIT, IRON MOUNTAIN, MISSOURI.

This cut is worked in three levels or benches, A, B, C (Fig. 164), which change their relative shapes and dimensions as the veins of ore vary and are followed.

A is the upper level, B the second, and C the third. At II, on the southwest spur, the vein is worked in five benches, descending in steps of 10 to 15 feet to a depth of 80 feet, all attacking the same lead of ore. The pit now collects much water, and constant pumping is necessary. The surface ore is at present principally worked on the southeast slope of the mountain, at III and IV, Fig. 163.

The vein ore of Iron mountain is a massive blue specular ore, having a metallic luster, a more or less crystalline structure, at times highly crystalline, and a hardness of about 6. Its fracture shows a bright steely surface, and the streak is of a cherry red, often of a rich purple color. It is more or less magnetic, the pure, highly crystalline varieties showing at times strong attraction and distinct polarity, while other varieties act but faintly on the needle and show no polarity whatever. (a)

The ore is much contaminated in places by clear quartz in irregular masses, and by well-defined and thickly-scattered crystals of pink apatite, the latter being most common. Though these crystals of apatite are for the most part unaltered, in certain exposed portions of the veins they have completely decomposed, leaving the impressions of their hexagonal prisms, which often give to the ore a honeycombed appearance. The apatite seems at the present time to be increasing at C (Fig. 164), as a greater depth is reached; but similar areas of impure ore containing crystals of apatite as thickly scattered, were seen at higher levels when the mountain was visited in 1877.

In the west cut (II, Fig. 163) beautiful specimens of ore were obtained, having much the appearance of an open-grained Bessemer pig-iron, filled with large, splendid, lamellar, crystals, and more coarsely crystalline than anywhere else mined on the mountain.

The surface ore, the main distributions of which are shown in the figure, is similar to the vein ore in character, though it occurs in worn and rounded pebbles, scattered over the surface and through the surface clay to a depth in some places as great as 50 feet. It varies in size from boulders 2 feet in diameter to the finest sand, all of which is now being saved by the process of hydraulic mining and washing now in use.

f The following are the analyses of average samples of different varieties of the ore from Iron mountain:

	542.	543.	544.	545.	546.
	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.
Metallic iron.....	66.93	59.06	65.57	64.67	62.84
Phosphorus.....	0.071	0.398	0.082	0.019	0.005
Phosphorus ratio.....	0.106	0.674	0.049	0.029	0.008

No. 542 is a sample of No. 1 ore at K, level B (Fig. 164). Fine-grained variety free from apatite or quartz. No. 543 is the No. 2 ore from deepest level, C. It is a dense blue ore, thickly scattered, with crystals of apatite. No.

a The ore of Iron mountain is really martite, altered from magnetite.—R. P.

544. Surface ore, chestnut size, from C and D). No. 545. Finest of surface ore from the same cuts; taken from a sorted pile of 100 tons at the washer. No. 546. No. 1 ore; large, lamellar crystals; free from apatite or quartz; strongly magnetic; taken from the fourth level, from the top, at the west cut, II (Fig. 163).

The mountain had yielded 2,258,922 tons of ore up to June, 1880.

Pilot Knob, in Iron county, Sec. 29, T. 34, R. 4 E., is a second great deposit of specular ore in porphyry (see description of Dr. A. Litton, *Second Annual Report of Missouri*, p. 79; also, *Missouri Geological Survey*, 1872, Part I, pp. 1, 109). Since the above reports were written the ore-bed has been extensively worked.

In the spring of 1879 underground work was commenced on the ore-bed, which was attacked at two points by tunnels running with the strike, the lower tunnel entering from the level of cut A, the upper tunnel from cut B (*Geological Survey of Missouri*, 1872, Part I, p. 110).

Since no survey of the workings had been made at the time when visited no diagrams could be obtained; the excavations, however, are confined to the ore-bed proper, and the ore is worked in large rooms 50 feet square, separated by ribs or walls 20 feet thick for the purpose of support. The first room opening from the lower tunnel is 75 feet from the tunnel mouth. The ore-bed in this chamber is 25 feet in thickness, overlaid by a seam of slate 1 foot thick, which is taken out in mining the ore. The north wall of this room exposed a working-face 30 by 40 feet in solid ore. The lower 20 feet were composed of the finest ore on the knob, graded as No. 1. Sample 538 was taken on this face over an area 38 by 20 feet, all No. 1 ore.

This sample yields, upon full analysis, results as follows:

538.		538.	
	<i>Per cent.</i>		<i>Per cent.</i>
Sulphur	0.020	Phosphoric acid	0.011
Phosphorus	0.005	Hygroscopic water	0.12
Iron, metallic	50.52	Water of composition	0.37
Phosphorus ratio	0.008	Total	100.311
Silica	12.17	Per cent. of insoluble silicious matter	13.78
Iron, protoxide	0.78	Silica	12.17
Iron, peroxide	84.16	Alumina	1.11
Alumina	2.21	Lime	0.04
Lime	0.04	Magnesia	0.04
Baric oxide	0.10	Soda and potassa	0.22
Magnesia	0.04	Barium, sulphate	0.15
Sulphuric acid	0.05	Total	13.78
Soda and potassa	0.22		
Carbonic acid	0.04		

The upper tunnel, on April 30, 1880, had reached a distance upon the ore of 260 feet, running with the strike; this tunnel, 10 feet in diameter, widens into three chambers of similar dimensions to those of the lower tunnel.

A sample was taken at the extreme end of the tunnel deepest upon the bed, from the driving-face, on a bench near the roof. The sample represents the ore directly beneath the slate-seam, and was taken over 50 square feet of surface.

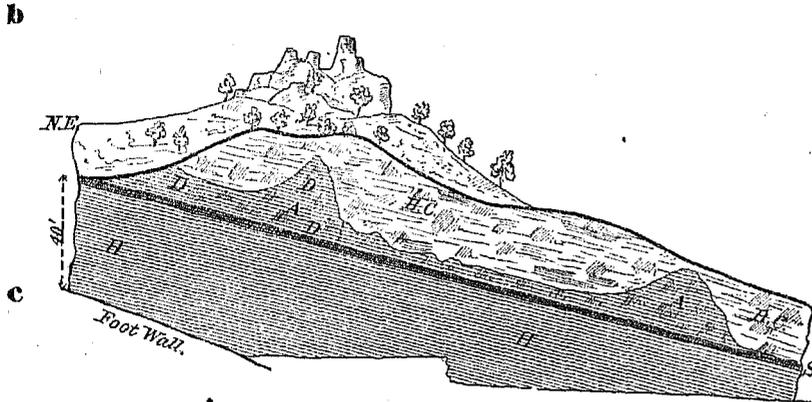
This sample gives, upon analysis, results as follows:

530.		530.	
	<i>Per cent.</i>		<i>Per cent.</i>
Sulphur	0.320	Carbon in carbonaceous matter	0.01
Phosphorus	0.018	Hygroscopic water	0.05
Iron, metallic	52.57	Water of composition	0.43
Phosphorus ratio	0.034	Total	100.071
Silica	18.71	Per cent. of insoluble silicious matter	23.74
Iron, protoxide	0.87	Silica	18.71
Iron, peroxide	73.13	Alumina	2.10
Alumina	2.87	Lime	0.04
Lime	0.04	Magnesia	0.06
Magnesia	0.06	Barium, sulphate	2.31
Sulphuric acid	0.80	Soda and potassa	0.47
Barium oxide	0.51	Total	23.78
Carbonic acid	0.08		
Phosphoric acid	0.041		
Soda and potassa	0.47		

The accompanying section (Fig. 165), taken from the *Missouri Geological Survey*, 1872, shows the exposure in what was formerly known as the "Big cut." Though no ore was mined above the slate-seam marked S, a selected sample was here taken from D, D, D. Though mostly composed of a dense and highly silicious porphyry, this often grades into good ore-masses, which may be distinguished by their higher metallic luster. From these seemingly good

a bunches of ore a sample was selected, avoiding the porphyry entirely, with a view to showing what might be saved from this upper bed by careful sorting. The sample so taken yields, upon analysis—

	540.
	<i>Per cent.</i>
Iron	50.40
Phosphorus	0.025
Phosphorus ratio	0.050



SECTION ON PILOT KNOB.

FIG. 165.

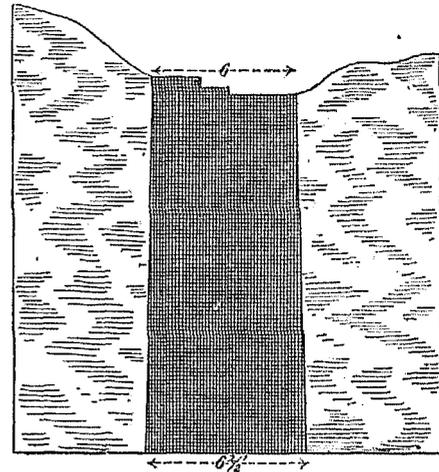


FIG. 166.—SECTION AT SHEPHERD MOUNTAIN, IRON COUNTY, MISSOURI.

(For a description of the ore, its qualities and appearance, see *Geological Survey of Missouri*, 1872, pp. 56-59.)

Shepherd mountain, situated in the NE. $\frac{1}{4}$ Sec. 31, T. 34, R. 4 E., in Iron county, 1 mile southwest of Pilot Knob, is the third great deposit of specular ore in porphyry of this region. In its general characteristics the deposit **d** much resembles Iron mountain, though the large deposit of surface-ore is wanting, and the porphyry is not so thoroughly decomposed. Two main cuts have been made on the ore, though the amount of ore taken has been comparatively small. The west cut has been recently reopened and some 700 tons taken out from a newly-exposed vein, a section across which is shown in Fig. 166.

This vein, which had been covered by an old dump-pile, strikes east and west where exposed, and rises between walls of yellow clay, showing no signs of porphyry or evidences of stratification. The ore of Shepherd mountain is of most excellent quality, and though sufficient work has not been done to determine its probable extent, the deposit is undoubtedly large.

The ore is very similar in appearance to that of Iron mountain, though in most instances the large splendid crystals resembling graphite are more common, and the streak is darker, varying from a rich dark purple to almost **e** black. It is further distinguished by numerous little cavities lined with minute crystals, or filled with a rich red oxide. A soft green chloritic mineral is also common, and the ore as a whole is softer and less brittle than that of Iron mountain. The ore is magnetic, different lumps showing different degrees of magnetism, and when powdered cling to the magnet more or less strongly. A sample was taken from a stock-pile at the cut, consisting of 700 tons of recently mined ore. It yields, upon complete analysis, results as follows :

	537.		537.
	<i>Per cent.</i>		<i>Per cent.</i>
Sulphur	0.077	Carbonic acid	0.09
Phosphorus	0.013	Phosphoric acid	0.020
Iron, metallic	65.39	Carbon in carbonaceous matter	0.01
Phosphorus ratio	0.020	Hygroscopic water	0.53
		Water of composition	1.00
Silica	3.18	Total	99.902
Iron, protoxide	1.76	Per cent. of insoluble silicious matter	4.27
Iron, peroxide	91.36	Silica	3.18
Alumina	1.37	Alumina (with trace of oxide of iron)	0.87
Manganese, protoxide	Trace.	Lime	0.06
Lime	0.43	Potassa	0.11
Magnesium	0.10	Soda	0.05
Iron, disulphide	0.143	Total	4.27
Copper, sulphide	Trace.		
Potassa	0.11		
Soda	0.05		

Cedar hill, half a mile directly north of Shepherd mountain, has been opened by a small test-pit on the west side near the crown, exposing an ore very similar to that of Pilot Knob. This pit was filled with water, and the sample was confined to 15 feet on the wall along the south side near the surface. The ore gives, upon analysis—

	541.
	<i>Per cent.</i>
Metallic iron.....	66.01
Phosphorus.....	0.006
Phosphorus ratio.....	0.009

SPECULAR ORES IN SANDSTONE (LOWER SILURIAN).

The specular ores of central Missouri, and their accompanying hematites, occur in what is known as the "Second sandstone" (*Second Geological Report of Missouri*, p. 125), or in the chert associated with that bed. Throughout the central region, especially in Dent, Phelps, and Crawford counties, this second sandstone is greatly faulted and broken, and it is in the cavities and depressions thus formed that the specular ores occur. The deposits are usually either lenticular or funnel-shaped, and their extent is very uncertain, so much so indeed that it is quite impossible to estimate with any degree of accuracy the amount of ore in any one bank. This will be further illustrated in the descriptions that follow. The ores are of three kinds; their general characteristics may be described as follows: c

1. The specular ore when freshly fractured is of a bluish-gray to a steel-gray color. It is dense in the mass, close-grained, more or less crystalline in structure, and has a hardness varying from 5½ to 6½. The fracture is

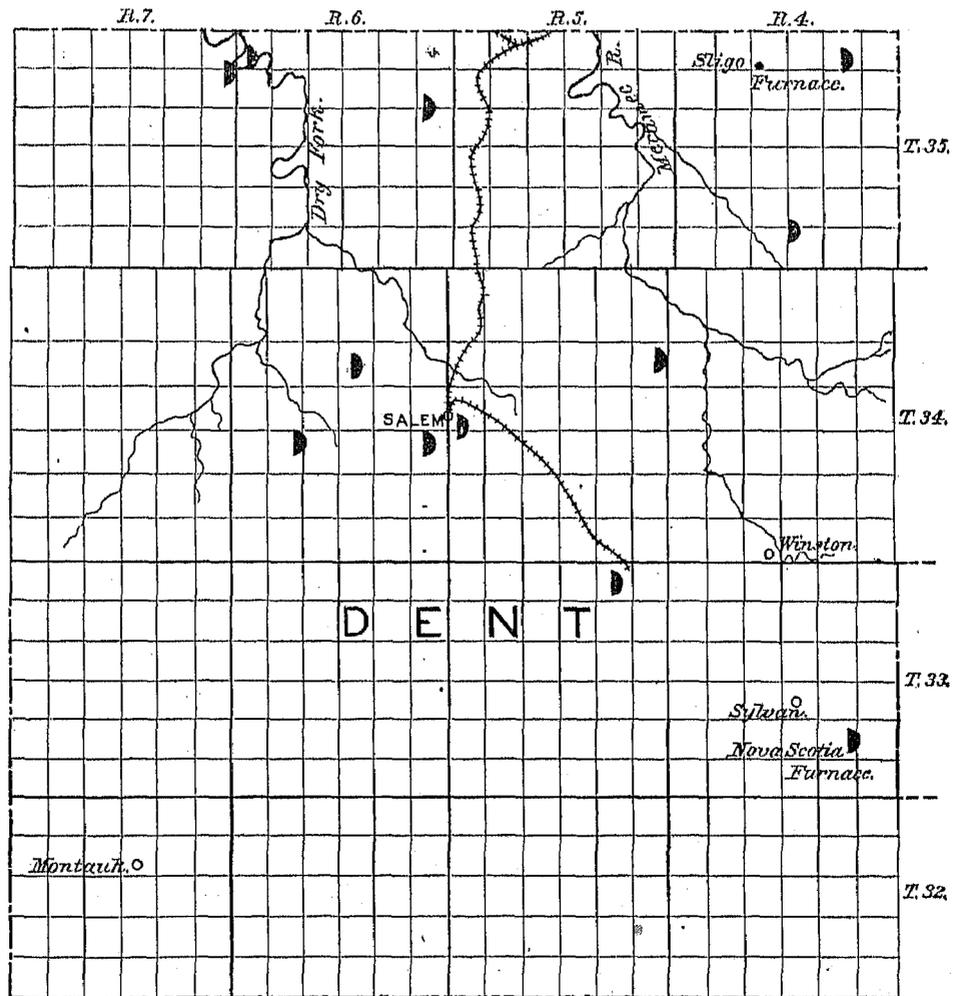


FIG. 167.—MAP OF DENT COUNTY, MISSOURI, SHOWING BANKS OF SPECULAR ORE SAMPLED.

brittle, and the fragments sharply angular. The ore is scattered throughout with minute cavities, lined in most instances with fine splendid crystals of hematite, but often with clear quartz and soft red oxide. These drusy cavities, though usually dull and velvety in luster, at times glow with the most brilliant prismatic colors. Yellow jasper is in places largely associated with the ore occurring in fine veins and irregular bunches in the mass, at times in such quantities as to render it unfit for use. Defined prisms of clear quartz are not uncommon.

a 2. The hard red hematite is the partly decomposed specular ore not yet reduced to a powder; it usually surrounds the specular ore, and occurs in broken lumps. It is of a deep-red or purple color, porous, and of a dull earthy luster and fracture. Remains of the original specular ore at times form a fine tracery through the mass, and occasional drusy cavities remain with their crystals still intact.

3. The soft hematite results from the thorough decomposition of the specular ore, and is associated with it and surrounds it in every degree of change. It occurs as a soft unctuous clay, usually of a rich purple color, leaving its stain freely upon all that it touches. When a surface is rubbed smooth with the hand it has a bright, almost metallic, luster, and a greasy feeling.

THE SALEM DISTRICT (DENT COUNTY).

b *Nova Scotia furnace*, in process of erection, is situated in the NE. $\frac{1}{4}$ of the SE. $\frac{1}{4}$ Sec. 26, T. 33, R. 4 W. Its ore-bank occupies the crown and south slope of the hill directly north of the furnace, and has been located by a number

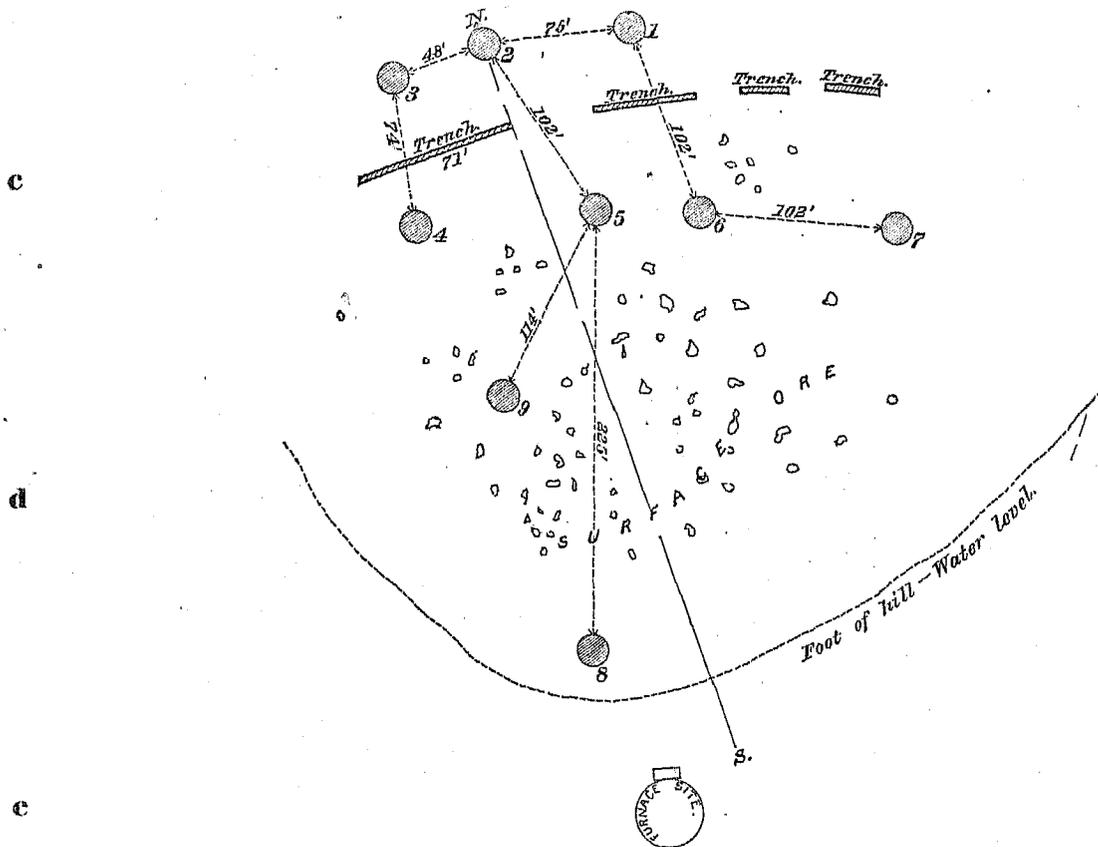
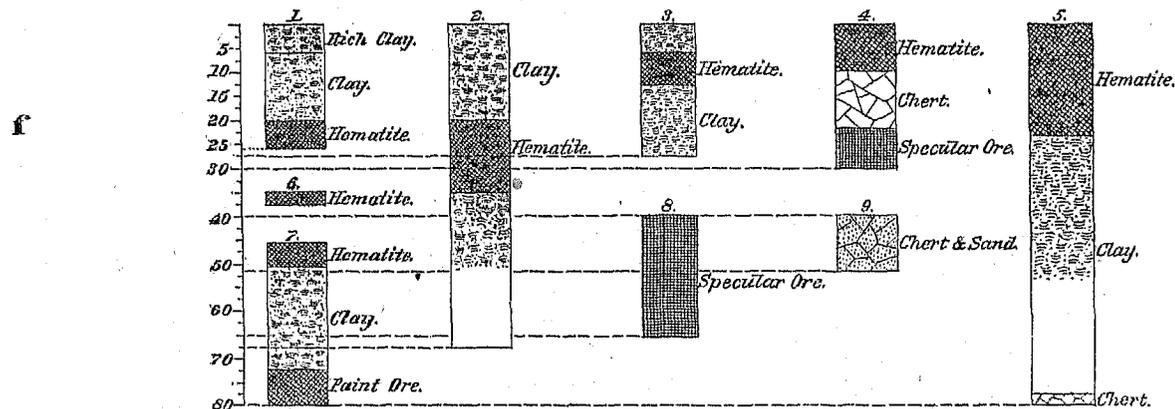


FIG. 168.—NOVA SCOTIA FURNACE AND VICINITY, DENT COUNTY, MISSOURI.

of vertical shafts, the positions of which are shown in Fig. 168. The sections exposed by these shafts are shown in Fig. 169. The deposit is one of specular ore in chert, and, as shown by the sections, is more or less changed to hematite in places.



NINE PITS ON NOVA SCOTIA BANK.—SECTIONS.

FIG. 169.

The surface of the hill, especially between pits 5 and 8, is thickly scattered with lumps of specular ore. The analyses of two samples taken give results as follows:

	563.	504.
	<i>Per cent.</i>	<i>Per cent.</i>
Metallic iron.....	63.77	67.02
Phosphorus.....	0.061	0.025
Phosphorus ratio.....	0.090	0.037

No. 563 is a hematite from pit No. 5; red on exposed faces, grayish blue when freshly fractured, porous, with clay-build cavities. No. 564 is a dense specular ore from pit No. 8.

The *Riverside* bank, in Sec. 2, T. 33, R. 5 W., has been recently opened and connected by rail with the Salem and Little Rock railroad at Salem. Several hundred tons of specular ore were taken from the area marked B, Fig. 170, where the ore was first attacked, but the bulk of the output was coming from A A when the bank was visited, and was a soft, unctuous, purple ore, surrounding denser cores of a greenish hue.

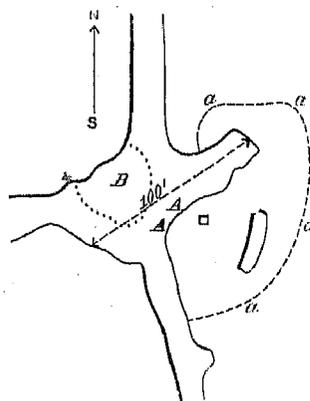


FIG. 163.—SKETCH OF THE RIVERSIDE BANK, DENT COUNTY, MISSOURI.

Two samples were here taken, which offer a direct comparison between the soft, unctuous hematite and the dense specular from which it is derived by decomposition. These samples were subjected to complete analysis, with the following results:

	505.	506.		565.	566.
	<i>Per cent.</i>	<i>Per cent.</i>		<i>Per cent.</i>	<i>Per cent.</i>
Sulphur.....	0.020	0.179	Carbon in carbonaceous matter.....	0.01	0.02
Phosphorus.....	0.029	0.063	Hygroscopic water.....		0.40
Iron, metallic.....	63.90	64.05	Water of composition.....	0.15	3.15
Phosphorus ratio.....	0.045	0.098	Total.....	90.903	90.800
			Per cent. of insoluble silicious matter.....	7.95	3.56
Silica.....	7.15	2.56	Silica.....	7.15	2.56
Iron, protoxide.....	1.19	0.46	Alumina.....	0.80	1.01
Iron, peroxide.....	89.93	90.77	Lime.....	0.01	0.02
Alumina.....	0.81	1.35	Magnesia.....	0.05	0.04
Lime.....	0.34	0.13	Total.....	8.01	3.63
Magnesia.....	0.09	0.06			
Iron, disulphide.....	0.637	0.337			
Carbonic acid.....	0.13	0.12			
Phosphoric acid.....	0.066	0.143			

Sample 565 is the specular ore from B. Sample 566 is the soft hematite from A A.

Simmons' Mountain, one of the largest deposits of specular ore in this region, is situated a quarter of a mile southwest of Salem, in the NW. $\frac{1}{4}$, Sec. 24, T. 34, R. 6 W. The deposit, occupying the center of a hill 90 feet high, has been worked in a large open cut, 300 to 400 feet wide at the top and irregularly excavated to a depth of something over 100 feet. The mountain had yielded, up to May 1, 1880, 164,763 tons. The bulk of the ore now occupies the bottom of the south side of this vast pit, where it is being mined by sinking vertically. This portion of the workings was flooded at the time when visited, and no samples could be obtained from the greatest depth upon the bed. Extensive stripping was in progress over the greater part of the pit, banks 80 feet high being thrown down in places. On this account the working faces were concealed and no opportunity was offered for sampling the varieties of ore, which are specular and both hard and soft hematite.

a A sample was taken which attempts to represent an average of the ore as now mined, though it was confined to 100 tons taken from the southwest side of the deepest working level and from the northeast side of the upper level, near the crown of the hill. It is a mixture of lump hematite and specular ore. This sample gives, upon analysis—

	500.
	<i>Per cent.</i>
Metallic iron	61.97
Phosphorus	0.039
Phosphorus ratio	0.063

b

The *Milsap and Orchard* bank is situated in the southern outskirts of the town of Salem. The open cut is 150 feet in width and 85 feet deep. The body of the hill is of sandstone, which as now exposed forms a broken wall on the east side of the pit through which the opening cut was made. The bottom of the pit was flooded to the depth of 12 feet, and therefore inaccessible. The slope of the hill east of the mine was scattered with surface lumps of specular ore. The product of the mine was a dense, blue specular ore, surrounded by soft, earthy hematite, both varieties being represented in a stockpile of some hundred tons. The following are analyses of these ores:

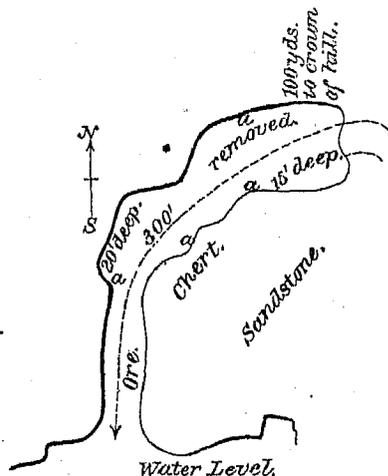
	501.	502.
	<i>Per cent.</i>	<i>Per cent.</i>
Metallic iron	57.06	60.39
Phosphorus	0.067	0.040
Phosphorus ratio	0.116	0.066

c

No. 561 is an average sample of a mixed pile of earthy hematite and specular ore, the hematite comprising two-thirds of the pile. No. 562 is the surface ore, from 20 tons after jigging.

The *Pomeroy* bank in the NW. and SW. $\frac{1}{4}$ Sec. 10, T. 34, R. 6 W., has proved one of the most extensive in this vicinity. Fig. 171 shows the present opening, which has reached a depth of about 20 feet, and shows shoulders of ore over the greater part of the bottom. Large masses of specular ore have been removed from the body of the pit, though at present the ore is principally hematite. This hematite is for the most part an altered limonite, and shows the stalactitic forms of the latter, while beautiful specimens of limonite are found near the surface of the hill, and at times deeper in the cut, having the radiating structure due to the rose crystals of pyrite from which they are derived. Rich masses of unctuous hematite, having a botryoidal form, sometimes drawn out into contorted stalactites, are also found. Porous varieties of limonite of a gray tint are found in the body of the deposit, closely associated with the specular ore; the cavities in such cases are filled with a rich red clay.

e



f

FIG. 171.—SKETCH OF THE POMEROY BANK, DENT COUNTY, MISSOURI.

The ore represented by the sample is principally a hard hematite, showing some lumps of limonite, and giving, upon analysis—

	558.
	<i>Per cent.</i>
Metallic iron	59.99
Phosphorus	0.079
Phosphorus ratio	0.132

The *Thomas* bank in the NE. $\frac{1}{4}$ Sec. 20, T. 34, R. 6 W., shows some peculiarities in its manner of occurrence. **a** Fig. 172 gives the dimensions of the pit upon the deposit. The shape of the ore-mass removed up to the present

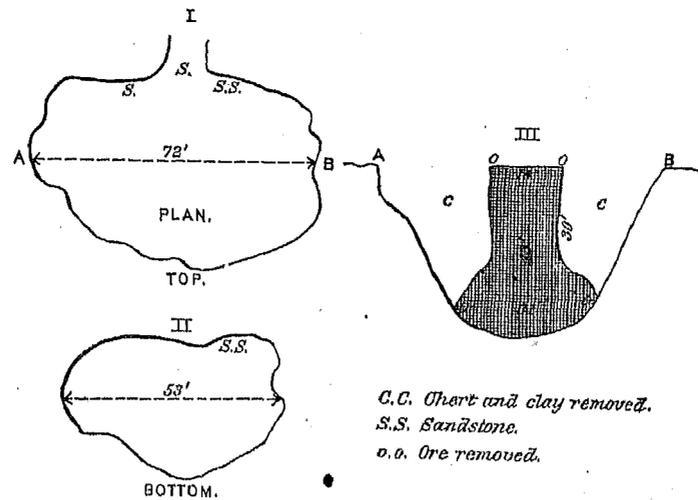


FIG. 172.—SKETCH OF THE THOMAS BANK, DENT COUNTY, MISSOURI.

time is shown in III and resembles an inverted funnel occupying a cavity in a bed of mixed sandstone, associated with chert. The ore is principally a soft hematite, showing lumps of fine columnar stalactitic ore at times. Some of these stalactites are jointed and somewhat resemble crinoid stems. The sample taken from the whole bottom of this pit, composed of soft crumbling hematite alone, gives upon analysis—

	550.
	<i>Per cent.</i>
Metallic iron	57.78
Phosphorus	0.127
Phosphorus ratio	0.220

Sligo furnace, now in course of erection, is situated in the SW. $\frac{1}{4}$ Sec. 4, T. 35, R. 4 W. The *Sligo* bank has been recently opened 2 miles east of the furnace. The ore so far taken out is all hematite, both hard and soft varieties. Fig. 173 shows the opening cuts upon the hill. Test-pits expose at (a) 6 feet of ore, at (b) 3 feet, at (c)

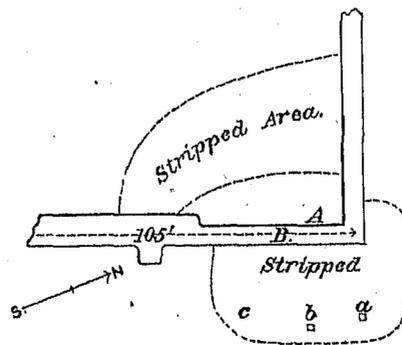


FIG. 173.—SKETCH OF THE SLIGO BANK, DENT COUNTY, MISSOURI.

none. At B at a depth of 3 feet is a bed of the finest most unctuous variety of paint-ore, 7 feet thick, overlain by a thin layer of bright yellow ocher, while a harder variety of hematite overlies this. Samples were taken from both varieties. The analyses are as follows:

	507.	508.
	<i>Per cent.</i>	<i>Per cent.</i>
Metallic iron	65.02	65.03
Phosphorus	0.040	0.026
Phosphorus ratio	0.061	0.040

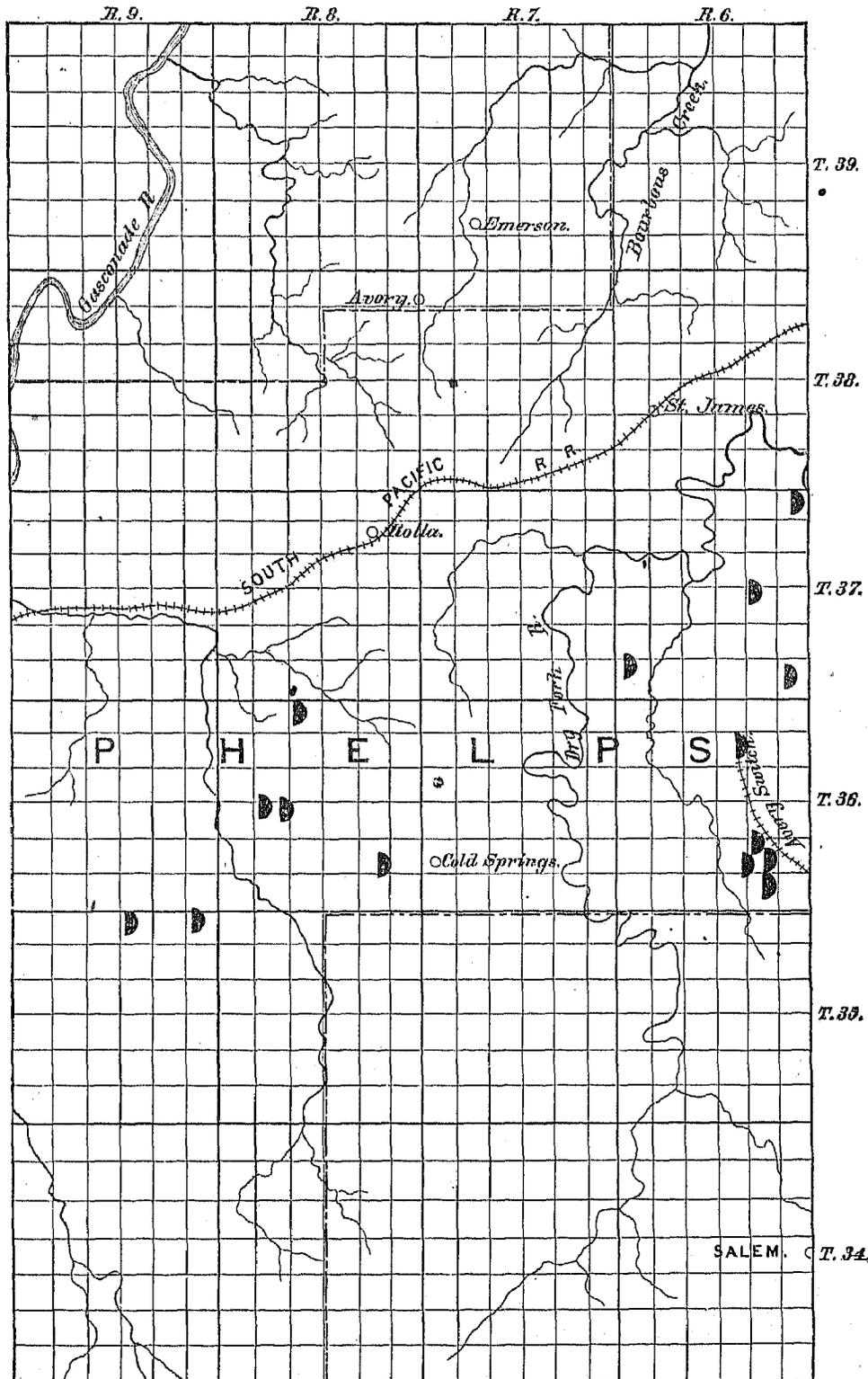


FIG. 174.—MAP OF PHELPS COUNTY, MISSOURI, SHOWING BANKS OF SPECULAR ORE SAMPLED.

No. 567 was taken at *A* from hard hematite partly mixed with soft ore. No. 568 is the finest variety of greasy aint-ore from *B*.

Fitzwater bank, in the NE. $\frac{1}{4}$ Sec. 33, and the NW. $\frac{1}{4}$ Sec. 34, T. 35, R. 4 W., has been recently opened for pig-iron furnace. A shaft was here sunk through 27 feet of solid specular ore. Twenty tons of ore from this shaft offered a fair sample. Some of the lumps show clusters of quartz crystals and yellow jasper, surrounded by clear blue, rather granular specular ore, and coated with red oxide. A sample from this pile shows, upon analysis—

	569.
	<i>Per cent.</i>
Metallic iron	62.95
Phosphorus.....	0.035
Phosphorus ratio	0.056

b

The *Norris* bank in the E. $\frac{1}{2}$ Sec. 13, T. 34, R. 5 W., and the *Thompson* bank, in Sec. 26, T. 36, R. 4 W., are now opened for mining.

Watkins bank, in the NW. $\frac{1}{4}$ of the NE. $\frac{1}{4}$ Sec. 12, T. 35, R. 7 W., has been recently opened. The ore is a soft, netuous hematite, showing many concretionary forms—nodules, hollow shells, and pipe-stems—with a radiating structure in the core, being common forms. Near the surface lumps of limonite are found, showing large rose crystals of unaltered pyrites, sometimes several inches in diameter, the radiating structure of which is presented when the mineral is thoroughly altered to limonite, and even when the limonite in turn has become hematite. The analysis of the soft hematite alone gives—

	555.
	<i>Per cent.</i>
Metallic iron	59.30
Phosphorus.....	0.070
Sulphur	0.060
Phosphorus ratio	0.118

d

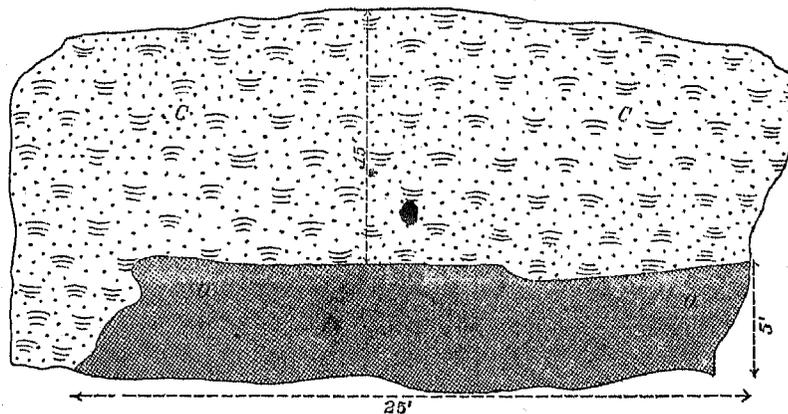
Dry Fork bank, in Sec. 6, T. 35, R. 6 W., is to be opened for mining, surface-ore being now hauled to *Avery switch*.

PHELPS COUNTY.

A large quantity of ore is at present mined in T. 36, R. 6 W., along a branch-track of the *Salem and Little Rock* railroad known as *Avery switch*.

The *Lamb* bank, in the NW. $\frac{1}{4}$ Sec. 35; the *Brady* bank, in the SW. $\frac{1}{4}$ Sec. 26; *Smith* No. 1 and No. 2; the *Hinton* bank, in the NW. $\frac{1}{4}$ Sec. 26, and the *Stinson* bank in the NE. $\frac{1}{4}$ Sec. 10, are the deposits at present worked, though preparations are being made for other openings.

f



C.O. Clay.
O.O. Hematite.

FIG. 175.—SECTION AT BRADY BANK, PHELPS COUNTY, MISSOURI.

The *Smith* banks, Nos. 1 and 2, seem pretty nearly exhausted, and are no longer worked. The *Lamb* bank was yielding a fine quality of blue specular ore, and was opened on the south side of the track by a small cut 100 feet long and 10 feet deep.

a An illustration of the variable nature of some of these deposits, and the uncertainty as to their extent, was offered at the Brady bank.

The opening at the time was a small one, 30 feet square and 15 feet deep, which had yielded a soft hematite, occurring in clay, free from chert or sandstone. When the ore was thought to be exhausted, and four walls of yellow clay alone appeared in the pit, it was decided to put in a final blast on the west side. A charge was therefore driven and the bank was thrown down, when the section shown in Fig. 175 was exposed, which was yielding good ore when visited some weeks later.

The Clinton bank has proved to be one of the most productive in this township. The deposit lies well upon the crown of the hill and has been opened by a pit 200 feet long and 100 feet wide, which descends along an inclined **b** bed of sandstone, to which the ore-bed conforms. Fig. 176 shows a sketch of the east wall of the pit. At a depth of 50 feet the ore seems to dip under the sandstone, and a tunnel is now being pushed horizontally at A.

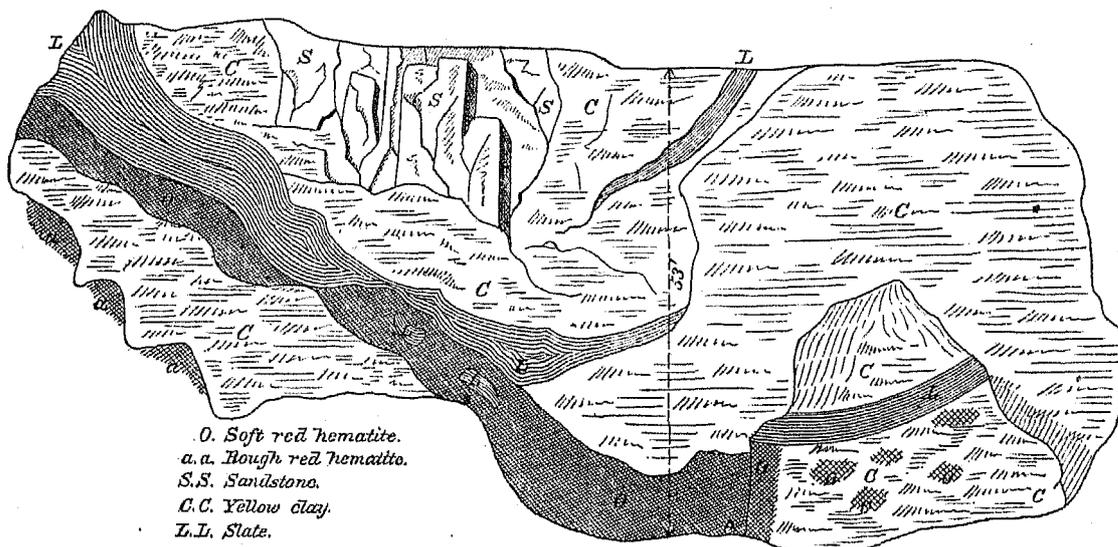


FIG. 176.—SKETCH OF THE CLINTON BANK, PHELPS COUNTY, MISSOURI.

The ore is a soft, purple paint-ore, coming from the bed in a crumbling mass. The bank, up to May 1, 1880, had yielded 12,850 tons.

The Stimson bank is opened on the south slopes of two adjoining hills, the deposit also extending well away from their bases, underlying the flat ground. The sandstone outcroppings west of No. 2 pit. Work had but just begun here, and the ore, an earthy hematite, is much mixed with red clay.

Samples taken from the group of banks just described yield, upon analysis, results as follows:

	553.	554.	556.	557.
	Per cent.	Per cent.	Per cent.	Per cent.
Metallic iron	63.13	54.00	63.88	62.66
Phosphorus	0.048	0.017	0.022	0.026
Phosphorus ratio	0.076	0.031	0.035	0.041

No. 553 is the paint-ore from Clinton bank. No. 554 is an average sample of the earthy hematite from the Stimson bank. No. 556, dense blue specular ore from the Lamb bank. No. 557 is an average of the soft hematite from the Brady bank.

f The *Hawkins* bank, in the SE. $\frac{1}{4}$ Sec. 13, T. 35, R. 6 W., was opened in December, 1879. The ore is a hematite of a dark-red color with occasional brown lumps, soft on the exterior, but often dense, and grayish-blue in the center, which color, however, changes to red when long exposed. Some blue specular ore also comes from the Hawkins bank. A sample taken from a large stock-pile at Avery, representing 1,000 tons of soft hematite and 200 tons of specular ore, gives, upon analysis—

	552.
	Per cent.
Metallic iron	56.19
Phosphorus	0.040
Phosphorus ratio	0.071

Seven miles south of Saint James, in the NW. $\frac{1}{4}$ Sec. 1, T. 37, R. 6 W., the old *Maramec* furnace, a built in 1826 and now abandoned, ran for many years upon ore from a large lenticular deposit of specular ore occupying the body of a prominent hill near by. The excavation is a circular one, several hundred feet wide and 80 feet deep. In its center stands a high mound of clay rising almost to the original level of the hill, and pierced some distance from the bottom by tunnels, from which a soft, unctuous hematite was taken. In the bottom of the old pit, which still contains a considerable quantity of ore, a shaft was sunk 35 or 40 feet deeper, reaching a depth of 115 feet from the surface, but no farther ore was struck. The shaft was filled and the working-faces all around the pit were fallen and covered. For a further description, see *Geological Survey of Missouri*, 1872, Part I, page 144. Not enough ore was left uncovered in the pit to offer a fair sample, but from a pile of 10 tons of hematite at the top of the furnace-stack a sample was taken, giving, upon analysis—

	570.
	<i>Per cent.</i>
Metallic iron	63.28
Phosphorus.....	0.050
Phosphorus ratio.....	0.079

The ore was a dark red hematite which had lost all its natural moisture during four years of exposure in the furnace stock-house.

The district immediately south of the towns of Rolla and Saint James is thickly scattered with small deposits of specular ore and hematite, the occurrence of which is similar to those above described.

The following list includes only those banks either at present worked or about to be opened for mining purposes:

Horse Hollow bank, NW. $\frac{1}{4}$ Sec. 1, T. 35, R. 9 W.; Ozark bank, NW. $\frac{1}{4}$ Sec. 3, T. 35, R. 9 W.; Mozelle, No. 1 bank, SE. $\frac{1}{4}$ Sec. 26, T. 36, R. 8 W.; Mozelle, No. 2 bank, NE. $\frac{1}{4}$ Sec. 20, T. 36, R. 8 W.; Southgate bank, NW. $\frac{1}{4}$ Sec. 20, T. 36, R. 8 W.; Railroad bank, NW. $\frac{1}{4}$ Sec. 4, T. 36, R. 8 W.; Grand Union bank, Sec. 31, T. 37, R. 6 W.; McDole bank, NW. $\frac{1}{4}$ Sec. 23, T. 37, R. 6 W.; Cole bank.

Fig. 174 shows the position of the *Horse Hollow* bank, which has been recently opened by a small cut, A, on

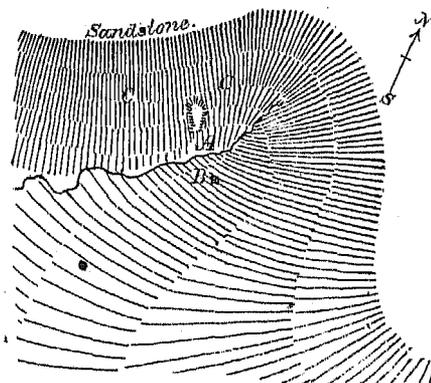


Fig. 177.—SKETCH OF THE VICINITY OF HORSE HOLLOW BANK, PHELPS COUNTY, MISSOURI.

the south side of a prominent hill of sandstone, which rock is found outcropping largely on the crown of the hill and lying in large bowlders at C 1, immediately above the ore-deposit. The cut A is 30 feet long and 20 feet deep, and exposes a very soft, greasy, paint-ore. At B a pit 12 feet deep showed no ore.

From the *Ozark* bank only a few tons of ore had been taken, which were sampled at Ozark furnace. These ores show, upon analysis—

	571.	572.
	<i>Per cent.</i>	<i>Per cent.</i>
Metallic iron	55.73	45.76
Phosphorus.....	0.032	0.042
Phosphorus ratio.....	0.057	0.092

No. 571 is a soft paint-ore from Horse Hollow. No. 572 is an earthy hematite, with much surface clay and some specular ore from Ozark.

The *Grand Union* and *Mozelle* banks were sampled at Rolla from stock-piles of some hundred tons. The ore so far mined is mostly a soft, earthy hematite, with some specular lumps. The specular ore from Grand Union often

a presents a bright-green appearance, due to the presence of carbonate of copper. The quantity of copper is at times large, and such lumps effervesce violently in acid. The following analyses offer comparisons:

	573.	574.	582.
	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>
Metallic iron.....	54.76	55.21	31.62
Phosphorus.....	0.121	0.074	0.027
Copper, metallic...	2.46	.....	21.60
Phosphorus ratio..	0.221	0.134	0.085

b No. 573, soft hematite associated with green specular lumps, but separated in the sample from Grand Union bank. No. 574, an earthy hematite from the Mozelle bank. No. 582, from green specular lumps alone at Grand Union. Sampled on cars at the Vulcan Steel Works.

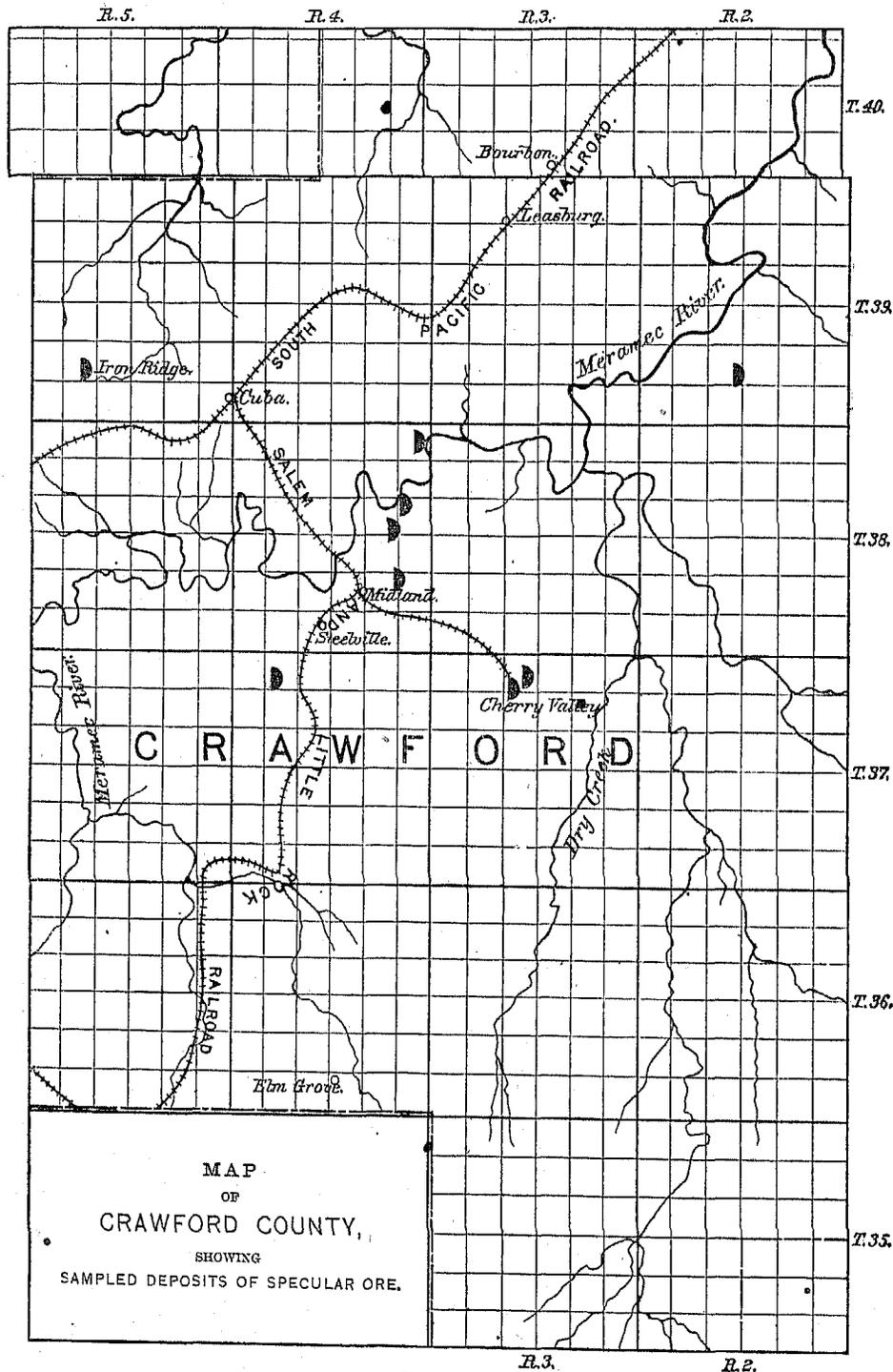


Fig. 175.

quartz crystals and glowing with a thousand varied colors, rendering the ore recognizable wherever seen. The **a** history of the Scotia bank, which is now exhausted, is derived from a description given by Mr. Thomas J. Scott. For a geological description of its surroundings, see *Geological Survey of Missouri*, Part I, p. 128. This is a very perfect example of a lenticular deposit.

The sketch given in Fig. 182, showing a horizontal plan of the pit, though somewhat ideal in the regularity of its lines, is not exaggerated in other respects.

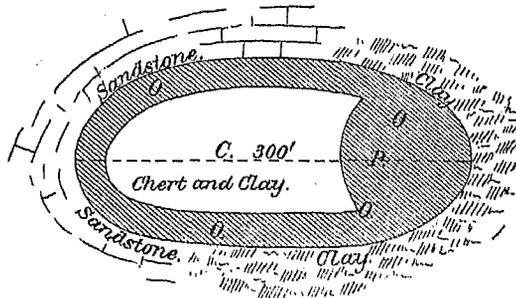


FIG. 182.—PLAN (PARTLY IDEAL) OF THE SCOTIA MINE, CRAWFORD COUNTY, MISSOURI.

The ore following the sandstone wall of the ellipse extended to the depth of 60 to 80 feet, but at the east end **c** of the pit at P, sunk downward in a great cylinder 100 feet thick, to a depth of 130 feet.

At this depth a sump was dug, which, after piercing a few remaining feet of ore, passed through 13 feet of pyrite but little decomposed and presenting a high metallic luster.

This portion of the pit was filled with water to the level (C) 60 feet below the original opening on the hillside. But little ore remained in the pit, and the sample was collected from pickings here and there along the old tramway and from scattered lumps in the stock-house of the furnace. The greater part of the ore which supplied Scotia furnace ten years and yielded 73,000 tons of pig metal was a porous hematite coming from the bed either in rough lumps or in a fine, soft, earthy condition, greasy to the touch. Scattered more or less thickly through this hematite the specular ore above described was found. The analysis of the sample collected here gives—

	577.
	<i>Per cent.</i>
Metallie iron	63.10
Phosphorus	0.063
Phosphorus ratio	0.001

The *McGarvey* bank, a small opening 8 miles southwest of Leasburg, completes the list in Crawford county from which samples were taken. A stock-pile containing 65 tons was sampled at Leasburg, representing only soft paint-ore, and yielding, upon analysis—

	578.
	<i>Per cent.</i>
Metallie iron	61.42
Phosphorus	0.056
Phosphorus ratio	0.115

FRANKLIN COUNTY.

But little ore is mined in Franklin county. The *Stanton* bank, 2 miles southeast of Stanton, was opened in November, 1879. Fig. 183 shows the shape and dimensions of the pit when visited in May, 1880.

The ore was exposed in shoulders at O, O, O, wherever the clay had been removed, and is 16 feet deep at A, where a pit has been sunk. It is a compact earthy hematite, somewhat specked with included pieces of chert, which is for the most part decomposed to a soft chalk. At B a dark purple ore occurs in boulders intimately associated with chert, which is also found in angular fragments in the clay. A sample taken from 300 tons in stock at Stanton is here compared with a second sample from the stock-pile of the Missouri Furnace Company:

	581.	584.
	<i>Per cent.</i>	<i>Per cent.</i>
Metallie iron	58.81	57.85
Phosphorus iron	0.058	0.072
Phosphorus ratio	0.099	0.124

a No. 581, from Staunton. No. 534, from pile at Missouri Furnace Company, Saint Louis.

The *Saint Clair* or *Basket* bank, in the SE. $\frac{1}{4}$ Sec. 28, T. 42, R. 1 W., has been newly opened. The surface of the hill shows a scanty scattering of limonite, and deeper upon the bed the ore is a soft hematite of a brown

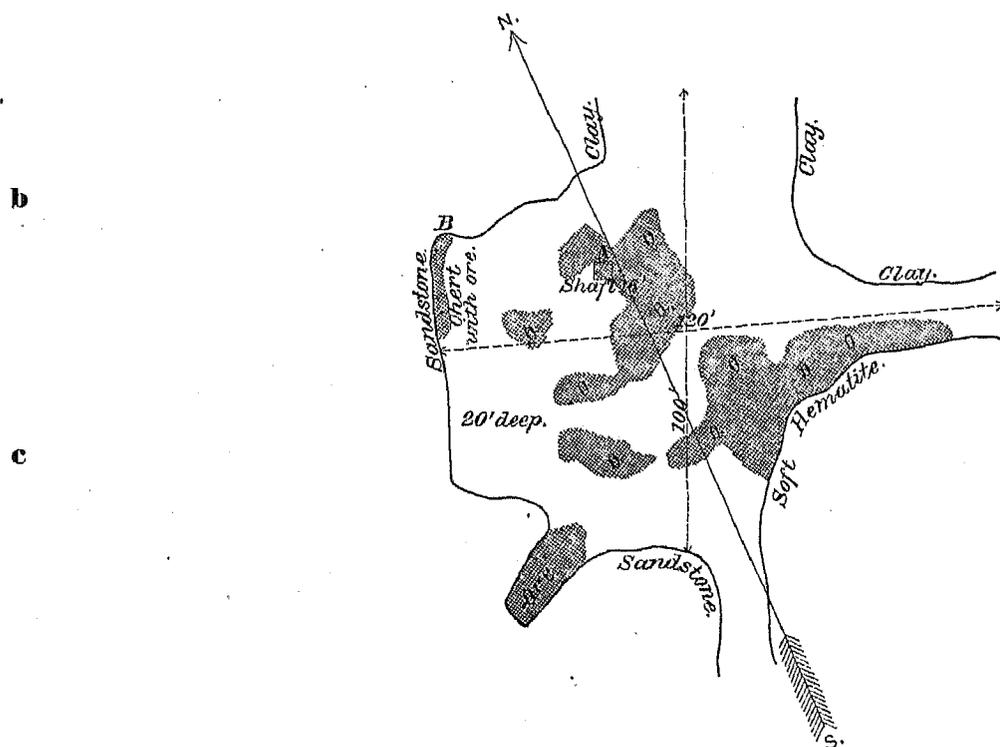


FIG. 133.—SKETCH OF THE STAUNTON BANK, FRANKLIN COUNTY, MISSOURI.

d color, due to clay, and interstratified with layers of sandy chert and streaks of brownish shale, much contorted. Occasional lumps of specular ore are met with. The careful separation of the ore from the clay and chert will be necessary to render it of value. The following results were obtained from two samples taken:

	579.	580.
	<i>Per cent.</i>	<i>Per cent.</i>
Metallic iron	62.40	58.86
Phosphorus	0.059	0.058
Phosphorus ratio	0.095	0.099

e No. 579, from 100 tons in stock at Saint Clair station. No. 580, from a mixed pile of recently-mined ore at the mine.

Besides the deposits above described there are in this region many located banks, and probably many which have not yet been opened for mining purposes.

As may be seen from the above examples, the size of a deposit can in no case be estimated from mere surface indications, as the occurrence of the ore is both variable and uncertain, and what seems to be an existing rule in one instance is proved untrustworthy in others. Already numerous deposits which seemed to promise a large amount of ore have been exhausted, while others, promising but little from surface indications, have opened into large workings. A sample of ore was taken from the mixed stock pile of the Missouri Furnace Company, Saint Louis.

f It represents ore from nine banks, namely: *Cherry Valley*, *McGarvey*, *Saint Clair*, *Handcock* (exhausted), *Horse Hollow*, *Stimson*, *Staunton*, *Pomeroy*, *Lamb*, and was composed of all the varieties of specular ore and hard and soft hematite. It yields, upon analysis, results as follows:

	536.
	<i>Per cent.</i>
Metallic iron	56.43
Phosphorus	0.065
Phosphorus ratio	0.115

NOTES ON THE SAMPLES OF IRON ORE COLLECTED IN MICHIGAN AND NORTHERN WISCONSIN.

BY BAYARD T. PUTNAM.

Iron ores in the upper peninsula of Michigan have thus far been found only in the Huronian series of rocks. This series consists of quartzites, schists, banded jaspers, greenstones, limestones, and iron ore, and contains in

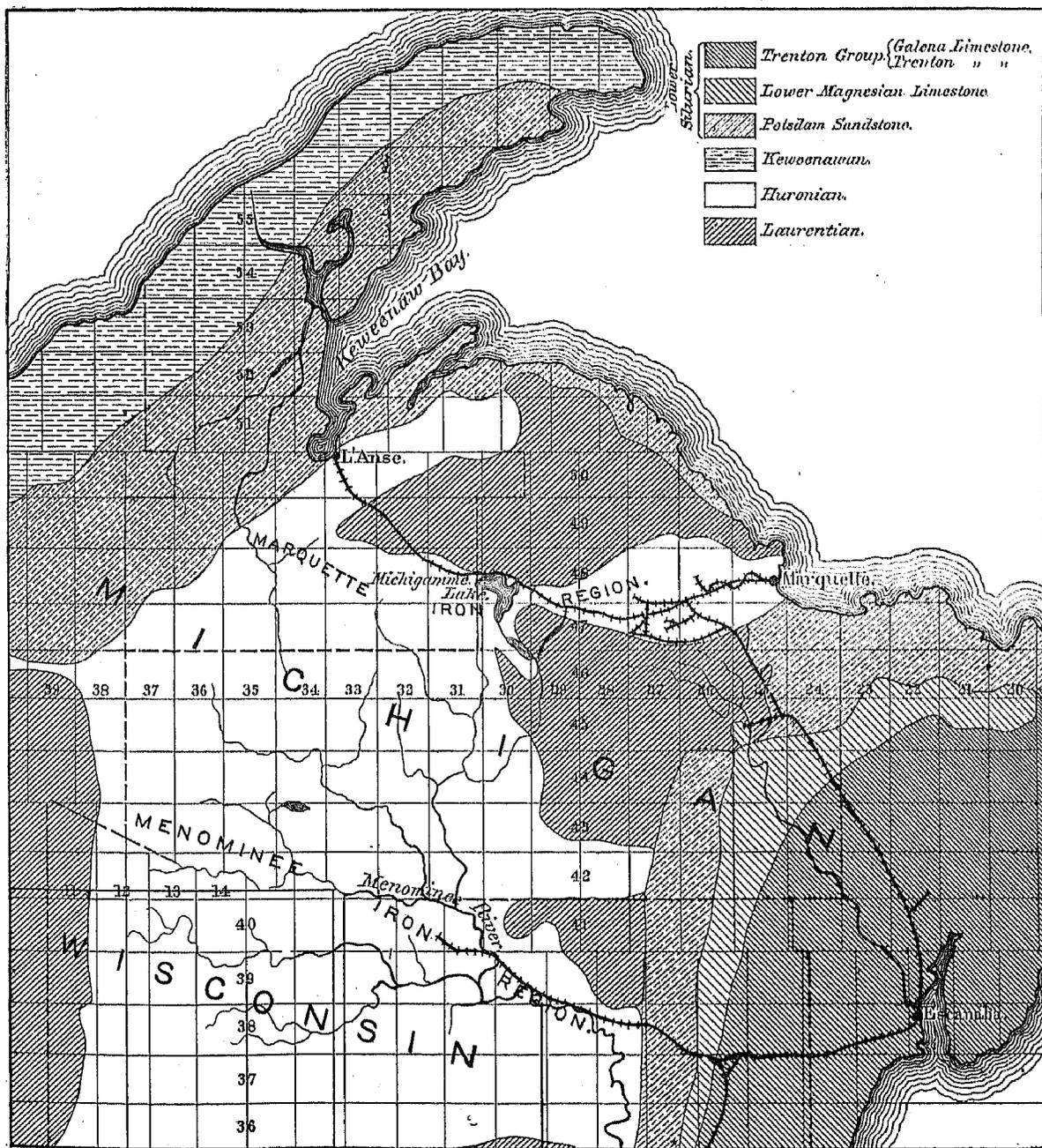


FIG. 184.—MAP OF PARTS OF MICHIGAN AND WISCONSIN, SHOWING POSITION OF BELTS OF IRON ORE. The geology is from a map compiled by R. D. IRVING, published in *Trans. Am. Inst. Min. Eng.*, Vol. VIII.

NOTE.—The boundaries of the field of Laurentian rocks in the eastern part of the Menominee region have not been definitely mapped.

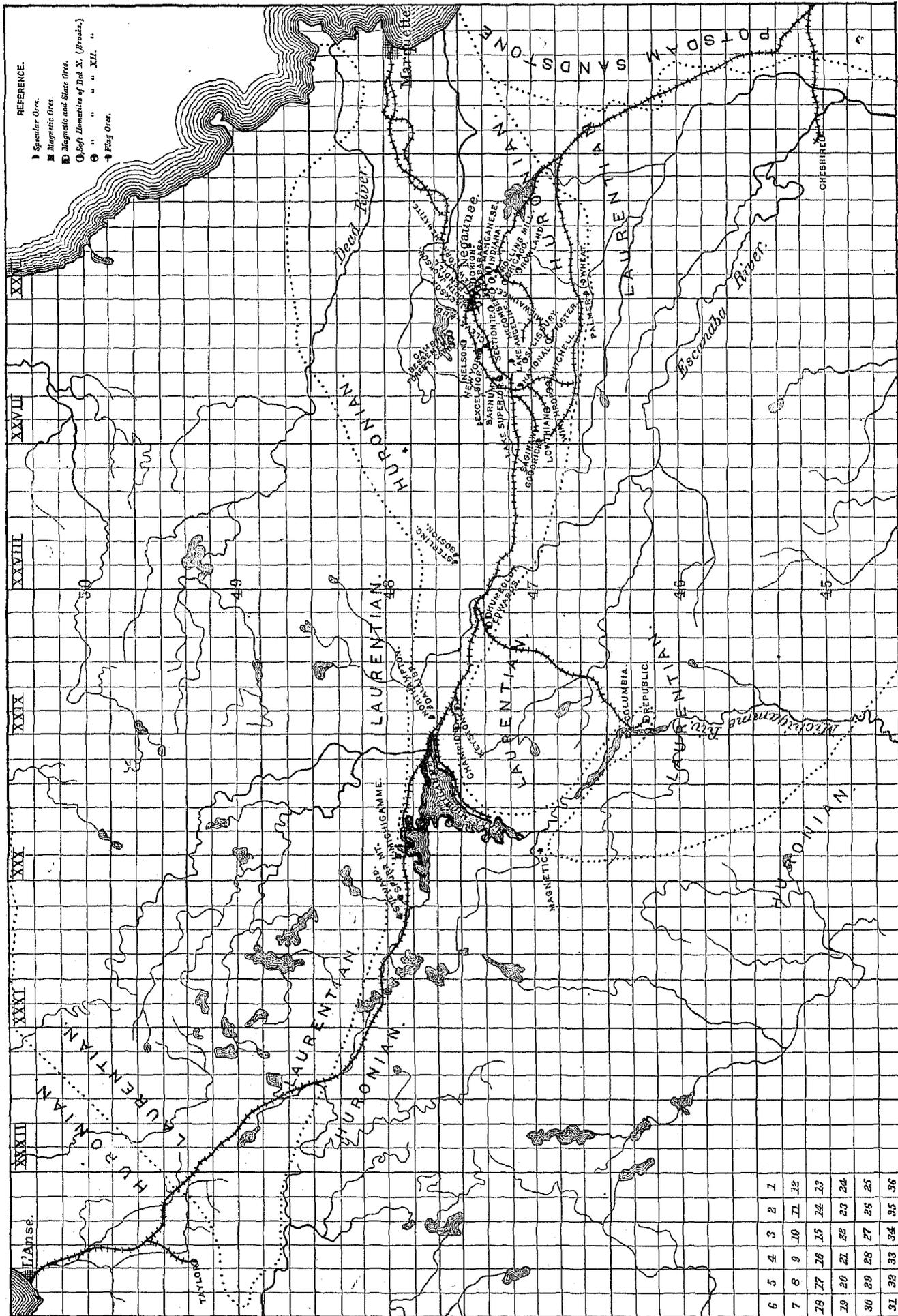


FIG. 185.—MAP OF THE MARQUETTE IRON REGION, MICHIGAN.

all, according to Brooks, twenty distinct members. (a) On Brooks' scheme these members are numbered from I to a XX. Iron ore has been proved to exist in workable quantities in beds VI, X, XII, and XIII, and in an horizon below V.

The accompanying map (Fig. 184) shows the distribution of the Huronian rocks in the portion of the upper peninsula containing the iron deposits now being worked. (b) The mines lie in two distinct groups or belts, approximately parallel, the one about 40 miles south of the other. The northern belt is called the Marquette iron region, and the southern belt the Menominee iron region.

THE MARQUETTE IRON REGION.

This region embraces the Huronian rocks, extending from Marquette westward, and contains all the iron mines b on the upper peninsula that shipped ore previous to 1877. At Marquette the Huronian field is about 6 miles wide. From there it widens to 13 miles at Negaunee, and thence narrows to Michigamme lake, where it is not more than 3 miles in width. Geologically, the strata form a broad synclinal trough, corrugated in the direction of its axis by several minor folds, resting on Laurentian rocks. The general trend of the formation is east and west. South of Michigamme lake a narrow tongue of Huronian is separated from the main field on the west by a Laurentian peninsula. On the southern extremity of this tongue is situated the Republic mine, the largest single deposit of ore in Michigan, and one of the largest in the world. About 20 miles south of Marquette, in township 45, range 25, there is a small isolated patch of Huronian rocks, surrounded on three sides by Laurentian, and on the fourth by Silurian strata, in which is situated the Cheshire mine; and northwest of Michigamme lake, in township 49, c range 33, is the so-called L'Anse range. With the foregoing exceptions the mines of the Marquette region are in one comparatively compact belt.

From Marquette to near Negaunee the upper members of the Huronian appear to be wanting. The most easterly deposits of iron ore known, excepting the Cheshire, are the so-called "soft hematites" about Negaunee, which are believed to belong to bed X. The specular or hard hematite ore first makes its appearance in traveling westward from Marquette, at the Jackson mine, immediately west of Negaunee. Here the basin formed by bed XIII, the horizon at which this ore occurs, is very narrow; but it widens toward the west, and at Michigamme lake its northern and southern rims are nearly 3 miles apart. All the ores of bed XIII contain some protoxide of iron, but in following the region westward the first deposit of magnetic ore is seen at the Humboldt mine, 13 miles west of the Jackson. At this locality specular hematite ("slate ore") is also present in considerable quantities; d but farther west, at the Michigamme and Spurr Mountain mines, the ore-mass is almost entirely magnetite. The ferruginous schists likewise become more magnetic as they are followed west.

The "soft hematite" deposits in the Saginaw range, southwest of Ishpeming, belong to bed XII, and the "flag-ores" of the Cascade range, in the southern part of township 47, range 23; and of the magnetic range, near the center of township 47, range 30, are believed to be older than the quartzite of bed V. In the Marquette region no workable deposits of ore have been found in bed VI, the horizon of the ores of the Menominee region in Michigan, nor in bed XV, supposed by Brooks to be the horizon of the Commonwealth and Florence ores in Wisconsin.

The following description of the ores is mainly an abstract from Major Brooks' chapter on Lithology, in Vol. I of the *Geological Survey of Michigan*:

Only such ores as are now employed in the manufacture of iron will be mentioned. They are, in order of present supply, (a) the e specular hematite, or red specular ore, as this class is designated in the iron trade; (b) the magnetic; (c) the mixed or second-class ore, which may be either specular or magnetic; (d) the soft hematite; and (e) the flag-ores. Another variety, the magnetic specular, might be added, which, as the name implies, is a mixture of the black and red oxides; it gives a purple streak. The local terms, "hard", embracing both the magnetic and the specular ores, and "soft", for the soft hematites, are convenient.

(a) *Red specular ores.*—Miners divide these into *slate* and *granular*. The former resembles closely in its structure the soft greenish chloritic schists, commonly associated with it. The slabs, into which the ore easily splits, are not uniform in thickness like roofing-slate, but taper always in one and often in three ways, producing elongated pieces often resembling in form a short, stout, two-edged sword-blade, with surfaces as bright as polished steel, but striated and uneven. Thin edges of such slates can be pulverized into a bright-red powder by the finger-nail, and occasionally the whole mass is very friable. The magnet will generally lift 1 or 2 per cent. of the powdered ore, and occasionally one-fourth of the whole. In the latter case the streak is purple, and the ore is more friable than the pure red specular slates, due in some way to the larger admixture of magnetite.

The *granular* or massive specular ore shows no tendency to split in slabs, and is made up usually of minute crystalline grains, which f are sometimes, however, so large that their octahedral form can be easily recognized without the aid of a lens. The granular ore is generally firm in texture, and is never friable like the granular magnetic. Some highly-compacted varieties, which contain a little silica, are very hard, constituting the hardest rock to drill which the miner encounters. This variety is called the "fine-grained steel ore". Some specimens of it possess almost the highest specific gravity observed, 5.23, while the rich softer ores of the same class averaged about 4.85.

(b) *Magnetic ore.*—The description given above of the granular specular ore applies with equal force to this class, except that the latter is more granular and is often friable; it has the magnetic property, and gives a black or purple powder. Sometimes the rich magnetites crumble easily into grains, like some of the lake Champlain ores, to which the term "shot-ore" is applied; again, the ore is very hard. The compact tabular form, so frequent in the magnetic ores of New Jersey and southern New York, is not common in the best ores of the Marquette region, nor are the latter ores as highly magnetic as the former, or, at least, good lodestones are not so

a *Geology of Wisconsin*, Vol. III, Table of Sequence of the Huronian Strata, facing p. 450. By T. B. Brooks.

b 1880. The Gogebic region in Northwestern Michigan and Northern Wisconsin (T. 47, R. 45, 46, and 47 W., Michigan; and T. 45 and 46, R. 2 E., and T. 46, R. 1 E. and 1 W., Wisconsin), in which there are now (1886) a number of important shipping mines, was a trackless wilderness in 1880, although the existence of iron ore in that vicinity was known.

a common. Typical *slate ores* occur with the magnetites, but they are of the character already described, that is, mixtures of the two oxides; the magnet not removing over one-fourth of the powder, while it takes all in the case of the granular variety.

(c) The *mixed* or second-class ores differ from those of the first class chiefly in containing a larger per cent. of silica. They are, in fact, highly ferruginous "jaspery" schists. These schists, which are invariably associated with the rich ores, consist of alternating bands or laminae of the so-called jasper (a ferruginous quartz, varying in color from a bright red to a dull-reddish brown), and usually pure specular or magnetic ore of high luster. Occasionally the silicious layers are white. The laminae vary in thickness up to an inch. They are usually parallel, but are sometimes highly contorted. In some cases the jaspery layers have been broken up into angular fragments, which have been forced into the more yielding ore-layers; in this case the mass often has the appearance of a true breccia. The total amount of oxide of iron contained in these ferruginous schists is very great, but it is at present, as a rule, unavailable for the manufacture of iron. Where the silicious laminae are so thin that the whole mass contains 45 to 50 per cent. of metallic iron, it can be shipped as a second-class ore.

b (d) The *soft hematites* of the Marquette region differ entirely from the ores above described, and are closely related to the brown hematites of eastern Pennsylvania and Connecticut. Chemically, they are mixtures of the hydrous and anhydrous oxides; they contain usually oxide of manganese. In color they are various shades of brown, red, and yellow. In texture they are earthy, and are so slightly compacted as to be easily mined with pick and shovel. These ores are invariably associated with or occur in a limonitic silicious schist, from which they seem to have been derived by decomposition and disintegration. They occur in two distinct formations, X and XII, and probably in others, in irregular bunches or pockets, surrounded by schist, and passing by gradations, often abrupt, into it. Scattered through the ore, and conforming in their positions with the original bedding of the rock, are fragments of schist. When the ore shows stratification, which it often does not, it also conforms with the bedding of the schist.

(e) *Flag-ores* correspond more nearly to the *mixed ores* (c) than to any of the other varieties mentioned. Like the mixed ores, they are banded, but the marking is seldom bright and is often obscure, and is produced by the interlamination of reddish or whitish quartz with a dull silicious, instead of a pure, ore. There are exceptions to this rule, but they are not numerous. As their name implies, the *c* flag-ores have a coarse slaty or flaggy structure. Stratigraphically, they are older than the rich ores of bed XIII, occupying beds X, VIII, VI, and below V. The per cent. of metallic iron in the ores and associated schists varies from 5 to nearly 60. The ores are apparently but local variations of the schists.

Average samples of the shipping product of the principal mines of the upper peninsula were collected by Mr. Bailey Willis from the large stock-piles of ore at Cleveland, Ohio, in November and December, 1879. In addition to these, samples were taken by the writer in several of the typical mines of the Marquette region and in all the mines of the Menominee region, with the object of determining whether the ore from different parts of the same deposit varied in composition, especially as to its contents in phosphorus.

The samples taken by Mr. Willis were from piles varying from 1,000 to 20,000 tons. They were made up of chips of about an inch maximum diameter, taken at regular intervals of 1 foot along a number of straight lines drawn across the ore-piles. In the larger piles these lines were fixed by cords stretched across them. Lump ore, fine ore, and foreign material were taken impartially. The total weight of the samples varied from 18 to 40 pounds, according to the size of the piles.

My samples consist generally of a series of chippings taken across the stope, from the hanging to the foot wall of the ore-mass, or across the band of ore selected for detail sampling. Where there was a seam or "horse" of rock in the ore which clearly could be thrown out in mining, no chippings of it were taken. But with this exception the sample represents as nearly as possible the material from a groove or channel cut across the ore-mass. In a few cases I have taken samples from the small stock-piles at the mines, in order to supplement those taken in the stopes.

In the following pages the analyses of the above-mentioned samples are arranged under the names of the mines to which they belong, and the mines are grouped according to the kind of ore produced, and are placed in each group, so far as possible, in order from east to west.

e The total output of the mines to the end of the year 1880 is taken from the *Annual Report of the Commissioner of Mineral Statistics of the State of Michigan for 1880*. The gross tons (2,240 pounds) there employed have, however, been reduced to net tons (2,000 pounds), as the latter unit is used exclusively in this volume.

Mines producing ore of Class I (hard specular).

(1) *Jackson*.—On Sec. 1, T. 47, R. 27 (at Negaunee). Operated by the Jackson Iron Company. It is the oldest mine in the Upper Peninsula; the original entry of the land was made in 1845, and about 28,000 tons were mined previous to 1854. Total product, 2,315,261 (a) tons. Product in census year, 134,584 (a) tons.

Samples of the ore collected at Cleveland by Mr. Willis contained—

	140.	150.		140.	150.
	<i>Per cent.</i>	<i>Per cent.</i>		<i>Per cent.</i>	<i>Per cent.</i>
Metallic iron.....	64.84	62.09	Titanic acid.....	Absent.	Absent.
Phosphorus.....	0.044	0.064	Insoluble silicious matter.....	6.00	8.46
Sulphur.....	0.027	0.027	Phosphoric acid.....	0.100	0.147
Silica.....	4.62	5.69	Phosphorus in 100 parts iron.....	0.068	0.103
Alumina.....	1.76	2.78	Specific gravity.....	5.029	.....
Manganese.....	Absent.	Trace.	Per cent. iron, divided by specific gravity....	12.89	.....

a These figures include the product of the Pioneer and South Jackson mines. The former is on the same body of ore as the Jackson, but is operated by the Iron Cliff Company. The latter produces soft hematite. a See samples Nos. 137 and 138, page 434.

Sample No. 140 is an average of a pile of 20,000 tons of "Specular No. 1". Texture of ore, compact, granular, a laminated. Sample No. 150 is a special sample of the fine ore in the same pile. It was sifted through a sieve containing 3 meshes to the linear inch.

(2) *Cleveland*.—On Secs. 10 and 11, T. 47, R. 27; operated by the Cleveland Iron Mining Company. Total product, 2,384,630 tons; product in census year, 125,440 tons. Samples of the ore collected at Cleveland by Mr. Willis contained—

	113.	131.		113.	131.
	<i>Per cent.</i>	<i>Per cent.</i>		<i>Per cent.</i>	<i>Per cent.</i>
Metallic iron.....	64.47	56.80	Titanic acid.....	Absent.	Absent.
Phosphorus.....	0.100	0.170	Insoluble silicious matter.....	5.03	14.51
Sulphur.....	0.049		Phosphoric acid.....	0.250	0.300
Silica.....	3.70	10.93	Phosphorus in 100 parts iron.....	0.100	0.200
Alumina.....	2.90	4.03	Specific gravity.....	4.005	4.705
Manganese.....	Trace.	Present.	Per cent. iron divided by specific gravity..	12.98	11.84

Sample 113 is from 15,000 tons of "Specular No. 1"; texture of ore, compact. Sample 131 is from 1,100 tons "Specular No. 2", or green specular; texture of ore, compact.

(3) *New York*.—On SE. $\frac{1}{4}$ of SE. $\frac{1}{4}$ of Sec. 3, T. 47, R. 27, adjoining the Cleveland on north and west; operated by the "New York Iron Mines". First shipment of ore in 1864; total product, 1,035,738 tons; product in census year, 44,971 tons.

The samples of ore collected at the mine yielded, on complete analysis—

	88.	89.		88.	89.
	<i>Per cent.</i>	<i>Per cent.</i>		<i>Per cent.</i>	<i>Per cent.</i>
Sulphur.....	0.060	0.030	Potassa.....	0.11	0.33
Phosphorus.....	0.002	0.105	Carbonic acid.....	0.00	0.12
Iron, metallic.....	67.34	63.81	Phosphoric acid.....	0.142	0.448
Phosphorus in 100 parts iron.....	0.002	0.300	Hygroscopic water.....		0.10
Specific gravity.....	4.040	5.033	Water of composition.....	0.40	1.17
Per cent. iron divided by specific gravity..	14.00	12.7	Total.....	99.974	100.034
Silica.....	1.80	3.04	Insoluble silicious matter.....	2.88	4.90
Iron, protoxide.....	.0.81	3.08	Silica.....	1.80	3.04
Iron, peroxide.....	95.22	87.00	Alumina.....	0.80	1.55
Alumina.....	0.81	3.04	Lime.....	0.01	0.04
Manganese.....		Trace.	Potassa.....	0.11	0.33
Lime.....	0.20	0.07	Total.....	2.87	4.00
Magnesia.....		0.30			
Iron, disulphide.....	0.112	0.050			

Sample No. 88 is from a pillar in the southeastern part of the main pit (pit No. 1). The chippings were taken from floor of mine (which is ore) to the roof (rock). Texture of ore, compact; ore is very hard. Sample No. 89 is from ore from pit No. 4, a new opening in the Beardsley pit. Texture of ore, compact, slaty; contains small octahedral crystals of magnetite (or martite). Ore in mass deflects compass needle. [It is shipped as a No. 2 ore; see sample No. 115.] The location of samples Nos. 88 and 89 is indicated on Fig. 186.

The samples of ore collected at Cleveland by Mr. Willis contained—

	114.	115.		114.	115.
	<i>Per cent.</i>	<i>Per cent.</i>		<i>Per cent.</i>	<i>Per cent.</i>
Metallic iron.....	64.40	61.34	Titanic acid.....	Absent.	Absent.
Phosphorus.....	0.110	0.104	Insoluble silicious matter.....	5.03	7.07
Sulphur.....	0.020	0.030	Phosphoric acid.....	0.252	0.370
Silica.....	5.10	5.82	Phosphorus in 100 parts iron.....	0.171	0.207
Alumina.....	2.20	2.98	Specific gravity.....	4.292	4.900
Manganese.....	Absent.	Present.	Per cent. iron divided by specific gravity..	15.00	12.50

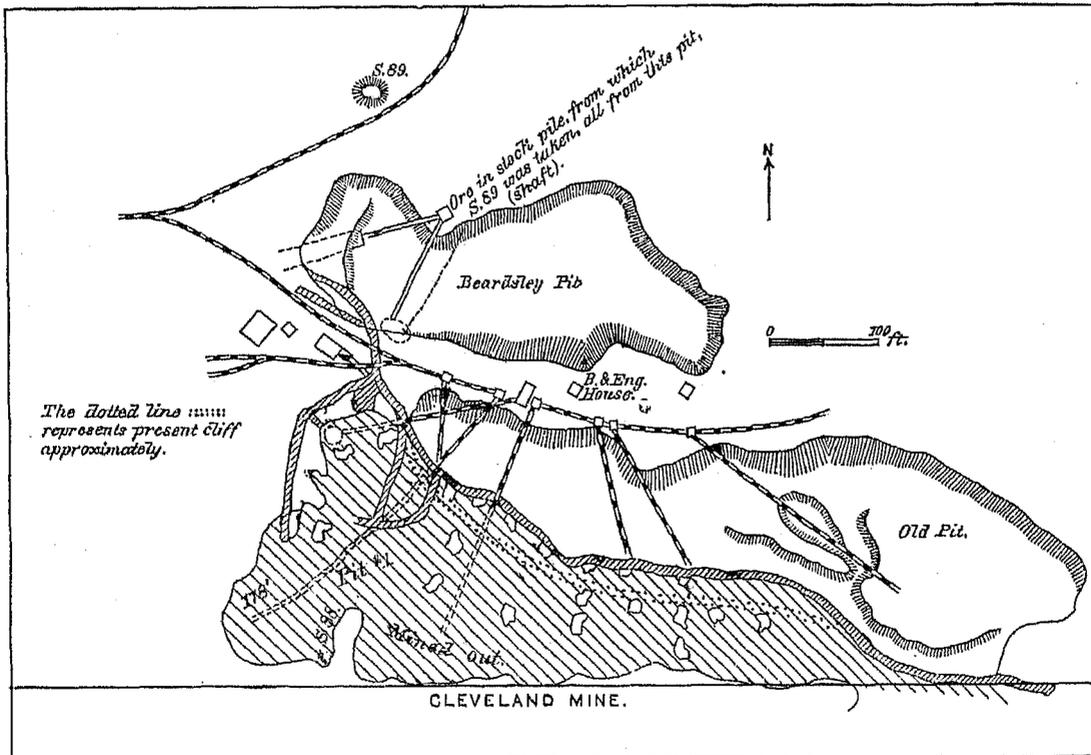
Sample No. 114 is from 9,000 tons of "Specular No. 1"; texture of ore, compact. Sample No. 115 is from 1,000 tons of "Specular No. 2, or "green specular"; texture of ore, compact, crystalline.

a (4) *Lake Superior*.—On Secs. 9 and 10, T. 47, R. 27 (at Ishpeming). Operated by the Lake Superior Iron Company. First shipment in 1858; total product, 2,664,115(a) tons; product in census year, 215,930(a) tons. Samples of the ore collected at Cleveland by Mr. Willis contained—

	141.	140.	139.	142.
	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>
Metallic iron	64.38	63.38	64.77	65.92
Phosphorus	0.057	0.057	0.016	0.057
Sulphur	0.074	0.057	0.055	0.074
Silica	4.27	4.06	3.05	14.51
Alumina	0.01	3.13	2.28	4.02
Manganese	Absent.	Absent.	Absent.	Absent.
Titanic acid	Absent.	Absent.	Absent.	Absent.
Insoluble silicious matter	6.43	7.58	6.35	17.65
Phosphoric acid	0.181	0.130	0.036	0.131
Phosphorus in 100 parts iron	0.089	0.090	0.025	0.102
Specific gravity	4.002	.....	4.090	4.318
Per cent. iron divided by specific gravity ..	12.97	.....	13.38	12.94

b

Sample 141 is from 20,000 tons of "Specular No. 1". Texture of ore, compact, laminated, micaceous. Sample 149 is a special sample of the fine ore from same pile (see under sample 150, Jackson mine). Sample 139 is from **c** 4,000 tons of specular ore from "Summit" opening, 300 feet west of main pit; texture of ore, compact. Sample 142 is from 1,500 tons of "Specular No. 2" ("Essex"); texture of ore, compact.



d

e

FIG. 186.—PLAN OF THE NEW YORK MINE, MARQUETTE COUNTY, MICHIGAN.

(5) *Barnum*.—On Sec. 9, T. 47, R. 27, adjoining Lake Superior mine. First shipment in 1868. Total product, **f** 514,259 tons. Product in census year, 28,000 tons. Operated by the Iron Cliff Company. A sample of the ore collected at Cleveland by Mr. Willis, from 2,000 tons of specular ore, contained—

	120.		120.
	<i>Per cent.</i>		<i>Per cent.</i>
Metallic iron	63.45	Titanic acid	Absent.
Phosphorus	0.006	Insoluble silicious matter	7.12
Sulphur	0.011	Phosphoric acid	0.219
Silica	5.47	Phosphorus in 100 parts iron	0.151
Alumina	2.41	Specific gravity	4.946
Manganese	Absent.	Per cent. iron divided by specific gravity ..	12.82

Texture of ore, compact.

a These figures include the product of the Lake Superior hematite and the Lowthian mines. (See under soft hematites.)

(6) *Lake Angeline*.—On N. $\frac{1}{2}$ Sec. 15, T. 47, R. 27, on south shore of lake Angeline. First shipment in 1864. **a** Total product, 568,553(a) tons. Product in census year, 16,719(a) tons. Operated by the Pittsburgh and Lake Angeline Iron Company. The ore in this mine is chiefly a silicious or "No. 2" specular. On the north side of the pit there is a hematite schist of unknown thickness; although containing more than 40 per cent. metallic iron, this is not at present considered an ore. A pocket of fair quality "soft hematite," resembling the Salisbury ore, has recently been uncovered in the western end of the pit, lying in the hard ore. The samples collected contained—

	11.	12.	13.	108.
	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>
Metallic iron	55.11	53.85	42.27	40.01
Phosphorus	0.007	0.001	0.051	0.031
Sulphur				0.030
Silica				27.72
Alumina				4.15
Manganese				Absent.
Titanic acid				Absent.
Insoluble silicious matter				30.50
Phosphoric acid				0.070
Phosphorus in 100 parts iron	0.013	0.113	0.121	0.060
Specific gravity	4.814	3.820	2.774	4.077
Per cent. iron divided by specific gravity	11.44	14.27	15.23	11.50

Sample No. 11 was taken across the west side of the pump-shaft pillar. The ore is hard and jaspery; texture, **c** compact. Sample No. 12 is from the pocket of soft hematite at the western end of the mine; texture, earthy; color, brown. It is probably a mixture of the hydrous and anhydrous oxides. Sample No. 13 is from the north wall of the pit near the pump-shaft pillar. It represents the hematite schist. It probably is not, however, an average sample. Sample No. 108 is from 4,000 tons of specular ore at the North Chicago rolling-mill. This sample was collected by Mr. Willis. It represents an average of the ore of which No. 11 is a special sample.

The location of samples Nos. 11, 12, and 13 is shown on Fig. 187.

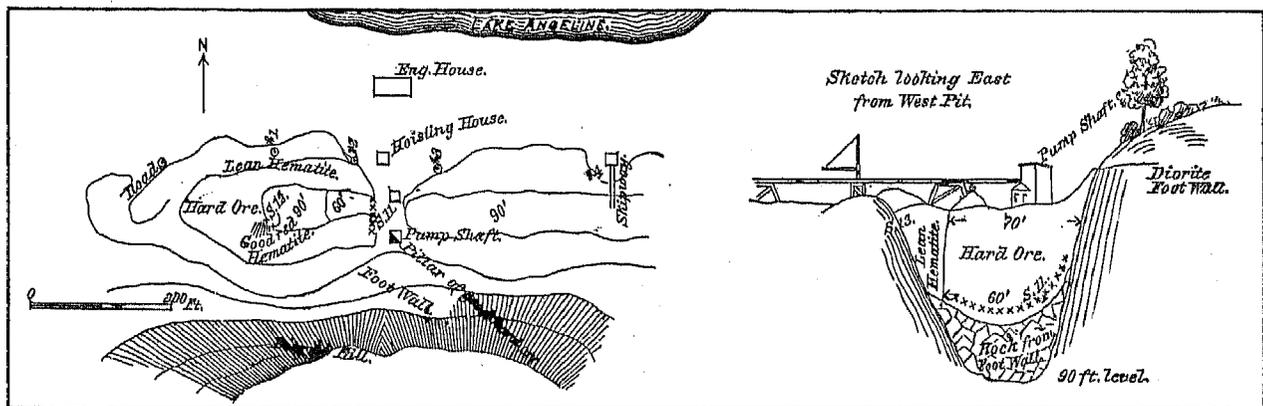


FIG. 187.—SKETCH OF THE LAKE ANGELENE MINE, MARQUETTE COUNTY, MICHIGAN.

(7) *National*.—On Sec. 16, T. 47, R. 27. Opened in 1878. Total product, 75,043 tons. Product in census year, 33,600 tons. Owners, Lake Superior Iron Company. Operated by Samuel Mitchell and A. G. Stone. The ore was not sampled.

The SAGINAW RANGE lies about a mile south of the National mine. It includes the following-named mines, arranged in order from east to west: Mitchell, Winthrop, Lowthian, [New England], [Section 19], Saginaw, and Goodrich. The mines the names of which are inclosed in brackets are not now being worked. The first four names on the list produce soft hematite ore, which is considered to belong to Formation XII. The analyses of these ores will be given under "Soft Hematites". Of the other mines of the range, the—

(8) *Saginaw* is on the NW. $\frac{1}{4}$ of NE. $\frac{1}{4}$ Sec. 19, T. 47, R. 27. Its first shipment was in 1872. Total product 436,778 tons. Product in census year, 30,240 tons. A sample of the ore, collected at Cleveland by Mr. Willis from **f** 3,000 tons, contained—

	144.		144.
	<i>Per cent.</i>		<i>Per cent.</i>
Metallic iron	62.53	Titanic acid	Trace.
Phosphorus	0.100	Insoluble silicious matter	8.08
Sulphur	0.057	Phosphoric acid	0.243
Silica	5.47	Phosphorus in 100 parts iron	0.170
Alumina	2.53	Specific gravity	4.963
Manganese	Absent.	Per cent. iron divided by specific gravity ..	12.50

Texture of ore, compact.

a Including product of hematite mine on south side of the hill adjoining the Salisbury mine.

a (9) *Goodrich*.—On W. $\frac{1}{2}$ of NW. $\frac{1}{4}$ Sec. 19, T. 47, R. 27. First shipment in 1872. Total product, 35,124 tons. Product in census year, 6,720 tons. Operated by Captain Goodrich. The ore was not sampled.

The NORTH or CONRAD RANGE has been traced from the Excelsior mine, in the NE. $\frac{1}{4}$ Sec. 6, T. 47, R. 27, to Michigamme lake. It now includes the following mines: Excelsior, Boston, Sterling, Dalliba, and Northampton.

(10) *Excelsior*.—On SE. $\frac{1}{4}$ Sec. 16, T. 47, R. 27. First shipment in 1872. Total product, 13,265 tons. Idle in census year. Owned by the Iron Cliff Company. The ore was not sampled.

(11) *Boston*.—On SE. $\frac{1}{4}$ of SW. $\frac{1}{4}$ Sec. 32, T. 48, R. 28. Opened in January, 1880. Shipped in 1880, 7,255 tons. Operated by "The Boston mine." A sample of the ore from the stock-pile at the mine was collected by Mr. George A. Fay. It contained—

b

	10.		10.
	<i>Per cent.</i>		<i>Per cent.</i>
Sulphur	0.007	Phosphoric acid	0.022
Phosphorus	0.009	Hygroscopic water	0.02
Iron, metallic	66.36	Water of composition	0.65
Phosphorus in 100 parts iron	0.014	Total	100.055
Silica	2.61	Insoluble silicious matter	4.88
Iron, protoxide	1.20	Silica	2.61
Iron, peroxide	93.39	Alumina	1.84
Alumina	1.59	Lime	0.04
Lime	0.04	Potassa	0.81
Iron, disulphide	0.013	Soda	0.07
Potassa	0.31	Total	4.87
Soda	0.07		
Carbonic acid	0.08		

c

(12) *Sterling*.—On SW. $\frac{1}{4}$ of SW. $\frac{1}{4}$ Sec. 32, T. 48, R. 28, adjoining the Boston on the west. Operated by Messrs. A. Kidder and J. Outhwaite. Opened in 1880. Total product, 1,341 tons. Samples of the ore collected by Professor Pumpelly contained—

d

	1.	2.	3.
	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>
Metallic iron	64.76	64.40	64.98
Phosphorus	0.053	0.039	0.025
Phosphorus in 100 parts iron	0.082	0.060	0.039

No. 1 is an average sample, No. 2 is a special sample of the granular ore, and No. 3 is a special sample of the slaty ore.

The *Dalliba*, on the N. $\frac{1}{2}$ of SW. $\frac{1}{4}$ Sec. 29, T. 48, R. 29, owned by the Dalliba Iron Company, and the *Northampton*, on SE. $\frac{1}{4}$ Sec. 30, T. 48, R. 29, owned by the Champion Iron Company, are both new openings. The ore is reported to average over 60 per cent. metallic iron, but to contain too much phosphorus for Bessemer. It was not sampled.

Mines producing ore of Class II (magnetic and slate).

Beginning at the east, the first mine belonging to this class is the Humboldt, although recent explorations by the Conrad Iron Company may result in the development of a mine on the NW. $\frac{1}{4}$ of NW. $\frac{1}{4}$ Sec. 18, T. 47, R. 28.

(1) *Humboldt* (formerly Washington).—On NE. $\frac{1}{4}$ of Sec. 11, T. 47, R. 29; owned by the Washington Iron Company; operated by the Humboldt Iron Company. First shipment in 1865. Total product, 514,298 tons. Product in census year, 17,321 tons. A sample of the magnetic ore, collected by Mr. Willis from a pile of 4,000 tons, contained—

f

	120.		120.
	<i>Per cent.</i>		<i>Per cent.</i>
Metallic iron	63.79	Titanic acid	Absent.
Phosphorus	0.154	Insoluble silicious matter	8.12
Sulphur	0.005	Phosphoric acid	0.352
Silica	7.61	Phosphorus in 100 parts iron	0.241
Alumina	2.84	Specific gravity	4.851
Manganese	Slight indication.	Per cent. iron divided by specific gravity ..	13.14

Texture of ore, granular.

(2) *Edwards*, contiguous to the Humboldt on the west. First shipment in 1866. Total product, 250,912 tons. Mine has been idle since 1879, but is soon to be reopened by the Argyle Iron Mining Company.

Samples of the ore collected by Mr. Willis from old stock-piles at Cleveland contained—

	132.	133.		132.	133.
	<i>Per cent.</i>	<i>Per cent.</i>		<i>Per cent.</i>	<i>Per cent.</i>
Metallic iron	50.80	60.02	Titanic acid	Present.	Present.
Phosphorus.....	0.072	0.107	Insoluble siliceous matter.....	11.52	11.10
Sulphur.....	0.096	0.199	Phosphoric acid	0.102	0.246
Silica	7.98	6.30	Phosphorus in 100 parts iron.....	0.120	0.178
Alumina.....	5.00	4.08	Specific gravity.....	4.726	4.730
Manganese	Present.	Absent.	Per cent. iron divided by specific gravity..	12.05	12.06

Sample No. 132 is from 1,000 tons of magnetic ore; texture of ore, granular. Sample No. 133 is from 1,000 tons of specular slate ore; texture of ore, micaceous.

(3) *Champion*.—On S. $\frac{1}{2}$ Sec. 31, T. 48, R. 29. Operated by the Champion Iron Company. First shipment in 1868. Total product, 929,220 tons. Product in census year, 99,609 tons. Samples of the ore collected at Cleveland by Mr. Willis contained—

	103.	104.	130.	147.
	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>
Metallic iron	64.01	60.70	59.17	60.75
Phosphorus.....	0.030	0.044	0.035	0.038
Sulphur	0.090	0.064	.....	0.085
Silica	4.92	6.29	8.63	2.60
Alumina.....	3.15	0.08	5.35	1.90
Manganese	Absent.	Present.	Absent.	Present.
Titanic acid	Absent.	0.07	Absent.	Absent.
Insoluble siliceous matter.....	7.86	9.84	12.20	3.94
Phosphoric acid	0.089	0.120	0.082	0.088
Phosphorus in 100 parts iron.....	0.060	0.073	0.059	0.057
Specific gravity.....	4.668	4.523	4.635	.....
Per cent. iron divided by specific gravity..	13.71	13.42	12.76	.....

Sample No. 103 is from a pile of 7,000 tons of magnetic No. 1; texture of ore, granular. Sample No. 104 is from a pile of 4,000 tons of "Chelsea" or No. 2 ore; it is a mixture of magnetic and specular ores; texture, granular and micaceous. Sample No. 130 is from a pile of 1,500 tons of "Beacon" or "specular and magnetic No. 2"; texture of ore, micaceous and granular. Sample No. 147 is a special sample of the fine ore in the pile from which sample No. 103 was taken (see under sample No. 150, Jackson mine, p. 425); texture of ore, granular.

The presence of titanic acid in sample No. 104 is noticeable. As it has been repeatedly stated that this element was absent from all the ores of the Marquette region. It has, however, been found also in the ore from the Keystone mine (samples Nos. 127 and 143) and the Edwards mine (samples Nos. 132 and 133).

(4) *Keystone*.—On SW. $\frac{1}{4}$ of SW. $\frac{1}{4}$ Sec. 32, T. 48, R. 29. Operated by the Keystone Iron Company; first shipment in 1872. Total product, 70,326. Product in census year, 10,080 tons. Samples of the ore collected at Cleveland by Mr. Willis contained—

	127.	143.		127.	143.
	<i>Per cent.</i>	<i>Per cent.</i>		<i>Per cent.</i>	<i>Per cent.</i>
Sulphur.....	0.102	0.055	Phosphoric acid	1.256	0.720
Phosphorus.....	0.548	0.314	Titanic acid	0.012	0.49
Iron, metallic.....	60.05	59.17	Carbon and carbonaceous matter .....	.....	0.12
Phosphorus in 100 parts iron.....	0.913	0.530	Hygroscopic water .....	.....	0.28
Specific gravity.....	4.567	4.567	Water of composition .....	.....	0.23
Per cent. iron divided by specific gravity..	13.14	12.90	Total .....	.....	100.043
Silica	0.60	7.01	Insoluble siliceous matter.....	9.910	11.01
Iron, protoxide .....	.....	11.36	Silica .....	.....	7.01
Iron, peroxide .....	.....	71.88	Alumina.....	.....	2.48
Alumina.....	3.59	3.45	Lime .....	.....	0.09
Manganese, protoxide	Absent.	0.04	Magnesia .....	.....	0.11
Lime.....	.....	1.84	Potassa .....	.....	0.54
Magnesia .....	.....	0.56	Soda .....	.....	0.65
Iron, disulphide .....	.....	0.083	Phosphoric acid .....	.....	0.147
Potassa .....	.....	0.92	Total .....	.....	11.027
Soda .....	.....	0.86			
Carbonic acid.....	.....	0.10			

a Sample No. 127 is from a pile of 1,000 tons of ore "shipped in 1878 from a drift, since abandoned on account of the poor quality of the ore". Sample No. 143 is from 3,000 tons of ore at "The River furnaces" of the Cleveland Rolling-Mill Company. Sample No. 127 contains a higher per cent. of phosphorus than any other ore from the upper peninsula, the analysis of which has been published. The presence of titanio acid is also noticeable.

(5) *Michigamme*.—On north side of lake Michigamme, on S. $\frac{1}{2}$ of Secs. 19 and 20, T. 48, R. 30. Operated by the Michigamme Iron Company. First shipment in 1872. Total product, 432,200 tons. Product in census year, 66,158 tons. The ore is all granular magnetite. Samples collected at the mine contained—

	1.	2.	3.	4.
	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>
Sulphur	0.103	0.297	0.068	0.027
Phosphorus.....	0.095	0.092	0.042	0.053
Iron, metallic.....	63.55	56.35	59.95	65.24
Phosphorus in 100 parts iron.....	0.140	0.103	0.070	0.081
Specific gravity.....	4.606	4.801	4.859	4.865
Per cent. iron divided by specific gravity..	4.621	3.852	12.86	13.41
Silica	5.24	15.14	13.75	5.78
Iron, protoxide	28.52			20.94
Iron, peroxide	58.99			59.89
Alumina.....	2.95			2.20
Manganese	0.34	Present.	Present.	0.16
Lime	0.94			0.27
Magnesia	0.78			0.63
Iron, disulphide	0.193			0.051
Carbonic acid.....	1.10			0.17
Phosphoric acid.....	0.217	0.211	0.006	0.121
Carbon in carbonaceous matter.....	0.05			
Hygroscopic water.....	0.04			0.02
Water of composition.....	0.72			0.88
Total	100.380			100.112
Insoluble silicious matter.....	6.24			6.11
Silica	5.24			5.78
Alumina.....	0.80			0.34
Magnesia.....	0.10			
Total	6.23			6.12

Sample No. 1 was taken across the stope in pit No. 4, fourth level, about 375 feet below surface and 130 feet east of shaft. The stope is 25 feet wide. Sample No. 2 is also from pit No. 4, first level, 375 feet east of shaft. This **e** pit is very wet, and part of the ore as it comes from the mine is covered with a coating of red oxide. Sample No. 3 is from pit No. 1, second level, 130 feet below surface and 140 feet west of shaft. The stope is 15 feet wide.

Pit No. 1 is about 900 feet east of pit No. 4; 100 feet west of pit No. 1 a shaft is (November, 1879) being sunk on a lens of ore recently discovered. The shaft is 35 feet deep. The ore, which at the bottom of the shaft is 9 feet wide, is represented by sample No. 4.

The greater part of the ore shipped in the census year was mined in pit No. 4, but some ore was raised from both pits Nos. 5 and 6, which are west of No. 4. The samples of the ore collected by Mr. Willis contained—

	110.	148.		110.	148.
	<i>Per cent.</i>	<i>Per cent.</i>		<i>Per cent.</i>	<i>Per cent.</i>
Metallic iron	61.95	60.08	Titanic acid	Absent.	Absent.
Phosphorus	0.118	0.101	Insoluble silicious matter.....	8.28	8.25
Sulphur	0.109	0.261	Phosphoric acid	0.272	0.232
Silica	7.09	7.00	Phosphorus in 100 parts iron	0.180	0.160
Alumina.....	1.98	2.90	Specific gravity	4.568	
Manganese	Present.	Present.	Per cent. iron divided by specific gravity..	13.55	

Sample No. 110 represents an average of a pile of 4,500 tons of ore at the North Chicago rolling-mill. Sample No. 148 is a special sample of the fine ore in the same pile (see note under sample No. 150, Jackson mine, page 425.)

(6) *Spurr Mountain*.—On SW. $\frac{1}{4}$ of NW. $\frac{1}{4}$ Sec. 24, T. 48, R. 31. First shipment in 1872. Total product, **a** 160,724 tons. Idle since 1878. A sample of the ore collected by Mr. Willis at Cleveland, from an old stock-pile of 800 tons, contained—

	121.		121.
	<i>Per cent.</i>		<i>Per cent.</i>
Metallio iron	62.21	Titanic acid	Absent.
Phosphorus	0.114	Insoluble silicious matter.....	7.30
Sulphur	0.016	Phosphorus in 100 parts iron	0.183
Silica	6.91	Specific gravity	4.564
Alumina.....	2.88	Per cent. iron divided by specific gravity..	13.63
Manganese	Trace.		

The ore is a granular magnetite.

(7) *Steward*.—On Sec. 23, T. 48, R. 31, west of Spurr mountain. First shipment in 1874. Total product, 3,335 tons. Idle since 1878. The ore was not sampled.

(8) *Republic*.—On Sec. 7, T. 46, R. 29. Operated by the Republic Iron Company. First shipment in 1872. Total product, 1,334,517 tons. Product in census year, 224,000 tons. The samples of the ore collected at the mine contained—

	5.	7.	8.	9.
	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>
Sulphur	0.037	0.050		
Phosphorus.....	0.024	0.051	0.001	0.033
Iron, metallic.....	67.02	69.03	64.01	68.17
Phosphorus in 100 parts iron	0.036	0.073	0.095	0.043
Specific gravity	5.113	5.071	4.196	4.630
Per cent. iron divided by specific gravity..	13.10	13.74	15.5	14.7
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Silica	3.38	1.41		
Iron, protoxide	1.05	20.37		
Iron, peroxide	94.68	76.27		
Alumina.....	0.38	0.52		
Lime	0.03	0.13		
Magnesia.....	0.33	0.25		
Iron, disulphide	0.007	0.004		
Carbonic acid.....	0.08	0.05		
Phosphoric acid	0.055	0.117		
Carbon in carbonaceous matter.....		0.01		
Hygroscopic water		0.10		
Water of composition	0.14	0.20		
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Total	100.002	100.021		
<hr/>				
Insoluble silicious matter.....	3.50	1.70		
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Silica	3.38	1.41		
Alumina (with a trace of oxide of iron)....	0.21	0.40		
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Total	3.50	1.81		

In pit No. 5 an approximate section across the north side of the pillar, 70 feet south from the shaft and 200 feet below surface, shows: 1st, 80 feet of micaceous specular slate ore; 2d, 40 feet of chloritic schist; and 3d, 30 feet of granular magnetite. The latter is next the quartzite (hanging wall). The chloritic schist is lens-shaped and pitches toward the north. At a higher level the magnetic and specular ores are almost in direct contact. **f** Magnetic ore has been found only in pits Nos. 3 to 6, which are all connected and form practically one pit. In 1879 the total product of the Republic mine was 151,369 tons. Of this amount, 16,952 tons was magnetic ore; the balance was micaceous specular.

Sample No. 5 was taken across the exposure of specular ore in pit No. 5, 200 feet below surface. Sample No. 7 was taken across the exposure of magnetic ore in the same pillar, but at the 250-foot level. Sample No. 8 was taken across the stope in the Morgan pit, 135 feet below surface (on the incline, 60°), and 80 feet east of shaft. The stope is about 60 feet wide. The ore is all micaceous specular. Sample No. 9 was taken in the Ely pit across the stope 75 feet east of shaft, on the 200-foot level. The character of the ore is the same as that of samples Nos. 5 and 8.

a The following analyses are of samples of the ore collected by Mr. Willis at Cleveland:

	101.	145.	102.	146.
	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>
Metallic iron.....	64.81	67.03	67.52	69.13
Phosphorus.....	0.050	0.042	0.081	0.062
Sulphur.....	0.053	0.054	0.008	0.022
Silica.....	4.62	2.33	2.78	1.60
Alumina.....	1.92	1.30	2.03	1.09
Manganese.....	Trace.	Absent.	Absent.	Absent.
Titanic acid.....	Absent.	Absent.	Absent.	Absent.
Insoluble silicious matter.....	5.86	3.05	4.61	2.69
Phosphorus in 100 parts iron.....	0.077	0.062	0.120	0.090
Specific gravity.....	4.872	.....	4.017	.....
Per cent. iron divided by specific gravity..	13.30	.....	13.73	.....

Sample No. 101 is an average of a pile of 25,000 tons of first-class micaceous specular ore. Sample No. 145 is a special sample of the fine ore in the same pile (see note to sample No. 150, Jackson mine, 425). Sample No. 102 is an average of a pile of 600 tons of magnetic ore. Sample No. 146 is a special sample of the fine magnetic ore. A little second class or No. 2 ore is shipped from the mine, but it was not sampled.

(8) *Kloman* (now *Columbia*).—On the extension of the east side of Republic trough, north of Michigan river. First shipment in 1873. Total product, 78,748 tons. Mine was idle from 1875 to 1880. Reopened in the latter year by the Columbia Iron Company. The ore was not sampled.

Mines producing ore of Class III (soft hematite).

(a) The mines in bed X can, geographically, be grouped into the Negaunee range, Teal Lake range, and Salisbury range.

NEGAUNEE RANGE.—The mines included in this range, with the exception of the South Jackson and Section 12, all lie in the NW. part of T. 47, R. 26.

(1) *Kowland*.—On W. $\frac{1}{2}$ of Sec. 17, near west section line. Owned by the Iron Cliff Company. Opened in 1872, but not worked steadily. Total product, exclusive of ore used in company's furnaces, 3,358 tons.

(2) *Indiana* (formerly *Green Bay*).—On W. $\frac{1}{2}$ of NW. $\frac{1}{4}$ Sec. 8. Operated by Blake & Allen. Total product, 16,214 tons.

(3) *Rolling Mill* (sometimes called *Berringer*).—On S. $\frac{1}{2}$ of NE. $\frac{1}{4}$ Sec. 7. Operated by Captain Berringer. First shipment in 1871. Total product, 239,718 tons. Product in census year, 14,156 tons.

A sample of the ore collected at Cleveland by Mr. Willis from 4,000 tons contained—

	130.		136.
	<i>Per cent.</i>		<i>Per cent.</i>
Metallic iron.....	47.13	Titanic acid.....	Absent.
Phosphorus.....	0.033	Insoluble silicious matter.....	28.34
Sulphur.....	0.060	Phosphoric acid.....	0.077
Silica.....	27.09	Phosphorus in 100 parts iron.....	0.070
Alumina.....	1.05	Specific gravity.....	3.996
Manganese.....	Present.	Per cent. iron divided by specific gravity..	11.79

Texture of ore, earthy.

(4) *Baraga*.—On SE. $\frac{1}{4}$ of SE. $\frac{1}{4}$ Sec. 6. Operated by the Baraga Iron Company. It is a new opening; no ore was shipped previous to the end of 1880.

(5) *Orion* (formerly the *Himrod Hematite*).—On N. $\frac{1}{2}$ SE. $\frac{1}{4}$ Sec. 6. Product in 1879, 561 tons. Not reported on census schedules.

(6) *New York Hematite* (formerly the *Grand Central*).—On E. $\frac{1}{2}$ of SW. $\frac{1}{4}$ Sec. 6. Operated by Neely & Sweeney. First shipment in 1870. Total product, 39,504 tons. Product in census year, 2,240 tons.

(7) *Pendill*.—On W. $\frac{1}{2}$ of SW. $\frac{1}{4}$ Sec. 6. Operated by the Union Mining Company. Opened in 1877. The mine was worked in 1879 by the McComber Iron Company, and its output for that year is included in the total product of the McComber mine. The total production of the Pendill mine cannot, therefore, be given. Its product in the census year was 20,160 tons.

(8) *Chicago* (formerly the *Calhoun and Spurr*).—On S. $\frac{1}{2}$ of SE. $\frac{1}{4}$ Sec. 7. Operated by J. F. Stevens and W. C. Calhoun. First shipment in 1880. Total product, 3,768 tons. Product in census year, 3,304 tons.

(9) *Manganese* (formerly the *Negaunee*).—On NE. $\frac{1}{4}$ of NW. $\frac{1}{4}$ of Sec. 7. Operated by J. W. Schodt. First shipment in 1871. Total product, 30,892 tons. Product in census year, 11,200 tons. The mine was idle from 1873 to 1877 (both years inclusive). A sample collected at Cleveland, by Mr. Willis, from 1,200 tons of the ore, contained—

	112.		112.
	<i>Per cent.</i>		<i>Per cent.</i>
Metallic iron	41.54	Titanic acid	Absent.
Phosphorus	0.077	Insoluble silicious matter	25.10
Sulphur		Phosphoric acid	0.177
Silica	23.80	Phosphorus in 100 parts iron	0.185
Alumina	3.00	Specific gravity	4.296
Manganese	Present.	Per cent. iron divided by specific gravity..	9.66

Texture of ore, earthy.

(10) *Milwaukee*.—On SE. $\frac{1}{4}$ of NE. $\frac{1}{4}$ Sec. 7. Operated by J. Q. Adams and James F. Foley. First shipment in 1879. Total product, 15,773 tons. Product in census year, 3,360 tons.

(11) *McComber*.—On NW. $\frac{1}{4}$ of NW. $\frac{1}{4}$ Sec. 7. Operated by the McComber Iron Company. First shipment in 1870. Total product, 251,229 tons. Product in census year, 33,600 tons. Samples of the ore yielded, on analysis—

	85.	86.	87.	111.
	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>
Sulphur		0.040	0.010	0.155
Phosphorus	0.090	0.028	0.026	0.058
Iron, metallic	54.85	59.27	55.47	52.43
Phosphorus in 100 parts iron	0.164	0.047	0.046	0.111
Specific gravity	4.040	4.320	4.575	4.044
Per cent. iron divided by specific gravity..			12.00	
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Silica		5.31	4.04	12.61
Iron, peroxide		84.63	70.23	
Alumina		3.57	3.04	2.88
Manganese, protoxide	0.11	0.44	1.96	Present.
Manganese, dioxide		0.11	8.23	
Lime		0.15	0.11	
Magnesia		0.12	0.14	
Iron, disulphide		0.075	0.010	
Potassa		0.02	0.15	
Soda			0.01	
Carbonic acid		0.13	0.11	
Phosphoric acid		0.005	0.000	0.132
Barium oxide			0.11	
Hygroscopic water		0.27	0.00	
Water of composition		5.10	2.00	
Total		100.070	100.100	
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Insoluble silicious matter		7.92	5.07	15.19
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Silica		5.30	4.04	
Alumina		2.55	1.68	
Lime		0.01	0.01	
Magnesia		0.01	0.07	
Potassa		0.02	0.15	
Soda			0.01	
Total		7.00	5.06	

At the southern end of pit No. 5, in which most of the ore shipped in the census year was mined, a section across the slope shows 6 feet of a soft, reddish-brown ore on the north, and 14 feet of a harder and darker-colored ore on the south. Sample No. 85 represents the hard ore, and sample No. 86 the soft ore. Sample No. 87 is from the bottom of shaft No. 6, a new opening west of the engine-house. The shaft is about 130 feet deep. The ore at the bottom of the shaft is 19 feet wide. Sample No. 111 was collected by Mr. Willis, at Cleveland, from a pile of 1,500 tons.

a (12) *South Jackson*.—On SE. $\frac{1}{4}$ Sec. 1, T. 47, R. 27, west of the McComber. Operated by the Jackson Iron Company. The shipments of ore are included with those of the Jackson mine. Samples collected by Mr. Willis, at Cleveland, contained—

	137.	138.		137.	138.
	<i>Per cent.</i>	<i>Per cent.</i>		<i>Per cent.</i>	<i>Per cent.</i>
Metallie iron.....	01.71	54.88	Titanic acid.....	Absent.	Absent.
Phosphorus.....	0.140	0.096	Insoluble silicious matter.....	4.82	12.40
Sulphur.....	0.078	0.093	Phosphoric acid.....	0.322	0.220
Silica.....	3.77	11.17	Phosphorus in 100 parts iron.....	0.227	0.175
Alumina.....	1.75	2.40	Specific gravity.....	4.488	4.475
Manganese.....	Present.	Present.	Per cent. iron divided by specific gravity..	13.75	12.26

b

Sample No. 137 is from 2,000 tons of "Jackson West", or "soft specular". The ore "is porous, stalactitic, and contains mammillary crystals". In mass its texture is earthy. Sample No. 138 is from 6,000 tons of "Jackson, southside hematite". Texture of ore, earthy.

(13) *Section 12 mine*.—On NE. $\frac{1}{4}$ Sec. 12, T. 47, R. 27, contiguous with one pit of the South Jackson. Owned by the Iron Cliff Company. Opened in 1879. Product in census year, 6,720 tons.

c The TEAL LAKE RANGE range extends along the south side of Teal lake, about $1\frac{1}{2}$ mile northwest of Negaunee. Beginning at the east, the first mine on the range is the—

(14) *Cambria*.—On SE. $\frac{1}{4}$ Sec. 35, T. 48, R. 27. Opened in 1874. Total product, 38,368 tons. Product in census year, 6,720 tons. The mine is leased by the Cambria Mining Company. A sample of the ore collected at Cleveland, by Mr. Willis, from a pile of 3,000 tons, contained:

	124.		124.
	<i>Per cent.</i>		<i>Per cent.</i>
Metallie iron.....	49.05	Titanic acid.....	0.07
Phosphorus.....	0.063	Insoluble silicious matter.....	23.00
Sulphur.....	0.043	Phosphoric acid.....	0.140
Silica.....	21.83	Phosphorus in 100 parts iron.....	0.128
Alumina.....	2.70	Specific gravity.....	3.722
Manganese.....	Absent.	Per cent. iron divided by specific gravity..	13.2

d

(15) *Bessemer*.—Adjoins the Cambria on the west, on the same section. Opened in 1876. Total product, 73,479 tons. Product in census year, 24,640 tons. Operated by J. H. King and C. M. Wheeler. A sample of the ore collected at Cleveland, by Mr. Willis, from a pile of 1,000 tons, contained—

	116.		116.
	<i>Per cent.</i>		<i>Per cent.</i>
Metallie iron.....	57.52	Titanic acid.....	Absent.
Phosphorus.....	0.062	Insoluble silicious matter.....	10.80
Sulphur.....	0.050	Phosphoric acid.....	0.186
Silica.....	3.55	Phosphorus in 100 parts iron.....	0.143
Alumina.....	2.70	Specific gravity.....	3.765
Manganese.....	Present.	Per cent. iron divided by specific gravity..	15.3

c

(16) *Forest City*.—Also on Sec. 35. Recently opened by the Forest City Iron Company. No ore has yet been shipped.

(17) *Cleveland Hematite* (now called the *Nelson*).—On NW. $\frac{1}{4}$ Sec. 2, T. 47, R. 27. Opened in 1876. Total product, **f** 54,914 tons. Product in census year, 18,729 tons. Leased by Robert Nelson.

A sample of the ore collected at Cleveland, by Mr. Willis, from a pile of 5,000 tons, contained—

	122.		122.
	<i>Per cent.</i>		<i>Per cent.</i>
Metallie iron.....	59.34	Titanic acid.....	Absent.
Phosphorus.....	0.056	Insoluble silicious matter.....	9.12
Sulphur.....	0.057	Phosphoric acid.....	0.123
Silica.....	7.23	Phosphorus in 100 parts iron.....	0.094
Alumina.....	3.04	Specific gravity.....	4.727
Manganese.....	Present.	Per cent. iron divided by specific gravity..	13.1

a (21) *Mitchell* (formerly the *Shenango*).—On Secs. 21 and 28, T. 47, R. 27. Leased by the Mitchell Iron Company. Opened in 1872. Total product, 60,981 tons. Product in census year, 17,920 tons.

(22) *Winthrop*.—On SW. $\frac{1}{4}$ Sec. 21, T. 47, R. 27. Leased by the Winthrop Hematite Company. Opened in 1870. Total product, 238,190 tons. Product in census year, 47,167 tons.

Samples of the ore, collected at Cleveland by Mr. Willis, contained:

	105.	106.		105.	106.
	<i>Per cent.</i>	<i>Per cent.</i>		<i>Per cent.</i>	<i>Per cent.</i>
b Metallic iron.....	50.54	49.45	Titanic acid.....	Absent.	Absent.
Phosphorus.....	0.043	0.053	Insoluble silicious matter.....	24.79	20.41
Sulphur.....	0.055	0.045	Phosphoric acid.....	0.102	0.121
Silica.....	23.06	25.25	Phosphorus in 100 parts iron.....	0.085	0.107
Alumina.....	1.66	1.94	Specific gravity.....	4.065	.....
Manganese.....	Present.	Present.	Per cent. iron divided by specific gravity..	12.4	.....

Sample 105 is from a pile of 1,000 tons from the "East Winthrop" pit. Sample 106 is from 2,000 tons of "Standard Winthrop" ore.

c (23) *Lowthian*.—On Sec. 20, T. 47, R. 27. Owned by the Lake Superior Iron Company. The product is included with that of the Lake Superior mine.

A sample of the ore, collected at Cleveland by Mr. Willis from 3,000 tons, contained—

	128.		128.
	<i>Per cent.</i>		<i>Per cent.</i>
d Metallic iron.....	56.27	Titanic acid.....	Absent.
Phosphorus.....	0.086	Insoluble silicious matter.....	14.56
Sulphur.....	0.078	Phosphoric acid.....	0.198
Silica.....	14.19	Phosphorus in 100 parts iron.....	0.153
Alumina.....	0.12	Specific gravity.....	4.104
Manganese.....	Present.	Per cent. iron divided by specific gravity..	13.7

Mines producing ore of Class IV (flag ore).

The ores of this class belong to an horizon below bed V. The only mines that have shipped this ore are in the so-called Cascade range, which lies about 4 miles south of Negaunee. They are the Gribben, Carr, Wheat, Pittsburgh and Lake Superior, and Palmer.

(1) *Gribben*.—Opened in 1872. Total product, 4,031 tons. It has been idle since 1873.

(2) *Carr*.—Opened in 1872. Total product, 2,666 tons. Abandoned in 1874.

e (3) *Pittsburgh and Lake Superior* (now a part of the *Palmer*).—Opened in 1872. Idle in 1875 and 1876. Total product, 29,144 tons. Product in census year, 981 tons.

(4) *Wheat* (formerly *Home*).—Opened in 1873. Operated by the Wheat Iron Company. Idle from 1875 to 1878 (both years inclusive); reopened in 1879. Total product, 8,292 tons.

(5) *Palmer*.—Adjoining the Wheat on the west. On Sec. 31, T. 47, R. 26. Opened in 1871. Total product, 232,987 tons. Product in census year, 33,508 tons.

A sample of the ore, collected at Cleveland by Mr. Willis from 8,000 tons, contained—

	118.		118.
	<i>Per cent.</i>		<i>Per cent.</i>
f Metallic iron.....	58.67	Titanic acid.....	Absent.
Phosphorus.....	0.066	Insoluble silicious matter.....	11.38
Sulphur.....	0.038	Phosphoric acid.....	0.151
Silica.....	8.03	Phosphorus in 100 parts iron.....	0.112
Alumina.....	5.50	Specific gravity.....	4.527
Manganese.....	Absent.	Per cent. iron divided by specific gravity..	12.8

The Magnetic, Cannon, and Chippeway mines, all in T. 47, R. 30, are described by Mr. Brooks in the *Geological Survey of Michigan*, Vol. I. He supposes the ore to belong to the same horizon as the Cascade Range ores. No shipments have been made from these mines.

There remain to be mentioned, to complete the list of mines in the Marquette region, the Cheshire and the Taylor mines.

Cheshire (formerly the *Silas C. Smith*).—On SE. $\frac{1}{4}$ Sec. 18, T. 45, R. 25. Opened in 1872. Operated by the *a* Cheshire Iron Company. Total product, 89,125 tons. Product in census year, 20,582 tons. The ore is a soft, blue hematite resembling the Menominee Range ores more than the soft ores of the Marquette region. Its geological horizon has not yet been definitely determined. A sample of the ore collected at Cleveland, by Mr. Willis, from 2,000 tons, contained—

	123.		122.
	<i>Per cent.</i>		<i>Per cent.</i>
Metallic iron.....	58.60	Titanic acid.....	Absent.
Phosphorus.....	0.053	Insoluble silicious matter.....	9.14
Sulphur.....	0.083	Phosphoric acid.....	0.121
Silica.....	6.50	Phosphorus in 100 parts iron.....	0.090
Alumina.....	1.24	Specific gravity.....	4.673
Manganese.....	Present.	Per cent. iron divided by specific gravity..	12.8

Taylor.—On NW. $\frac{1}{4}$ Sec. 9, T. 49, R. 33. In the so-called L'Anse range, 10 miles southeast of L'Anse. The Taylor Iron Company hold the lease of the property. The ore is a soft, brown hematite. Its existence has been known for several years, but the first shipment was made in 1880, after the close of the census year. One thousand two hundred and forty-three tons of ore were shipped during the season. The ore was not sampled.

THE MENOMINEE IRON REGION.

This region embraces the deposits of iron ore in the southern part of the upper peninsula of Michigan, and also those in the northern portion of Marinette county, Wisconsin. In Michigan there are two belts of iron ore separated by an area of Laurentian granites, gneisses, and schists (see Fig. 184, p. 421). The southern belt extends from near the center of T. 39, R. 28, in a direction a trifle north of west to the Menominee river in T. 40, R. 31, and includes two ranges of ore separated by a belt of silicious marble. Since the completion of the branch of the Chicago and Northwestern railroad to Quinnesec, in 1877, the mines on the southern belt east of that village have been extensively wrought. The railroad was extended in 1879-'80 across the Menominee river to the Florence mine, in T. 40, R. 18, Wisconsin, and the mines west of Quinnesec were opened and made their first shipments of *d* ore in the summer and autumn of 1880.

Of the *northern belt* comparatively little is known. Ore has been discovered in the southern tier of sections in T. 42, R. 28, 29, and 30, but on account of the want of transportation facilities no developments have as yet (December, 1879) been made. In the *southern belt* the ore consists principally of a soft, specular, blue hematite, which runs high in iron and low in phosphorus. Although quite soft, the ore usually resists hydration and rarely changes color except on handling, when it soon becomes more or less coated with its own red powder. This peculiarity is doubtless due to its physical structure. When examined fresh from the mine the ore is seen to be made up of innumerable fine crystalline particles of specular hematite, which are somewhat loosely agglutinated. On rubbing two pieces together these particles are readily separated and partially reduced to powder. By the time the ore reaches the dock at Cleveland its texture is apparently earthy.

An ore consisting of a mixture of the red and brown oxides is occasionally met with, however, associated with the blue ore, from which it has evidently been derived. But so far as observed by me this brown ore occurs in quantity only at the Emmet mine, and here the ore-body dips under a swamp. The conditions are therefore exceptional.

Geologically the Michigan (Menominee) ores belong to bed VI (*a*) of Brooks's scheme of the Lower Huronian series. The ore usually occurs in irregular pockets or lens-shaped masses in a banded quartzose ferruginous schist, which is often magnetic, and thus enables the ranges of ore to be traced with the dip-needle. The ore itself does not affect the compass-needle. The region was visited and sampled in December, 1879.

Beginning, as in the Marquette region, at the eastern end, the first mine is the—

(1) *Emmet*.—On NE. $\frac{1}{4}$ of NE. $\frac{1}{4}$ Sec. 22, T. 39, R. 28. Operated by the Emmet Mining Company. First shipment *f* in 1878. Total product, 73,928 tons. Product in census year, 31,447 tons. The workings (see Fig. 190) consist of an open pit about 90 feet long by 50 feet wide and 70 feet deep, the lower diameter of which has a direction nearly east and west, this being the course of the strike of the ore. The latter dips to the south underneath a swamp. The mine is very wet on this account. No rock has thus far been uncovered above the ore, but the latter is overlaid with (1) hard blue clay, (2) shell marl, (3) peat. The thickness of these layers varies considerably; at one point a section showed 3 to 4 feet of clay, 5½ feet of marl, and 3½ feet of peat. A section through the pit is shown in Fig. 190. Both brown and blue ore occur in this pit, and, contrary to what might reasonably be expected on first sight, the blue ore lies *above* the brown, that is, between the latter and the bottom of the swamp. It is evident, however, on closer examination, that the reason for this is to be found in the bed of blue clay above referred to, which has to a great extent prevented the water percolating directly downward, while on the other hand the character of

a *Geology of Wisconsin*, Vol. III, table facing p. 450 (Brooks), and *Ibid.*, p. 679 (Wright).

the foot-wall rock—a ferruginous silicious schist—has offered no obstacle to the water's reaching the body of ore **a** near it. That the water has drained through this schist is evidenced by the yellow ocher which the latter contains. The samples of ore taken in the pit are compared in the following analyses:

	78.	77.	84.
	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>
Metallic iron	50.58	52.07	22.54
Phosphorus.....	0.103	0.008	0.107
Phosphorus in 100 parts iron. . .	0.204	0.015	0.475

Sample No. 78 represents the brown ore, and sample No. 77 the blue ore. These samples were taken from the **c** stopes in the pit. Sample No. 84 is of the yellow ocher from the foot-wall. By a comparison of these analyses it seems highly probable that the phosphorus in Nos. 78 and 84 has been derived from surface drainage.

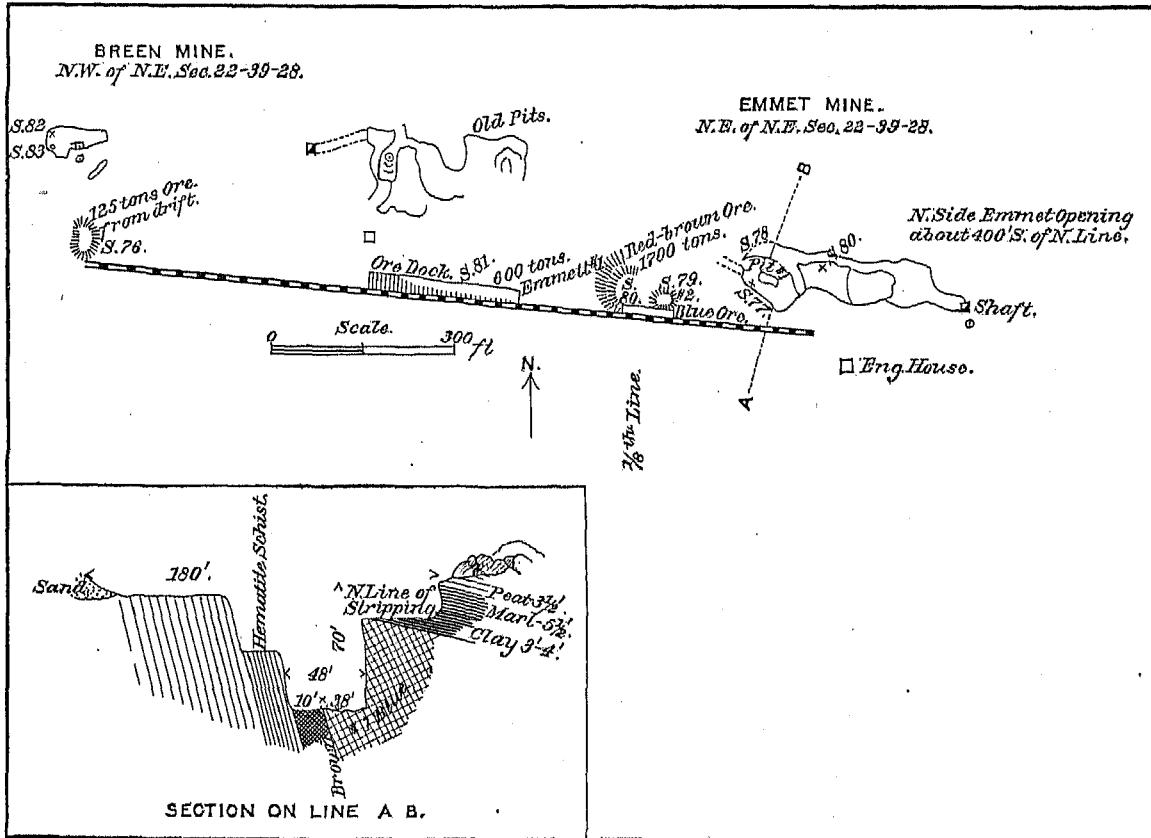


FIG. 190.—SKETCH OF THE EMMET AND BREEN MINES, MENOMINEE COUNTY, MICHIGAN.

Two grades of blue ore are shipped. The following partial analyses are of samples from the stock-piles at the mine:

	81.	79.	80.
	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>
Metallic iron	56.07	40.96	42.19
Phosphorus.....	0.027	0.018	0.076
Phosphorus in 100 parts iron...	0.048	0.044	0.180

Sample No. 81 is from 600 tons "No. 1 blue". Sample No. 79 is from 100 tons "No. 2 blue". Sample No. 80 is from 1,700 tons "brown ore". From July 1 to December 18, 1879, the relative amounts of the three grades of ore shipped were as 7:7½:5. Samples taken by Mr. Willis at Cleveland contained—

	107.	125.		107.	125.
	<i>Per cent.</i>	<i>Per cent.</i>		<i>Per cent.</i>	<i>Per cent.</i>
Metallic iron	38.53	47.34	Manganese	Absent.	Present.
Phosphorus.....	0.058	0.135	Titanic acid	Absent.	Absent.
Sulphur.....	0.190	0.005	Insoluble silicious matter.....	41.62	21.76
Silica	40.83	29.95	Phosphorus in 100 parts iron...	0.151	0.285
Alumina.....	1.32	1.68	Specific gravity.....	4.073	3.814

a Sample No. 107 is from 600 tons "No. 2 blue". Sample No. 125 is from 1,000 tons "brown ore". "No. 1 blue" was not sampled at Cleveland.

(2) *Breen*.—On NW. $\frac{1}{4}$ of NE. $\frac{1}{4}$ Sec. 22, T. 39, R. 28, adjoining the Emmet on the west (see Fig. 190). Operated by the Emmet Mining Company. First shipment in 1877. Total product, 19,533 tons. Product in census year, 5,600 tons. The Breen was the first mine opened on the Menominee range. The deposit was not a large one, however, and is now practically exhausted. The workings, as indicated on the sketch, consist of two pits, some 400 feet apart. From the eastern pit, when the mine was visited, a drift was being driven westward in a mixed ore. About one-quarter of the material mined here is sent to the rock-dump, and the balance is shipped, as a second-class ore to the company's furnaces at Sharon, Ohio. Its character is shown by sample No. 76, from a pile of 125 tons.

b Two samples were taken from the breast on the west side of the western pit, although no work was being done here at the time. The ore is of two kinds: Sample No. 82 represents a soft, blue specular ore, which occurs in small seams and pockets between layers of a harder ore having a slaty cleavage. The character of the latter is shown by sample No. 83. Both these samples probably contain more iron than would the average run of the pit. The above samples contained—

	76.	82.	83.
	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>
Metallio iron.....	50.17	50.79	58.14
Phosphorus.....	0.026	0.012	0.005
Phosphorus in 100 parts iron...	0.052	0.020	0.009

c

(3) *East Vulcan* (now called the *Lowell*).—On S. $\frac{1}{2}$ of S. $\frac{1}{2}$ Sec. 11, T. 39, R. 29. Operated by the Menominee Mining Company. First shipment in 1880. Total product, 16,320 tons. The developments on this property in the fall of 1879 are indicated on Fig. 191. A sample of the ore thrown out from the trench and the two shafts contained:

	07.
	<i>Per cent.</i>
Metallio iron.....	58.33
Phosphorus.....	0.008
Phosphorus in 100 parts iron.....	0.010

d

e

f

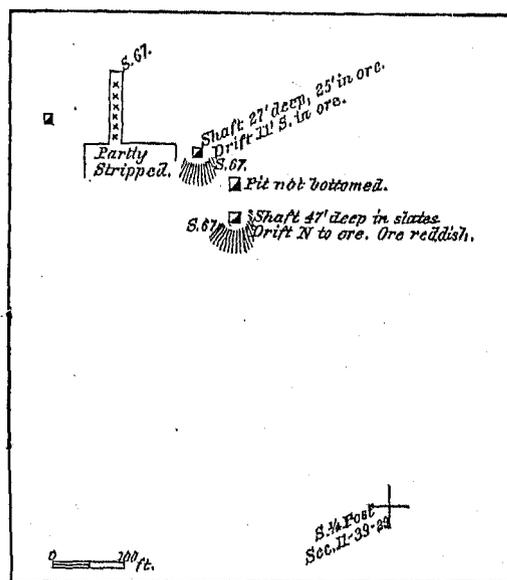


FIG. 191.—SKETCH PLAN OF THE EAST VULCAN (LOWELL) MINE, MENOMINEE COUNTY, MICHIGAN.

(4) *Vulcan*.—On Secs. 9 and 10, T. 39, R. 29. Operated by the Menominee Mining Company. First shipment in 1877. Total product, 194,294 tons. Product in census year, 83,394 tons. The mine includes two distinct groups of workings (see Fig. 192). The Old Vulcan, or pit No. 1, where the first mining was done, is entered by a tunnel at a point about 40 feet below the original outcrop. The lens of ore dips to the south and pitches westward. With the exception of a small pocket of ore immediately west of the tunnel, the ore-body is worked out down to the tunnel-level. Sample No. 65 was taken from this pocket of ore. The ore is peculiar in that it becomes covered with an ashy-gray coating on exposure to the air. In December, 1879, sinking was progressing at a point near the

south side of the pit and some 40 paces west of the tunnel. At a depth of about 50 feet below the tunnel-level a body of ore 20 to 25 feet wide and 40 to 50 feet long had been uncovered. The character of this ore is indicated by sample No. 66. The above samples contained—

	65.	66.		65.	66.
	Per cent.	Per cent.		Per cent.	Per cent.
Metallic iron.....	62.89	62.88	Phosphoric acid.....	0.002	
Phosphorus.....	0.001	0.005	Titanic acid.....	0.075	
Sulphur.....	0.023		Hygroscopic water.....		0.10
Phosphorus in 100 parts of iron.....	0.002	0.008	Water of composition.....	0.72	
			Total.....	99.990	
Silica.....	6.23		Per cent. of insoluble silicious matter.....	7.81	
Iron, protoxide.....	1.06		Silica.....	6.23	
Iron, peroxide.....	88.02		Alumina.....	0.72	
Alumina.....	1.08		Lime.....	0.04	
Manganese, protoxide.....	0.02		Magnesia.....	0.05	
Lime.....	0.13		Potassa.....	0.30	
Magnesia.....	0.01		Total.....	7.84	
Iron, disulphide.....	0.043				
Potassa.....	0.30				
Carbonic acid.....	0.10				

The presence of titanium in sample No. 65 is noticeable as the Menominee ores, like those in the Marquette region, are usually free from this element.

Pit No. 3, or New Vulcan, is situated about 500 feet northwest of pit No. 1. There are here two openings, connected at the tram-road level by a drift. The eastern opening is about 75 feet long by 25 feet wide, and is entered by a tunnel at about 25 feet below the original outcrop. From the bottom of this opening a shaft has been sunk to a depth of 57 feet on the dip of the ore, which is toward the south, at an angle of about 45°. At the bottom of the shaft a room 20 by 25 feet has been worked out, the width of the ore here being a little more than 20 feet. The ore is a beautiful soft, blue specular, perfectly free from rock intermixture, from hanging - to foot-wall. Its character is shown by sample No. 60.

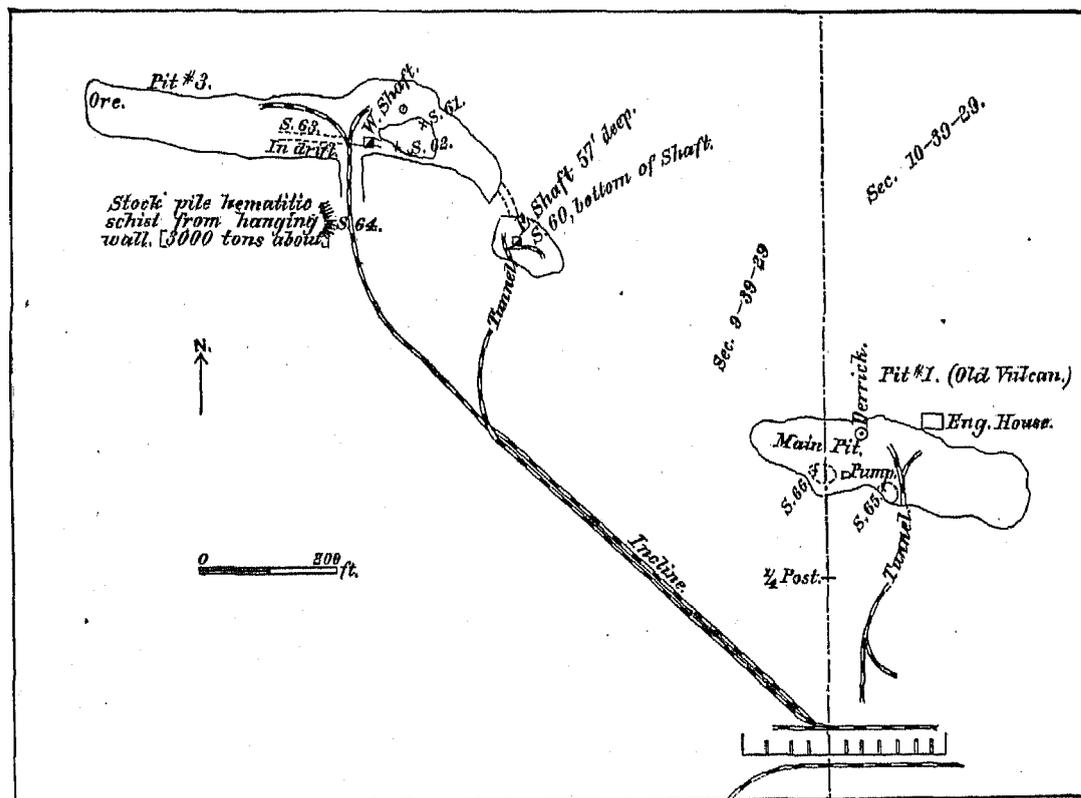


FIG. 192.—SKETCH PLAN OF THE VULCAN MINE, MENOMINEE COUNTY, MICHIGAN.

The western pit has thus far been chiefly wrought open to day, but the workings on the south side are now partly under the hanging-wall. Along the foot-wall in this pit there is a red hematitic schist, which, in places, is 3 to 4 feet thick. A little of this schist has been shipped as an iron ore; sample No. 61 was taken from about a ton

a of it in the pit. Sample No. 62 was taken from the breast of blue ore on the south side of the pit. East of the tram-road a shaft has been sunk to a depth of about 50 feet, and from it drifts have been driven in either direction. Sample No. 63 is from the end of the western drift, about 100 feet west from the shaft. As shown by the sketch, the stripping has been removed for some distance west of the shaft. No ore had been mined from this portion of the pit, however, at the date of my visit. The ore is overlaid by a ferruginous silicious schist, which, near the ore-body, sometimes contains so much iron as to constitute a lean ore. A good exposure of this schist is seen in the cut through which the tramway enters the western pit. At this point there is probably a thickness of 15 feet of the schist, containing as much iron as the pile of 3,000 tons from which sample No. 64 was taken. None of this has been shipped, but when it has been necessary to take it down, it has been kept separate from the rock.

b Sample No. 134 represents the shipping product of the mine. It was taken at Cleveland by Mr. Willis. The above-mentioned samples contained:

	60.	61.	62.	63.	64.	134.
	<i>Per cent.</i>	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.
Metallic iron.....	67.62	58.41	66.00	66.73	34.69	62.00
Phosphorus.....	0.001	0.014	0.001	0.001	0.013	0.024
Sulphur.....	0.050					0.075
Phosphorus in 100 parts iron....	0.001	0.024	0.002	0.002	0.037	0.038
Silica.....						4.98
Alumina.....						2.20
Insoluble.....						6.03

Following is the complete analysis of No. 60:

	60.		60.
	<i>Per cent.</i>		<i>Per cent.</i>
Silica.....	1.23	Per cent. of insoluble silicious matter.....	1.55
Iron, protoxide.....	1.19		
Iron, peroxide.....	95.22	Silica.....	1.23
Alumina.....	0.74	Alumina.....	0.21
Lime.....	0.21	Lime.....	0.02
Magnesia.....	0.50	Magnesia.....	0.01
Iron, disulphide.....	0.098	Potassa.....	0.06
Potassa.....	0.06	Total.....	1.53
Carbonic acid.....	0.19		
Phosphoric acid.....	0.003		
Titanic acid.....	Traces.		
Water of composition.....	0.55		
Total.....	99.986		

e (5) *Curry*.—On W. $\frac{1}{2}$ of NE. $\frac{1}{4}$ Sec. 9, T. 39, R. 29. Operated by the Curry Iron Company. First shipment in 1879. Total product, 38,921 tons. Product in census year, 21,813 tons. The plan of the workings is indicated in Fig. 193. There are two pits. In the western pit the strike is a trifle north of west, and the dip is nearly vertical. The ore is from 10 to 12 feet wide, and has been worked by carrying back one slope for a distance of 150 feet. At the eastern end the pit is about 15 feet deep, and here a shaft has been sunk in preparation for another slope. About 100 feet east of this shaft the formation makes a sharp bend to the north and northwest, forming a complete bow, and returning finally to its original direction, *i. e.*, approximately east and west. The ore dips toward the center of the basin thus formed; it has been uncovered and exploited, on the north side of the bend, to a depth of 25 or 30 feet. When visited, no ore was being mined, and the bottom of the pits were covered with snow and frozen gravel. Four samples were taken, as follows:

f Sample No. 56, across the bottom of the western pit. Sample No. 57, from a mass of ore recently uncovered at the point where the vein bends sharply, and about 3 feet below grass-line. The ore is very soft, and a portion of it has an indigo tinge of color. Sample No. 58, across the bottom of the main pit. Sample No. 59, from a layer of ore about a foot thick, found near the hanging-wall (on the east side of the main pit). The ore resembles No. 65 (Vulcan mine) in weathering to a grayish color. The samples contained—

	56.	57.	58.	59.
	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>
Metallic iron.....	66.49	67.40	67.53	67.03
Phosphorus.....	0.062	0.010	0.008	0.005
Phosphorus in 100 parts of iron.	0.093	0.015	0.012	0.007

(6.) *Saginaw Section 4* (now called the *Perkins*).—On SW. $\frac{1}{4}$ of SW. $\frac{1}{4}$ Sec. 4, T. 39, R. 29. Operated by the **a** Saginaw Iron Company. First shipment in 1879. Total product, 70,476 tons. Product in census year, 35,840 tons. The formation, as exposed by the present workings, has an east and west trend, and dips to the south at

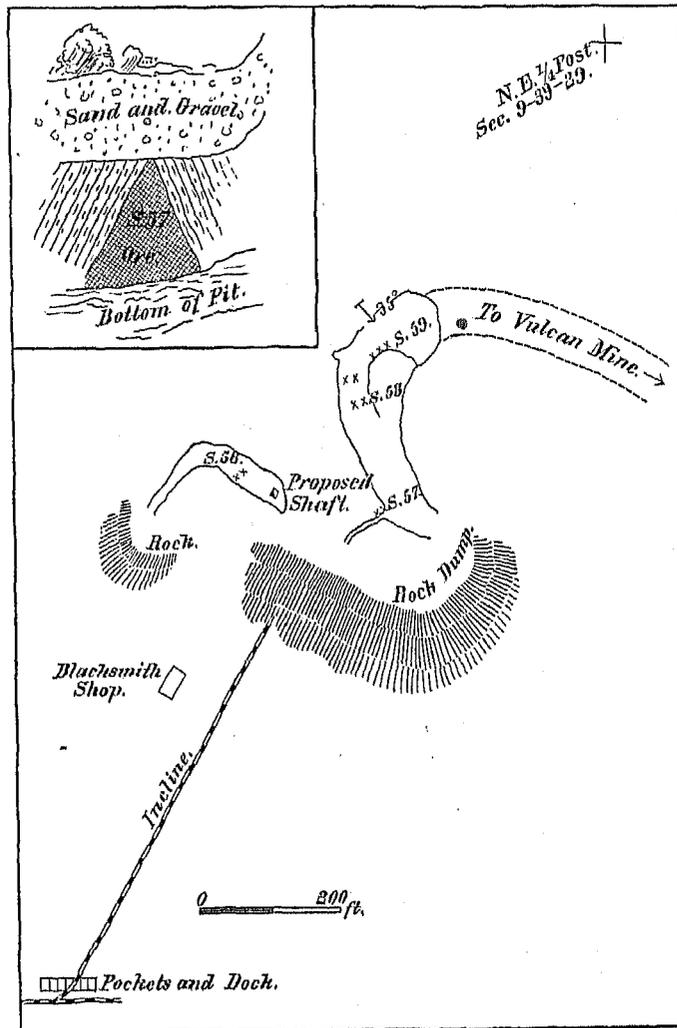


FIG. 193.—SKETCH PLAN OF THE CURRY MINE, MENOMINEE COUNTY, MICHIGAN.

an angle of about 70°. The ore-body varies in width from 10 to 25 feet. It has been uncovered for a length of **e** several hundred feet, and into the ledge thus exposed four pits have been sunk to depths varying from 25 to 60 feet. The pits are numbered from 1 to 4, No. 1 being the easternmost. No. 4 is the deepest (see Fig. 194). The samples collected at the mine contained—

	48.	51.	49.	50.	54.
	<i>Per cent.</i>	Per cent.	Per cent.	Per cent.	Per cent.
Metallic iron	59.86	63.25	50.47	51.71	59.30
Phosphorus.....	0.005	0.032	0.006	0.008	0.004
Phosphorus in 100 parts iron...	0.008	0.051	0.010	0.015	0.007

Sample No. 48 consists of a series of chippings taken across the west side of pit No. 1. The ore is here about 17 feet wide. Much of it has a brecciated appearance, the angular fragments being hard, specular ore (more or less silicious), and the cement a soft, reddish hematite. Sample No. 51 is from the west side of pit No. 2, near the foot-wall. A section across the ore-body at this point is shown in the figure. The ore near the foot-wall (and represented by this sample) is made up of alternating layers of hard specular and soft ore, the structure being similar to that of the jaspery schist, except that the silicious matter is replaced by iron oxide. Sample 49 is from a layer of hard, compact, specular ore (the so-called "steely-ore") from the east side of pit No. 3. This layer is 6 inches wide and lies next the hanging-wall. Layers and bunches of ore similar to this are found to some extent in all parts of the mine. The ore resembles the hard ore of the Marquette region. Sample No. 50 was taken also from the east side of pit No. 3, and consists of a series of chippings taken across the stope, exclusive of the above-mentioned

a layer of hard ore. This ore, as a whole, has a laminated or slaty structure and is quite soft. Sample No. 54 is from the east side of pit No. 4. It resembles the ore from pit No. 1 (sample No. 48), both in general appearance and in composition.

Through the ore-body there are many bunches of silicious material, which are, to a greater or less degree, sorted out in mining. In order to obtain a fair average of the shipping product of the mine samples were taken from the two stock-piles. These samples contained—

	52.	53.
	<i>Per cent.</i>	<i>Per cent.</i>
Metallic iron	57.37	50.91
Phosphorus.....	0.007	0.006
Phosphorus in 100 parts iron...	0.012	0.010

Sample No. 52 is from 1,700 tons of ore from pits Nos. 1 and 2. Sample No. 53 is from 2,000 tons of ore from pits Nos. 3 and 4. The ore was not sampled at Cleveland.

(7) *Stephenson*.—On NW. $\frac{1}{4}$ of SW. $\frac{1}{4}$ Sec. 4, T. 39, R. 29. Operated by the Lumberman's Mining Company. First shipment in 1879. Total product, 27,036 tons. Product in census year, 14,000 tons. From the dip of the ore, which is toward the south, at an angle of about 45°, it results that the mine, as limited by the property lines,

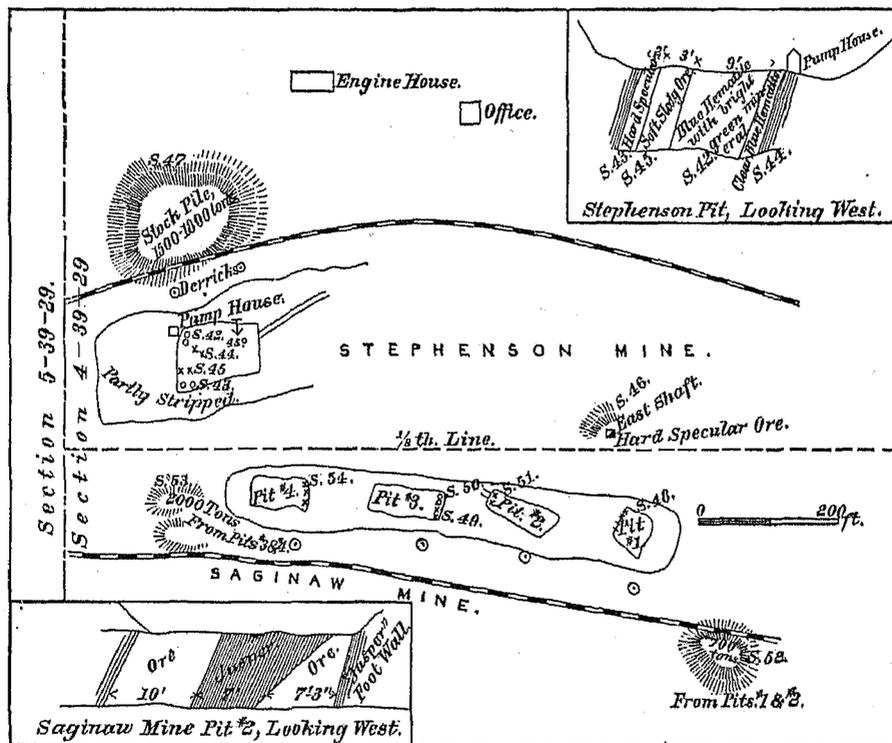


FIG. 194.—SKETCH PLANS OF THE SAGINAW (PERKINS) AND STEPHENSON MINES, MENOMINEE COUNTY, MICHIGAN.

will soon be exhausted. But the ore will doubtless be exploited at some future time by the lessees of the Saginaw mine. The one pit on the property is about 125 feet long and 75 feet wide. The stope is at the western end of the pit, where the ore is 15 feet wide. The latter width is made up of four bands of ore, as shown on the sketch f (Fig. 194). There is no rock between the walls. The samples collected at this mine contained—

	44.	42.	45.	43.	47.	46.
	<i>Per cent.</i>	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.
Metallic iron	52.50	50.47	61.48	63.53	58.20	52.78
Phosphorus	0.066	0.094	0.048	0.068	0.081	0.060
Sulphur						0.004
Phosphorus in 100 parts iron...	0.163	0.100	0.078	0.107	0.139	0.131

Following is the complete analysis of No. 46:

46.		46.	
	Per cent.		Per cent.
Silica	13.85	Hygroscopic water	0.04
Iron, protoxide	2.97	Water of composition.....	2.75
Iron, peroxide	72.06	Total	100.055
Alumina	3.39		
Manganese, protoxide	0.11	Per cent. of insoluble siliceous matter	14.26
Lime	0.33	Silica	13.85
Magnesia	4.29	Alumina	0.44
Iron, disulphide	0.007	Total	14.29
Carbonic acid	0.10		
Phosphoric acid	0.158		

Samples Nos. 42 to 45, inclusive, are from the stope in the main pit. Beginning at the foot-wall, sample No. 44 represents a layer, 1 foot thick, of a clean blue ore which turns to a grayish color on exposure. Sample No. 42 a compact blue ore, containing a large admixture of a greenish magnesian mineral, the color of which is very bright and striking, especially when the ore is wet. The width of the band is 9 feet. The ore is mediumly soft. Sample No. 45, a soft, blue, slaty ore, 3 feet thick, which lies next the 9-foot band, and sample No. 43, a hard specular ore 2 feet thick, which lies next the hanging-wall. The location of these samples is marked on the sketch. **c**

Sample No. 47 represents an average of a pile of about 1,800 tons of the ore mined from this pit, and indicates the composition of the shipping product. The ore was not sampled at Cleveland.

Sample No. 46 was collected from a pile of about 75 tons of ore, which had been thrown out from a test-shaft sunk near the property line, about 100 feet north of pit No. 1 of the Saginaw mine. The shaft is reported to be 75 feet deep; it was filled with water. The ore is a hard specular.

(S) *Norway*.—On NE. $\frac{1}{4}$ of SE. $\frac{1}{4}$ Sec. 5, T. 39, R. 29. Operated by the Menominee Mining Company. First shipment in 1878. Total product, 312,803 tons. Product in census year, including product of the Cyclops mine, 210,874 tons. The trend of the formation is about N. 60° W.; the dip is southward. The openings extend for a distance of about a quarter of a mile, but are chiefly shallow, open pits. **d**

The general plan of the workings and location of the samples is shown on Fig. 195. The pits are numbered from 1 to 10, the latter being at the northwestern end of the workings, near the top of the ridge.

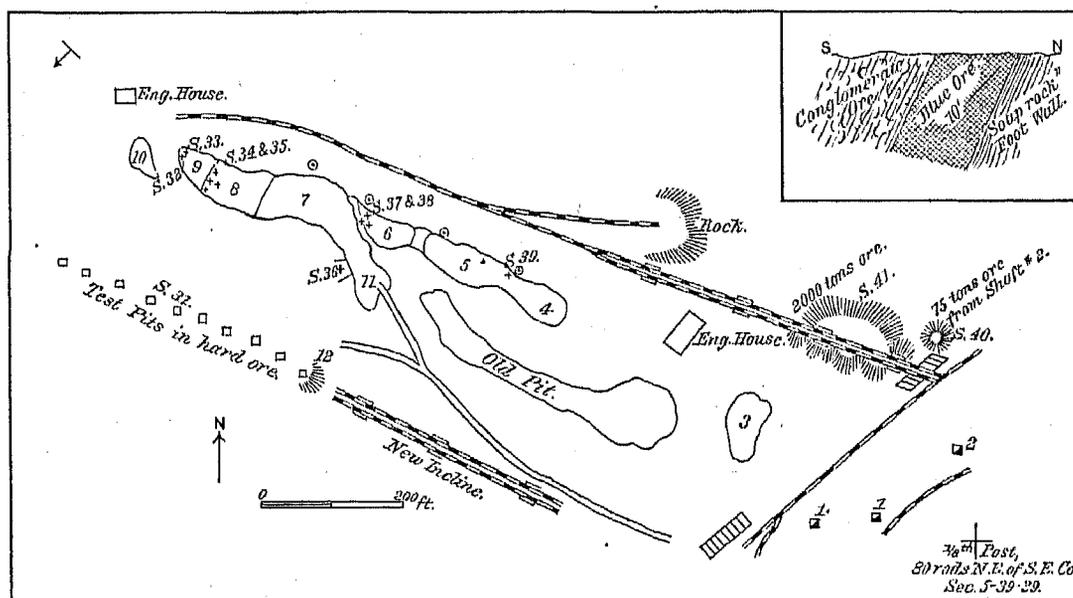


Fig. 195.—SKETCH PLAN OF THE NORWAY MINE, MENOMINEE COUNTY, MICHIGAN.

Pit No. 10 is about 100 feet south of the new engine-house. It is a new opening and was not being worked at the date of my visit to the mine.

Pit No. 9 is 15 feet deep. The stope is on the east side of the pit and presents two varieties of ore—the one having a slaty and the other a brecciated structure. The latter is composed of irregular angular pieces of hard specular ore cemented together with soft brown hematite. The blue slaty ore lies next the foot-wall and is about 10 feet thick. The thickness of the brecciated ore is undetermined, as the hanging-wall has not been reached. Sample No. 32 represents the brecciated ore, and sample No. 33 the blue slaty ore.

a Pit No. 8.—The ore in this pit is essentially a soft, reddish-brown hematite containing pieces and bunches of various sizes, of hard specular ore. Selected chippings of these two varieties of ore were collected in the pit. Sample No. 34 represents the soft ore and sample No. 35 the hard ore.

The above-mentioned samples are compared in the following analyses:

	32.	33.	34.	35.
	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>
Metallie iron.....	49.56	59.72	52.97	58.35
Phosphorus.....	0.035	0.030	0.045	0.014
Phosphorus in 100 parts iron ...	0.071	0.050	0.085	0.024

b

In the eastern part of pit No. 7 a width of 150 feet or more of ore has been uncovered without exposing the hanging-wall rock. The foot-wall, on the north side of the pit, dips, however, at a flat angle (25° to 30°), so that the horizontal width is necessarily much greater than the normal width of the deposit. The southern portion of this pit is known as No. 11. The ore in pit No. 7 proper resembles that in pit No. 8. Sample No. 36 was taken across the stope.

c In pit No. 11 a large proportion of the ore is the hard specular variety. A sample (No. 55) of the shipping product of this pit, in which the hard ore formed about two-thirds of the whole, was taken from loaded cars.

In pit No. 6 two samples were taken. Sample No. 38 is from a pile of broken ore, and represents the average output of the pit.

Sample No. 37 consists of selected chippings of an ore which contains a yellowish-green mineral, and which, although found in several of the pits, is here concentrated in a well-defined band along the south side of the pit. The above-mentioned samples contained—

	36.	55.	38.
	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>
Metallie iron.....	59.26	57.99	62.08
Phosphorus.....	0.019	0.41	0.064
Phosphorus in 100 parts iron...	0.032	0.071	0.103

d

	37.		37.
	<i>Per cent.</i>		<i>Per cent.</i>
Metallie iron.....	62.73	Carbon in carbonaceous matter.....	0.006
Phosphorus.....	0.084	Hygroscopic water.....	0.27
Sulphur.....	0.058	Water of composition.....	1.21
Phosphorus in 100 parts iron.....	0.134	Total.....	100.207
		Per cent. of insoluble silicious matter.....	3.70
Silica.....	3.42	Silica.....	3.42
Iron, protoxide.....	0.82	Alumina (with trace of oxide of iron).....	0.12
Iron, peroxide.....	88.77	Lime.....	0.26
Alumina.....	2.37	Magnesia.....	0.02
Lime.....	1.10	Total.....	3.82
Magnesia.....	1.44		
Iron, disulphide.....	0.109		
Carbonic acid.....	0.50		
Phosphoric acid.....	0.102		

e

In pit No. 4, sample No. 39 was taken across the stope, which latter is 16 feet wide. The ore resembles closely that from pit No. 6 (sample No. 38).

f South and southwest from pits Nos. 4 and 5 is a long trench, from which the ore has been all exploited. East of this latter is pit No. 3, an oval excavation 100 feet long, 75 feet wide, and 70 feet deep. The sides are irregular, but nearly vertical. Only exploratory work was being done here in December, 1879.

West of pit No. 3 shafts have been sunk on what are supposed to be the extensions of the Saginaw Section 4 (Perkins) and the Stephenson veins. Shaft No. 2, called the Stephenson shaft, is about 75 feet deep. The ore takes a grayish tinge of color on exposure, and in this respect differs greatly from the ore from the open pits, which soon becomes red on handling. Sample No. 40 is from a pile of 75 tons of ore from shaft No. 2.

Returning to the top of the ridge, a line of test-pits has been sunk about 80 paces south of pits Nos. 7, 8, and 9, and nearly on a line with the new incline. The majority of these pits are bottomed in a hard specular ore, which on fresh fracture resembles that in pit No. 1. Sample No. 31 was collected from the numerous pieces thrown out from these pits.

Sample No. 41 is from a stock-pile of about 2,000 tons of ore from pits Nos. 4, 5, 6, 7, and 9, and sample No. a 135 is from a stock-pile of 6,000 tons of ore at Cleveland. The latter was collected by Mr. Willis. The above-mentioned samples contained—

	30.	40.	31.	41.	135.
	<i>Per cent.</i>	Per cent.	Per cent.	Per cent.	Per cent.
Metallic iron	61.04	51.09	60.20	56.12	55.40
Phosphorus	0.108	.....	0.047	0.068	0.057
Sulphur .....	.....	0.058	0.043	.....	0.071
Phosphorus in 100 parts iron ...	0.174	.....	0.078	0.121	0.103

b

	31.	40.	135.		31.	40.	135.
	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>		<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>
Silica	12.43	11.88	16.03	Hygroscopic water .....	.....	.....	0.00
Iron, protoxide	0.03	3.77	.....	Water of composition	0.284	3.52	.....
Iron, peroxide	85.10	68.74	.....	Total	100.088	100.290	.....
Alumina	0.02	5.49	1.78	Per cent. of insoluble silicious matter.....	12.78	12.30	16.86
Manganese, protoxide.....	.....	0.03	} Present.	Silica	12.43	11.88	} c
Manganese, dioxide .....	.....	.....		Silica (with trace of oxide of iron).....	0.20	0.31	
Lime	0.68	0.93	.....	Lime	0.07	0.10	.....
Magnesia	0.21	5.55	.....	Magnesia	0.03	0.04	.....
Iron, disulphide	0.080	0.100	.....	Total	12.70	12.42	.....
Carbonic acid	0.40	0.13	.....			
Phosphoric acid	0.108	.....	.....		
Titanic acid .....	.....	.....	Absent.				
Carbon in carbonaceous matter	0.006	.....	.....		

(9) *Cyclops*.—One SW. $\frac{1}{4}$ of SE. $\frac{1}{4}$ Sec. 5, T. 39, R. 29. Operated by the Menominee Mining Company. First shipment in 1878. Total product, 75,169 tons. Product in census year included with product of Norway mine. Fig. 196 indicates the general plan of the mine. Shaft No. 1 is 100 feet deep, and the ore has been mined out on either side to a depth of about 60 feet. West of the shaft the pit has been abandoned, as the ore was there too much mixed with rock to be profitably mined. East of the shaft the ore is of good quality. The stope is about d 90 feet distant, and is 30 feet wide. The ore dips southward at about 60°, and is capped by horizontal (Potsdam),

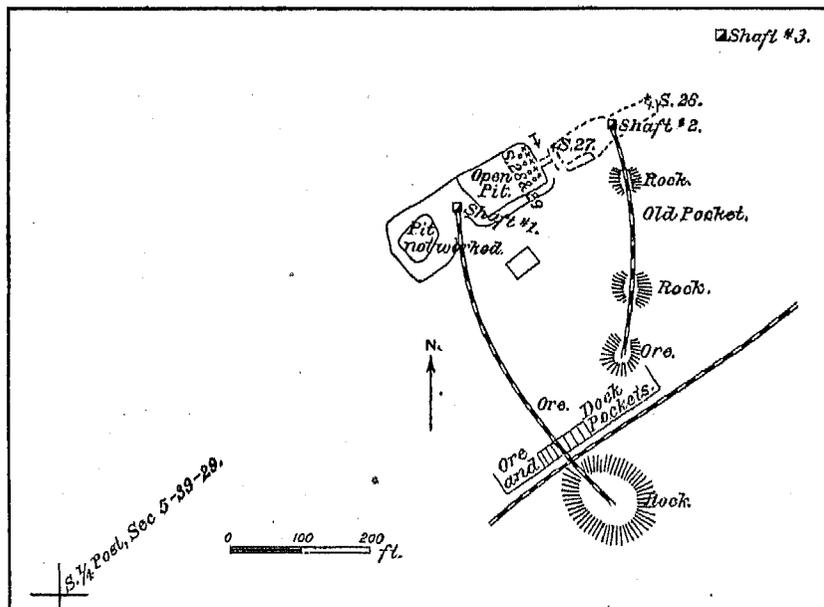


FIG. 196.—SKETCH PLAN OF THE CYCLOPS MINE, MENOMINEE COUNTY, MICHIGAN.

sandstone. Near the foot-wall the ore has a more slaty structure than elsewhere, and contains a good deal of the yellowish-green mineral noticed as occurring at the Norway mine. Sample No. 29 was taken from the hanging wall to within about 10 feet of the foot-wall, so as to avoid as far as possible the ore containing this substance. Sample No. 30 was taken entirely across the stope.

Shaft No. 2, 200 feet northeast of No. 1, is 75 feet deep, and passes through 30 feet of sandstone, which latter forms the roof of the mine. Sample No. 27 is from a band of ore in the west stope near the foot-wall, similar to that seen in pit No. 2. This sample, therefore, supplements No. 29. The lens of good ore pinches out at a point about 75 feet east of shaft No. 2.

a Sample No. 28 was taken from the lean ore in the stope, principally for the determination of phosphorus Sample No. 117 was taken at Cleveland by Mr. Willis from a pile of 1,000 tons, and represents the shipping product of the mine. The above-mentioned samples contained—

	29.	30.	27.	28.	117.
	Per cent.	Per cent.	Per cent.	Per cent.	<i>Per cent.</i>
Metallic iron	65.90	64.38	53.58	20.58	62.05
Phosphorus.....	0.012	0.013	0.013	0.012	0.013
Sulphur					0.006
Phosphorus in 100 parts iron...	0.018	0.020	0.024	0.041	0.021

	117.
	<i>Per cent.</i>
Silica	5.01
Alumina.....	2.50
Manganese	Absent.
Titanic acid	Absent.
Per cent. of insoluble silicious matter	6.91

c (10) *Quinnesec*.—On SE. $\frac{1}{4}$ of Sec. 34, T. 40, R. 30. Operated by the Menominee Mining Company. First shipment in 1878. Total product, 135,465 tons. Product in census year, 63,688 tons. The workings are entirely

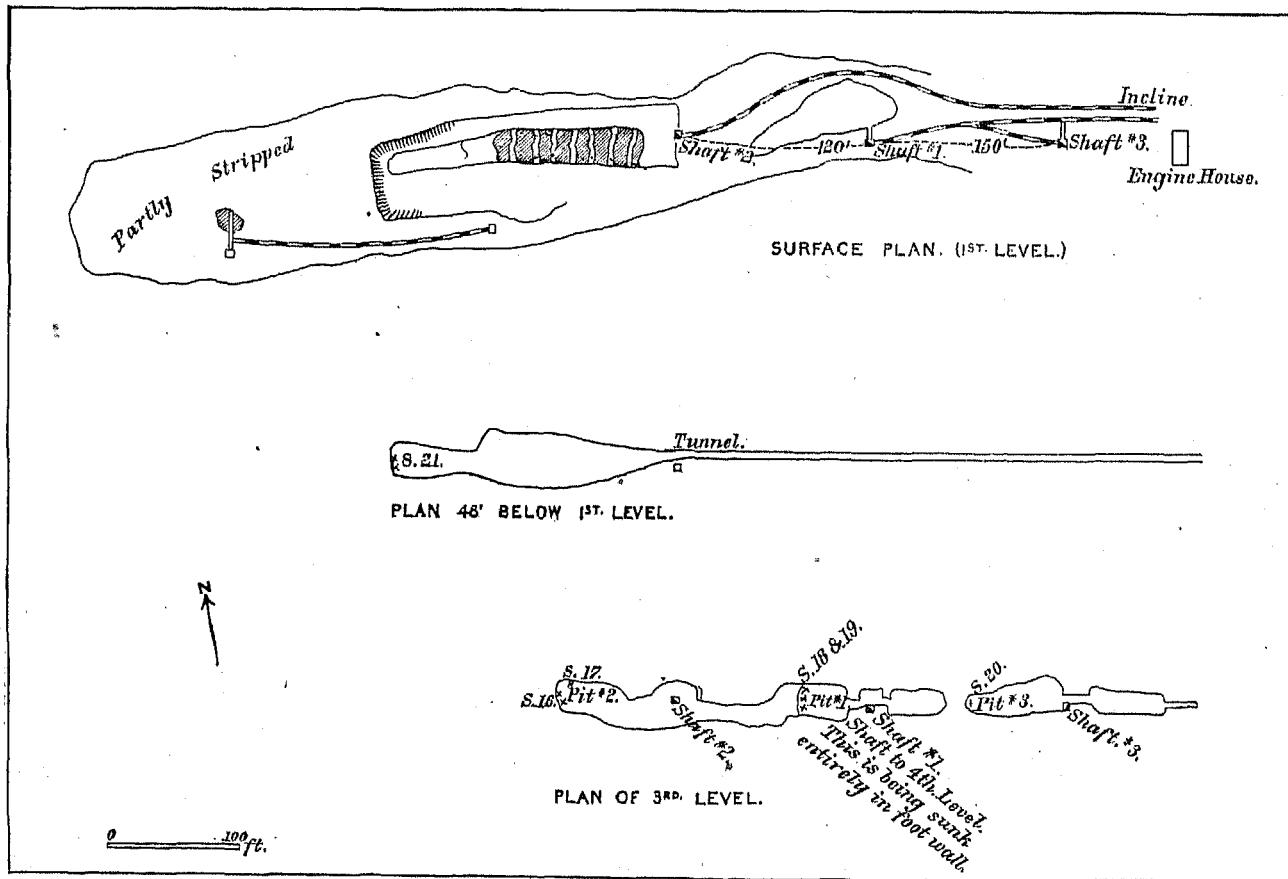


FIG. 197.—SKETCH-PLANS OF THE QUINNESEC MINE, MENOMINEE COUNTY, MICHIGAN.

underground, and are entered by three shafts sunk on the ore, which dips northward at an angle of 70° (see Fig. 197). The present surface around the shafts is the bottom of the original open cut, and is known as the first level. The second or adit level is 48 feet below the first level, and the third level is 112 feet below the same datum. All the ore above the adit, with the exception of a little at the extreme western end of the mine, has been removed, and the main workings are on the third level. In pit No. 2, at the western end of this level, and 95 feet west of shaft No. 2, the stope is 28 feet wide. The ore is a blue specular, usually quite soft, but varying somewhat in hardness in different portions of the stope. Near the hanging-wall there is a band of ore 10 inches wide, which contains thin layers of a greenish magnesian mineral of the same character as that found in the Norway and Cyclops mines. Its

peculiar color readily distinguishes it, and judging from the analyses of sample No. 17, which consists of selected a chippings taken in this stope, it is chemically a silicate of alumina and magnesia. Sample No. 11 was taken entirely across the stope in this same room. In pit No 1, west of shaft No. 1, the ore is 32 feet wide. It is similar to that in pit No. 2, excepting that the proportion of hard ore is, perhaps, greater. This latter occurs in pockets and in narrow layers; it is as a rule much softer than the specular ore of the Norway mine. Sample No. 18 consists of a series of chippings across the stope, and sample No. 19 of selected pieces of the hard ore.

The above-mentioned samples were subjected to complete analysis, with the following results:

	16.	17.	18.	19.
	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>
Sulphur	0.050	0.050	0.086	0.050
Phosphorus.....	0.010	0.009	0.012	0.005
Iron, metallic.....	61.81	55.49	60.39	64.47
Phosphorus in 100 parts iron	0.016	0.016	0.018	0.008
<hr/>				
Silica	7.37	9.29	2.58	6.99
Iron, protoxide	1.97	2.87	1.81	2.36
Iron, peroxide	86.05	70.02	92.73	89.41
Alumina.....	1.81	4.68	0.86	0.35
Manganese, protoxide			Trace.	Trace.
Lime	0.41	0.27	0.50	0.29
Magnesia.....	0.84	3.54	0.31	0.13
Iron, disulphide	0.099	0.110	0.161	0.099
Potassa.....	0.55	0.99	0.37	0.05
Soda.....		0.02		0.03
Carbonic acid.....	0.19	0.30	0.38	0.24
Phosphoric acid	0.024	0.021	0.027	0.013
Hygroscopic water.....	0.20	0.16	0.01	
Water of composition.....	0.59	1.72	0.30	0.01
Total	100.004	99.991	100.038	99.966
<hr/>				
Per cent. of insoluble silicious matter.	8.94	12.00	3.65	7.40
<hr/>				
Silica	7.37	9.29	2.58	6.99
Alumina.....	0.98	1.01	0.70	0.25
Lime	0.14	0.09	0.01	0.02
Magnesia.....	0.05	0.09	0.12	0.05
Potassa.....	6.40	0.93	0.30	0.05
Soda.....				0.03
Total	8.95	12.01	3.71	7.39

b

c

d

Pit No. 3, west of shaft No. 3, is about 20 feet wide. Sample No. 20 was taken across the vein at the end of the drift over the stope. The eastern limit of the lens of ore is reached in a drift at a point about 100 feet east of shaft No. 1; the lens apparently has a westerly pitch. On the second or adit level a sample (No. 21) was taken e near the foot-wall of the pocket of ore there being mined. The ore is quite hard and has a laminated or slaty structure, the laminæ being often highly contorted; it is called "curly" ore by the miners. Sample 119 shows the character of the shipping product of the mine; it was taken from a pile of 4,000 tons of the ore at Cleveland by Mr. Willis. The above-mentioned samples contained—

	No. 20.	No. 21.	No. 119.		No. 20.	No. 21.	No. 119.
	<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	65.60	64.38	63.40	Phosphoric acid	0.021		
Phosphorus.....	0.009	0.008	0.038	Hygroscopic water.....	0.04		
Sulphur	0.053		0.008	Water of composition.....	0.27		
Phosphorus in 100 parts iron	0.014	0.012	0.060	Total	09.980		
<hr/>							
Silica	3.03		5.52	Per cent. of insoluble silicious matter.....	4.61		7.00
Iron, protoxide	1.97			<hr/>			
Iron, peroxide	91.47			Silica	3.03		
Alumina.....	1.53		1.87	Alumina.....	0.93		
Manganese, protoxide			Trace.	Lime	0.07		
Lime	0.36			Magnesia.....	0.06		
Magnesia.....	0.21			Potassa.....	0.51		
Iron, disulphide.....	0.099			Soda.....	0.03		
Potassa.....	0.57			Total	4.63		
Soda.....	0.06			<hr/>			
Carbonic acid.....	0.38						

f

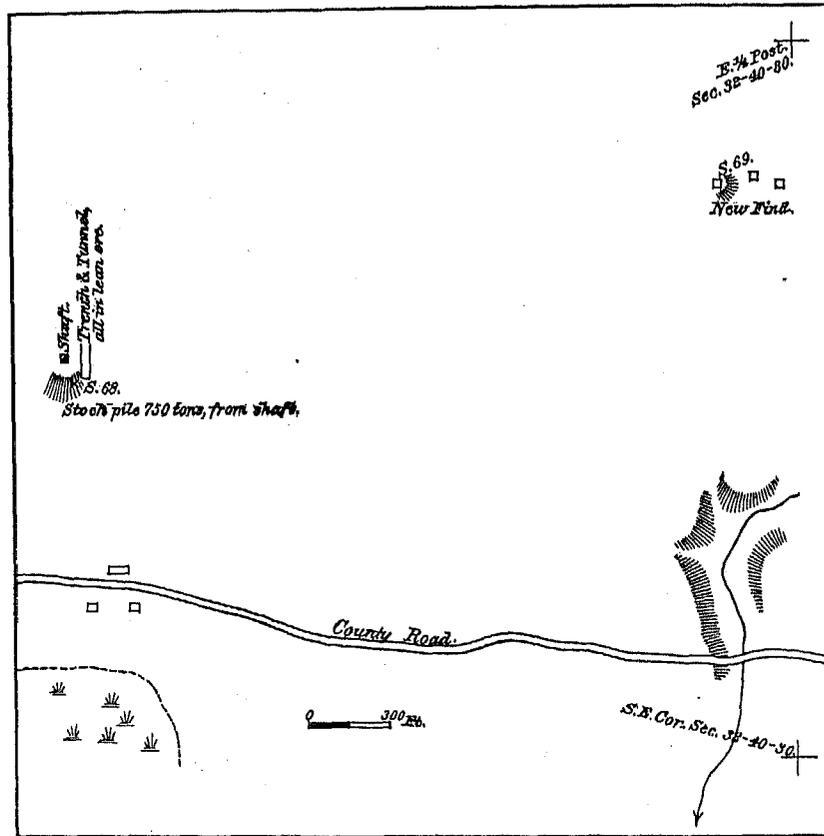
a The Quinnesec completes the list of the mines in the Menominee range which shipped ore previous to the year 1880. The samples that follow were taken from outcrops and exploration pits, and probably do not, therefore, represent a fair average of the shipping product of the since-developed mines.

Keel Ridge mine (now so-called).—On NW. $\frac{1}{4}$ of SE. $\frac{1}{4}$ of Sec. 32, T. 40, R. 30. Operated by the Emmet Mining Company. Product in 1880, 12,818 tons. At the date of my visit the developments consisted of two shafts (then filled with water), and a short tunnel cross-cutting the strata (see Fig. 198). A sample (No. 68) was taken from

b

c

d



ME KENNA MINE.

FIG. 198.—SKETCH-PLAN OF THE KEEL RIDGE MINE, MENOMINEE COUNTY, MICHIGAN.

about 750 tons of ore from the shafts. On the NE. $\frac{1}{4}$ of SE. $\frac{1}{4}$ of the same section three or four test-pits have been sunk through the sandstone and are bottomed in ore. The ore is a blue, specular hematite, but in the small pile from which sample No 69 was taken a considerable amount of silicious material was mixed through it. Samples Nos. 68 and 69 contained—

e

	68.	69.
	<i>Per cent</i>	<i>Per cent.</i>
Metallic iron	54.39	50.00
Phosphorus	0.061	0.005
Phosphorus in 100 parts iron	0.112	0.010
Silica	3.04	.....
Iron, protoxide	1.36	.....
Iron, peroxide	76.18	.....
Alumina	1.18	.....
Manganese, protoxide	0.17	.....
Lime	4.87	.....
Magnesia	3.00	.....
Carbonic acid	7.12	.....
Phosphoric acid	0.139	.....
Hygroscopic water	0.23	.....
Water of composition	1.20	.....
Total	100.079	.....
Per cent. of insoluble silicious matter	4.05	.....
Silica	3.04	.....
Alumina	0.17	.....
Total	4.11	.....

f

a is bottomed in ore, but not sufficient work has been done to determine the latter's extent. About 150 tons of ore has been taken from the trench and is piled at the mine; it is a soft, blue specular of excellent quality, as is shown by the following analysis of an average sample of the pile:

	24.
	Per cent.
Metallic iron.....	62.23
Phosphorus.....	0.008
Phosphorus in 100 parts iron.....	0.013

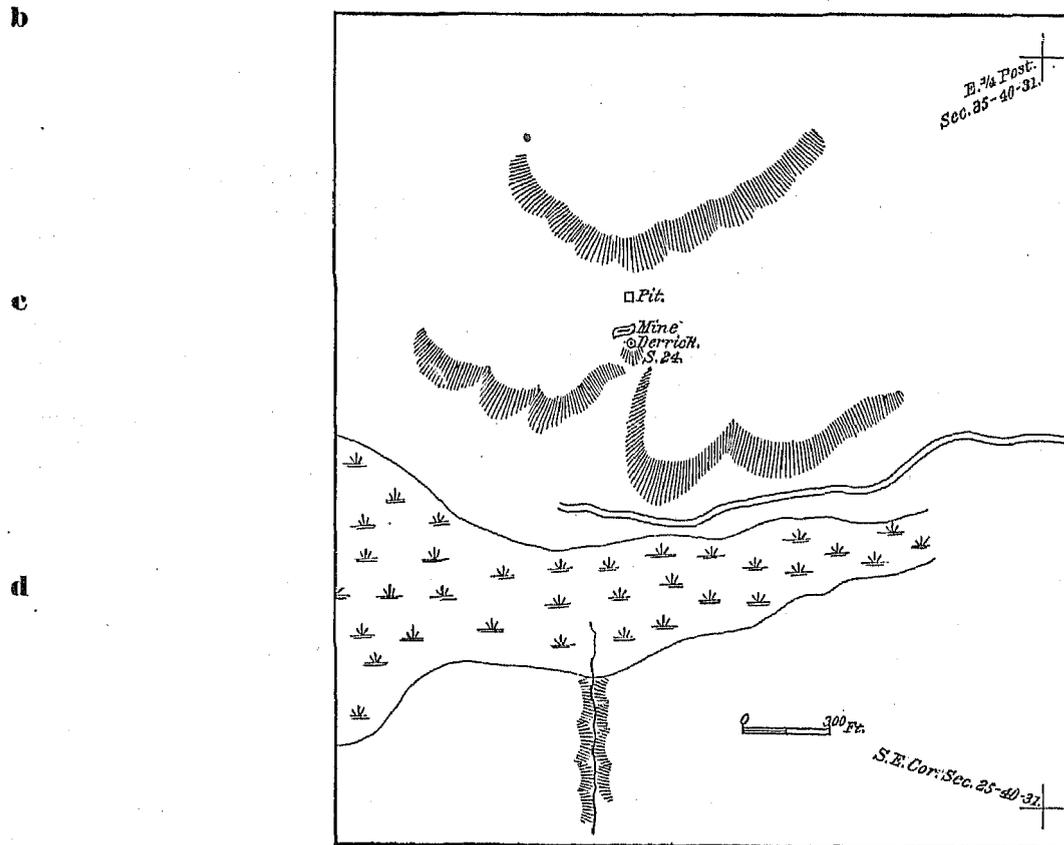


FIG. 200.—SKETCH-PLAN OF THE LUDINGTON MINE, MENOMINEE COUNTY, MICHIGAN.

e Cornell.—On the north side of lake Antoine, 1 mile S. of N. 1/4 post, Sec. 20, T. 40, R. 30. Operated by R. A. Wight and A. B. Cornell. Product in 1880, 34,559 tons: product in census year, 7,840 tons. When visited the

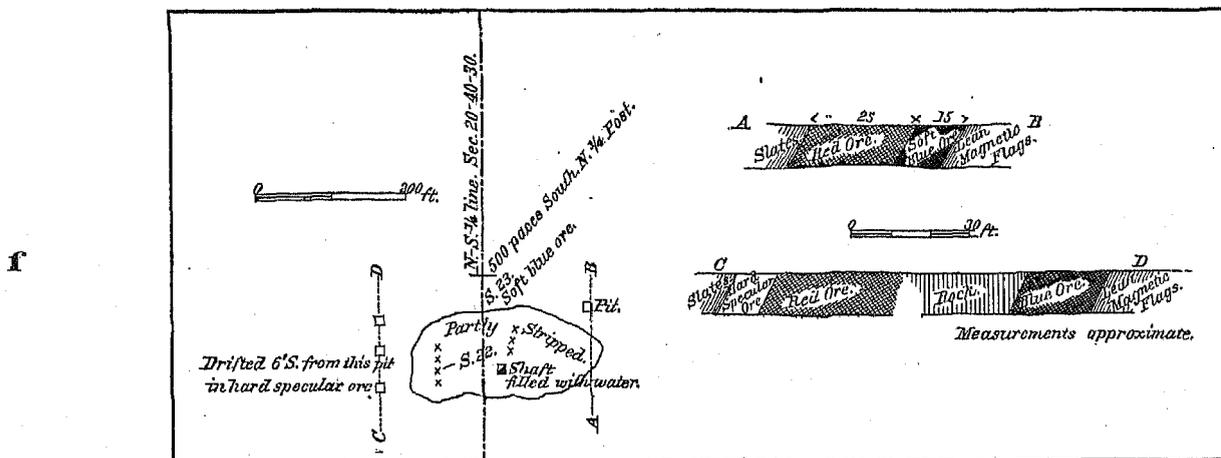


FIG. 201.—SKETCHES OF THE CORNELL MINE, MENOMINEE COUNTY, MICHIGAN.

outlook for the mine appeared very promising; the removal of the surface material had exposed a body of ore 60 feet long and at one point 40 feet wide. The trend of the formation is nearly east and west, and the dip is to

the south at an angle of 70° to 75°. On the north the ore is bounded by a lean magnetic schist; lying next this a schist is a band of soft, blue specular ore 15 feet wide, and south of this a band of "red" ore 25 feet in width (see Fig. 201). Sample No. 22 represents the red ore and sample No. 23 the blue ore. These samples contained—

	22.	23.		22.	23.
	<i>Per cent.</i>	<i>Per cent.</i>		<i>Per cent.</i>	<i>Per cent.</i>
Metallie iron	58.06	56.90	Phosphoric acid.....	0.097	0.074
Phosphorus.....	0.043	0.032	Hygroscopic water.....	0.11	0.07
Sulphur.....	0.069	0.078	Water of composition	1.13	0.56
Phosphorus in 100 parts iron.....	0.074	0.056	Total	99.988	99.950
Silica.....	9.04	10.71	Per cent. of insoluble silicious matter	13.61	16.44
Iron, protoxide	1.10	1.10	Silica	9.04	10.71
Iron, peroxide	81.64	80.09	Alumina	2.77	3.21
Alumina.....	3.89	3.88	Lime	0.01	.....
Lime.....	0.19	0.17	Magnesia.....	0.26	0.08
Magnesia.....	0.86	0.48	Potassa	1.44	2.23
Iron, disulphide.....	0.111	0.146	Soda.....	0.11	0.20
Potassa.....	1.54	2.20	Total	18.63	16.43
Soda.....	0.17	0.30			
Carbonic acid	0.18	0.08			

WISCONSIN.

Explorations west of the Menominee river in Wisconsin have resulted in the discovery of important deposits of iron ore in T. 40, R. 18. These ores belong to a higher horizon than do those east of the river. Major Brooks places them in bed XV;(a) he therefore regards them as younger than the ores of the Marquette region. Wright, (b) however, considers them as stratigraphically the equivalent of the rich ores of the Marquette region. The ores of the Menominee region in Michigan (of bed VI) have thus far not been traced in Wisconsin.

Commonwealth mine.—The explorations made near the center of Sec. 34, T. 40, R. 18 have uncovered a total width of 118 feet of ore lying in three belts, respectively, 36, 68, and 14 feet wide. The two larger belts are d separated by 10 feet of lean ore, and 28 feet of silicious schist lies between the narrowest and the widest ore-belts. The extent of the developments in the fall of 1879 are fully described by Mr. Wright in Vol. III of the *Geology of Wisconsin*, and when the location was visited by the writer, in December of the same year, no further work had been done, and the old excavations were filled with ice and snow. Two samples of the ore were taken. Sample No. 72 is from a pile of about 700 tons of ore, partly from a shaft in the 36-foot seam and partly from a trench across the 68-foot seam. Sample No. 73 is from the sides of the shaft in the 14-foot seam. The samples contained—

	72.	73.
Metallie iron.....	60.25	57.84
Phosphorus.....	0.205	0.239
Phosphorus in 100 parts iron.....	0.340	0.412

To further show the character of the ore, a complete analysis was made of a mixture of the above mentioned samples, with results as follows :

	72 and 73.		72 and 73.
	<i>Per cent.</i>		<i>Per cent.</i>
Metallie iron	59.86	Phosphoric acid.....	0.512
Phosphorus.....	0.224	Hygroscopic water.....	0.21
Phosphorus in 100 parts iron	3.77	Water of composition.....	1.95
Silica	7.81	Total	100.062
Iron, protoxide	0.09	Per cent. of insoluble silicious matter	8.05
Iron, peroxide.....	83.69	Silica	7.81
Alumina	1.07	Alumina	0.21
Manganese, protoxide.....	0.82	Lime.....	0.05
Lime.....	0.86	Total	8.07
Magnesia.....	1.34		
Carbonic acid.....	0.41		

a *Geology of Wisconsin*, Vol. III, table facing p. 450.

b *Geology of Wisconsin*, Vol. III, p. 679.

a The ore is a hard specular, resembling the hard Marquette ores. The mine is now operated by the Commonwealth Iron Company. The first shipment of ore was made in October, 1880.

About $2\frac{1}{2}$ miles west of the Commonwealth mine proper the Commonwealth Iron Company have made some explorations on SW. $\frac{1}{4}$ of SW. $\frac{1}{4}$ Sec. 32, T. 40, R. 18, sinking a shaft to a depth of 65 feet, and numerous test-pits to a less depth (see Fig. 202).

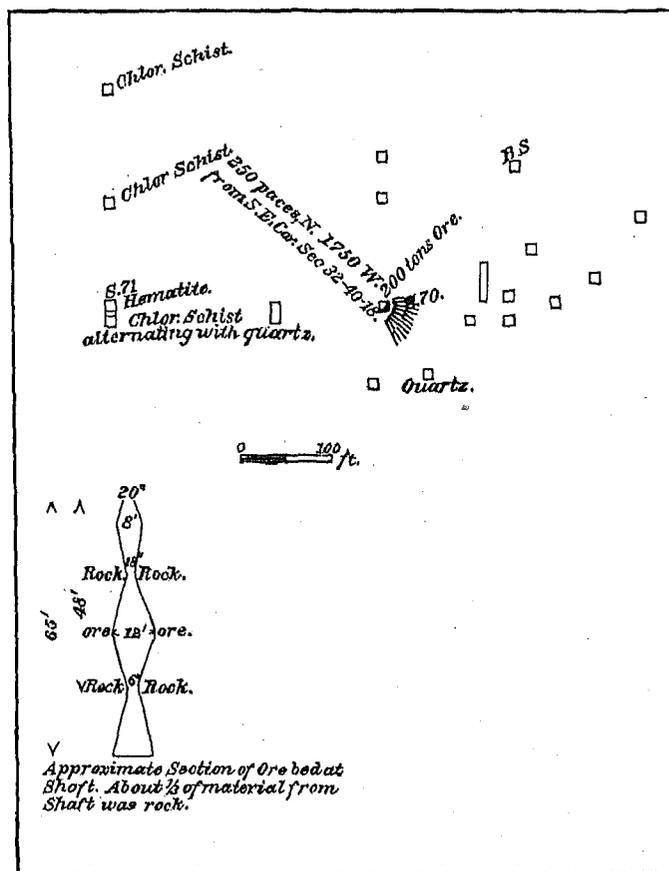


FIG. 202.—SKETCHES AT THE COMMONWEALTH MINE, SEC. 32, WISCONSIN.

The ore from the shaft is a coarsely granular martite; its character is shown by the analysis of sample No. 70, taken from a pile of about 200 tons. The body of ore is said to be very variable in width, as is indicated by the section through the shaft. The shaft was filled with water when the locality was visited. The section is given on **c** the authority of the foreman under whose direction the shaft was sunk. About 300 feet west of the shaft a bed of reddish-brown hematite 4 feet thick is uncovered in a trench. The ore is represented by sample No. 71. Samples Nos. 70 and 71 contained—

	70.	71.		70.	71.
	Per cent.	Per cent.		Per cent.	Per cent.
Metallic iron.....	59.61	40.21	Phosphoric acid.....	0.396	.....
Phosphorus.....	0.172	0.041	Carbon in carbonaceous matter.....	0.12	.....
Sulphur.....	0.370	.....	Hygroscopic water.....	0.05	.....
Phosphorus in 100 parts iron.....	0.288	0.088	Water of composition.....	2.90	.....
			Total.....	100.070	.....
Silica.....	5.71	.....	Per cent of insoluble silicious matter.....	6.28	.....
Iron, protoxide.....	7.51	.....		
Iron, peroxide.....	70.86	.....	Silica.....	5.71	.....
Alumina.....	4.22	.....	Alumina (with trace of oxide of iron).....	0.50	.....
Manganese, protoxide.....	0.11	.....	Lime.....	0.04	.....
Lime.....	0.40	.....	Magnesia.....	0.01	.....
Magnesia.....	1.88	.....	Total.....	6.26	.....
Iron, disulphide.....	0.004	.....		
Carbonic acid.....	0.16	.....		

f Florence (formerly known as the *Eagle*) mine.—The explorations and discoveries in N. $\frac{1}{2}$ of SE. $\frac{1}{4}$ Sec. 20, T. 40, R. 18 are described by Mr. Wright on page 682 of *Geology of Wisconsin*, Vol. III. Mr. Wright there gives a section across the ore formation as uncovered in an open trench dug on a north and south line. This section shows,

beginning at the south end of the trench, (1st) chloritic rock, 10 feet; (2d) steely specular ore, 10 feet; (3d) lean ore, a jasper, and chloritic rock, 16 feet; (4th) loose, broken, hard, hematitic ore, 15 feet; (5th) soft hematite and limonite, 18 feet; (6th) soft hematite ore, 9 feet; (7th) hard hematite and brown ore, 9 feet; (8th) hard, steely, specular ore, 6 feet. Samples from the different bands of ore yielded Mr. Wright as follows: (2d) Metallic iron, 49 per cent., phosphorus, 0.14 per cent.; (4th) metallic iron, 53.03 per cent.; (5th) metallic iron, 57 per cent., phosphorus, 0.40 per cent.; (6th) metallic iron, 58.10 per cent.; (7th) metallic iron, 58.10 per cent., phosphorus, 0.39 per cent.

No further work had been done at this locality when visited in December, 1879, and the trench from which Mr. Wright obtained his section was filled up. There was, however, a pile of ore near the test-pit, immediately east of the north end of the trench, and from this a sample (No. 74) was taken. It contained—

74.	
<i>Per cent.</i>	
Metallic iron	54.91
Phosphorus	0.369
Phosphorus in 100 parts iron.....	0.072

b

During the year 1880, the Menominee Mining Company opened the Florence mine and shipped therefrom 15,840 tons of ore before the close of navigation.

Northwest of the above-mentioned exploration pits there were several test-pits in the NE. $\frac{1}{4}$ of the section. A sample from a few lumps of ore near the top of one of these yielded, on partial analysis—

c

75.	
<i>Per cent.</i>	
Metallic iron.....	59.17
Phosphorus.....	0.285
Phosphorus in 100 parts iron.....	0.482

This ore is a hard specular, spotted with limonite and hematite.