NOTES ON THE SAMPLES OF IRON ORE COLLECTED IN NEW JERSEY.

By BAYARD T. PUTNAM.

The most important iron ore in New Jersey is magnetite. Limonite (or brown hematite, as it is more commonly called amongst miners) has been found in a number of localities, and is mined to a small extent. Bog-ore is known to exist in the central and southern portions of the state, and in the early part of the present century it was used both in charcoal furnaces and in forges. At the present time, however, no ore of this variety is dug.

Hematite and specular ore have both been found, but in small quantities only.

Franklinite, although primarily an ore of zinc, is a source of iron also—the residues from the zinc-works being used in the manufacture of *spiegeleizen*. The ore is mined at Sterling Hill and at Franklin, in Sussex county. An ore known as franklinite iron ore has recently been found at the former-named locality. It contains so little zinc that it can be used in the blast-furnace as it comes from the mine, and yet manganese is present in sufficient quantities to make the ore valuable, mixed with more manganiferous ores, in the manufacture of "spiegel".

MAGNETIC IRON ORES.

The magnetic iron ores are confined to the belt of Archæan rocks which, as is shown on the accompanying Fig. 43, enters the state from Pennsylvania opposite Easton and crosses it in a northeasterly direction. The belt is about 10 miles wide at the Delaware river and 22 miles wide at the New York State line.

The rocks of the belt are chiefly varieties of hornblendic gneiss, or syenite, granite, and crystalline limestone, and are believed to be geologically the equivalent of the Canadian Laurentian. At nearly all localities where observations have been made the lamination planes of the rocks have a northeast and southwest trend, and dip to the southeast, usually at a high angle.

The topographical features of the region are well marked. The Archæan rocks form the highlands of New Jersey, which comprise a number of parallel ridges, having about the same direction as the belt itself. A peculiarity of these ridges is, that they are rarely cut by transverse valleys, but extend across the state in almost unbroken lines. They are separated by broad valleys, in which the Archæan rocks are sometimes covered with Paleozoic limestones and slates. It is associated with these latter rocks that the beds of limonite occur.

The magnetic ore is found in beds or layers, usually in gneiss, though occasionally in crystalline limestone. When in gneiss, the layers of ore conform to the former's stratification, and the ore-mass is to a greater or less extent mixed with the same minerals as compose the wall-rock. There is, in fact, as a rule, no sharp line of demarcation between the ore and the rock on either side, but the former gradually grades into the latter. When the percentage of magnetite to the whole mass of the rock is small, the magnetite is clearly seen to lie in layers parallel with the other mineral constituents of the gneiss; or more particularly, so far as the writer's observations go, to be closely associated with the layers of hornblende. Receding from the ore-mass, the magnetite at first disappears, and finally, too, a large part of the hornblende. The gneiss near masses of iron ore is usually of a much darker color than that found elsewhere, owing to the presence of a greater percentage of dark-green hornblende. Masses of nearly pure hornblende sometimes occur between the ore-mass and the gneiss walls; hornblende- or mica-schist next the ore is not uncommon. The walls are, however, occasionally, feldspathic-quartz rock containing but little hornblende.

Seams and masses of rock, called by the miners "horses" or "horsers", are frequently found alternating with the ore or inclosed in it. They have the same mineral constituents as the wall-rock, and the lamination of the seams or direction of the axes of the masses is parallel with the lamination of the gneiss walls.

The bodies of ore usually have a distinctly lenticular, pod-shaped, or shoot structure, the plane of the lens or pod lying in the plane of the stratification of the inclosing rock, and the axis of the pod being inclined. The inclination of the axis of a pod of ore is called its *pitch*.

a In New Jersey the *strike* of the ore-mass or "veins" (*a*) is with but few exceptions northeast and southwest; the *dip* is toward the southeast and the *pitch* toward the northeast.

The following diagrams, in part from the *Geology of New Jersey*, 1868, illustrate the pod or shoot structure. Fig. 44 shows a longitudinal section of a shoot of ore as it would appear to an observer looking toward the northwest; Fig 45, a cross-section on the line A B, supposing the observer to be looking toward the northeast; and Fig. 46, a

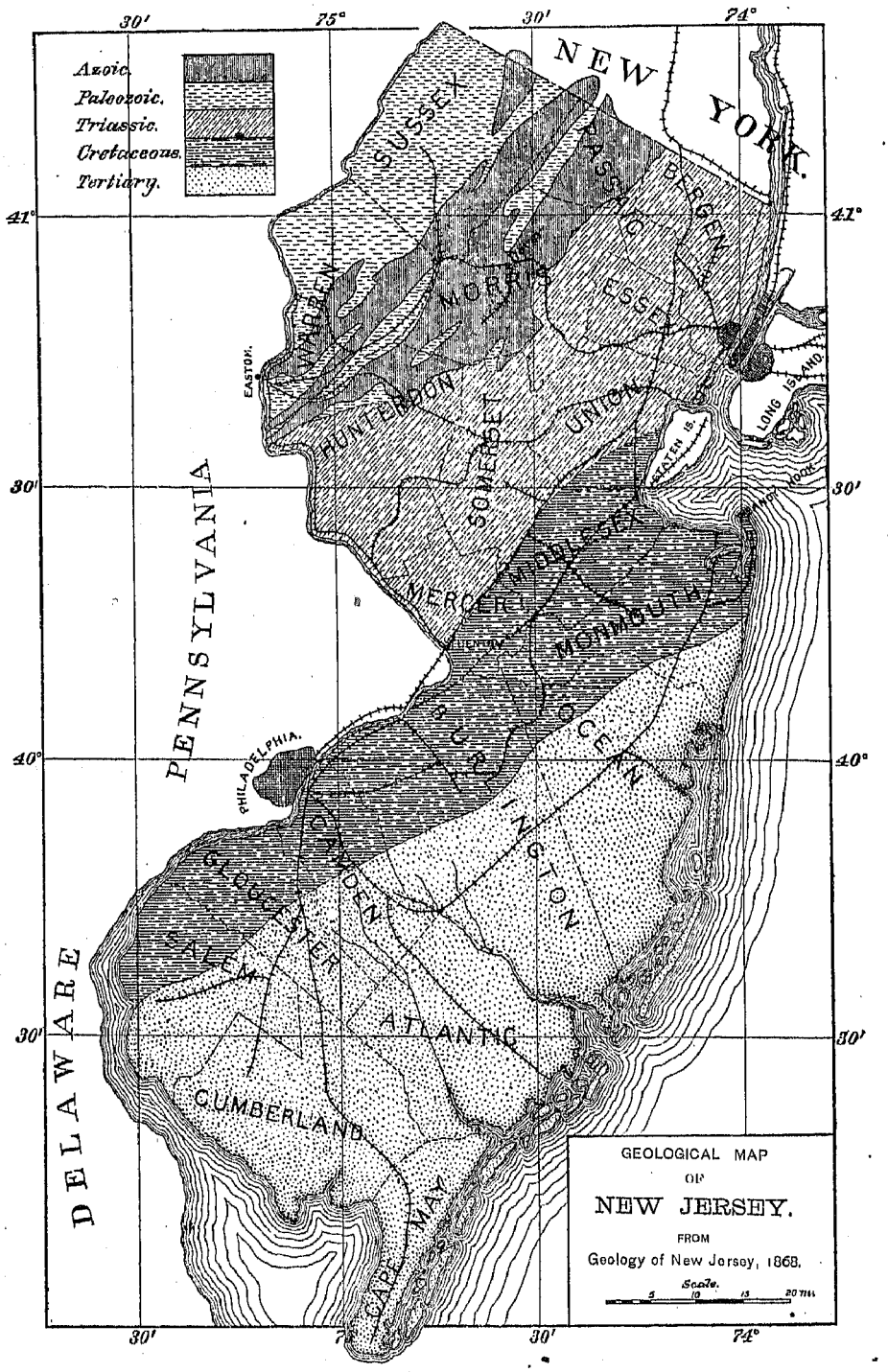


FIG. 43.

plan. The rock over the ore, *i. e.*, that under which the ore *pitches*, is called the *cap* rock; the rock under the ore is called the *bottom* rock.

In many cases a vein of ore exhibits what is called a *pinch and shoot* structure. The meaning of these terms is evident from Figs. 47, 48, and 49.

The best examples of the simple shoot structure are the Hurdtown mine in New Jersey and the Forest of Dean mine in Orange county, New York. The pinch and short structure is more common; it is finely exhibited

a The word "vein" is used in these notes in accordance with the custom of the New Jersey geologists (see *Geol. of N. J.*, 1868, p. 533), as there seems to be no simple word that so well describes the general shape of these upturned, highly metamorphosed beds.

in the large veins at Mount Hope and Hibernia. A single ore-shoot is in some instances produced by the perfect development of the pinches on either side, resulting in reducing the ore below a workable thickness, if not in cutting it out altogether. But in other cases, as at the two mines above mentioned, the ore apparently lies in the trough of a narrow cyclinal fold. (See Fig. 1, p. 5.)

The ore is a mixture of magnetite, hornblende, quartz, feldspar, mica, pyrite, and apatite in varying proportions, though all the above-named minerals are not always present in a single specimen. Hornblende is the most persistent

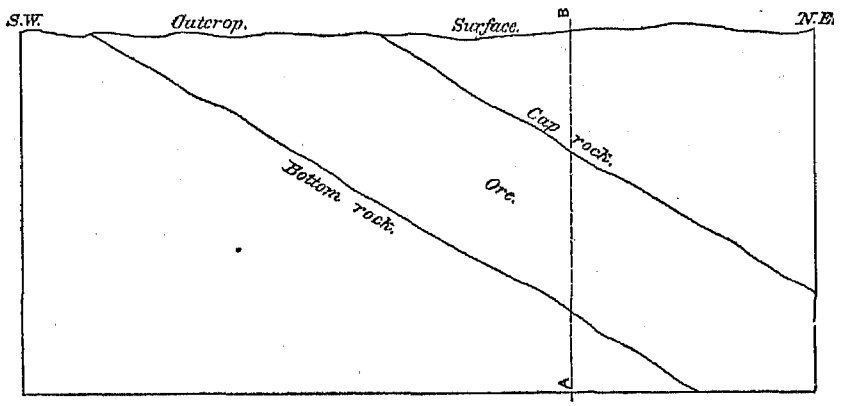


FIG. 44.—LONGITUDINAL SECTION IN PLANE OF DIP.

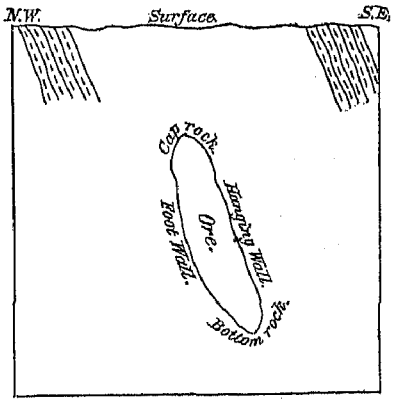


FIG. 45.—CROSS SECTION AT A—B.

associate of the ore. Quartz is often present in small granules, as well as in massive form. Pyrite (or pyrrhotite) is very rarely entirely absent, and is so plentiful in the ores from some of the mines as to necessitate their being roasted before they can be used in the blast-furnace. Apatite in the form of light-greenish colored granules is common in many of the ores, especially in those carrying a high percentage of iron. Calcite in thin layers on fracture planes is sometimes present.

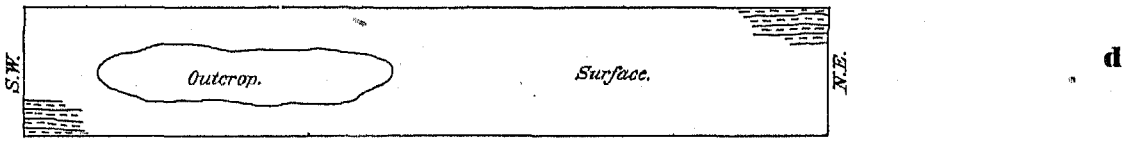


FIG. 46.—PLAN.

When much mica is present the ores have a laminated or schistose structure, and a similar structure is also sometimes occasioned, but in a less marked degree, by the hornblende. When free from foreign intermixture the ore often has a cubical fracture. In texture it varies from finely-granular to very coarsely-granular. The latter variety, locally known as "shot-ore", is very fragile and breaks up on handling into grains about the size of large buckshot.

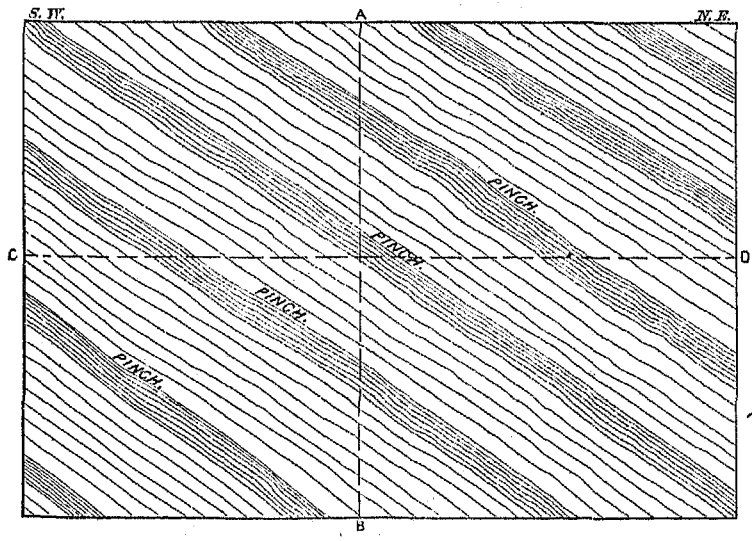


FIG. 47.—LONGITUDINAL SECTION.

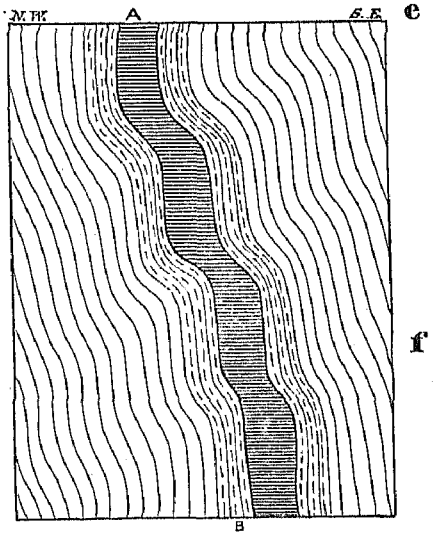


FIG. 48.—CROSS SECTION ON LINE A—B.

Note.—The vein of ore is generally relatively much thinner at the pinches than is indicated on Fig. 48. The ore is sometimes completely "cut out" by the walls coming together.

a Although ores showing all varieties of texture and containing their mineral constituents in all proportions are often met with in the same mine, the prevalent character of the ore from each deposit is usually quite constant. A person familiar with the New Jersey ores can as a rule tell, on examining a pile of ore, from whence it came.

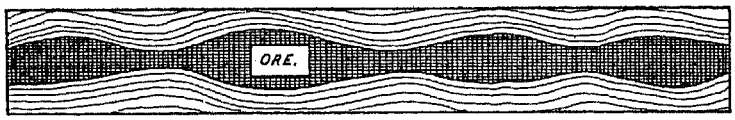


FIG. 49.—HORIZONTAL SECTION ON LINE C—D.

b For convenience in reference, Professor Cook, in the *Geology of New Jersey*, 1868, divided the range of Archæan rocks into four parallel belts. A brief description of these belts in the *Annual Report, etc., for* 1879, is as follows:

RAMAPO BELT.—This belt begins near Peapack, in Somerset county, and extends on in a northeast direction by Pompton to the state line, and, in New York, to and beyond the Hudson river. It is about 2 miles wide at the southwest, and at the New York line its width is 5 miles. Mine mountain, Trowbridge mountain, the low mountains between Danville and Boonton, the mountain extending from Boonton to Pompton, and the Ramapo mountain, are all in this belt. Its southeast border is defined by its meeting the red sandstones and conglomerates of the Triassic formation. Its northwest border is marked by a characteristic white, crystalline limestone, containing serpentine, in grains, in large masses, and in fibrous forms, known as chrysolite. There are outcrops of this limestone near Mendham, at Turkey mountain, north of Montville, near Wynokie, near Monks, and at the Old Blue mine, Ringwood.

PASSAIC BELT.—The Passaic belt is the next belt to the northwest, and the line just described is its southeast boundary. It begins at Clinton, Hunterdon county, at the southwest. Its breadth is nearly uniform and is about 5 miles. It is bounded by the red sandstone **c** and conglomerate of the Triassic age from Lebanon to Peapack. Nearer Clinton the magnesian limestone adjoins it on the southeast and south. The northwest border is marked by a continuous valley. This valley begins at the Spruce run, north of Clinton, where its first eastern branch comes in, and follows up the valley of that branch and over into German valley. Thence the Berkshire, Longwood, and West Milford valleys are the parts of this long depression. No crystalline limestone has been found in this belt, but it is distinguished by its rich mines of iron ore.

MUSCONETCONG BELT.—The valley above described, as far as it goes southwest, is the southeast boundary of this belt. From the Spruce run to the Delaware river it is bordered by the newer limestones and sandstones. The northwestern boundary is marked, as it runs from the Delaware, by Lower Harmony, up Harker's hollow, and over the mountainous divide near mount No More to Oxford furnace; thence up the valley of the Pequest to Vienna, and then up Bacon creek to Warrenville and Allamuchy; along the east foot of Allamuchy mountain and east of the Cranberry reservoir and the Roseville iron mine to the high dividing ridge between the streams running into the Musconetcong and those running into the Wallkill; from this divide it descends into the valley of the Wallkill and follows along the east border of that valley by Franklin, Hamburg, and Vernon to the New York line. Musconetcong, Pohatcong, **d** Schooley's, Hamburg, Wawayanda, and other mountain ridges are in this belt. It ends near Newburg, in New York. It is 6 to 8 miles wide, including several long valleys of magnesian limestone. No crystalline limestone has been found in it, in which respect it differs from the belt next adjoining it on the west.

PEQUEST BELT.—In the Pequest belt are included all the Azoic rocks northwest of the boundary-line just described. It extends across the state from the Delaware to the New York line. Its northwestern edge is overlaid by Paleozoic rocks. Marble, Scott's, Jenny Jump, and Pochuck mountains are in it. Its greatest breadth is about 3 miles. Crystalline limestone is very abundant in this belt, and it is also characterized by its rich zinc mines and by its iron ores containing manganese.

The following table shows the relative importance of the above-described belts as sources of magnetic iron ore:

Belt.	Number of openings.	Number of mines worked in census year. (*a*)	Total production of ore, census year.
			Net tons.
Ramapo	15	5	1,646
Passaic	115	57	540,495
Musconetcong	130	41	140,084
Pequest	42	12	56,194
Total	302	112	739,369

a Nine mines numbered in this column produced no ore in the census year; the work done was chiefly explanatory.

The Passaic belt produces over five-sevenths of the total output.

f Fig. 55 (on page 163) is a map of a group of mines near Dover, Morris county. The area covered by the map is about 11 by 25 miles. The production of the mines within this area in the census year was—

	Net tons.
Passaic belt (Morris county)	498,926
Musconetcong belt (Morris and Sussex counties)	60,298
Total	559,224

or over three-fourths of the total output of the state.

Counting the Oxford Furnace group of mines, the Mount Hope group of mines, and the Ringwood group of **a** mines each as one mine,(*a*) there are 25 mines which produced in the census year over 10,000 tons of magnetic ore each. The total output of these 25 mines for the census year was 585,508 net tons, or over 79 per cent. of the total output of the state.

Mines which were idle throughout the census year may generally be considered as either exhausted or as too small to pay for working. In a few cases, however, a mine has been abandoned because the ore contains too much sulphur, and in one instance at least on account of the presence of 10 or 12 per cent. of titanic acid.

In sampling the mines it was found convenient to follow the belts previously described. The Pequest belt was visited first, and the mines within its limits will first be mentioned, beginning with those situated in the southwestern part of the belt.

Many small mines were reopened in the early part of 1880, and were only worked for a few weeks. With but **b** few exceptions samples were taken only from those mines which were being worked when visited.

The numbers attached to the mines refer to the map (Fig. 50). Fig. 55 shows the location of the mines near Dover, on a map of a larger scale.

PEQUEST BELT.

In the southwestern portion of this belt, in Oxford and Hope townships, Warren county, a great deal of exploring has been done at different times, and twelve "mines" have been opened. From but four of these, however, viz, the Schuyler (1), the Roseberry (2), the Pequest (3), and the Hoagland (4), was ore raised during the census year. The total product from the four mines was 950 tons. The ore was not sampled.

The *Kishpaugh* mine (5), in Hope township, 2 miles northwest of Danville, on the Jenny Jump mountain, is **c** the only mine on this portion of the belt that has been successfully wrought. It was opened in 1871, and has yielded fully 81,200 tons of ore, including 12,710 tons raised in the census year. The mine is entered by two slopes, the one 246 feet long and the other 216 feet long, both driven on the foot-wall of the vein. The strike of the vein is northeast and southwest, and the dip is toward the southeast at an average angle of about 35°. At the bottom of the workings the ore is reported to be between 8 and 10 feet thick, but owing to the decomposed state of the hanging-wall part of the ore is left on the roof. On exposure to the atmosphere the ore soon softens and crumbles to an earthy powder. It is but slightly magnetic. A remarkable feature of the mine is the extent to which the wall-rock has disintegrated. Lagging is necessary along the slopes for a considerable distance from the surface, and even at the bottom of the mine very careful timbering is required. The rock from the mine soon falls to powder on exposure to the air. **d**

The following analyses show the character of the ore:

	No. 96.	No. 97.
	Per cent.	*Per cent.*
Metallic iron	49.08	54.71
Phosphorus	0.036	0.036
Sulphur	0.755	0.542
Manganese	Present.	Present.
Titanic acid	Present.	Present.
Phosphorus in 100 parts iron	0.072	0.066

e

Sample No. 96 is from a pile of 200 tons of ore from the northeast slope. Sample No. 97 is from a pile of 100 tons of ore from the southwest slope. The ore in both piles was mostly fine material, apparently a mixture of magnetite, hornblende, mica and chlorite (?). Only a few lumps of solid ore could be found in each pile. A lump from the pile represented by sample No. 96 consists of magnetite and green hornblende in roughly parallel and alternating layers. Small crystals of pyrite occur distributed through the specimen. Part of the hornblende has weathered to a brownish color. A specimen from the other pile contained greenish-brown mica.

The mine is worked by the Crane Iron Company, and the ore is sent to the furnaces at Catasauqua, Pennsylvania, via team to Pequest (9 miles), thence by rail.

Northeast of the Kishpaugh mine, along the top of the Jenny Jump mountain, in Hope and Independence townships, numerous exploration shafts or test-pits have been sunk on lines of magnetic attraction in search of **f** ore; but, so far as the writer could learn, no deposits had been found sufficiently large to pay for working, although from some of the shafts several hundred tons of ore have been raised. According to analyses published in the annual reports of the state geologist, samples (specimens ?) of ore from this district contained 49 to 63 per cent. of iron; 0.006 to 0.370 per cent. of phosphorus, and 0.65 to 2.74 per cent. of oxide of manganese.

East of the Great Meadows, which lie at the foot of Jenny Jump mountain, and near Warrenville, in Allamuchy township, several lines of magnetic attraction have been traced out and shafts opened thereon. At one of these

a In the table on page 148 these groups figure each as three mines, but on the census schedules the output from the several pits is united.

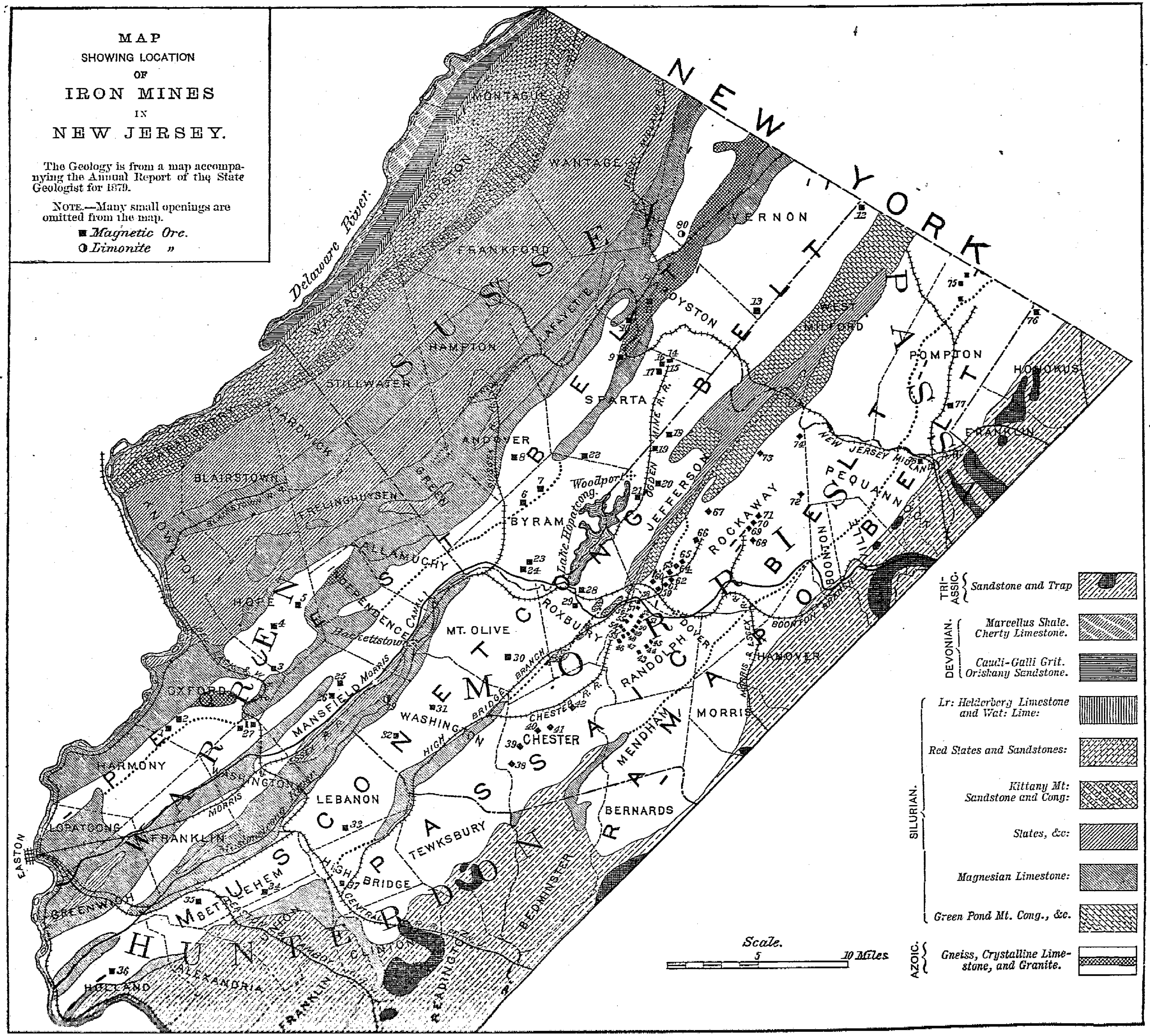

MAP
SHOWING LOCATION
OF
IRON MINES
IN
NEW JERSEY.
The Geology is from a map accompanying the Annual Report of the State Geologist for 1879.
NOTE.—Many small openings are omitted from the map.
Magnetic Ore.
Limonite "
NEW YORK
Delaware River
Lake Hopatcong
Woodport
EASTON
Scale.
5
10 Miles.
TRI-ASSIC. Sandstone and Trap
DEVONIAN. Marcellus Shale. Cherty Limestone.
Cauda-Galli Grit. Oriskany Sandstone.
SILURIAN. Lr. Helderberg Limestone and Wat: Lime:
Red Slates and Sandstones:
Kittany Mt: Sandstone and Cong:
Slates, &c:
Magnesian Limestone:
Green Pond Mt. Cong., &c.
AZOIC. Gneiss, Crystalline Limestone, and Granite.

FIG. 50.

"mines" some work was done in the census year toward driving a tunnel into Allamuchy mountain, from the a
west shore of Allamuchy pond, in order to cut a vein of ore which outcrops on the mountain top. No ore was mined however.

Northeast of the "Livesey's Tunnel" mine, above mentioned, and about 2 miles west of Cranberry reservoir, is the old Glendon mine. The ore occurs in crystalline limestone and contains a large amount of garnet. The mine has been idle for many years. Beyond the Glendon some work was done during the census year at the *McKean* (6) mine, in Byram township, Sussex county; but only 224 tons of ore were raised. The mine was opened first in 1873, and has produced in all about 1,000 tons of ore. It is owned by John McKean, and was worked under lease by Clarkson, Bird & Son.

The *Roseville* mine (7), in Byram township, about 3 miles southeast from Andover, was reopened by its owners, the Andover Iron Company, in February, 1880, after having been idle for eight or ten years. The mine was described b
in the *Geology of New Jersey*, 1868, and has changed but little since. The workings form an open cut 700 to 800 feet long, 30 feet wide, and 25 to 50 feet deep, with very irregular walls. The pit had been only partly freed from water when visited. Ore was being mined from the southwest end of the pit only, and chiefly, too, from the west wall. This wall is a crystalline limestone. The east wall is gneiss. The character of the ore changes greatly in the different parts of the pit. A sample taken to represent an average of a pile of 50 tons of sorted ore (ready for shipment) contained—

	No. 320.
	Per cent.
Metallic iron	53.92
Sulphur	0.013
Phosphorus	0.035
Phosphorus in 100 parts iron	0.065

c

The ore is teamed to the Sussex railroad and thence shipped by rail to the company's furnaces at Phillipsburg. The mine produced, in the census year, 1,347 tons of ore. The total production is estimated at 67,000 tons.

The old *Andover* mine (8), 1 mile northwest of the village of Andover, in the township of the same name, has been idle for many years. But in the spring of 1880 Messrs. Williams & Co. leased the property and opened the *Sulphur Hill* mine, immediately northeast of the old Andover workings. The accompanying sketch (Fig. 51) represents a plan of both mines, and shows also the location of the samples of ore taken. The mine is described with d
a great deal of detail in the *Geology of New Jersey*, 1868. One of the peculiarities of the locality is the occurrence of specular hematite, and a great number of different minerals associated with the magnetic ore. Mr. Wurtz found: Garnet, willemite, manganese, calcite, blende, fluorspar, galena, cerusite?, chalcopyrite, malachite, azurite, magnetite, talc, mica, hematite, calamine?, limonite, pyrite, hornblende, apatite, epidote, pyrrhotite, and feldspar. The workings on Sulphur hill consist of an open pit 100 feet long by 50 feet wide and 85 feet deep, entered by a tunnel on a level with the bottom of the pit. Through this tunnel the ore and rock are taken out on tram-cars, and the water drains naturally, so that at present no machinery is required. The samples of ore collected yielded, on partial analysis—

	No. 301.	No. 302.	No. 303.	No. 304.	No. 305.	No. 306.
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
Metallic iron	42.63	36.91	32.73	62.31	63.32	41.60
Phosphorus	0.024	0.022	0.100	0.001	0.018	0.110
Sulphur	2.290	2.527	0.270	0.059	0.057	0.071
Manganese	Present.	Present.	Present.	Present.	Present.	Present.
Titanic acid	Present.	Present.	Present.	Present.	Present.	Present.
Phosphorus in 100 parts iron	0.056	0.060	0.306	0.002	0.028	0.265

e

Sample No. 301 consisted of a series of chippings taken around the north and west sides of the Sulphur Hill pit. The ore contains garnet, pyrite, and pyrrhotite in considerable quantities, while numerous other minerals are often found associated with it. The magnetite is in coarsely granular bunches and in fine intermixture with the garnet, which latter forms an essential part of the mass and gives to it a reddish color. Some pieces of the ore contain green hornblende in place of a portion of the garnet, but the garnetiferous ore forms the chief output of f
the mine. Sample No. 302, from 80 tons of "cobbed" ore on the dock, was taken to represent the average run of the shipping product of the mine. The ore was all mined in the main pit. Sample No. 303 was taken from several "stringers" of soft brown ore, which occur near the outcrop of the magnetite, and often penetrate the latter to a depth of 8 or 10 feet. The ore has evidently resulted from the oxidation of the magnetite along cracks and fissures which have admitted the surface drainage. Commercially it is of little importance as the total amount is small, but its comparatively high percentage of phosphorus is noticeable. Sample No. 304 is from a small opening on the hill east of the north end of the old Andover pit. The ore is very strongly magnetic, and pieces of it exhibit polarity to a marked degree. The vein is about 3 feet wide. Sample No. 305 is from an old pillar near the north end of

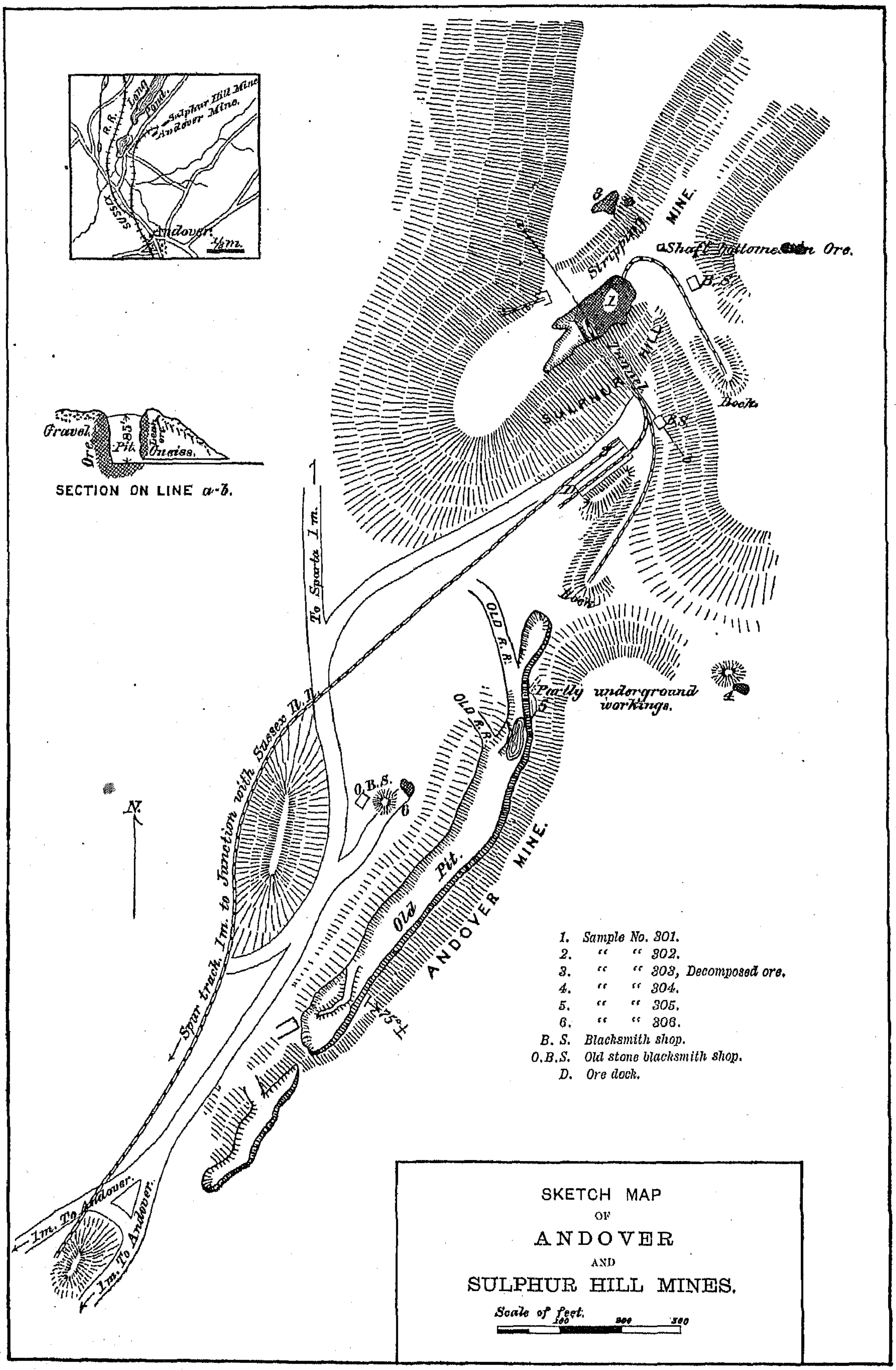

Long Pond.
Sulphur Hill Mine
Andover Mine.
R. R.
SUSSEX
Andover.
1/2 m.
Gravel.
Ore
85'
Pit.
Gneiss.
SECTION ON LINE a-b.
Stripping
MINE.
Shaft bottomed in Ore.
B. S.
Dock.
SULPHUR HILL
B.S.
To Sparta 1 m.
OLD R. R.
OLD R. R.
Partly underground workings.
Spur track 1m. to Junction with Sussex R. R.
O.B.S.
Old Pit.
ANDOVER MINE.
75°
1m. To Andover.
1m. To Andover.
N.
1. Sample No. 301.
2. " " 302.
3. " " 303, Decomposed ore.
4. " " 304.
5. " " 305.
6. " " 306.
B. S. Blacksmith shop.
O.B.S. Old stone blacksmith shop.
D. Ore dock.
SKETCH MAP OF ANDOVER AND SULPHUR HILL MINES.
Scale of feet.
100
200
300

FIG. 51.

the Andover pit. The ore gives a purplish streak, and its powder is readily taken up by the magnet; but it affects the compass-needle but slightly. If this sample represents the ore from the old pit it explains why the Andover iron was so highly prized. Sample No. 306 is from a small opening west of the old pit. A couple of men were at work here, and a few tons of ore were on the bank, but no ore had been shipped. The ore gives a reddish-brown or purplish streak, and soon disintegrates and falls to powder on exposure. The powder is largely taken up by the magnet. Sample No. 302 was subjected to complete analysis, with results as follows:

	No. 302.		No. 302.
	Per cent.		*Per cent.*
Silica	21.86	Phosphoric acid	0.051
Iron, protoxide	15.42	Titanic acid	0.13
Iron, peroxide	32.56	Hygroscopic water	0.12
Alumina	3.97	Water of composition	0.33
Manganese, protoxide	0.32	Total	100.031
Lime	18.57		
Magnesia	0.16	Per cent. of insoluble silicious matter	23.67
Iron, disulphide	4.530		
Zinc, sulphide	0.24	Silica	21.86
Nickel, sulphide	0.01	Alumina	1.08
Cobalt, sulphide	0.01	Lime	0.51
Copper, sulphide	0.12	Magnesia	0.16
Lead	Trace.	Potassa	0.05
Potassa	0.05	Total	23.66
Carbonic acid	1.58		

The ore is chiefly used in the company's furnace at Chester, New Jersey. Before being charged into the furnace it is roasted in Taylor's patent gas-kilns. A sample was collected from 100 tons of the roasted ore, and contained—

	No. 347.
	Per cent.
Metallic iron	46.53
Phosphorus	0.020
Sulphur	0.786
Phosphorus in 100 parts iron	0.043

Before the close of the census year 15,201 tons of ore were shipped from the Sulphur Hill mine. The total product of the Andover and Sulphur Hill mines together is estimated to have been in the neighborhood of 400,000 tons.

Near Franklin furnace, in Hardyston township, Sussex county, are two mines known as the *Hill* mine (10) and the *Pike's Peak* or *Furnace Vein* mine (11), respectively. The first-named is south of the furnace and is in gneiss, while the latter is in crystalline limestone. Openings have been made along the Hill Mine vein for a distance of about a half-mile, and on both sides of the Wallkill river. The present workings are southwest of the previous ones, and were begun in the summer of 1879. When visited the shaft was about 60 feet deep, and from the bottom the ore was being stoped out in either direction. A sample from a pile of 1,000 tons of ore at the top of the shaft yielded on analysis—

	No. 307.
	Per cent.
Metallic iron	27.88
Phosphorus	0.045
Sulphur	0.267
Phosphorus in 100 parts iron	0.161

The ore is an intimate mixture of magnetite and dark-green hornblende, and is somewhat deceptive on this account. It appeared to be richer in iron than is shown by the analysis. The *Pike's Peak* or *Furnace Vein* mine (11) is on the hill north of the Wallkill, and is but a few rods distant from the celebrated veins of zinc ore (franklinite, willemite, etc.) for which this region is famous. The ore-mass is in the form of a shoot, dipping to the southeast at about 55°, and pitching to the northeast. The slope on the foot-wall is 250 feet long, but at the bottom the ore has pinched out. All the ore now being mined comes from a level about 100 feet from surface and northeast of the slope. Here the ore is concentrated in two bands, the centers of which are about 5 feet apart. On either side of the center of each band the mass gradually grades off from a magnetite with calcite to a crystalline

a limestone with magnetite, the grains of magnetite always being arranged in lines parallel with the walls of the mine. The width of the stope is from 6 to 8 feet, and perhaps, on an average, 4 feet of this goes to the furnace. A sample taken from 150 tons of the ore at the furnace contained:

	No. 308.
	Per cent.
Sulphur	0.439
Phosphorus	0.033
Iron, metallic	33.15
Phosphorus in 100 parts iron	0.099

b

	No. 308.
	Per cent.
Silica	1.67
Iron, protoxide	14.43
Iron, peroxide	30.69
Alumina	0.28
Manganese, protoxide	2.90
Lime	17.63
Magnesia	7.53
Iron, disulphide	0.780
Iron, arsenide ($FeAs_2$)	0.47
Antimony, sulphide (Sb_2S_3)	0.05
Copper, sulphide	0.03
Carbonic acid	22.25
Phosphoric acid	0.077
Graphite	0.08
Hydroscopic water	0.06
Water of composition	0.18
Total	100.007
Insoluble silicious matter	2.41
Silica	1.67
Alumina	0.45
Lime	0.19
Magnesia	0.08
Total	2.39

c

The Hill and the Pike's Peak mines belong to the Franklin Iron Company. The ore is used at the Franklin furnace. During the census year the Hill mine produced 6,720 tons, and the Pike's Peak mine 8,960 tons of ore.

MUSCONETCONG BELT.

In the northeastern part of the Musconetcong belt, the *Centennial* mine (12), in West Milford township, Passaic county, was worked for a few months in the census year by E. H. Wright. One thousand three hundred and forty tons of ore were raised. The total yield of the mine is estimated at about 2,200 tons.

d The *Welling*, *Green*, *Wawayanda*, *Williams'*, and *Canistear* mines, all in Vernon township, Sussex county, were reopened in the census year. A couple of hundred tons of ore were raised from the *Welling* mine by M. F. Ten Eyck, but no shipments were made. The ore is reported to run low in phosphorus.

The *Canistear* mine (13) in the southeastern corner of Vernon township, near the road between Canistear and Stockholm, was reopened in 1879, and 10,000 tons of ore were mined. When visited, in March, 1880, the mine was idle, and the shafts were filled with water. The Franklin Iron Company owns the mine.

e A sample collected at the Franklin furnace from a pile of 350 tons of the ore yielded on partial analysis—

	No. 310.
	Per cent.
Metallic iron	35.38
Phosphorus	0.084
Sulphur	0.942
Phosphorus in 100 parts iron	0.237

The ore is very silicious.

f The Green, Wawayanda, and Williams' mines were in operation for a few weeks only.

Continuing in a southwesterly direction, the next mines met with are the Ogden mines, on Wallkill mountain, in Sparta township, Sussex county, 2 miles southeast of Ogdensburgh (see Fig. 52). Ore was mined at this locality in the last century. The vein has been traced and opened upon for nearly 2 miles, but only at four or five points has it been worked to any great depth. To-day the Ogden mines consist of four pits, known as the *Davenport* mine (17), the *Old Ogden* mine (16), the *Roberts* mine (15), and the *Pardee* mine (14).

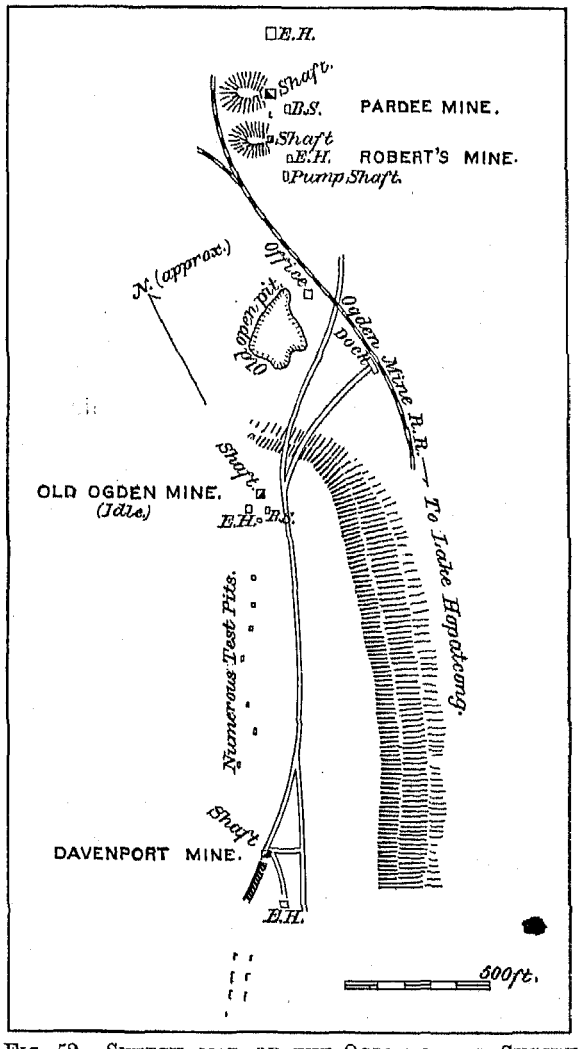


FIG. 52.—SKETCH MAP OF THE OGDEN MINES, SUSSEX COUNTY, NEW JERSEY.

The ore is all shipped via the Ogden Mine railroad to Lake Hopatcong, and thence by lake and the Morris a canal to furnaces in New Jersey and Pennsylvania. Shipments are made only in the summer season.

The *Davenport* mine is on a shoot of lean ore, which pitches toward the northeast at an angle of about 35°. The walls are almost vertical, and are quite smooth and solid; so that, although the pit in the northeastern end is 165 feet deep, and is open to daylight, no pillars have been left, and very little timbering is required. At the stope the vein is 6 to 8 feet wide. The ore is raised in buckets, but the men enter and leave the mine on the incline formed by the "bottom rock" of the shoot of ore. The chief gangue of the ore is colorless quartz, which often forms 50 per cent. (by volume) of a lump. Pyrite is present in small quantities. A sample was taken from a pile of 200 tons of ore on the railroad dock, and contained—

	No. 314.
	Per cent.
Metallic iron	47.76
Phosphorus	0.398
Sulphur	0.208
Phosphorus in 100 parts iron	0.833

b

The mine is worked by Atkins Brothers, under lease from the owners, the Sussex Iron Company. The ore is shipped to the lessees' furnaces at Pottsville, Pennsylvania. During the census year 1,120 tons of ore were mined. The mine was not, however, reopened before the winter of 1880. It had been idle since 1873.

When visited, the *Old Ogden* mine was idle, but it was afterward reopened by its owners, the Coplay Iron c Company, and 2,464 tons of ore were shipped from it before May 31.

The *Roberts* mine is owned by the Ogden Iron Company, and is now worked by the Allentown Rolling-Mill Company. The mine was reopened in June, 1879. The production of ore in the census year was about 16,800 tons. There are two shafts to the mine, about 130 feet apart. The northeast shaft, through which all the ore is raised, is 270 feet deep; it starts from the surface nearly vertically, but following the foot-wall of the vein, flattens at a depth of 75 feet, the vein being there bent toward the hanging-wall, pinching down to 18 inches in width. Below this pinch the walls dip at an angle of about 65° to the southeast, and at the present level the vein is about 15 feet wide. Stoping is progressing both east and west from the shaft. Samples taken across each stope yielded on partial analysis—

	No. 312.	No. 313.
	Per cent.	*Per cent.*
Metallic iron	63.91	64.22
Phosphorus	0.613	0.746
Sulphur	0.133	0.105
Phosphorus in 100 parts iron	0.959	1.162

d

Sample No. 312 is from the east stope, about 30 feet from the shaft. Sample No. 313 is from the west stope, about 50 feet from the shaft. Both stopes are on the same level, about 270 feet below surface.

The *Pardee* mine adjoins the Roberts on the northeast, the two mines being on the same shoot of ore. Between the shafts of the two mines the shoot pitches under a "cap-rock". The Roberts shaft starts from the surface in e ore, while the Pardee shaft was sunk through the cap-rock before the ore was reached. The Pardee shaft is 300 feet deep, and at the stope, 60 feet northeast of the bottom of the shaft, the ore is reported to average 20 feet in width. The shaft is within 10 feet of the property line, so there is of necessity but one stope in the mine. A sample was taken from a pile of about 2,500 tons of ore stocked at the mine. It yielded on complete analysis—

	No. 311.		No. 311.
	Per cent.		*Per cent.*
Sulphur	0.113	Phosphoric acid	2.444
Phosphorus	1.067	Titanic acid	0.09
Iron, metallic	59.23	Water of composition	0.38
Phosphorus in 100 parts iron	1.801	Total	100.306
Silica	7.63	Per cent. insoluble silicious matter	9.69
Iron, protoxide	25.34		
Iron, peroxide	56.37	Silicia	7.63
Alumina	3.08	Alumina (with a trace of iron oxide)	1.99
Manganese, protoxide	0.34	Lime	0.04
Lime	4.09	Magnesia	0.02
Magnesia	0.27	Total	9.68
Iron, disulphide	0.212		
Carbonic acid	0.06		

f

a The Pardee mine is owned by the Ogden Iron Company. It is now worked by the Musconetcong Iron Company, and the ore is used at Stanhope. During the census year 8,089 tons of ore were mined.

About 4 miles due south of the Ogden mines and 3 miles northeast of Woodport, at the head of Lake Hopatcong, is the *Ford* mine (18), in Jefferson township, Morris county. It is owned and operated by the Musconetcong Iron Company. A spur-track from the Ogden Mine railroad passes the mine, and the ore is shipped to Stanhope via this railroad, Lake Hopatcong and the Morris canal, there to be used in the company's furnaces. The mine has two shafts. No. 2 (the northeast shaft) is 200 feet deep. The stope is 250 feet northeast of the shaft, where the vein is 15 feet wide. Fifty feet above this level a drift has been driven 150 feet beyond the stope. At the level of this drift, *i. e.*, about 150 feet below the surface, the vein has been opened for a length of about 750 feet. Shaft No. 1, now used as an auxiliary pump shaft only, is 150 feet southwest of No. 2, and is bottomed in b the bottom rock of the shoot of ore. The bottom rock pitches toward the northeast at an angle of about 30°. The ore has been followed from the surface along the bottom rock and has practically been all exploited southwest of the hoisting-shaft.

A sample of the ore was collected from the stock-pile at the mine. This stock-pile contained some 6,000 tons of ore, part of which had been mined several years since. The mine was idle for two or three years previous to the spring of 1879. The sample yielded on partial analysis—

c

	No. 315.
	Per cent.
Metallic iron	50.70
Phosphorus	0.313
Sulphur	0.753
Phosphorus in 100 parts iron	0.617

The ore is finely granular, and contains hornblende, pyrite, and apatite. During the census year 17,584 tons of ore were shipped from the mine.

Less than two rods east of the shoot of ore now being worked, is another and parallel shoot, known as the old Glendon vein. It was from this that the first ore was raised, the western shoot having been discovered by a drift from the old mine. No work has been done on this vein for many years; but when the locality was visited, an old shaft, 200 feet northeast of No. 2 shaft, was being repaired preparatory to resuming mining. At the bottom of d this shaft the vein is 3 feet wide. The ore is pyritiferous.

The *Scofield* mine, owned by the Crane Iron Company, is believed to be on the Glendon vein. It lies adjacent to the Ford on the northeast. It has been idle since 1874.

The *Dodge* mine (19), 1 mile southwest of the Ford, was, like the latter, idle for some years previous to 1880. The pumps were started in January, and when visited the mine was dry and the shaft was being repaired, preparatory to resuming mining operations. The mine is owned by William E. Dodge, jr., and is worked by the Weldon Iron Company. Before May 31, 358 tons of ore were raised. The structure of the ore-mass is similar to that at the Ford mine. The pitch of the shoot is the same (30°), and the only exceptional feature is that the vein dips to the northwest. The hoisting-shaft is 165 feet deep and is bottomed in the bottom rock of the shoot, along which the ore has been worked from the surface. Descending along the bottom rock, at a point about 230 feet from the foot of e the shaft, the cap-rock makes a sharp bend downward and apparently cuts the ore entirely off.

Exploration into the foot (east) wall at this point resulted in the discovery of another shoot of ore, separated from the first one by 10 to 12 feet of rock. Judging from the size of the chamber this second shoot must have been 15 or 20 feet wide at the point where it was broken into. But toward the southwest the walls come together and the vein narrows to about 8 feet. A drift has been started from this chamber southwestward, and the only ore in sight in the mine, excepting on the floor at the bottom of the incline, when visited, was in this drift. The occurrence of two parallel shoots of ore near together is a peculiarity of this district. The most perfect example of this "twin" structure is seen at the Weldon mine.

About 3,000 tons of lean ore mined several years ago were stocked on the railroad dock at the mine. In the process of loading this ore the rock is sorted out. A sample was taken from 4 car-loads of ore ready for shipment, f and contained—

	No. 316.
	Per cent.
Metallic iron	50.70
Phosphorus	0.168
Sulphur	0.443
Phosphorus in 100 parts iron	0.331

About one-eighth of a mile west of the mine, and near the Ogden mine railroad, a shaft is being sunk on a line of magnetic attraction. The shaft is 60 feet deep, and at the bottom the vein is 3 feet wide. In appearance the ore is similar to that from the mine.

The *Weldon* mine (20), 1 mile east of Woodport, was also reopened in the winter of 1880, after having been idle a for six or seven years. In the census year 1,276 tons of ore were raised. The mine is the property of William E. Dodge, jr., and others, and is worked by the Weldon Iron Company. The ore lies in two shoots, which pitch toward the northeast at the same angle (30° to 32°), and slightly approach each other as they descend. At the shaft, 80 feet below the surface, the shoots are 29 feet apart, while at the stopes, about 200 feet northeast of the shaft, measured on the bottom-rock, they are separated by but 7½ feet of rock. Both shoots dip to the southeast, at an angle of 75° to 80°. The height of the shoots, *i. e.*, the normal distance between the bottom and cap rocks, is about 30 feet. The stope in the west shoot is 3 to 4 feet wide; in the east shoot, 4 to 5 feet wide. The track is laid down the east chute, and the mine cars are switched at the bottom of the mine into either stope, the rock between the shoots being cut through to allow of their passage.

The ore is a finely- to coarsely-granular magnetite, with quartz and hornblende. A portion of the ore is b "shotty", and resembles the Hurdtown ore. A sample was taken from a pile of about 300 tons of the ore at the mine and yielded on analysis—

	No. 317.
	Per cent.
Metallic iron	54.80
Phosphorus	0.554
Sulphur	0.266
Phosphorus in 100 parts iron	1.010

The *Hurdtown* mine (21), located three-fourths of a mile southwest of the Weldon and 1 mile southeast of c Woodport, in Jefferson township, Morris county, is one of the largest deposits of ore in the state. Like all the large mines, it is an old one. It is the property of the Hurd heirs, and is worked under lease by the Glendon Iron Company. The ore is used in the Glendon furnaces, in Pennsylvania. From January 1, 1870, to December 31, 1878, over 251,000 tons of ore were raised from the mine. The total production is estimated at over 500,000 tons. In the census year 29,232 tons of ore were mined. The mine was fully described in the *Geology of New Jersey*, 1868, but since the date of that report all the openings near the turnpike have been abandoned, and the present operations are in the deep mine only. The form of the ore-mass is that of an immense pod. The angle of pitch averages 32°. The height of the chute is about 90 feet; its width, at the present stope, is 35 feet, and it has been worked for a length of 1,600 feet. As described by the New Jersey geologists, the surface-workings (now covered d up) clearly showed this ore-body to lie in the axis of a narrow synclinal fold, the bottom-rock being the inverted arch of the fold. (See Fig. 2, p. 5.)

The skip-road is laid on the bottom-rock. The walls are nearly vertical, except near the bottom of the shoot, where they gradually approach each other and form the bottom-rock. Along the upper ridge of the shoot the ore is lean, and is left in arch-form to support the roof. The walls are solid, requiring only an occasional pillar and no timbering. Water is not troublesome. Altogether the conditions for winning the ore cheaply appear to be most favorable. The Hurdtown is one of the few New Jersey mines worked without interruption from 1873 to 1879. About 30,000 tons of ore were stocked at the mine in April, 1880. The ore is as a rule coarsely granular; much of it is "shotty". It has a blue-black color, metallic to submetallic luster, and is generally free from foreign intermixture. Some specimens of the ore have an irridescent coating. A sample taken from 17 car-loads (about 110 tons) of ore ready for shipment yielded on complete analysis— e

	No. 318.		No. 318.
	Per cent.		*Per cent.*
Sulphur	0.169	Titanic acid	0.14
Phosphorus	0.190	Carbon in carbonaceous matter	0.03
Iron, metallic	66.62	Hygroscopic water	0.05
Phosphorus in 100 parts iron	0.255	Water of composition	0.24
Silica	4.06	Total	99.793
Iron, protoxide	29.78	Per cent. insoluble silicious matter	5.36 f
Iron, peroxide	61.13		
Alumina	1.73	Silica	4.06
Manganese, protoxide	Trace.	Alumina	0.17
Lime	1.29	Lime	0.27
Magnesia	0.43	Magnesia	0.17
Iron, disulphide	0.144	Potassa	0.03
Potassa	0.03	Soda	0.09
Soda	0.09	Iron, protoxide	0.58
Carbonic acid	0.26	Total	5.37
Phosphoric acid	0.389		

a The *Sickles* mine (22), in Sparta township, Sussex county, 2½ miles south of the village of Sparta, was opened in 1870. It is now leased by the Blooming Ridge Iron Company. All recent work has been done in a shaft 500 feet southwest of the old mine, which was abandoned, as the ore there lies in thin seams between seams of rock; and it did not pay to mine it. The new shaft is 60 feet deep. At the bottom of the shaft the vein of ore is 3 to 4 feet wide. A sample of the ore from a pile of about 50 tons at the top of this shaft contained—

	No. 319.
	Per cent.
Metallic iron	38.11
Sulphur	0.976
Phosphorus	0.050
Phosphorus in 100 parts iron	0.131

b

The total product of the mine is reported at about 4,000 tons. In the census year 1,000 tons of ore were raised. This latter was shipped to Stanhope and Secaucus, and was partly used for Bessemer metal.

Continuing in a southwesterly direction, the next mine sampled was the *Wright* or *Budd* mine (23), in Byram township, Sussex county, about 2 miles north from the village of Stanhope. Ore was discovered here about 5 years ago, and some work was then done toward developing the property. Work was resumed in October, 1879, by Smith and Ruslin. When visited three shafts had been sunk to depths of 55, 60, and 30 feet, respectively. The deepest shaft is between the other two. The strike of the ore is north 50° east; the dip is 30° to southeast. The c wall-rock is much decomposed near the surface, and the ore, too, is partially peroxidized and has a reddish color. The middle and the northeast shafts have passed through the "red ore" into a hard "blue" ore, containing much pyrite. To determine the effect of the partial oxidation on the sulphur and phosphorus in the ore, two samples were taken, one of the "red" and one of the "blue" ore. Below are the results of their analyses:

	No. 323.	No. 324.
	Per cent.	*Per cent.*
Metallic iron	49.88	47.62
Phosphorus	0.342	0.521
Sulphur	1.382	2.824
Phosphorus in 100 parts iron	0.685	1.094

d

Sample No. 323 was taken in the mine, from a breast of "red" ore; sample No. 324 is from a few tons of "blue" ore from the northeast shaft.

The ore is shipped to the Chestnut Hill furnaces in Pennsylvania. In the census year 2,016 tons of ore were mined. The total yield of the mine is estimated at 5,600 tons. William Wright is the owner of the property.

Southwest of the Wright mine, and about 1 mile north from Stanhope, is a ridge or hill, locally known as Mine hill. The western, southern, and southeastern slopes of the hill are completely honeycombed with small openings. These openings collectively go by the name of the *Hude* or *Stanhope* mine (24). The tract of land is owned by the Dickerson estate. The mine was worked in the census year by John M. Barnes. Two samples of the ore were e collected. They contained—

	No. 321.	No. 322.
	Per cent.	*Per cent.*
Metallic iron	49.95	50.23
Sulphur	0.178	1.220
Phosphorus	0.037	0.057
Phosphorus in 100 parts iron	0.074	0.113

Sample No. 321 represents ore from a small opening on the west side of the hill. The ore was much weathered. Sample No. 322 is from a pile of about 500 tons of ore at Stanhope furnace. The ore came from various openings, f but principally from the large pit on the east side of the hill. The ore from this pit is an unaltered magnetite and contains much pyrite.

During the census year 2,887 tons of ore were mined; it was shipped mainly to Stanhope. The total yield of the mine is estimated at 29,000 tons.

Passing southwestward along the ridge west of the Musconetcong valley, samples were taken from the *Egbert* and *Bald Pate* mines, in Mansfield township, Warren county, about 4 miles southwest from Hackettstown, and near Mount Bethel.

The *Egbert* mine (25) has been idle since 1876. Previous to that year several thousand tons of ore were mined, and about 100 tons were stocked at the mine when visited. The vein is reported to have been worked to a depth

of 130 feet and a length of 215 feet. Nothing definite could be learned in regard to the width of the ore, and a the mine was of course filled with water. The ore contains a great deal of pyrite. The analysis of the sample shows—

	No. 100.
	Per cent.
Metallic iron	47.37
Phosphorus	0.418
Sulphur	4.010
Phosphorus in 100 parts iron	0.882

The *Bald Pate* mine (26) is one-half mile southwest of the Egbert. It had produced, up to 1876, 2,000 tons of b ore. From 1876 to 1879 the mine was idle; but it was reopened in the fall of the latter year by H. J. Boardman. About 150 tons of ore were raised, when work was again stopped. When visited, in February, 1880, the shafts were filled with water. A sample was taken from a pile of about 75 tons of ore near the top of one of the shafts. Much of the material in the pile was fine and earthy. The sample contained—

	No. 99.
	Per cent.
Metallic iron	54.10
Phosphorus	0.039
Sulphur	0.025
Phosphorus in 100 parts iron	0.072

c

The *Oxford Furnace* mines (27) are located at Oxford Furnace, in the northeast corner of Washington township, Warren county, on the north slope of a spur of Scott's mountain. Ore was mined here before 1743, as in that year a blast-furnace was put in operation near the mines. The mines are, *therefore, among the oldest in the country.* They are owned by the Oxford Iron Company. Their total product is not known, but from 1869 to 1877 the average annual yield was about 23,000 tons of ore. *In the census year* 22,359 tons of ore were produced. Near the mines, d and under the same management, are two blast-furnaces and a nail-mill. All the iron in the ore is turned *into nails within a mile of the mines.* As shown by the accompanying sketch (Fig. 53), several veins of ore on the property have been wrought. Though not parallel, three of the veins worked have a general northwest and southeast trend, thus differing from the usual course of New Jersey iron-ore deposits. In this they conform, however, to the stratification of e the inclosing gneiss.

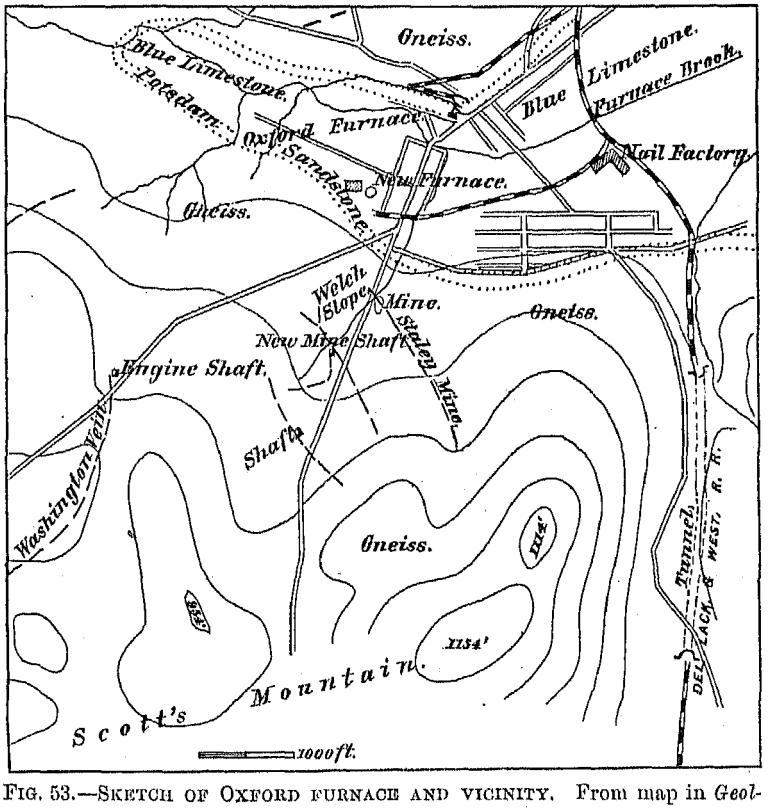


FIG. 53.—SKETCH OF OXFORD FURNACE AND VICINITY. From map in *Geology of New Jersey*, 1868.

The *Staley* mine is the most northerly of the group. The vein of ore is now believed to be exhausted.

About 700 feet southwest of the Staley shaft is the *New Mine* shaft, and 400 feet northwest of the latter the Welch slope is situated. The ore from two veins is raised through each opening. In the New mine the veins are called the "Car-wheel" or "red-ore" vein, and the "New Mine" or "gray-ore" vein; and in the f Welch mine they go by the names of the "Welch vein" and the "Slope vein". It is believed that the slope is the extension of the Car-wheel vein, and the Welch the continuation of the New Mine vein. But the continuity of both veins is interrupted by a "crossing" of feldspathic (orthoclase) rock, and possibly, too, by a fault.

The New mine shaft is sunk near the foot-wall of the Car-wheel vein; it is about 250 feet deep. A plan of the mine, some 25 feet above the present level, from a survey made by Mr. William Scranton, is given in Fig. 54.

This plan shows the veins to be separated by from 15 to 25 feet of rock. West of the bottom of the shaft, that is, in a direction toward the Welch mine, the ore in each vein is cut off by rock. This rock pitches rapidly toward the east, and will probably be cut by the shaft at another level. East of the shaft the "gray-ore" vein has been

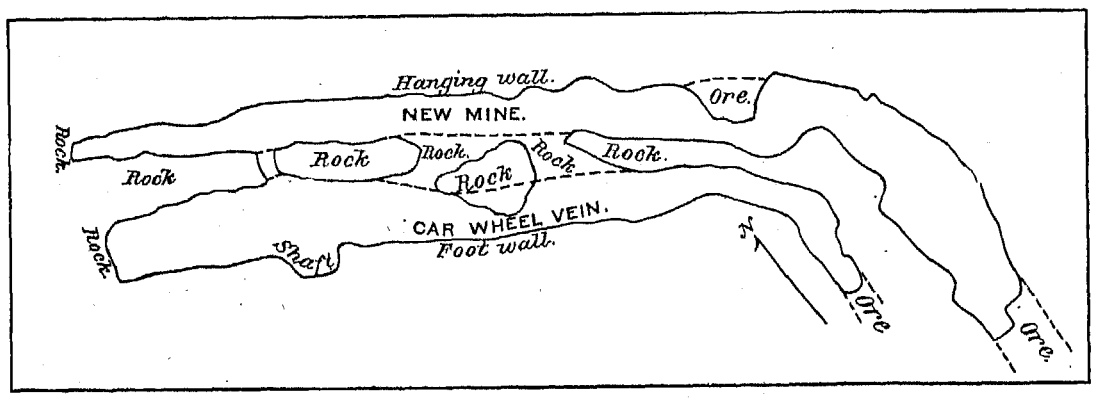
a worked at the level of the sketch for a length of 330 feet, and the Car-wheel vein for a length of 258 feet. The sketch is chiefly interesting as showing the bend in both veins. At the surface it would appear from the map that only the Car-wheel vein was bent, but at the level of the sketch both veins are bent, and continue, moreover, nearly parallel beyond the bend. Between the bottom of the mine and the surface the Car-wheel mine was in places 20 feet wide. It has narrowed, however, at the present stope to about 4 feet. The stope in the gray-ore vein is 20 feet wide. Samples were taken from each stope, and contained—

b

	No. 91.	No. 92.
	Per cent.	*Per cent.*
Metallic iron	54.84	39.54
Phosphorus	0.151	0.044
Sulphur	0.225	0.758
Manganese	Present.	Present.
Titanic acid	Present.	Present.
Phosphorus in 100 parts iron	0.275	0.111

Sample No. 91 is from the Car-wheel vein. The ore is a finely granular to compact magnetite, and has a peculiar purplish tinge of color. A hand specimen contained thin layers of calcite. Sample No. 92 is from the "gray-ore" vein. This ore is carefully hand-picked before it is sent to the furnace.

c



d

FIG. 54.—PLAN OF THE NEW MINE, NEAR OXFORD, NEW JERSEY. From surveys by Mr. William H. Scranton.

The ore from the two veins is not kept separate. Two samples were taken to show the run of the shipping product of the mine. These samples contained—

e

	No. 95.	No. 330.
	Per cent.	*Per cent.*
Metallic iron	43.31	46.66
Phosphorus	0.072	0.095
Sulphur	0.307	0.270
Manganese	Present.	Present.
Titanic acid	Present.	.....
Phosphorus in 100 parts iron	0.166	0.204

Sample No. 95 is from a pile of 75 tons of ore at the furnace. Sample No. 330 is supposed to be an average of a week's output of the mine. It was collected as follows: A barrel was placed near the road between the mine and the furnace, and teamsters were ordered by Mr. Scranton to throw half a shovelful of ore from each wagon-load into the barrel as they drove by. On the writer's return to the mine the barrel was full. He was told that it had taken about a week to fill it. Its contents were emptied onto the floor of the engine-house, and a sample was carefully taken from the pile.

f In the Welch mine but very little ore was seen. No work was being done in the slope vein, and the ore in the Welch vein was very much mixed with rock. Sample No. 94 was taken from a pile of 100 tons of the ore at the furnace, and sample No. 329 was obtained in a manner similar to sample No. 330. The samples yielded on analysis—

	No. 94.	No. 329.
	Per cent.	*Per cent.*
Metallic iron	46.59	41.60
Phosphorus	0.077	0.059
Sulphur	0.342	0.585
Manganese	Present.	.....
Titanic acid	Present.	.....
Phosphorus in 100 parts iron	0.165	0.142

The *Washington* mine is about two-thirds of a mile southwest from the Welch slope. It was originally opened a some twenty-six years ago; but it was abandoned after being worked for twelve years, because the ore was too pyritiferous to be used in the furnace. Work was begun toward reopening the mine in the autumn of 1879. When visited in February, 1880, actual mining had just been resumed. The shaft in use is west of the road, and is 95 feet deep. From this shaft a long line of magnetic attraction extends in a southerly and southeasterly direction. There are numerous old openings along this line, and a new shaft was started in November, 1879, 1,100 feet southeast of the working-shaft, after a careful magnetic survey had been made of the property by Mr. William Scranton. (*a*) At the present stope, 75 feet southeast from the shaft, the vein is 8 feet wide; it dips toward the north at an angle of about 45°. The following analyses show the character of the ore:

	No. 90.	No. 93.
	Per cent.	*Per cent.*
Metallic iron	57.43	61.36
Phosphorus	0.505	0.657
Sulphur	0.620	0.609
Manganese	Present.	Present.
Titanic acid	Present.	Present.
Phosphorus in 100 parts iron	0.879	1.070

b

Sample No. 90 was taken across the stope in the mine, and sample No. 93 from a pile of 75 tons of the ore at the furnace. Lumps of ore containing a great deal of pyrite are sorted out; hence sample No. 93 is lower in c sulphur than is the "run" of the mine.

Returning to near the foot of Lake Hopatcong:

The *Gove* mine (28), in Roxbury township, Morris county, 1 mile northwest of Drakesville station, was opened in 1874. It was reopened in October, 1879, and produced in the census year 3,920 tons of ore. The total yield is estimated at 11,200 tons. The mine is owned and operated by Francis N. Gove. The ore is shipped to the Colerain furnace, Lehigh valley, Pennsylvania. It was not sampled.

The *High Ledge* mine (29) and the *King* mine, both near Drakesville, were worked for a few months in the census year. The product was 1,120 tons of ore from the former and 280 tons from the latter. The mines were idle when visited and the ore was not sampled.

Extending in a southwesterly direction from a point about 2 miles southwest of Drakesville is a long line of d magnetic attraction which has been opened upon in numerous places. As a rule only narrow veins of ore were discovered, and very little work has been done along the range in recent years. In January, 1880, however, the *Mount Olive* mine (30), near the village of Mount Olive, in Mount Olive township, Morris county, was reopened by William E. George & Co., and worked until May; 1,625 tons of ore were produced. The total yield of the mine is estimated at 22,400 tons. There are several old shafts on the property. The one in use is 165 feet deep. At the bottom of the shaft the vein is 6 to 8 feet wide. The ore at this depth is a hard blue magnetite and contains much pyrite. A sample from 600 tons at the shaft yielded on analysis—

	No. 326.
	Per cent.
Metallic iron	58.92
Sulphur	1.900
Phosphorus	0.182
Phosphorus in 100 parts iron	0.309

e

Northeast of the above-mentioned shaft a new shaft is being sunk. When visited it was 35 feet deep. It had passed through 8 feet of surface material, 22 feet of soft, partially oxidized ore, and was bottomed in a hard blue ore. A sample from a pile of 75 tons of the partially oxidized ore contained—

	No. 327.
	Per cent.
Metallic iron	63.36
Sulphur	0.145
Phosphorus	0.090
Phosphorus in 100 parts iron	0.142

f

The *Stoutenburgh* mine (31) is located on Schooley's mountain, in Washington township, Morris county, about 3½ miles from Hackettstown. A mine was opened on the property in 1872 and about 6,700 tons of ore were mined.

a A map of this survey was published in the *Annual Report of the State Geologist* for 1879.

a Owing to the vein pinching out the mine was abandoned in 1873. In 1877, Mr. Stoutenburgh resumed prospecting for other veins and sunk numerous test-pits. The present workings are 350 feet southwest of the old mine. There are two shafts 35 feet apart, the one 90 the other 64 feet in depth. The vein at the bottom of the workings is reported to be 3 feet in width. The mine is very wet, and when visited was partly filled with water, and no mining was being done. New pumping machinery is about to be put in. A sample was taken from a pile of 50 tons of the ore at the mine, and yielded on analysis—

b

	No. 328.
	Per cent.
Metallic iron	56.37
Sulphur	0.155
Phosphorus	0.639
Phosphorus in 100 parts iron	1.134

The ore is red in color and is mottled. The mottling is possibly produced by the partial removal of crystals of apatite. During the census year 1,680 tons of ore were raised. The mine is leased by Joseph Wharton. The ore is used at the Hackettstown furnace.

About 2 miles southwest of the Stoutenburgh mine, William W. Marsh did some exploring in the spring of 1880 near the *Hann* mine (32), and raised about 150 tons of ore from a new opening.

c The *Gray* mine (33), near Whitehall, Lebanon township, Hunterdon county, was worked the greater part of the census year by the Saucon Iron Company; 1,940 tons of ore were produced. The total yield of the mine is estimated at 8,400 tons.

The *Pidcock* and *Eveland* mines, also in Lebanon township, were worked for a short time in the spring of 1880, producing 156 and 224 tons of ore, respectively.

The *Mayberry*, *Asbury*, *Rodenburg*, *Case* and *Petty* mines, all in Bethlehem township, Hunterdon county, were worked for about a month in the census year, and produced altogether a little less than 500 tons of ore.

The *Church* or *Van Syckle's* mine (34), on John T. Leigh's farm, in Bethlehem township, near Valley station, on the Central railroad of New Jersey, although not worked since 1876, is mentioned here because the ore is reported to contain a large percentage of titanium. A mean of ten analyses is reported to show the presence of over 12 per d cent. of titanic acid—the extremes being 9.82 per cent. and 15.05 per cent. The mine was opened in 1871, but was abandoned, after 4,300 tons of ore had been mined, as the ore was too difficult to smelt. Titanic acid is commonly present in the New Jersey magnetites, but, so far as I know, this is the only locality where it has been found in such quantities as to render the ore unfit for use.

The *Swayze* mine, also near Valley station, was reopened in November, 1879, by the West End Iron Company. No ore was, however, raised before the end of the census year.

The *Turkey Hill* or *West End* mines (35), near Bethlehem, Bethlehem township, Hunterdon county, were opened in 1872. During the census year 11,086 tons of ore were mined. There are two parallel veins of ore on the property, but thus far the west vein has alone been worked to any extent. The strike of the veins is north 75° east, and the dip is about 60° toward the southeast. Seven shafts have been sunk: No. 1 is at the southwest end of the mine e and on higher ground than the others; it is 90 feet deep. No. 2 is 630 feet beyond No. 1; it is 163 feet deep. Between shafts Nos. 1 and 2 there is a small strip of land which is being explored by Daniel Runkle. Shaft No. 3 is 380 feet northeast of No. 2, and No. 4 is 340 feet beyond No. 3. No. 3 is 175 feet deep and No. 4 is 235 feet deep, and these two shafts are connected by underground workings. Pits Nos. 1 and 2 are separate. Shaft No. 5 is 600 feet beyond No. 4 and is 140 feet deep; No. 6 is 2,400 feet northeast of No. 5, and shaft No. 13 is about midway between Nos. 5 and 6. In May, 1880, no ore had been raised from shafts Nos. 5, 6, and 13, and shaft No. 2 had been idle for two or three years. On account of a strike of the miners the whole mine was temporarily idle when visited, and I was unable to go through it; but according to the report of the state geologist for 1879 the ore varies in thickness from 6 to 20 feet, this variation being caused by rolls in the foot-wall.

Samples were taken of the ore from shafts Nos. 1, 3, and 4. The samples contained—

f

	No. 331.	No. 332.	No. 333.
	Per cent.	*Per cent.*	*Per cent.*
Metallic iron	35.31	30.45	52.48
Phosphorus	0.006	0.000	0.004
Sulphur	0.126	0.034	0.013
Phosphorus in 100 parts iron	0.017	0.000	0.008

Sample No. 331 is from shaft No. 1, No. 332 is from shaft No. 3, and No. 333 is from shaft No. 4. The ore is a finely-granular magnetite, with hornblende, brown mica, a little calcite (in thin layers), and occasionally a speck of pyrite. As it comes from the mine it has a grayish color. Sample No. 332 is unique among New Jersey ores in containing no phosphorus.

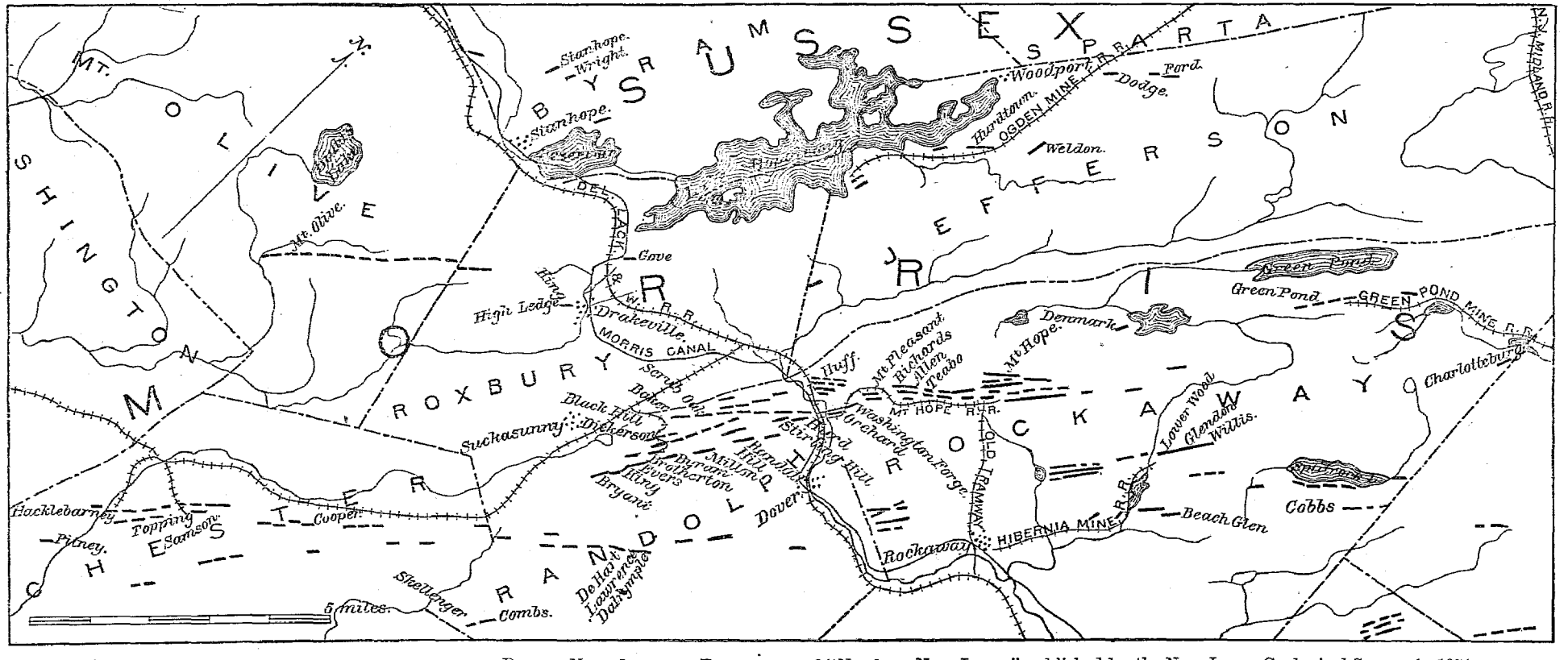


FIG. 55.—MAP OF A GROUP OF IRON MINES NEAR DOVER, NEW JERSEY. From a map of "Northern New Jersey" published by the New Jersey Geological Survey in 1874.

a The *Hager* mine (36), in Holland township, Hunterdon county, 1¼ miles west of Spring Mills, and on the Musconetcong mountain, was worked during the census year by the Holland Mining Company. About 800 tons of ore were raised. The total yield of the mine is estimated at 1,680 tons. Early in May, 1880, the shafts described in the *Annual Report of the State Geologist for* 1879 had been temporarily abandoned on account of water, and a new shaft had been started northeast of the old mine. This shaft was 20 feet deep, and it had uncovered two narrow veins of ore separated by 2 feet of rock. One of the veins is 2 feet and the other 4 feet wide. A sample was taken from a few tons of ore at the top of the shaft. It contained—

b

	No. 334.
	Per cent.
Metallic iron	62.71
Phosphorus	0.274
Sulphur	0.093
Phosphorus in 100 parts iron	0.437

The ore is nearly all soft, owing to partial decomposition. In the deeper shafts a hard, blue, pyritous ore was reached.

The Hager completes the list of working mines in the Musconetcong belt.

c

PASSAIC BELT.

Large's mine, in Clinton township, Hunterdon county, was worked one month in the census year and produced about 100 tons of ore. The *Annandale* mine, in High Bridge township, was in operation two months; 625 tons of ore were raised. The mines were not sampled.

The old *High Bridge* mines (39), worked early in the last century, are located north of the village of High Bridge. The ore occurs in small independent shoots, and the old workings extend in a northeast and southwest direction for about half a mile. The western end of the vein or line of shoots belongs to John Kane and the eastern end to the Thomas Iron Company. The deeper workings are now filled with water, but during the census year about 2,000 tons of ore were mined, above the water-line, in the Taylor opening, on the Thomas Iron d Company's property. A sample was taken from a few tons of ore which had come from this pit. The sample yielded on analysis—

	No. 335.
	Per cent.
Metallic iron	55.15
Phosphorus	0.609
Sulphur	5.172
Phosphorus in 100 parts iron	1.104

e The ore is partly covered with an efflorescence of sulphate of iron.

The *Silverhorn* or *Kane* mine and the *Cregar* mine, both in High Bridge township, were worked for a short time in the census year, and about 250 tons of ore were raised at each locality. Some exploratory work was also done at the *Old Furnace* mine, but no ore was produced.

After considerable exploring a mine has recently been opened by Cooper & Hewitt on the *Pitney* farm (38), in Chester township, Morris county, near the Black river, and about a mile and a quarter from Hacklebarney. In the census year 2,800 tons of ore were produced. The total yield of the various openings on the property is estimated at 6,700 tons. The ore thus far mined is much decomposed. It is reddish in color, and is quite soft and earthy. It is usually washed before it is shipped. A sample taken at the mine from a pile of about 25 tons of washed ore contained—

f

	No. 346.
	Per cent.
Metallic iron	50.84
Phosphorus	0.112
Sulphur	0.142
Phosphorus in 100 parts iron	0.220

The *Hacklebarney* mine (39), in Chester township, consists of fourteen or fifteen shallow pits, mostly open cuts, located on both sides of the Black river. Ore was mined at this locality in the last century, and the mine has been worked quite steadily for many years. In the census year over 31,000 tons of ore were produced. The mine is owned and operated by the Chester Iron Company. The ore is shipped to different Pennsylvania furnaces.

On the hill southwest of the river there are three openings. Two of these are open pits, 135 feet long by 40 a feet wide, and 45 feet deep, on the same vein of ore. The vein is worked to a width of from 25 to 35 feet, but less than one-half of this width is merchantable ore. About 100 feet west of the above pits is a narrow vein of ore which is being exploited by underground mining. The shaft is 125 feet deep, and the ore is 4 to 6 feet wide. Samples were collected from piles containing about 400 tons of ore from each of the open pits, and 100 tons of ore from the shaft. These samples were carefully mixed after being pulverized. The following analysis of the united samples indicates, therefore, the run of the ore from the southwest hill:

	Nos. 336, 337, and 338.
	Per cent.
Metallic iron	47.21
Phosphorus	0.098
Sulphur	3.290
Phosphorus in 100 parts iron	0.207

The ore contains a large per cent. of green mica, which gives to it a highly developed schistose structure. Pyrrhotite is present in abundance.

The coal-house pit is at the foot of the hill on the west side of the river. It is probably 50 feet deep and 25 to 30 feet wide. Near the surface the ore is decomposed, owing to the oxidation of the pyrite, but at the bottom of the pit it is a hard, granular magnetite, with green and brown mica, hornblende, and pyrrhotite. The surface-ore c is washed. Sample No. 339 is from 75 tons of ore from the bottom of the pit, and sample No. 345 is from 20 tons of the washed surface-ore. The samples contained—

	No. 339.	No. 345.
	Per cent.	*Per cent.*
Metallic iron	50.59	48.38
Phosphorus	0.025	0.057
Sulphur	3.653	0.529
Phosphorus in 100 parts iron	0.044	0.118

d

Opposite the coal-house pit, on the northeast side of the river, two cuts have been driven into the hillside. In the larger of these, known as the Andrew's open cut, the ore has been in places 25 to 30 feet in width. But the walls are very irregular. Immediately east of the Andrew's cut is the "East cut", on a smaller but parallel vein of ore. Samples were taken from piles of ore from each opening. The united samples yielded on analysis—

	Nos. 340 and 341.
	Per cent.
Metallic iron	52.00
Phosphorus	0.048
Sulphur	3.703
Phosphorus in 100 parts iron	0.092

e

On the hill northeast of the river samples were taken of ore from the Tunnel vein, the George vein, and the Foley vein. An average of three samples contained—

	Nos. 342, 343, and 344.
	Per cent.
Metallic iron	46.47
Phosphorus	0.075
Sulphur	3.517
Phosphorus in 100 parts iron	0.161

f

The Tunnel and Foley openings appear to be on a line with the Andrews' open cut, while the George vein is several hundred feet east of this line. The veins are narrow and are worked underground. In the George mine the shoot of ore pitches toward the northeast at an angle of about 30°. The ore is 4 to 5 feet wide. The mine is the most northerly opening on the property, and is distant nearly a half mile from the Andrews open cut at the river.

a The *Topping* mine (40), in the village of Chester, near the depot, was worked for several months in the spring of 1880 by W. J. Taylor & Co. About 875 tons of ore were raised. The ore was used in the Chester furnace. Numerous openings have been made on the property; the ore at present worked is about 30 feet deep. The ore is all soft "surface" ore, but it is used in the furnace without washing. A sample from a pile of 75 tons contained—

	No. 348.
	Per cent.
Metallic iron	55.84
Phosphorus	0.086
Sulphur	0.000
Phosphorus in 100 parts iron	0.154

b

The *Samson* mine (41), on property adjoining the Topping farm, was reopened in January, 1880, by Cooper, Hewitt & Co. It produced 3,360 tons of ore in the census year. The mine was first opened in 1867, and has yielded a total of 39,200 tons. The Samson Mining Company is the owner. Near the surface the ore was of the same character as that now mined on the Topping farm, but at the present depth, 180 feet, the ore is a hard, blue magnetite, carrying a large percentage of magnetic pyrite. The mine is opened for a length of 350 feet. A sample taken from a pile of 1,000 tons of the ore contained—

	No. 349.
	Per cent.
Metallic iron	51.39
Phosphorus	0.097
Sulphur	4.158
Phosphorus in 100 parts iron	0.188

c

The *Cooper* mine (42) is located about 1 mile northeast of the village of Chester, on the farm of the late Nathan A. Cooper. It was opened by the Cooper Mining Company in December, 1879. Before the close of the census year 5,860 tons of ore were shipped from the mine. The ore thus far mined is all "surface" ore; it is washed before it is shipped away. A sample from a few tons of washed ore contained—

	No. 350.
	Per cent.
Metallic iron	62.89
Phosphorus	0.156
Titanic oxide	Present.
Phosphorus in 100 parts iron	0.248

d

The *Combs'* mine (43), in Randolph township, Morris county, 1½ miles southwest of Walnut Grove, on lands of J. Combs and J. Styles, was worked in part by E. Canfield and in part by Fitzgerald & Scofield during the census year. Canfield worked the northwestern part of the vein—the portion on Combs' property—and raised 4,480 tons of ore e in the census year. The vein is quite regular. It has a north 50° east strike, a dip to the southeast of about 40°, and is 9 to 10 feet thick. It has been opened for a length of 500 to 600 feet and to a depth of over 100 feet. The present workings are 50 to 60 feet below surface.

On the Styles property about 1,000 tons of ore were mined during the winter of 1880, and were stocked at the mine when visited. A sample from this pile contained—

	No. 351.
	Per cent.
Metallic iron	37.15
Phosphorus	0.036
Titanic oxide	Present.
Phosphorus in 100 parts iron	0.097

f

Immediately south of the road, and about an eighth of a mile from the Combs mine, a shaft was sunk in 1878 on the Skellenger farm. In the census year Mr. Canfield worked this pit and produced 4,480 tons of ore. The total yield of the mine is 9,840 tons. The ore is similar to that from the Combs mine, and a separate sample of it was not taken. The product of the Combs and Skellenger mines is used for Bessemer pig by the Lackawanna Iron and Coal Company.

The *De Hart* (43), *Lawrence* (44), and *Dalrymple* (45) mines, in Randolph township, Morris county, 4 miles south of Dover, form nearly continuous openings for a distance of about a quarter of a mile. The De Hart is the southernmost mine of the group. It is worked by one shaft to a depth of 100 feet. The vein is 3 feet wide. The

a Lawrence adjoins the De Hart on the northeast and has three shafts. The only work being done at the mine in May, 1880, was in sinking shaft No. 1—the northeast shaft. It is about 115 feet deep, and at the bottom the vein is not more than 2½ feet wide. In descending the shaft the greatest width observed between the walls was about 4 feet. Samples taken from a few tons of ore from each mine contained—

b

	No. 354.	No. 355.
	Per cent.	*Per cent.*
Metallic iron	50.70	51.62
Phosphorus	0.633	0.246
Titanic oxide	Present.	Present.
Phosphorus in 100 parts iron	1.248	0.477

Sample No. 354 is from the De Hart mine; sample No. 355 is from No. 1 shaft of the Lawrence mine.

The mines were reopened in November, 1879, by the Reading Iron Company. In the census year the product of both mines was 760 tons of ore.

The *Dalrymple* mine was reopened by the Crane Iron Company in September, 1879. It produced 2,650 tons of ore before the close of the census year. The ore was shipped to Catasauqua, Pennsylvania. There are two groups of workings on the property. Shaft No. 9 is near the Lawrence mine; it is 180 feet deep. Pit No. 5 is several hundred feet northeast of shaft No. 9. It is entered by two shafts, and has been worked to a depth of nearly 300 feet. The vein dips at an angle of 75° to 80°, and the ore varies in thickness, owing to the rolls in the walls, from c 18 inches to 5 feet. The ore separates from the walls readily, leaving them remarkably smooth and well defined. Sample No. 356 is from a pile of 20 tons of ore from shaft No. 9; sample No. 357 is from a few tons of ore from pit No. 5. The samples contained—

d

	No. 356.	No. 357.
	Per cent.	*Per cent.*
Metallic iron	59.54	55.02
Phosphorus	0.366	0.222
Titanic oxide	Present.	Present.
Phosphorus in 100 parts iron	0.615	0.397

The *Bryant* mine (46), in Randolph township, Morris county, is on the southern end of a long range upon which are located many of the principal iron mines of New Jersey. The mine has been worked for the past five years by John D. Evans, and has produced in that time 22,400 tons of ore. The production in the census year was 6,720 tons. Two shoots of ore are worked on the property. The largest of these averages 20 feet in height, 7 to 8 feet in width, and has been worked for a length of about 700 feet. The slope is designated *No. 1.* The ore from the other shoot is raised through shaft No. 2, which is 175 feet deep. Samples of the ore from each shoot contained—

e

	No. 352.	No. 353.
	Per cent.	*Per cent.*
Metallic iron	63.24	50.70
Phosphorus	0.038	0.025
Titanic oxide	Present.	Present.
Phosphorus in 100 parts iron	0.060	0.049

Sample No. 352 is from slope No. 1; sample No. 353 is from shaft No. 2. The ore is used by the Bethlehem Iron Company for Bessemer steel.

The *King* mine (47), 1 mile northeast of the Bryant, was worked for a few months in the census year, and 2,560 tons of ore were raised. When visited in May, 1880, the pumps had been taken out and the mine had been abandoned.

The *Evers* mine (48), northeast of the King, was worked throughout the census year by the Saucon Iron Company. f The ore was shipped to Hellertown, Pennsylvania. In the census year 2,500 tons of ore were produced, all of which was mined quite near the surface, the deeper workings not having been pumped out. The ore is teamed to McCainsville, and there loaded on the cars. A sample from the cars contained—

	No. 358.
	Per cent.
Metallic iron	47.86
Phosphorus	0.086
Titanic oxide	Present.
Phosphorus in 100 parts iron	0.180

a The *Brotherton* mine (49), adjacent to the Evers, was reopened by Messrs. George & Pullman in August, 1879, and worked until June 1, 1880. It produced 4,730 tons of ore. The ore was raised from five shafts, the deepest of which is 130 feet. A slope on the premises, which is reported to be over 200 feet in depth, was not freed from water. The ore lies in two narrow veins, and as it comes from the mine it is largely mixed with rock. It has to be carefully cobbed over before it is shipped. A sample of the ore from the cars at McCainsville contained—

b

	No. 359.
	Per cent.
Metallic iron	50.08
Phosphorus	0.214
Titanic oxide	Present.
Phosphorus in 100 parts iron	0.420

The *Byram* mine (50) is the next in order. It is owned and worked by the Andover Iron Company. In the census year 16,605 tons of ore were mined. It was used in the company's furnaces at Phillipsburgh. The present operations on the property form two distinct mines. Of the southwest mine or group of workings, shaft No. 7 is near the road; northeast of this is No. 8, then No. 12, and lastly No. 6, the latter being near the engine-house. Shafts Nos. 6, 8, and 12 are on one and the same shoot, and are connected underground. Shaft No. 7 is on a chute about 18 feet west of the ore first mentioned. Shafts Nos. 6 and 8 are about 300 feet deep. The vein is very much broken up by small faults or "throws". It varies in width from 3 to 5 feet. When visited no ore was being raised **c** from shaft No. 8, but samples were taken from several tram-car loads of cobbed ore from the three other shafts. The samples contained—

	No. 360.	No. 361.	No. 362.	No. 363.
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*
Metallic iron	38.52	28.24	40.70	59.54
Phosphorus	0.393	0.605	0.700	0.245
Titanic oxide	Present.	Present.	.....	.....
Phosphorus in 100 parts iron	1.020	2.142	1.940	0.441

d Sample No. 360 is from shaft No. 7; No. 361 is from shaft No. 12; Nos. 362 and 363 are from shaft No. 6. The stope in pit No. 6 is 3 or 4 feet wide, and about 18 inches of the vein-matter is a partially decomposed horublende (?) schist. This does not lie in one solid body by itself, but is interlaminated between layers of magnetite. The greater proportion of the ore from this pit is in the form of an earthy powder. Near the hanging-wall there is, however, a seam of coarsely granular magnetic ore, between 4 and 8 inches thick, which has a well-developed cubical fracture. Sample No. 362 represents an average of the run of the pit, from a few tons of ore at the top of the shaft. Sample No. 363 is a special sample of this band of rich ore.

The northwest workings comprise two slopes, known as the old Byram slope and the Russell slope, 700 and 800 feet long, respectively. The slopes follow the foot-wall of the vein, which dips at an angle of 50° to the southeast. The Russell mine has been idle for some months, owing to the great influx of water, which the pumps **e** have been unable to keep down. When visited on May 21, some work was being done toward sinking the old Byram slope. At that time the superintendent expected to have the Russell mine in operation the following week, and the sampling of the mine was therefore left till another visit. Unfortunately the engine-house burned down a day or two afterward, and the water soon rose and stopped all work in the old Byram mine also. In the following week no work was being done in either of these deep pits, with the exception of robbing a pillar located about 400 feet down the slope of the old Byram mine. A sample of the ore from this pillar contained—

f

	No. 364.
	Per cent.
Metallic iron	57.75
Phosphorus	2.110
Phosphorus in 100 parts iron	3.653

The ore is very coarsely granular, and contains a very large per cent. of apatite. Part of a specimen is over one-third (by volume) granular apatite.

The ore from the several shafts of the Byram mine is run to the bottom of the hill on tram-cars by gravity. The empty cars are drawn back by mules.

The *Millon* mine (51), northeast of the Byram, was reopened in February, 1880, by the executors of the estate of James C. Lord. The mine belongs to the estate. Before the close of the census year 1,263 tons of ore were

raised. There are two shafts to the mine. The hoisting shaft is about 255 feet deep. The vein is said to vary a
from 2 to 5 feet in width. A sample of the ore from several car-loads contained—

	No. 365.
	Per cent
Metallic iron	43.73
Phosphorus	0.583
Phosphorus in 100 parts iron	1.333

The *Randall Hill* mine (52) is worked by the Crane Iron Company. Its production in the census year was 8,360 tons of ore. The ore is used at Catasauqua, Pennsylvania. The vein has ranged from 2 to 8 feet in thickness, b
and has been worked in one slope to a depth of 700 feet on a dip of 45° to the southeast, and in the other slope to a depth of 300 feet. Between the two slopes there is a right hand throw of 21 feet. At the deepest part of the mine the vein is 3 to 3½ feet wide. The ore is teamed to the cars at McCainsville. A sample of the ore from the cars contained—

	No. 366.
	Per cent.
Metallic iron	44.51
Phosphorus	0.577
Phosphorus in 100 parts iron	1.296

c

The *Dickerson* (53), west of the Byram, and about half way down the hill, is one of the largest as well as one of the oldest mines in the state. It is owned by the Dickerson-Suckassunny Mining Company, and is operated under royalty lease by A. Pardee. The ore is used in the Musconetcong Iron Company's furnaces at Stanhope, and in different parts of Pennsylvania. In the census year the mine produced 28,900 tons of ore. Its total yield is estimated at 896,000 tons. The ore lies in three parallel shoots, known as the "Main vein", the "Side vein", and the "Cowbelly vein". These shoots all pitch to the northeast. The angle of pitch, taken on the skiproad in the "Main vein", varies from 35° to 48°. The "Main vein" has been worked for a length of nearly 1,000 feet, or to a vertical depth of over 600 feet. The workings in the "Side vein" are about 400 feet, and those in the "Cowbelly vein" about 500 feet, below surface. When visited the "Cowbelly vein" was full of water, and no work was being done in it. Samples were taken of the ore from the "Side vein", and from the main stope, and also from the sink d
in the "Main vein". The samples yielded on analysis—

	No. 367.	No. 368.	No. 369.
	Per cent.	*Per cent.*	*Per cent.*
Metallic iron	61.62	65.17	63.03
Phosphorus	1.186	0.282	0.178
Phosphorus in 100 parts iron	1.924	0.433	0.279

Sample No. 367 represents ore from the sink, "main vein" ("pit No. 11"); sample No. 368, ore from the main stope, near bottom of "main vein", and sample No. 369, ore from the "side vein". The samples were collected at e
the ore-dock at the mine, from piles containing about 25 tons each. All the ore from the mine is a typical "shot-ore"; it is almost wholly in the form of fine material when it reaches the cars. In the mine the jointed structure of the ore-mass is seen to be highly developed. Apatite is present in quantities in all parts of the ore-bed.

The *Black Hill* mine (54), near the Dickerson, and belonging to the same company, was worked for a portion of the census year, and produced 2,195 tons of ore. The ore is said to be lean, but to run low in phosphorus. It has been used for Bessemer steel. The mine had been abandoned when visited.

The *Baker* mine (55) is situated at the foot of "Mine Hill" or "Mount Ferrum", a short distance northeast of the Dickerson mine. The mine has recently been bought by the Lackawanna Iron and Coal Company, and the ore, which, like the Black Hill ore, is comparatively free from phosphorus, is being used for Bessemer. In the census year 14,695 tons of ore were mined. The vein is reported to average from 8 to 9 feet in width. The present depth of the mine is about 165 feet. A sample of the ore taken from the cars at McCainsville contained— f

	No. 370.
	Per cent.
Metallic iron	32.02
Phosphorus	0.033
Phosphorus in 100 parts iron	0.103

The ore contains much quartz and feldspar. Owing to the decomposition of the latter the ore is soft near the outcrop.

a The *Scrub Oak* mine (56), northeast of the Baker, was reopened in February, 1880, by its owners, the Andover Iron Company, after having been idle for twelve years. Work was stopped in June, and the ore was not sampled. During the time the mine was in operation 1,680 tons of ore were produced. The ore is lean. The total yield of the mine is estimated at 56,000 tons.

Of the group of mines known as the Irondale mines, situated near Port Oram, 2 miles from Dover, the Sterling and the Hurd were worked during the census year by the Thomas Iron Company. The other mines were idle. The Irondale mines are owned by the New Jersey Iron Mining Company.

The *Sterling* mine (57) is located on the top of the hill, southwest of the village of Port Oram. The ore lies in a single shoot, which has been worked for a length of about 600 feet. The angle of pitch of the shoot is from 10° to 18°. The ore is 3 to 10 feet wide, and averages, perhaps, 6 feet in width. The mine yielded 16,800 tons of ore b in the census year. A sample taken from 5 car-loads (about 60 tons) of the ore contained—

	No. 371.
	Per cent.
Metallic iron	58.80
Phosphorus	1.342
Phosphorus in 100 parts iron	2.282

The *Hurd* mine (58) is situated at the foot of the hill, near the Morris canal. The working shaft of the mine c is about 300 feet deep. The vein varies from 4 to 7 feet in width. The mine is very wet, and the ore is all partially peroxidized. It is red in color, and usually mottled. In the census year 11,200 tons of ore were mined. A sample from about 50 tons of the ore on the cars contained—

	No. 372.
	Per cent.
Metallic iron	57.11
Phosphorus	1.618
Phosphorus in 100 parts iron	2.833

d

The *Orchard* mine (59), north of the railroad track at Port Oram, was reopened in February, 1879. It is owned by the estate of James C. Lord and is worked by the executors of the estate. During the census year 14,000 tons of ore were shipped. The total yield of the mine is estimated at 168,000 tons. The mine is between 500 and 600 feet deep. A sample of the ore from the cars contained—

	No. 373.
	Per cent.
Metallic iron	55.00
Phosphorus	1.722
Phosphorus in 100 parts iron	3.130

e

The *Huff* mine (60), in Rockaway towuship, and also near Port Oram, was reopened in October, 1879, by the Chester Iron Company. Work was discontinued after a few months, and the mine was idle when visited. In the census year 5,015 tons of ore were mined. The total production of the mine is estimated at over 78,000 tons.

The *Washington Forge* mine (61), east of the Huff, was likewise reopened in October, 1879. It is being operated by R. P. Brown & Co. under lease from the Carbon Iron Manufacturing Company. The mine produced before the end of the census year 2,721 tons of ore. The average depth of the workings is 175 feet. One shaft is, however, down to a depth of 300 feet. The mine is wet, and the ore resembles that from the Hurd mine in general appearance. A sample from a pile of 50 tons of the ore contained—

f

	No. 374.
	Per cent.
Metallic iron	57.39
Phosphorus	1.261
Phosphorus in 100 parts iron	2.197

The *Mount Pleasant* mine (62) is northeast from the Washington Forge. It is owned by the estate of James C. Lord, and is operated by the executors. In the census year 22,525 tons of ore were raised. The total yield of

the mine is estimated at 336,000 tons. When visited no ore was being mined in the southwestern workings (see *Geology of New Jersey*, 1868, page 579). The northeastern pit is now 550 or 600 feet deep. A sample from 10 car-loads, about 110 tons, of the ore contained— a

	No. 375.
	Per cent.
Metallic iron	64.80
Phosphorus	0.185
Phosphorus in 100 parts iron	0.285

The *Richards'* mine (63) is owned and worked by the Thomas Iron Company. It produced in the census year 35,463 tons of ore. The ore is all used at Hokendauqua, Pennsylvania. The ore is raised through three shafts. Beginning at the southwest, shaft No. 7 is not far from the old Baker mine, abandoned in 1877; it is 160 feet deep. Shaft No. 6 is the next in line, and is 375 feet deep. Shaft No. 3 is about 500 feet beyond No. 6, and is 400 feet deep, but as it starts from higher ground its bottom is about on a level with No. 6. These two shafts are connected by a drift for drainage purposes. The pump is located in shaft No. 6. The vein between the shafts is reported to be from 6 to 10 feet wide. Samples of ore from each shaft, collected on the cars, contained— b

	No. 376.	No. 377.	No. 378.
	Per cent.	*Per cent.*	*Per cent.*
Metallic iron	61.43	58.05	62.32
Phosphorus	0.881	0.851	0.661
Phosphorus in 100 parts iron	1.434	1.465	1.061

c

Sample No. 376 is from 4 car-loads of ore from shaft No. 7; sample No. 377 from 5 car-loads of ore from shaft No. 6, and sample No. 378 from 5 car-loads of ore from shaft No. 3. Like nearly all the ores of the Mount Hope range it is, as a rule, coarsely granular (but rarely "shotty"), and contains apatite.

The *Allen* mine (64), which adjoins the Richards on the northeast, is owned by the New Jersey Iron Mining Company, and is worked by the Andover Iron Company. The ore is used at Phillipsburg. In the census year 10,130 tons of ore were mined. The mine is entered by a tunnel driven northward into the hill to cut the vein. The stope is northeast of the tunnel and about 250 feet below the tunnel level. When visited in early June, 1880, very little ore was being mined, as the vein had pinched to 18 inches in width. A sample from 3 car-loads of ore contained— d

	No. 379.
	Per cent.
Metallic iron	56.99
Phosphorus	0.593
Phosphorus in 100 parts iron	1.041

The *Teabo* mine (65), northeast of the Allen, is owned and worked by the Glendon Iron Company. The ore is used in Glendon, Pennsylvania. The mine produced in the census year 22,468 tons of ore. The total yield of the mine is not known; but from January 1, 1871, to January 1, 1879, 144,766 tons were raised. Ore is now raised through two shafts, Nos. 2 and 3, 460 and 355 feet deep, respectively. These shafts are connected underground. The vein averages 10 feet in width between the two shafts. Shaft No. 1 is southwest of No. 2, and is not in use. A sample from 12 car-loads of the ore contained— e

	No. 380.
	Per cent.
Metallic iron	59.31
Phosphorus	0.468
Phosphorus in 100 parts iron	0.789

f

A portion of the ore is very finely granular to compact in texture, has a jointed structure, and a purplish tinge of color. Other specimens of the ore are coarsely-granular magnetite with quartz and mica.

The *Mount Hope* mines (66). Of the five or six distinct veins of ore on mount Hope and Hickory hill, the "Small" and the "Side Hill" are not worked, the Brannin is worked on Hickory hill only, while the Elizabeth or Cross vein and the Taylor or Jugular vein are both worked largely, and the Teabo vein is worked to a small extent through the Elizabeth mine. The Jugular vein was, however, reopened in January, 1880, and the Elizabeth alone has been steadily worked during the past five years. The production of the several openings in the census year was 50,379 tons of ore. The mines are owned and operated by the Mount Hope Mining Company. The ore is sold to New Jersey and Pennsylvania furnaces. Some years ago a tunnel was driven in from the bottom of the hill to

a cut the Jugular vein, and the ore has since been run out through this opening. The workings are now some 200 feet below the tunnel level. The vein exhibits the pinch and shoot structure to a marked degree, the ore varying in width along a level from 18 inches to 25 feet. A sample from 8 car-loads of the ore contained—

	No. 381.
	Per cent.
Metallic iron	58.77
Phosphorus	1.177
Phosphorus in 100 parts iron	2.003

b The Elizabeth vein is worked by a slope from the south side of the hill. The track is laid along a pinch which pitches toward the northeast at an angle of 25° to 35°. The slope is about 700 feet long. At the present stope the ore is 20 to 25 feet wide. A sample from 14 car-loads of the ore contained—

	No. 383.
	Per cent.
Metallic iron	57.07
Phosphorus	0.971
Phosphorus in 100 parts iron	1.683

c The Teabo vein is cut into from the Elizabeth mine about 60 feet below the surface. The ore is finely granular, and has a purplish tinge of color, resembling some of the ore from the Teabo mine. The ore differs very much from the Elizabeth ore, which is as a rule coarsely granular, and has a blue-black color. A sample of the Teabo ore taken across the stope, where the vein is about 10 feet wide, contained—

	No. 382.
	Per cent.
Metallic iron	60.61
Phosphorus	0.577
Phosphorus in 100 parts iron	0.952

d The ore from the Brannin vein, on Hickory hill, is very much weathered. The present opening is about 60 feet deep, and the vein is about 6 feet in width. A sample from 2 car-loads of ore contained—

	No. 384.
	Per cent.
Metallic iron	60.81
Phosphorus	1.230
Phosphorus in 100 parts iron	2.023

e About 3 miles northwest from Mount Hope, near *Denmark Pond*, a small mine (67), on land belonging to E. C. Fiedler, was reopened in January, 1880; 475 tons of ore were shipped from the mine in the census year, but 200 tons of this were mined two or three years ago. The ore contains much pyrrhotite, and resembles the Green Pond ore (sample No. 393). A sample of it, from a few tons of ore at the mine, contained—

	No. 385.
	Per cent.
Metallic iron	49.70
Phosphorus	0.056
Phosphorus in 100 parts iron	0.113

f The *Beach Glen* mine (68) is located near Hibernia, about 3 miles northeast of Mount Hope. It is owned by the estate of James C. Lord, and is operated by the executors. During the census year 9,486 tons of ore were shipped. A sample of the ore from the cars contained—

	No. 386.
	Per cent.
Metallic iron	48.63
Phosphorus	0.025
Chromium	Present.
Phosphorus in 100 parts iron	0.051

The *Hibernia* mines are all located on the same bed or vein of ore, which is remarkable among New Jersey a iron-ore deposits for its great size and regularity. It has been worked almost continuously for a length of 5,000 feet, and the total yield is estimated at over 2,000,000 tons. During the census year nearly 140,000 tons of ore were produced, and the mines were worked to their full capacity but for part of the time. A map of the mines is given in the *Geology of New Jersey*, 1868, facing page 564, and, excepting that the workings have been deepened, the conditions are about the same now as they were when the map was made. Beginning at the southwest, the *Lower Wood* mine (69), owned by the New Jersey Iron Mining Company, is worked by the Andover Iron Company. The average depth of the mine is about 260 feet, while the deepest portion is some 380 feet below surface. In the southwestern stope there is but one vein of ore, but in the northeastern stope there are two veins, each 2 to 3 feet in width, and separated by about 2 to 4 feet of rock. The northwest vein is continuous from the Lower Wood to the Willis, but the southeast one extends only through the Scott tract, or, possibly, to the De Camp. b

The *Glendon*, *Scott*, and *De Camp* (or *Upper Wood*) mines (70) are all worked by the Glendon Iron Company. A track has been laid, partly on stulls and partly on pillars, along the vein from the hill-side to the De Camp mine; the track has been stulled over, and through the tunnel thus formed the ore is all run out on cars drawn by a small Baldwin locomotive. The ore is raised to the tunnel-level in skips or buckets by hoisting-engines on the top of the hill.

In the northeast stope in the Scott mine, about 80 feet below the tunnel-level, the northeast vein is $3\frac{8}{10}$ feet wide, the southeast vein is 9 feet wide, and the veins are separated by 5 feet of rock. This intervening rock is blasted down and raised to the surface. Samples were taken across each of the above-described veins and contained— c

	No. 387.	No. 388.
	Per cent.	*Per cent.*
Metallic iron	58.22	57.27
Phosphorus	0.407	0.139
Phosphorus in 100 parts iron	0.699	0.243

Sample No. 387 is from the northwest vein; sample No. 388 is from the southeast vein.

Average samples of the ore from the mines worked by the Glendon Iron Company and the mine (Lower Wood) worked by the Andover Iron Company were collected from the cars. The samples contained— d

	No. 389.	No. 390.
	Per cent.	*Per cent.*
Metallic iron	53.75	56.00
Phosphorus	0.304	0.223
Phosphorus in 100 parts iron	0.077	0.398

Sample No. 389 is from 24 car-loads of ore from the Glendon mines; sample No. 390 is from 14 car-loads of ore from the Lower Wood mine.

From January 1, 1867, to December 31, 1879, 412,695 tons of ore were raised from the Lower Wood mine; from January 1, 1871, to December 31, 1879, 311,754 tons were produced from the Glendon mines. During the census e year the product was 41,576 tons and 85,622 tons, respectively.

The ore is shipped over the Hibernia railroad to Rockaway, and thence by rail or Morris canal principally to Phillipsburg, New Jersey, and Glendon, Pennsylvania.

The *Willis* mine (71) is at the northeast end of the Hibernia vein. It is owned by the New Jersey Iron Mining Company, and is worked by the Bethlehem Iron Company. The mine was reopened in November, 1879, after having been idle for about 18 months. In the census year 10,975 tons of ore were raised. The production of the mine from January 1, 1868, to May 31, 1880, was 142,160 tons. The ore is teamed to the foot of the hill, and thence is shipped by rail and canal. A sample taken from a canal-boat load at Rockaway contained— f

	No. 391.
	Per cent.
Metallic iron	49.82
Phosphorus	0.343
Phosphorus in 100 parts iron	0.689

Southwest of the Lower Wood mine, and on the other side of Hibernia brook, the *Beach* or Montauk mine was reopened in March, 1880, by the Andover Iron Company. Before the end of May 357 tons of ore were mined. The mine is believed to be on the extension of the Hibernia vein. The ore was not sampled.

a About 2½ miles northeast of the Willis mine, and east of Splitrock pond, the *Cobb* mine (72) was worked during the census year by the Splitrock Forge and Mining Company for the supply of the Wilson forge, at Splitrock; 1,288 tons of ore were produced. The vein of ore has been opened for a length of several hundred feet and to a depth of about 120 feet. At the stope the vein is 5 feet wide, but nearly one-half of the material from the mine goes to the rock-dump. The ore is calcined in an ordinary lime-kiln and then crushed between rolls before it is ready for the forge. A sample from 25 tons of the calcined and crushed ore contained—

b

	No. 392.
	Per cent.
Metallic iron	59.79
Phosphorus	0.426
Phosphorus in 100 parts iron	0.712

The *Splitrock Pond* mine, at the northeast end of the pond, was reopened in the spring of 1880 by William S. De Camp, and 560 tons of ore were mined. Work had been discontinued before the mine was visited, and the ore was not sampled.

The *Green Pond* mine (73) is on the east side of Copperas mountain. It was worked in the census year by the creditors of the Green Pond Iron Mining Company, Charles E. Maxwell, trustee; 18,053 tons of ore were raised and shipped to different furnaces in New Jersey and Pennsylvania via the Green Pond Mine railroad to Charlotteburg, c and thence by the New Jersey Midland and other railroads. The mine is comparatively a new one, having made its first shipment of ore about the year 1873. The ore lies in several distinct shoots, which pitch at about 30° and dip at about 40°. Two shoots have been worked to a depth (or length) of 320 feet, a third to 125 feet, and a fourth to 85 feet. The ore from all the openings is very much alike. It contains hornblende and pyrrhotite (the latter in such quantities as to necessitate the ore being roasted before being used in the blast-furnace), and often green mica. A sample was collected from 2 car loads of ore from each of the four pits (8 car-loads in all); it contained—

d

	No. 393.
	Per cent.
Metallic iron	51.33
Phosphorus	0.033
Phosphorus in 100 parts iron	0.064

The *Charlotteburgh* mine (74), near Charlotteburgh, was reopened in February, 1880, by Cooper, Hewitt & Co. From this and the Davenport opening near to it 3,920 tons of ore were mined in the census year. The Charlotteburgh mine is 60 feet deep. A sample of the ore from a pile of about 30 tons contained—

e

	No. 394.
	Per cent.
Metallic iron	58.15
Phosphorus	0.151
Phosphorus in 100 parts iron	0.260

The *Rockaway Valley* or *De Camp* mine, and the *Pike's Peak* or *Stony Brook* mine, were both reopened in the fall of 1879. About 500 tons of ore were raised from the former and 100 tons from the latter. The mines were, however, idle when visited in June, 1880, and the ore was not sampled.

The *Ringwood* mines (75), situated in the northern part of Pompton township, Passaic county, are owned and worked by Cooper, Hewitt & Co. In the census year 26,482 tons of ore were mined. From May 31, 1874, to May 31, 1880, 103,398 tons were produced. The total yield is estimated at 896,000 tons. Many of the openings were f worked in the last century. Of the many mines on the tract four only were worked in the spring of 1880. These were the Cannon, the Peter, the Hope, and the Hewitt (see Fig. 56). By far the largest amount of ore raised came from the Cannon and Peter mines.

The *Cannon* mine is near the southern side of the tract. The large opening described in the *Geology of New Jersey* has been abandoned, and a new opening has been made east of the old pit upon another shoot of ore. The new pit is 60 feet wide.

The *Peter* mine is about a mile northeast of Cannon. It was worked in pre-revolutionary times, and some of the old timbers still remain and are in good condition. The structure of the ore-body is complicated; two or three shoots of ore, all pitching toward the northeast, appear to unite not far below surface, there forming a large pocket. The mine is dry, and the ore is easily exploited.

The *Hope* mine, comprising a number of openings along the side of Hope mountain, is on the extension of the Peter range. An old pit about half-way up the hillside was worked a little while in the spring of 1880; but nearly all the operations (they have not been extensive) have been on several small shoots of ore at the foot of the hill, near the tramway.

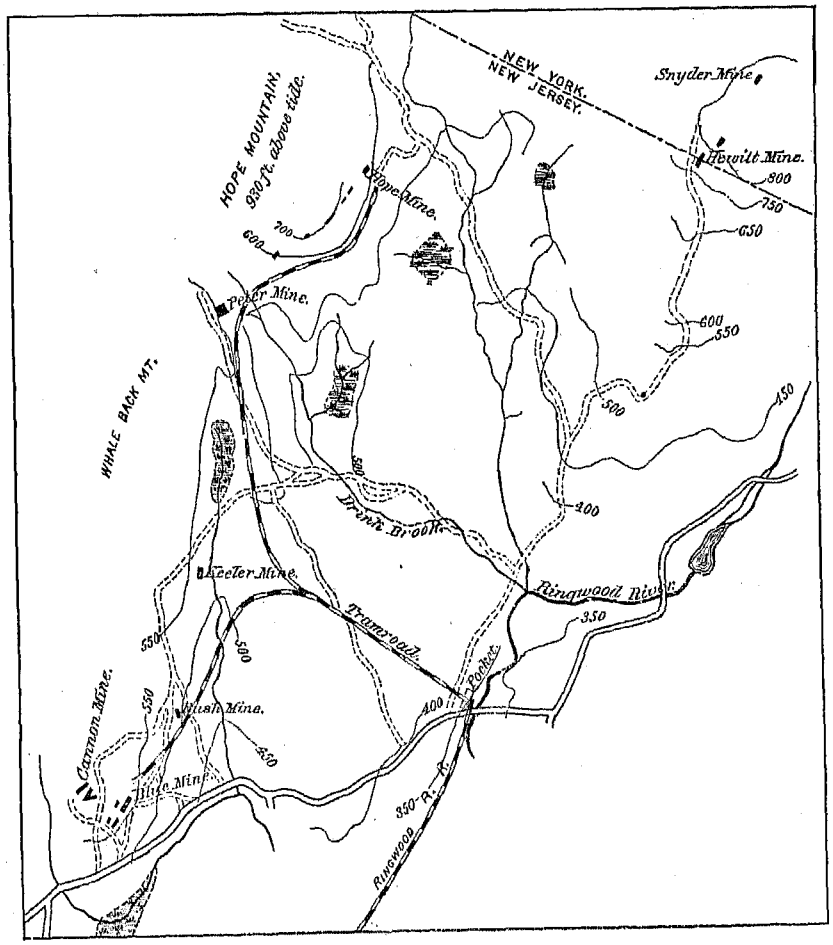


FIG. 56.

The *Hewitt* mine is near the state line. The vein stands almost vertically, and has been worked in open cut to a depth of about 25 feet. The ore is 6 to 8 feet wide; it is reddish in color, owing to partial peroxidation.

Samples of the ore from each of the above-mentioned mines contained—

	No. 395.	No. 396.	No. 397.	No. 398.	No. 399.
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
Metallic iron	55.25	55.56	62.66	63.20	52.32
Phosphorus	1.567	1.556	0.458	0.448	0.078
Sulphur					3.324
Phosphorus in 100 parts iron	2.818	2.801	0.731	0.709	0.149

Sample No. 395 is from the Cannon mine; the sample was collected from the cars. Sample No. 396 is from the Peter mine; it was also collected from the cars. Both ores vary in texture, but on the whole resemble each other in mass. The Cannon ore has, however, a purple color when powdered, which distinguishes it.

Samples Nos. 397 and 398 are from the Hope mine. Sample No. 398 is from the opening on the hillside. The ore is "shotty", while that from the newer openings, at the bottom of the hill, is finely granular (sample No. 397). The samples were taken from piles of ore at the mine.

Sample No. 399 represents the Hewitt ore. It was taken from the cars.

RAMAPO BELT.

The *Butler* mine (76), near Sufferns, Hohokus township, Bergen county, was worked for one month in the census year and produced 280 tons of ore.

The *Brown* mine (77), near Midvale, Pompton township, Passaic county, was reopened in February, 1880. Before the close of the census year 1,232 tons of ore were mined.

a The *Kahart* mine, in Pequannock township, Morris county, was in operation for three or four weeks and 50 tons of ore were raised.

The *De Bow* mine (78), near Pompton Plains, Pequannock township, Morris county, was worked for two months and 112 tons of ore were mined.

The *Beer's* mine, near Morris Plains, Hanover township, Morris county, was in operation one month and a half and produced 22 tons of ore.

No samples of ore were taken from this belt.

LIMONITE.

In the *Annual Report of the State Geologist of New Jersey for* 1880 twenty-two localities are given where limonite b has been found. At fifteen of these some work was done in the census year, and ore was raised from eleven mines. The total production of limonite in the state during the census year was 15,503 tons, and of this amount 12,354 tons were raised from three pits near Beattyestown, Warren county.

The ore occurs associated with the magnesian limestone in the valleys lying between the gneiss ridges of the Highlands. Beginning at the southwestern portion of the belt, there are three openings on the same body of ore near Carpentersville, Greenwich township, Warren county, southeast of Pohatcong creek. The pits are known as the Rapp, Carpenter, and Riegel mines. In the census year 392 tons of ore were mined at the Rapp opening. The others were not worked. In Lopatcong township a mine on William Hamlen's farm produced 344 tons of ore, and one near New Village 374 tons. On Marble mountain, Lopatcong township, some work was done in the summer of 1880 in searching for limonite, but no ore was raised before June.

c In Hunterdon county 565 tons of "hematite and ocher" were raised from the Wean mine. Most of this was sold for paint. From the Radley mine, Lebanon township, 78 tons of ore were shipped. In German valley, both in Lebanon township, Hunterdon county, and in Washington township, Morris county, ore has been mined. The Neighbour mine, on Sylvester Neighbour's farm, in Washington township, 2 miles northeast of Califon, produced 896 tons of ore in the census year, which was used in the Chester furnace. The ore contained, however, according to an analysis made in the state survey laboratory, (*a*) 3.74 per cent. metallic lead and 10 per cent. metallic zinc, which proved troublesome in the furnace, and the use of the ore was discontinued and the mine was abandoned. The Dafford mine, near the Neighbour, produced about 500 tons of ore in the census year. It, too, was worked but part of the year.

Near Beattyestown, about 3½ miles south of Hackettstown, in Mansfield township, Warren county, are the d *Thomas*, *Shields'* and *Brown* mines (79). They are all on land belonging to Thomas Shields.

The Shields mine is the largest of the three, and lies between the other two. It is worked by A. Pardee & Co. The ore is used at Stanhope. In the census year 9,870 tons of ore were mined. From 1872 to June, 1880, 41,121 tons of ore were produced. The pit is about 60 feet deep and about 400 feet long by 80 feet wide. The stripping has varied from 6 to 30 feet. The east wall of the pit is blue limestone (magnesian), and the slate outcrops not far from the pit on the southwest. The ore is mixed with yellow clay. About three-quarters of the material raised from the mine is lost in washing. Very little lump-ore is found in the mine.

A sample of the ore collected at Stanhope furnace from a pile of about 25 tons yielded, on complete analysis—

e

	No. 325.		No. 325.
	Per cent.		*Per cent.*
Sulphur	0.041	Phosphoric acid	0.588
Phosphorus	0.257	Carbon in carbonaceous matter	0.11
Iron, metallic	42.73	Hygroscopic water	0.52
Phosphorus in 100 parts iron	0.601	Water of composition	8.88
Silica	19.24	Total	99.095
Iron, peroxide	60.99		
Alumina	4.72	Per cent. of insoluble silicious matter	24.91
Manganese, protoxide	1.81		
Lime	0.34	Silica	19.24
Magnesia	0.70	Alumina (with trace of oxide of iron)	4.06
Iron, disulphide	0.077	Lime	0.07
Nickel, oxide	0.06	Magnesia	0.48
Cobalt, oxide	0.04	Potassa	1.02
Potassa	1.46	Soda	0.03
Soda	0.10		
Carbonic acid	0.06	Total	24.90

f

The *Thomas* mine is north of the Shields. It is worked by Joseph Wharton, and the ore is used in the Hackettstown furnace. In the census year 2,050 tons were produced. The *Brown* mine, which adjoins the Shields on the south, is also worked by Joseph Wharton for the supply of the Hackettstown furnace. It was reopened in April, 1880, and 434 tons of ore were mined before May 31.

a Annual Report State Geologist for 1880, p. 120.

In Hope township, Warren county, 3 miles south of Blairstown, the *Swayze* mine was worked in the summer of 1880, but no ore was mined there in the census year.

Limonite has been mined at several localities along the east slope of Pochuck mountain, in Vernon township, Sussex county. The old *Pochuck* mine (80) is west of McAfee's valley, half-way up the mountain side. In 1873 a gravity road was built to the railroad in the valley, and preparations were apparently made for mining on a large scale. Work was stopped, however, in 1876, and since that date the mine has been idle. The pit was filled with water when visited, and no ore was seen in place. No limestone is present near the pit. In the *Annual Report for* 1879, p. 93, the state geologist says: "The mine has been an interesting geological locality, as the ore occurred in small lumps and masses in earths, and the ore-mass was bounded on the northwest and southeast sides by rotten gneissic rocks. These soft strata continue for over 100 feet in depth and 500 to 600 feet in length." The ore contains *graphite*, which is quite common in the magnetic ores of this region. From this, and the fact of the ore occurring in partially-decomposed gneiss, it seems probable that the limonite is merely the outcrop of a vein of magnetite.

A sample of the ore was collected from 75 tons at the Franklin furnace; it contained—

	No. 300.
	Per cent.
Metallic iron	38.60
Phosphorus	0.562
Sulphur	0.132
Phosphorus in 100 parts iron	1.456

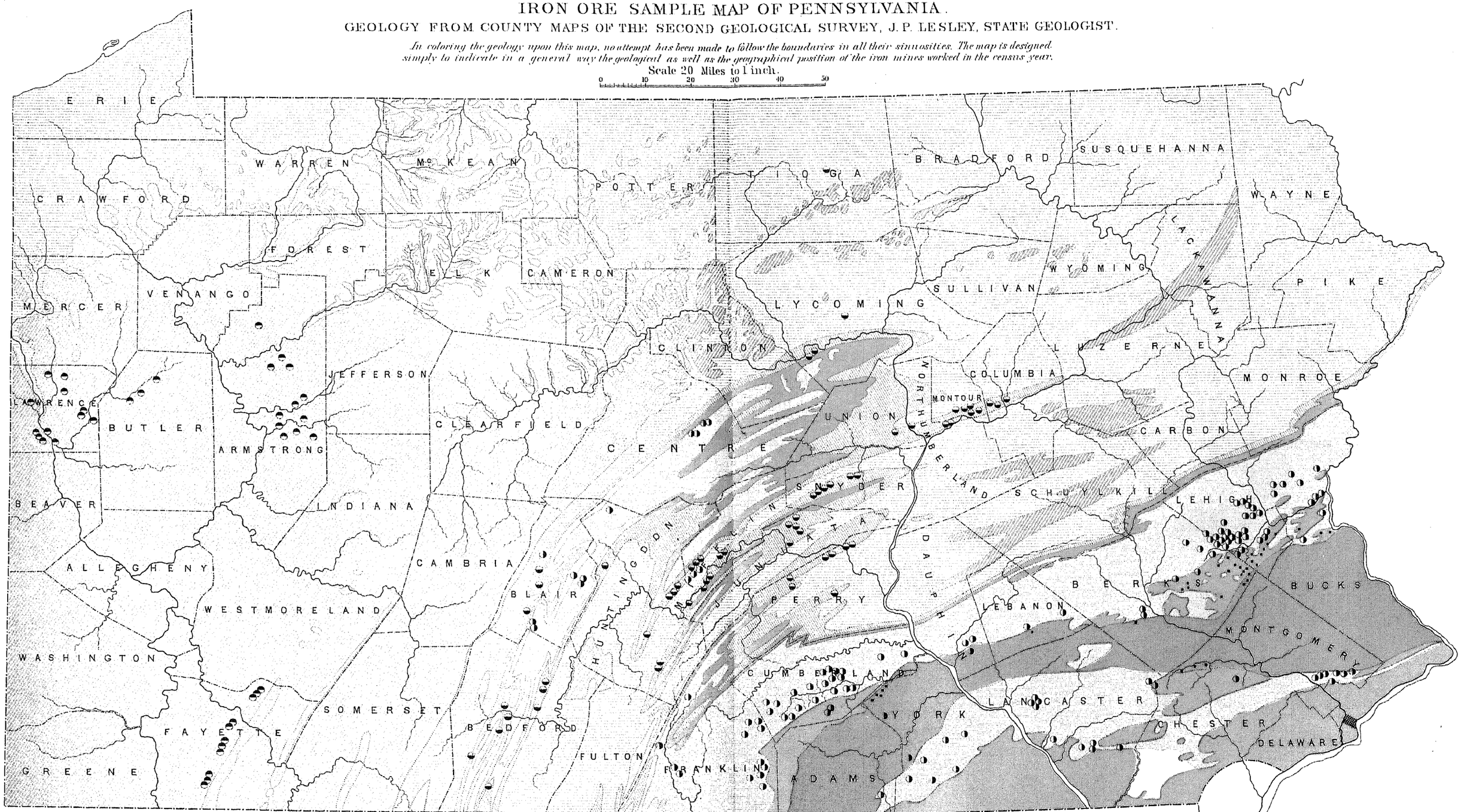
IRON ORE SAMPLE MAP OF PENNSYLVANIA.

GEOLOGY FROM COUNTY MAPS OF THE SECOND GEOLOGICAL SURVEY, J. P. LESLEY, STATE GEOLOGIST.

In coloring the geology upon this map, no attempt has been made to follow the boundaries in all their sinuosities. The map is designed simply to indicate in a general way the geological as well as the geographical position of the iron mines worked in the census year.

Scale 20 Miles to 1 inch.

0 10 20 30 40 50



Mesozoic. | Conglomerate and Coal Measures. | Devonian. | Upper Silurian. | Middle Silurian (Medina and Oneida.) | Lower Silurian. | Cambrian, Huronian, Laurentian, Azoic or Primary.

■ Magnetite. ◑ Limonite. ◒ Fossil. ◓ Carbonate and Derivatives. ◗ Specular.

Note: *The ore symbols indicate in a general way the position and relative approximation of the iron mines worked in the census year. In most cases a single symbol stands for a group of mines.*

Julius Bien & Co. Lith

NOTES ON THE IRON ORES OF PENNSYLVANIA.

COMPILED FROM THE REPORTS AND UNPUBLISHED MATERIAL OF THE SECOND GEOLOGICAL SURVEY OF PENNSYLVANIA, J. P. LESLEY, STATE GEOLOGIST, AND THE CENSUS SCHEDULES, BY BAYARD T. PUTNAM.

The deposits of magnetic ore associated with the Mesozoic sandstones in Lebanon, York, Berks, and Chester counties were visited and sampled by Mr. Bailey Willis, and Mr. Bayard T. Putnam collected a series of representative samples of the iron ores mined in other parts of the state. Mr. Putnam's samples were not analyzed because the appropriation allotted to this portion of the census work was exhausted before these samples were reached in the laboratory. As Dr. McCreath has made, for the second geological survey of the state, a very great number of analyses of the Pennsylvania iron ores, it was thought best to give preference to the iron ores from the other states, c and the analysis of the Pennsylvania samples was therefore left until the last, and was finally omitted. In order to present in this volume as complete an exhibit as possible of the iron-ore product of the United States in the census year, permission was freely granted by Professor Lesley, state geologist of Pennsylvania, to reprint the analyses published in the reports of the survey, and Dr. McCreath has kindly added to these, by permission of the state geologist, a number of analyses made for the survey which have not yet been published.

Iron ore is widely distributed throughout the state of Pennsylvania. In the census year it was mined in 35 counties, and the state ranked first on the list as a producer of iron ore. The geological range of the iron ores is greater in Pennsylvania than in any other state of the Union.

The accompanying map (Plate XXIX) was compiled to show the geological as well as geographical position of the deposits of iron ore worked in the state in the census year. d

Following the plan of Mr. McCreath's report (MM. of the Pennsylvania survey), the analyses in the following pages are arranged under the *kind* of ore, and are further grouped under each kind in accordance with the geological age of the ore.

I. MAGNETITE.

The magnetic ores of Pennsylvania may be conveniently grouped according to their associated wall-rock, as follows: (1) Magnetic ores in the Archæan gneisses and slates. (2) Magnetic ores associated with the trap-dikes in the Mesozoic sandstone.

For a description of deposits of the second class, see the report of Mr. Bailey Willis. e

The magnetic ores of the first class occur throughout the Archæan slates and gneissoid rocks in the southeastern part of the state. But the workable deposits appear to be almost entirely confined to that portion of the South Mountain belt which lies in the northeastern corner of Bucks county, the southern part of Lehigh county, and the west central part of Berks county. This belt is the southwestern extension of that which in New Jersey and New York forms the highlands, and the general character of the associated ore, and its relation to the inclosing rock in Pennsylvania, is much the same as it is farther north. The Pennsylvania magnetites of both classes differ, however, from the run of the magnetites in New Jersey and southern New York in containing, as a rule, but little phosphorus. Over 80 per cent. of the total magnetic ore product of Pennsylvania was reported to be adapted to the manufacture of Bessemer pig, and it was largely used for that purpose. It is probable that but little of this class of ore will average over 50 per cent. metallic iron, and a large amount of it will run under 45 per cent.

Berks county.—Product of magnetic ore from the Archæan belt in census year, 57,547 tons. The following f analyses are from Report D^3, Vol. II:

	No. 994.		No. 994.
	Per cent.		*Per cent.*
Metallic iron	42.700	Alumina	3.411
Metallic manganese	7.997	Lime	0.040
Sulphur	0.020	Magnesia	1.502
Phosphorus	0.135	Insoluble residue	14.305

994. *Clymer Iron Company's* mine, on Cornman's farm, 2½ miles northeast of Pricetown. Ore for the most part in powder; soft, dull black to brownish black. Shows numerous small scales of mica. Iron for the most part as magnetic oxide.

a

	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
Iron	35.050	35.500	28.100	30.250	28.950	24.650	41.900	38.400	22.100	59.100
Manganese	.....	.....	.....	.....	.....	1.534	2.478	.....	0.720	7.507
Alumina	.....	.....	.....	.....	8.070	1.501	3.787	.....	6.748	.....
Lime	.....	.....	.....	.....	13.770	25.410	3.880	.....	22.400	.....
Magnesia	.....	.....	.....	.....	8.740	4.396	1.048	.....	9.830	.....
Sulphur	0.023	0.003	0.025	0.175	0.002	0.312	0.175	0.006	0.028	None.
Phosphorus	0.025	0.042	0.059	0.020	0.006	0.024	0.055	0.037	0.018	0.068
Silicious matter	42.340	43.785	48.710	51.190	26.020	10.100	18.610	40.060	30.590	0.860
Phosphorus in 100 parts iron	0.070	0.118	0.210	0.066	0.020	0.097	0.131	0.096	0.081	0.115

b

1. *Greiss & Weudling's* mine.
2. *Frederick's* mine.
3. *Butz's* mine.
4. *Charles Geary's* mine, Rittenhouse gap.
5. *Tatham Brothers'* mine, near Topton.
6. *Guiterman's* mine; *hard ore*, with carbonates of lime and magnesia.
7. *Guiterman's* mine; *soft ore.*
8. *Haines & Klutz's* mine (George Wetzel), half mile west from Red Lion station, Bethlehem Iron Company.
9. *Fritch & Brother's* mine, near Mertztown.
10. *Clymer Iron Company's* open cut, 2 miles southwest from Pricetown; soft ore.

c

In *Lehigh county*, 70,398 tons of magnetite were mined; in *Bucks county*, 24,192 tons; and in *Northampton county*, 732 tons—all from the gneiss belt. No analyses of these ores are available, but they are similar in character to the corresponding ores in Berks county.

II. HEMATITE.

Deposits of anhydrous sesquioxide of iron are of rare occurrence in Pennsylvania. A so-called "red oxide" is found associated with limonite at some of the banks, notably at Haldeman's bank, in York county, northeast of Hanover. An analysis of this ore shows, however, the presence of nearly 6 per cent. of water (see Professor d Frazer's *Report on York County*, C, p. 62). Grains of both specular and magnetic ore are often found with the limonite elsewhere in York county, both in the Archæan gneisses and primal slates, and "red hematite" occurs in small quantities associated with primal slates in Berks and Lehigh counties.

Micaceous specular ore occurs in the belt of Mesozoic sandstone near Dillsburg, in York county, and in the neighboring counties. Outside of York county, however, this variety of ore was mined in Pennsylvania in the census year at but one locality—near Hummelstown, Dauphin county.

The character of this class of ore is shown in the following analyses, taken from Report MM, p. 222:

e

York county.	No 438.	No. 185.
	Per cent.	*Per cent.*
Protoxide of iron	2.121	.....
Sesquioxide of iron	88.357	82.607
Sesquioxide of manganese	0.016	0.041
Oxide of copper	None.	0.222
Alumina	3.424	4.843
Lime	1.290	0.760
Magnesia	0.479	0.018
Sulphuric acid	0.010	0.150
Phosphoric acid	0.291	Traces.
Carbonic acid	None.	0.123
Water	0.551	1.277
Insoluble residue	3.373	9.530
Total	99.913	100.471
Metallic iron	63.500	57.825
Metallic manganese	0.011	0.029
Sulphur	0.024	0.060
Phosphorus	0.127	Trace.

f

438. *Mine ore-bank*, 2¼ miles southwest from Wellsville. McCormick & Co., lessees. See Report CC, page 236. Red hematite, with foliated, micaceous hematite; unctuous; reddish-brown and iron black. Slightly impregnated with magnetite.

185. *Mine ore-bank*, 2¼ miles southwest from Wellsville. McCormick & Co., lessees.

Adams county.	No. 435.	Percentages.
	Per cent.	
Protoxide of iron	0.321	= 50.000 per cent. iron.
Sesquioxide of iron	72.357	
Sesquioxide of manganese	0.091	= 0.022 per cent. manganese.
Alumina	0.999	
Lime	0.240	
Magnesia	0.133	
Sulphuric acid	0.017	= 0.007 per cent. sulphur.
Phosphoric acid	0.007	= 0.003 per cent. phosphorus.
Water	0.224	
Silicic acid (SiO_2)	25.660	
Total	99.989	

435. *George Cole's* ore-opening, 1½ miles from Newmans, on the Cole's Valley road. See Report CC, p. 249. Specular iron ore; foliated, brittle; iron black, with gangue of quartz.

In *Perry county* a thin seam of hematite occurs in the Catskill formation (IX), (see Report M³, pp. 37 and 38) and occasional nodules of hematite have been found in the Coal Measures (see Report MM, p. 373). In neither case, however, does the ore occur in quantities of economic importance.

III. LIMONITE.

LIMONITE ORES OF THE SILURO-CAMBRIAN FORMATION.

Everywhere throughout Pennsylvania, wherever the great limestone formation No. II occurs, there are found more or less important deposits of brown hematite iron ore. It is this horizon that has supplied the greater part of the stock to the furnaces along the Lehigh, Schuylkill, and Susquehanna rivers, and the whole of the stock to the old furnaces of the Kishicoquilis, Nittany, and Canoe valleys, and Morrison's Cove, in middle Pennsylvania, as well as to the furnaces in Mountain Creek valley, in Cumberland county, and Path valley and the Conecocheague region of Franklin county.

They are scattered over the surface of the southern or limestone half of the Cumberland valley, from the Lehigh river to Maryland, and southward through Virginia and East Tennessee to Alabama (MM, p. 199). But they are distinguishable into ores at the top, ores in the middle, and ores at the bottom of the great limestone formation No. II. Those at the top form a belt along the middle of the valley where the Magnesian limestone underlies the Trenton limestone, or, in its absence, the Utica or Hudson river slates, formation No. III. This line of ore-deposits is represented by the great mines of Ironton in Lehigh and Moselm in Berks counties; the mines along Spruce creek, in Centre and Blair; the Henrietta, Leathercracker, and Bloomfield mines, in Morrison's Cove, Blair county; and the old Mount Pleasant and Carrick furnace banks, in Path valley, Franklin county.

Those in the middle are connected with various horizons of ferruginous limestones in the Chazy and Calciferous. Those at the bottom, along the north or west foot of the South Mountain-Blue Ridge range, are geologically connected with the Potsdam sandstone, or the slates which intervene between it and the base of the Calciferous, and are *locally* known as "mountain ores". This lower line of ore-deposits is represented by the great mines of Springfield, in Canoe valley, Blair county; at Pine Grove, Boiling Springs, and at the No. 1 Clover mammoth bank, in Cumberland county; at Pond bank and Mont Alto, in Franklin county; and a long line through the Shenandoah valley, in Virginia.

In the Cumberland valley, in York, Cumberland, and Franklin counties, these ores have been very extensively mined both for local use in the furnaces of the valley and for shipment to Harrisburg, Reading, Columbia, etc., to be smelted along with the more refractory magnetites. The best developments have been made along the line of the South Mountain railroad; at Boiling Springs, at Cleversburg, and near Shippensburg, in Cumberland county; along the line of the Mont Alto railroad; and in Path valley, in Franklin county; and on Dogwood run, in York county. (*a*)

Northampton county.—Production of limonite in census year, 121,794 tons. The character of some of this ore is shown by the following analyses, taken from Report MM, p. 218:

	No. 980.	No. 967.		No. 980.	No. 967.
	Per cent.	*Per cent.*		*Per cent.*	*Per cent.*
Sesquioxide of iron	49.928	63.714	Water	11.384	11.080
Sesquioxide of manganese	7.353	0.455	Insoluble residue	26.700	21.040
Sesquioxide of cobalt	0.140	0.040	Total	100.302	100.586
Alumina	3.053	1.090			
Lime	0.110	0.180	Metallic iron	34.950	44.600
Magnesia	0.418	0.324	Metallic manganese	5.123	0.317
Sulphuric acid	0.042	0.027	Sulphur	0.017	0.011
Phosphoric acid	1.169	0.836	Phosphorus	0.509	0.365

980. *Wharton* mine of Saucon Iron Company, 2 miles east from Hellertown. Specimens from higher level, about 80 feet deep. Lump- and wash-ore. Compact, brittle, sandy; dark-brown to reddish-brown.

967. *Wharton* mine of Saucon Iron Company, 2 miles east from Hellertown. From deep shaft, 126 feet under ground. Lump- and wash-ore. Hard, tough, fine-grained; color, liver-brown.

a Report M³, p. ix, *et seq.*

a *Lehigh county.*—Production of limonite in census year, 349,302 tons. The following analyses and notes of the limonite of Lehigh county are from Report M, pp. 48 to 54, and Report MM, pp. 213 to 218:

	I.	II.	III.	IV.	V.	VI.	VII.	VIII.	IX.	X.	XI.	XII.	XIII.
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
Iron	37.000	32.700	46.600	45.300	46.500	33.300	47.000	47.900	44.600	44.500	51.250	43.000	51.950
Manganese	3.033	0.374	0.454	0.749	0.590	6.612	0.518	0.266	0.576	0.280	0.381	4.575	0.960
Sulphur	0.035	0.030	0.027	0.032	0.022	0.007	0.030	0.003	Trace.	0.019	0.016	0.040	Trace.
Phosphorus	0.186	0.179	0.597	0.137	0.128	0.170	0.111	0.165	0.151	0.316	0.100	0.109	0.100
Insoluble residue	28.990	39.050	16.230	21.060	16.300	34.250	16.050	11.890	20.340	6.280	11.010	19.060	11.430

b

	XIV.	XV.	XVI.	XVII.	XVIII.	XIX.	XX.	XXI.	XXII.	XXIII.	XXIV.	XXV.	XXVI.
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
Iron	48.500	48.000	38.000	48.250	42.360	48.200	48.100	57.500	58.500	45.700	48.500	51.750	49.300
Manganese	0.194	0.173	1.484	0.432	0.048	0.418	0.360	0.749	0.223	0.048	0.360	0.309	0.216
Sulphur	Trace.	0.032	0.020	0.045	0.026	0.005	0.045	Trace.	0.084	0.034	0.002	Trace.	Trace.
Phosphorus	0.123	0.120	0.108	0.025	0.100	0.158	0.164	0.165	0.043	0.157	0.328	0.270	0.295
Insoluble residue	16.560	15.950	30.070	18.450	24.120	14.810	13.440	3.470	2.800	20.210	15.580	10.350	15.120

	XXVII.	XXVIII.	XXIX.	XXX.	XXXI.	XXXII.	XXXIII.	XXXIV.	XXXV.	XXXVI.	XXXVII.	XXXVIII.
c												
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
Iron	46.600	49.000	51.700	45.000	28.100	51.400	47.000	36.500	49.000	43.700	42.800	50.400
Manganese	0.144	0.187	Trace.	0.626	5.029	0.295	7.464	2.932	0.583	0.763	0.252	1.203
Sulphur	Trace.	Trace.	0.214	Trace.	0.002	0.021	0.003	0.031	0.007	0.005	0.036	0.002
Phosphorus	0.276	0.172	0.066	0.190	0.551	0.238	0.630	3.135	1.288	0.869	0.222	0.093
Insoluble residue	19.880	15.400	10.550	21.000	36.430	11.290	4.040	18.900	9.440	18.580	25.040	10.050

I. *Harry Kaiser's* mine, leased by Mull & Hagenbuch, north of Lock ridge, 1 mile west of Alburtis. (R. P., 1874, D, p. 18.) Sample partly lump and partly fine ore. Limonite, hard and sandy, with considerable quartz in fine ore.

II. *Jonas Kreischmann's* mine, leased by Allentown Rolling-Mill Company, 1 mile east of Alburtis. Vein ore. (R. P., 1874, D, p. 18.) Limonite hard, compact, and very sandy.

d III. *Jonas Kreischmann's* mine, leased by Coleraine Iron Company, 1 mile east of Alburtis. Wash ore. (R. P., 1874, D, p. 19.) Limonite, wash ore, with considerable admixture of ferruginous clay.

IV. *Wiand's* mine, leased by the Temple Iron Company. (R. P., 1874, D, p. 21.) Sandy limonite, with considerable quartz in the fine ore.

V. *P. Marck's* mine, leased by Lehigh Iron Company. (R. P., 1874, D, p. 21.) Limonite, hard, compact, arenaceous, with somewhat slaty structure.

VI. *Maple Grove Mill* property, near Hensingerville. (R. P., 1874, D, p. 21.) Limonite, hard, compact, exceedingly silicious, with slaty structure, and light-brown color.

VII. *J. Barber & Company's* mine, Hensingerville, 1½ mile south-southwest of Alburtis. (R. P., 1874, D, p. 22.) Limonite, compact, with large mass of fibrous ore.

VIII. *Shankweiler* lot, at Hensingerville, 78 feet below the surface. (R. P., 1874, D, p. 23.) Limonite, very hard and compact, slaty structure, surface somewhat velvety.

e IX. *Thomas Iron Company's* mine, at Hensingerville. (*a*) (R. P., 1874, D, p. 24.) Limonite, hard, compact, and of somewhat slaty structure.

X. *Hensinger Heirs'* farm, 1½ mile south of Alburtis. (R. P., 1874, D, p. 24.) Limonite, bomb-shell ore, curiously honeycombed, with lage amount of göthite.

XI. *Ludwig's Old* mine, 1 mile west-northwest of Alburtis. (R. P., 1874, D, p. 26.) Limonite, hard, arenaceous, with broken concretions of pipe ore.

XII. *Blank's* mine, leased by Ludwig, Hertzog & Co., one-fourth mile northwest of Alburtis. (R. P., 1874, D, p. 27.) Limonite, compact, arenaceous, containing cavities lined with göthite and lepidocrocite. Specimen also contained a small piece of arenaceous red hematite, and a small amount of pipe ore.

XIII. *Reuben Romig's* mine, leased by Allentown Iron Company, three-fourths of a mile east of New Texas. (R. P., 1874, D, p. 29.) Limonite, compact, cellular, with considerable admixture of yellow clay.

XIV. *Werner & Reinhart's* mine, leased by the Allentown Iron Company, one-half mile east of New Texas. (R. P., 1874, D, p. 29.) Limonite, compact and cellular, with admixture of ochreous earth.

f XV. *Werner & Reinhart's* mine, mined by the Allentown Iron Company. (R. P., 1874, D, p. 29.) Limonite, hard, arenaceous, and compact.

XVI. *Milton Lauer's* mine, leased by Carbon Iron Company. (R. P., 1874, D, p. 29.) Limonite, hard, compact, and very sandy.

XVII. *Frank S. Lichtenwalner's* mine, three-fourths of a mile east of Alburtis. (R. P., 1874, D, p. 30.) Limonite, compact, with nodular concretions and small seams of ochreous iron ore.

XVIII. *Elwin Bastian's* mine, leased by the Lehigh Iron Company. (R. P., 1874, D, p. 31.) Limonite, hard, compact, sandy, with considerable quartz in fine ore.

XIX. *Francis Guth's* mine, leased by Carbon Iron Company, three-fourths of a mile west-northwest of Wescoeville. (R. P., 1874, D, p. 32.) Limonite, hard, compact, and sandy.

a This analysis is put down under Hensinger & Saul's mine in Professor Prime's report, but specimen was from Thomas Iron Company's mine.

XX. *Francis Breinig's* mine, 1½ mile north-northwest of Breinigsville. (R. P., 1874, D, p. 32.) Limonite, silicious, somewhat slaty structure, spongy form; color, various shades of brown and brick red. a

XXI. *Oliver Moser's* mine, leased by Northampton Iron Company, one-third of a mile north of Breinigsville. (R. P., 1874, D, p. 33.) Limonite, compact mass of pipe ore, the pipes in some pieces being somewhat obliterated; somewhat cellular, the cells being partially filled with yellow clay; color, dark-brown generally.

XXII. *Thomas Breinig's* mine, leased by Northampton Iron Company, one-third of a mile north of Breinigsville. (R. P., 1874, D, p. 34.) Limonite, very compact, somewhat cellular and stalactitic, botryoidal; color, various shades of brown.

XXIII. *Nathan Whitely's* mine, 1 mile from Trexlertown, on road to Breinigsville. (R. P., 1874, D, p. 35.) Limonite, hard, arenaceous; structure flaggy; some of the pieces decidedly fibrous.

XXIV. *William B. Fogel's* mine, leased by Carbon Iron Company, one-half mile northwest of Trexlertown. (R. P., 1874, D, p. 36.) Limonite, hard, compact, arenaceous, with somewhat laminated structure, and considerable admixture of yellow clay.

XXV. *Henry Swartz and W. B. Fogel's* mine, leased by the Crane Iron Company, at Trexlertown. (R. P., 1874, D, p. 36.) Limonite, sandy, containing small cavities lined with göthite. b

XXVI. *Alwyn Bortz's* mine, one-half mile east of Trexlertown. (R. P., 1874, D, p. 36.) Limonite, compact, argillaceous, with considerable admixture of ochreous earth.

XXVII. *Alwyn Bortz and William Koch's* mine, leased by Carbon Iron Company, one-half mile east of Trexlertown. (R. P., 1874, D, p. 37.) Limonite, cellular, somewhat nodular, of a dark-brown color.

XXVIII. *Jonas Grammis'* mine, one-half mile east of Trexlertown. (R. P., 1874, D, p. 37.) Limonite, soft and cellular, some of the cells being filled with yellow clay; partly laminated structure.

XXIX. *Gackenbach's* mine, leased by the Crane Iron Company, 2 miles northeast of Trexlertown. (R. P., 1874, D, p. 38.) Limonite, stalactitic, cellular, sandy; color, various shades of brown and vermillion; contains 10.83 per cent. of water.

XXX. *Francis Fisher's* mine, leased by the Coleraine Iron Company, 1½ miles northwest of Wescoeville. (R. P., 1874, D, p. 38.) Limonite, arenaceous, exceedingly hard and tough, with nodular concretions and velvety surface.

XXXI. *J. & D. Smith's* mine, leased by Millerstown Iron Company, 1 mile south-southwest of Fogelsville. (R. P., 1874, D, p. 39.) Limonite, compact and exceedingly sandy, with considerable adhering yellow clay; color, various shades of light and dark brown. c

XXXII. *Charles Miller's* mine, three-fourths of a mile south-southwest of Fogelsville; stripping ore. (R. P., 1874, D, p. 39.) Limonite, arenaceous, with a large admixture of ochreous iron ore.

XXXIII. *J. D. Scholl & Co.'s* mine, leased by Lehigh Valley Iron Company, 1½ mile south-southeast of Fogelsville. (R. P., 1874, D, p. 40.) Limonite, compact, cellular, with numerous seams of ochreous earth.

XXXIV. *Jacob Steininger's* mine, leased by James Lanigan, three-fourths of a mile southwest of Fogelsville. (R. P., 1874, D, p. 40.) Limonite, compact, arenaceous, with considerable admixture of ferruginous clay.

XXXV. *Henry Stein's* mine, leased by Thomas Iron Company, 1 mile west-southwest of Fogelsville. (R. P., 1874, D, p. 41.) Limonite, rather compact, with considerable coating of white clay; some of the pieces of a brick red, and others of a foxy color.

XXXVI. *Jesse Laro's* mine, leased by the Crane Iron Company, 1½ mile southwest of Fogelsville. (R. P., 1874, D, p. 41.) Limonite, compact, arenaceous, of a very dark color.

XXXVII. *Levi Lichtenwalner's* mine, leased by the Crane Iron Company. (R. P., 1874, D, p. 42.) Limonite, hard, sandy, with considerable ochreous iron ore. d

XXXVIII. *Kræmlich & Lichtenwalner's* mine, leased by the Crane Iron Company, at Fogelsville. (R. P., 1874, D, p. 42.) Limonite, hard, cellular, the pieces being generally of a slaty structure; color, dark-brown and cinnamon-brown.

	XXXIX.	Percentages.
	Per cent.	
Sesquioxide of iron	68.590	=48.013 per cent. iron.
Alumina	2.010	
Oxide of manganese	Trace.	
Lime	0.270	
Magnesia	1.480	
Phosphoric acid	0.340	=0.140 per cent. phosphorus.
Sulphuric acid	0.060	=0.025 per cent. sulphur.
Water, combined	10.750	
Water, hygroscopic	0.950	
Insoluble residue	9.930	
Total	100.380	

e

XXXIX. *Ludwig's New* mine, 1 mile from Alburtis (R. P., 1874, D, p. 25). Average of 6 cars. Analyzed for Pennsylvania Steel Company in 1874, and published by permission of S. M. Felton, esq., president.

f

	No. 61.	No. 62.	No. 63.	No. 391.	No. 369.
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
Iron	30.300	47.700	50.000	47.000	26.400
Manganese	0.065	2.968	0.208	0.041	17.648
Sulphur	0.008	0.040	0.080	0.058	0.010
Phosphorus	1.269	0.328	0.086	0.061	0.095
Insoluble residue	28.195	12.595	12.520	15.770	21.860

61. *J. Ritter's* mine, at Ironton; leased by the Crane Iron Company. Limonite forming vein in Utica shale and damourite clay. Compact, flaggy, with more or less adhering clay.

a 62. *J. Ritter's* mine, at Ironton. Lump- and wash-ore from bottom of mine (see Report DD, p. 44). Compact, botryoidal; considerable adhering clay and some quartz in wash-ore.

63. *P. Brown's* mine, at Ironton. Lump-ore. Compact, rather fine-grained; dark brown.

391. *P. Brown's* mine, at Ironton. Lump- and wash-ore. Compact, arenaceous; dark brown. (D. McCreath.)

369. *Ironton Railroad Company's* mine, at Ironton. Lump- and wash-ore. Compact, botryoidal; also stalactitic; general structure somewhat flaggy. Some of the ore carries considerable binoxide of manganese.

b

	No. 301.	Percentages.
	Per cent.	
Binoxide of manganese	77.960	=52.631 per cent. manganese.
Protoxide of manganese	4.320	
Sesquioxide of iron	3.660	=2.562 per cent. iron.
Alumina	0.711	
Oxide of cobalt	0.390	
Oxide of nickel	Trace.	
Oxide of copper	Trace.	
Baryta	0.152	
Lime	0.770	
Magnesia	0.236	
Soda	0.368	
Potash	3.042	
c Sulphuric acid	Trace.	
Phosphoric acid	0.149	=0.063 per cent. phosphorus.
Water	3.980	
Silicic acid	4.845	
Total	100.583	

301. *Ironton Railroad Company's* mine, at Ironton. Manganese wash-ore. Stalactitic, botryoidal, reniform; partially compact and cellular, with cells more or less filled with iron oxide.

	No. 195.	No. 196.	No. 64.	No. 190.	No. 194.	No. 340.	No. 74.	No. 367.	No. 352.	No. 189.
d	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
Iron	41.200	51.300	40.000	40.000	41.000	44.200	43.000	46.000	46.300	32.500
Manganese	0.028	0.064	0.554	0.115	0.036	0.036	0.165	0.050	0.201	0.338
Sulphur	0.191	0.106	0.027	0.140	0.098	0.043	0.038	0.073	0.033	0.038
Phosphorus	0.056	0.192	0.393	0.099	0.240	0.760	0.164	0.210	0.264	0.168
Insoluble residue	25.945	9.145	25.460	26.860	26.735	20.315	21.860	17.870	17.500	42.370

	No. 357.	No. 368.	No. 355.	No. 366.	No. 363.	No. 365.	No. 356.	No. 361.	No. 362.	No. 358.
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
Iron	49.500	49.200	53.000	46.300	34.000	45.200	39.250	36.500	30.100	47.200
Manganese	0.194	0.317	0.216	0.475	0.115	2.132	5.512	1.325	0.489	2.709
e Sulphur	0.019	0.005	0.024	0.018	0.020	0.026	0.020	0.107	0.062	0.039
Phosphorus	0.102	0.180	0.096	0.160	0.676	0.657	0.149	0.547	0.299	0.075
Insoluble residue	13.410	14.005	7.290	15.290	37.095	12.780	21.880	31.215	43.035	14.980

195. *John Heninger's* mine, near Siegersville, 4½ miles west of Catasauqua. Wash-ore (see DD, p. 39.) Compact, arenaceous; carries considerable adhering clay; color, various shades of brown and vermilion.

196. *Hiram Boyer's* mine, near Siegersville, 4½ miles west of Catasauqua. Wash-ore. Leased by Lehigh Valley Iron Company. Cellular, stalactitic; argillaceous. (D. McCreath.)

64. *Samuel Sieger's* mine, at Siegersville, 4½ miles west of Catasauqua. Lump- and wash-ore. Leased by Bethlehem Iron Company. Arenaceous, cellular; cells much filled with clay. Some of the ore is compact and fine-grained, with flaggy structure. Wash-ore carries considerable quartz.

190. *Daniel Levan's* mine, near Siegersville, 4½ miles west of Catasauqua. Wash-ore. Arenaceous, cellular; cells carrying f considerable clay.

194. *Calvin Guth's* mine, near Guthville, 4 miles west of Catasauqua. Leased by Bethlehem Iron Company. Arenaceous, cellular; some of the pieces fine-grained and flaggy. Color, various shades of brown and vermilion.

340. *Benjamin Weaver's* mine, near Guth's station, 4½ miles west of Catasauqua. Lump- and wash-ore. Compact, brittle; dark brown. Fine ore carries considerable quartz.

74. *James Kline's* mine, at Orefield, 5 miles west of Catasauqua. Lump- and wash-ore. Leased by Thomas Iron Company. Compact, flaggy, arenaceous; considerable yellow, white, and pink-tinted clay.

367. *Sheiver's* mine, 1½ miles west of Catasauqua. Lump- and wash-ore. Compact, arenaceous; also cellular. Dark brown, reddish-brown.

352. *Ruch & Brothers'* mine, at Ruchsville, 3 miles northwest of Catasauqua. Lump- and wash-ore. Cellular, botryoidal, with considerable clay. Wash-ore carries a good deal of quartz.

189. *Jonas Biery's* mine, about 4 miles northwest of Allentown. Exceedingly sandy; somewhat cellular, with considerable free quartz and clay. a

357. *Charles Glick's* mine, 3½ miles northwest of Emaus. Lump-ore. Leased by Allentown Iron Company. Compact; also cellular, with considerable adhering clay; color, dark brown.

368. *Solomon Kehm's* mine, 2½ miles northwest of Emaus. Lump-ore. Hard, compact, and tough; carries some particles of quartz and considerable adhering clay.

355. *John Roth's* mine, 3 miles north of Emaus. Lump-ore. Exceedingly compact and fine-grained; dark brown.

366. *H. & F. Jobst's* mine, 2½ miles west of Emaus. Wash-ore. Rather compact; shelly, with a large amount of clay. (D. McCreath.)

363. *Schwartz's* mine, one-half mile south of Emaus. Lump-ore. Very hard and tough, arenaceous; dark brown.

365. *Elias Dancy's* mine, 1 mile south of Emaus. Lump-ore. Leased by Coleraine Iron Company. Brittle, shelly, botryoidal; dark brown. (D. McCreath.) A sample of titaniferous iron ore found in the top clay when working this mine gave the following analysis: Fe, 38.16; Mn, .35; S, none; P, trace; CaO, .52; MgO, 3.87; Al_2O_3, 2.79; TiO_2, 32.18 per cent. b

356. *Keck & Ritter's* mine, 2 miles east of Emaus. Lump-ore. Leased by Emaus Iron Company. Compact, sandy, nodular, with specks of quartz.

361. *Trexler & Kline's* mine, three-quarters of a mile east of Emaus. Lump-ore. Compact, arenaceous; dark brown. (D. McCreath.)

362. *Henry Kline's* mine, three-quarters of a mile east of Emaus. Lump-ore. Sandy, shelly; dark brown; ore carries considerable quartz. (D. McCreath.)

358. *Jesse Kline's* mine, one-half mile east of Emaus. Lump-ore. Compact; also cellular and bomb-shell; considerable clay.

	No. 364.	Percentages.
	Per cent.	
Sesquioxide of iron	69.714	= 48.80 per cent. iron.
Sesquioxide of manganese	1.292	= 0.900 per cent. manganese.
Alumina	2.388	
Lime	0.300	
Magnesia	0.317	
Sulphuric acid	0.035	= 0.014 per cent. sulphur.
Phosphoric acid	0.448	= 0.196 per cent. phosphorus.
Water	11.340	
Insoluble residue	13.915	
	99.749	

c

364. *Conrad Seam's* mine, 1½ mile east of Emaus. Lump- and wash-ore. Hard, tough, shelly, botryoidal; reddish-brown. Ore carries considerable adhering clay. (D. McCreath.) d

	No. 968.	No. 969.	No. 970.	No. 981.
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*
Sesquioxide of iron	64.428	75.714	68.785	47.000
Sesquioxide of manganese	0.982	0.228	0.207	0.880
Sesquioxide of cobalt	0.040	0.010	0.020	0.080
Alumina	2.108	1.421	2.974	3.696
Lime	0.170	0.160	0.120	0.100
Magnesia	0.288	0.288	0.288	0.418
Sulphuric acid	0.032	0.447	0.612	0.062
Phosphoric acid	1.104	1.175	0.941	0.584
Water	11.374	12.724	12.866	8.022
Insoluble residue	19.760	7.700	13.310	38.940
	100.286	99.957	100.123	100.391
Metallic iron	45.100	53.000	48.150	32.900
Metallic manganese	0.684	0.159	0.144	0.619
Sulphur	0.013	*a* 0.179	*b* 0.245	0.025
Phosphorus	0.482	*c* 0.513	0.411	0.255

e

a Duplicate sulphur determination gave 0.179.
b Duplicate sulphur determination gave 0.246.
c Duplicate phosphorus determination gave 0.514.

f

968. *David Schneider's* mine, 3 miles from Friedensville, and 7 miles southwest from Hellertown. Lump- and wash-ore. Leased by Saucon Iron Company. Generally compact and fine-grained, with considerable bomb-shell ore; the walls of the bombs being lined with dark-brown fibrous iron oxide.

969. *Widow Kurtz's* mine, near Friedensville, and 4 miles southwest from Hellertown. Pipe-ore. Leased by Saucon Iron Company. Cellular, pipe-ore, generally of a dark-brown color.

970. *Morgan Mory's* mine, near Friedensville, and 4 miles southwest from Hellertown. Lump- and wash-ore. Leased by Saucon Iron Company. Brittle, cellular; the cells for the most part filled with ochreous iron ore. Color, light- and dark-brown.

981. *G. & W. Mory's* mine, near Friedensville, and 4 miles southwest from Hellertown. Lump- and wash-ore. Leased by Saucon Iron Company. Cellular, brittle, with considerable ferruginous clay and free quartz. Color of ore, dark-brown to yellowish-brown.

a *Berks county.*—Production of limonite in census year, 161,575 tons. The following analyses and notes are from Report MM, pp. 210 to 213:

	No. 983.	No. 992.	No. 993.	No. 984.	No. 982.	No. 986.	No. 988.	No. 987.	No. 990.	No. 985.	No. 989.	No. 991.
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
Sesquioxide of iron	67.857	62.857	65.000	75.857	74.571	67.428	64.000	52.214	63.857	46.857	51.643	57.571
Sesquioxide of manganese	0.155	0.557	0.288	0.950	0.496	0.320	3.414	0.195	0.505	2.183	3.320	2.441
Sesquioxide of cobalt	Trace.	0.060	0.040	Trace.	0.020	0.020	0.040	0.010	Trace.	0.060	0.050	0.050
Alumina	3.685	3.450	3.881	1.906	2.714	3.333	2.030	3.337	3.468	4.291	4.740	3.159
Lime	0.020	0.150	0.170	0.110	0.020	0.290	0.120	0.250	0.080	0.150	0.230	0.060
b Magnesia	0.237	0.432	0.421	0.230	0.201	0.360	0.245	0.302	0.331	0.604	0.518	0.470
Sulphuric acid	0.037	0.052	0.070	0.155	0.012	0.085	0.032	0.085	0.020	0.057	0.065	0.065
Phosphoric acid	0.527	1.266	0.330	0.087	0.405	0.250	0.601	0.029	0.355	1.172	0.827	1.034
Water	12.504	12.008	11.280	12.306	12.034	11.098	12.308	10.888	11.442	11.162	11.090	11.822
Insoluble residue	15.185	19.270	18.610	7.850	8.460	16.580	17.490	32.380	20.100	32.710	20.910	23.590
	100.207	100.102	100.009	99.511	99.893	100.573	100.379	100.380	100.158	99.246	99.993	100.262
Metallic iron	47.500	44.000	45.500	53.100	52.200	47.200	44.800	36.550	44.700	32.800	36.150	40.300
Metallic manganese	0.108	0.388	0.201	0.662	0.346	0.223	2.377	0.129	0.353	1.520	2.312	1.700
Sulphur	0.015	0.021	0.028	0.002	0.005	0.034	0.013	0.034	0.008	0.023	0.026	0.026
Phosphorus	0.230	0.553	0.148	0.038	0.177	0.113	0.302	0.275	0.155	0.512	0.361	0.453

c 983. *Fleetwood Iron Company's* mine, 1 mile northwest of Mertztown, at station 2312. Lump- and wash-ore. Generally compact and fine-grained, also cellular; dark-brown.

992. *Samuel Lewis'* mine, 1½ mile northwest from Mertztown, at station 2321. Lump- and wash-ore. Compact, also cellular; full of seams of ochreous iron ore; dark-brown to yellowish-brown. Wash-ore carries considerable quartz.

993. *D. K. Kline's* mine, 2½ miles from Mertztown; Kline's corners. Lump- and wash-ore. Leased by Temple Iron Company. Compact, also cellular, with cells for the most part filled with ochreous iron ore. Color, dark-brown and yellowish-brown.

984. *Charles Miller's* mine, 3 miles northwest of Mertztown, near station 2472. Lump- and wash-ore. Cellular; full of seams of ochreous iron ore, with spangles of quartz. Generally dark-brown.

982. *E. H. Trexler's* mine, 1 mile northeast of Mertztown. Lump- and wash-ore. Generally compact and fine-grained, with admixture of fibrous iron ore. Color, dark-brown to brownish-black.

986. *Mrs. John Merkel's* mine, at Farmington, 2 miles north of Mertztown. Lump- and wash-ore. Cellular, with cells filled with clay; shows some masses of quartz. Color of ore, light- and dark-brown.

d 988. *Jonathan Ziegler's* mine, at Farmington, 2 miles north of Mertztown. Lump- and wash-ore. Cellular, brittle, dark-brown.

987. *David Ziegler's* mine, near Farmington, 3 miles north-northeast of Mertztown. Lump- and wash-ore. Leased by Temple Iron Company. General appearance very sandy; cellular; also compact and fine-grained. Carries considerable quartz. Color of ore, dark-brown and reddish-brown.

990. *William Miller's* mine, 3 miles north of Topton. Lump- and wash-ore. Arenaceous, brittle, dark-brown.

985. *D. H. Smyer's Heirs'* mine, 1 mile south from Bauers, near station 2709. Lump- and wash-ore. General appearance very sandy, with dark-brown to yellowish-brown color. Carries a small admixture of manganiferous ore.

989. *Charles Heffner's* mine, one-half mile south from Lyons. Lump- and wash-ore. Leased by Temple Iron Company. Sandy; full of seams of ochreous iron ore; compact; also cellular, with cells filled with clay. Color of ore various shades of light- and dark-brown.

991. *Clymer Iron Company's Udree* mine, 2 miles northwest of Pricetown. Lump- and wash-ore. Generally very compact and fine-grained, with conchoidal fracture and dark-brown color.

e The following eight analyses of limonite from Berks county have not before been published:

	1.	2.	3.	4.	5.	6.	7.	8.
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
Protoxide of iron	None.	None.	None.	.....	None.	None.	None.	None.
Sesquioxide of iron	53.893	66.178	76.357	64.535	58.028	59.392	56.071	49.142
Sesquioxide of manganese	1.447	0.930	1.189	0.248	1.851	1.334	0.650	0.216
Sesquioxide of cobalt	0.120	0.100	0.110	.....	.....	.....	.....	.....
Oxide of zinc	None.	None.	None.	.....	.....	.....	.....	.....
Alumina	2.050	1.560	1.150	2.865	3.586	3.254	3.061	3.043
Lime	0.860	0.750	0.870	0.530	0.470	0.610	0.380	0.450
Magnesia	0.012	0.430	0.443	0.580	0.583	0.533	0.533	0.558
f Sulphuric acid	0.012	0.010	0.032	0.200	0.080	0.010	0.050	0.030
Phosphoric acid	0.916	0.052	0.405	0.355	1.697	0.469	0.327	0.364
Water	0.270	0.050	10.350	10.442	11.392	9.066	5.866	8.862
Silicious matter	31.000	20.050	9.200	20.040	21.200	25.000	32.920	37.050
Total	100.186	100.310	100.196	99.795	99.787	99.668	99.858	99.715
Metallic iron	37.725	46.325	53.450	45.175	41.250	41.575	39.250	34.400
Metallic manganese	1.008	0.648	0.828	0.173	1.289	0.929	0.453	0.151
Sulphur	0.005	0.004	0.013	0.080	0.032	0.004	0.020	0.012
Phosphorus	0.400	0.285	0.177	0.155	0.741	0.205	0.143	0.159
Phosphorus in 100 parts iron	1.060	0.615	0.331	0.343	1.796	0.493	0.364	0.462

1. *Moselem* bank, 1 mile south from Moselem. Sample, 225 pieces, taken from pile in stock-house at Keystone furnace, Reading, Pennsylvania. Ore from the two washers at old large cut, and chiefly surface-ore. a

2. *Moselem* bank. Sample, 75 pieces, from the small "Red cut" washer.

3. *Moselem* bank. Sample, 95 pieces, from the new "Separator washer" at "Red cut".

4. *Joseph Albright* bank, 2½ miles north-northeast from Topton. Sample, 98 pieces, from ore-pile.

5. *Frank Brownbeck's* mine, one-half mile southwest of Lyons. Sample, 245 pieces, from ore-pile.

6. *Benfield* bank, one-half mile north from Mertztown. Sample, 220 pieces, from ore-pile at Reading Iron Works.

7. *Shaefer* mine, near Evansville. Sample, 253 pieces, from ore-pile at Reading Iron Works.

8. *Weiler* (Dankel) bank, 1¼ miles north from Hancock station, East Pennsylvania railroad. Sample, 192 pieces, from pile at Reading Iron Works.

Lebanon county produced 5,629 tons of limonite in the census year. The following six analyses of these ores have not before been published: b

	1.	2.	3.	4.	5.	6.
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
Bisulphide of iron	0.427					
Sesquioxide of iron	72.001	63.500	48.742	58.071	68.302	50.642
Sesquioxide of manganese	0.133	0.258	0.143	0.268	0.258	0.237
Alumina	0.745	3.420	2.802	1.442	2.346	3.024
Lime	0.170	0.310	0.510	0.580	0.480	0.410
Magnesia	0.371	0.601	0.605	0.443	0.475	0.634
Sulphuric acid	1.805	0.105	0.140	0.070	0.105	0.105
Phosphoric acid	0.378	0.396	0.536	0.302	0.302	0.275 c
Water	14.734	11.206	10.124	11.242	12.066	10.334
Silicious matter	9.330	19.710	36.140	27.710	15.390	33.890
Total	100.154	99.506	99.832	100.128	99.874	99.551
Metallic iron	50.600	44.450	34.050	40.650	47.875	35.450
Metallic manganese	0.093	0.180	0.100	0.187	0.180	0.165
Sulphur	0.974	0.042	0.056	0.028	0.042	0.042
Phosphorus	0.165	0.173	0.234	0.132	0.158	0.120
Phosphorus in 100 parts iron	0.326	0.389	0.687	0.324	0.330	0.338

1. *Bowman* bank (H. S. Eckert & Brother), near Cornwall, and about 4 miles south from Lebanon. Sample, 285 pieces, from ore around washer. d

2. *Groh* bank, about 3½ miles south from Prescott. Sample, 215 pieces, from small pile at washer.

3. *Strickler's* bank, 1 mile west-northwest from Achey's Corners. Sample, 156 pieces, from ore-pile at washer.

4. *Moyer's* bank, 1 mile west from Achey's Corners. Sample, 135 pieces, from loose ore around the mine.

None of the above in operation when samples were taken, August, 1881.

5. *Bucher's* bank, about 3½ miles south from Prescott. Sample, 243 pieces, from ore-pile.

6. *Yingst's* bank, three-quarters of a mile north from Achey's Corners. Sample, 225 pieces, represents the wash-ore.

Dauphin county produced 1,956 tons of limonite in the census year. The following analyses of these ores have not before been published:

	1.	2.
	Per cent.	*Per cent.*
Sesquioxide of iron	56.285	63.785
Sesquioxide of manganese	1.107	2.225
Sesquioxide of cobalt	0.070	0.080
Alumina	2.436	0.587
Lime	0.890	1.450
Magnesia	0.346	0.418
Sulphuric acid	Trace.	0.037
Phosphoric acid	0.589	1.088
Water	10.062	11.834
Silicious matter	27.830	18.070
Total	99.615	99.574
Metallic iron	39.400	44.650
Metallic manganese	0.771	1.549
Sulphur	Trace.	0.015
Phosphorus	0.257	0.475
Phosphorus in 100 parts iron	0.652	1.063

e

f

1. *Swatara* bank, 3½ miles east-southeast from Hummelstown.

2. *Derry* bank, 1½ miles south of Swatara station, Philadelphia and Reading railroad. Sample, 286 pieces, represents the clean ore, free from quartz. As mined the ore will yield from 5 to 10 per cent. less iron than is shown in the above analysis.

a *Cumberland county.*—In this county 75,915 tons of limonite were mined in the census year. The following analyses show the character of the ores (see Report MM, pp. 208 and 209, and Report M³, pp. 15 to 24):

	51.	52.	53.	54.	55.	56.	57.	58.	59.	60.	61.
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
Protoxide of iron				None.	Trace.	Trace.					
Sesquioxide of iron	69.785	64.214	52.571	75.042	67.928	71.857	58.000	72.314	62.857	64.214	77.428
Sesquioxide of manganese	0.351	1.417	8.054	0.382	0.133	0.153	1.212	3.032	1.831	2.431	0.123
Sesquioxide of cobalt	0.420	0.040	0.230	Trace.	0.060	0.060	0.070	0.270	0.200	0.110	0.140
Alumina	1.071	2.350	1.777	1.250	2.205	2.356	2.250	2 100	1.853	2.230	1.502
b Lime	0.620	0.580	1.090	0.380	0.510	0.460	0.630	0.540	0.660	0.580	0.740
Magnesia	0.410	0.504	0.374	0.331	0.403	0.457	0.306	0.302	0.270	0.342	0.443
Sulphuric acid	0.067	0.062	0.047	0.097	0.115	0.102	0.057	0.067	0.075	0.020	0.112
Phosphoric acid	0.334	1.225	4.092	0.300	0.107	0.197	0.705	1.266	0.728	1.708	0.471
Water and organic matter	11.240	12.604	13.134	12.166	10.158	10.164	10.778	13.013	10.896	11.756	12.266
Silicious matter	14.780	16.860	18.640	9.500	17.720	13.440	25.350	7.750	20.520	15.050	6.560
Total	99.984	99.856	100.009	100.048	99.429	99.226	99.358	100.654	99.890	99.341	99.785
Metallic iron	48.850	44.950	36.800	52.950	47.550	50.300	40.600	50.620	44.000	44.950	54.200
Metallic manganese	0.245	0.987	5.620	0.266	0.094	0.094	0.844	2.111	1.275	1.693	0.086
Sulphur	0.027	0.025	0.010	0.039	0.046	0.041	0.023	0.027	0.030	0.008	0.045
Phosphorus	0.140	0.535	1.787*a*	0.131	0.086	0.086	0.308	0.553	0.318	0.746	0.206
c Phosphorus in 100 parts iron	0.208	1.190	4.856	0.247	0.180	0.170	0.758	1.090	0.722	1.659	0.308

a A duplicate determination of the phosphorus, by Mr. John M. Stinson, gave 1.778 per cent.

	62.	63.	64.	65.	66.	67.	68.	68*a*.	69.	70.	71.
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
Sesquioxide of iron	68.857	60.212	58.000	54.428	59.071	52.043	51.214	71.785	64.500	49.285	51.571
Sesquioxide of manganese	0.527	3.891	4.408	10.379	1.799	2.173	3.227	0.103	0.507	0.050	2.266
Sesquioxide of cobalt	0.240	0.130	0.340	0.520	0.240	0.280	0.210	0.070	0.230	0.040	0.260
Alumina	1.684	1.559	4.206	1.565	2.365	2.324	1.885	3.630	3.868	5.867	2.064
d Lime	0.610	0.950	0.500	0.800	0.500	0.460	0.500	0.260	0.630	0.600	0.580
Magnesia	0.328	0.771	0.627	0.418	0.504	0.468	0.468	0.194	0.630	0.072	0.385
Sulphuric acid	0.002	0.070	0.085	0.056	0.060	0.060	0.080	0.017	0.035	0.102	0.037
Phosphoric acid	3.110	0.620	1.124	0.887	1.525	0.783	0.421	1.175	1.772	0.538	2.095
Water and organic matter	11.287	11.176	11.022	11.373	11.332	10.420	9.078	11.644	12.127	10.385	11.204
Silicious matter	12.800	20.000	19.260	20.220	22.000	29.070	31.890	10.650	14.970	30.840	28.620
Total	99.514	100.288	100.262	100.236	99.480	99.531	99.663	99.528	99.269	99.279	99.982
Metallic iron	48.200	42.150	40.600	38.100	41.350	36.850	35.850	50.250	45.150	34.500	36.100
Metallic manganese	0.367	2.709	3.069	7.226	1.253	1.513	2.247	0.072	0.353	0.453	1.578
Sulphur	0.025	0.028	0.034	0.022	0.024	0.024	0.032	0.007	0.014	0.041	0.015
Phosphorus	1.365	0.275	0.491	0.169	0.666	0.320	0.184	0.513	0.774	0.235	0.915
Phosphorus in 100 parts iron	2.831	0.652	1.209	0.443	1.610	0.868	0.513	1.020	1.714	0.681	2.534

e	71*a*.	72.	73.	73*a*.	74.	75.	76.	77.	77*a*.	78.	78*a*.	79.
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
Sesquioxide of iron	67.000	62.785	54.643	69.285	64.142	61.357	64.428	49.071	45.928	58.428	52.785	69.571
Sesquioxide of manganese	1.841	0.178	3.921	1.044	2.038	0.133	0.330	0.510	4.469	3.725	1.034	0.852
Sesquioxide of cobalt	0.170	0.070	0.360	0.230	0.180	0.260	0.200	0.180	0.170	0.130	0.120	0.040
Alumina	3.010	3.546	2.010	1.141	1.130	2.555	1.740	2.368	4.677	2.861	4.080	1.560
Lime	0.210	0.380	0.150	0.070	2 010	0.530	0.500	0.500	0.500	0.500	0.610	0.350
Magnesia	0.183	0.321	0.304	0.145	0.418	0.562	0.200	0.342	0.637	0.504	0.753	0.248
Sulphuric acid	0.007	0.115	0.012	0.015	0.056	0.067	0.050	0.055	0.055	0.075	0.072	0.062
Phosphoric acid	1.852	0.190	3.144	3.708	0.898	3.188	0.403	2.471	2.425	2.081	1.695	0.870
Water and organic matter	10.870	12.874	11.312	12.298	12.035	11.668	11.200	11.674	11.814	12.186	12.240	11.796
f Silicious matter	13.370	18.860	23.550	11.270	16.180	18.060	21.020	26.370	28.800	19.290	24.360	15.090
Total	99.413	99.328	99.406	99.806	99.087	99.280	100.350	99.550	99.475	99.780	99.540	99.089
Metallic iron	46.900	43.950	38.250	48.500	44.900	42.950	45.100	34.350	32.150	40.900	36.950	48.700
Metallic manganese	1.282	0.124	2.730	0.727	1.337	0.093	0.230	4.589	3.112	2.594	1.347	0.245
Sulphur	0.003	0.046	0.005	0.006	0.022	0.027	0.020	0.022	0.022	0.030	0.029	0.025
Phosphorus	0.809	0.087	1.373	1.619	0.392	1.392	0.176	1.079	1.059	0.909	0.740	0.380
Phosphorus in 100 parts iron	1.725	0.197	3.589	3.338	0.873	3.240	0.390	3.141	3.293	2.222	2.003	0.780

51. *John H. Cressler's* bank (old "Clippinger"), 2½ miles southeast of Shippensburg. Wash-ore. Sample consisted of 710 pieces a taken from pile of ore at washer.

52. *George Clever* bank, at Cleversburg. Worked by Wisegarver & Peacock. Lump- and wash-ore. Sample consisted of 315 pieces taken from ore-pile at washer.

53. *No.* 1 *Clever Mammoth* bank (now Ahl's), on Clever farm, 1¼ mile southeast of Cleversburg, Southampton township. Sample consisted of 144 pieces taken from ore lying around and in mine at different places. Bank not in operation.

54. *John Bridge's* opening, 2 miles southeast of Shippensburg. Sample consisted of 103 pieces selected from ore taken out of trial-shaft; also from ore lying near same.

55. *Calico* bank—*Coover* opening (McCormick & Co.), 3 miles northeast of Shippensburg. Wash-ore. Sample consisted of 524 pieces from ore-pile at washer; also from pile at railroad wharf.

56. *Calico* bank—*Rutherford* opening (McCormick & Co.), 3 miles northeast of Shippensburg. Wash-ore. Sample consisted of 351 pieces taken from ore lying around mine.

57. *Chestnut* bank (McCormick & Co. and Lawton & Stewart), 4 miles east of Shippensburg. Wash-ore. Sample consisted of 953 b pieces taken from ore-pile at washer. Mine not in operation.

58. *George H. Clever* bank, 1½ mile east of Cleversburg, Southampton township. Lump- and wash-ore. Sample consisted of 356 pieces taken from pile of ore prepared for shipment.

59. *Big Pond* bank (Philadelphia and Reading Coal and Iron Company), about 5 miles east of Shippensburg, or about one-half mile west of Big Pond furnace. Sample consisted of 175 pieces taken from ore found in place and lying around the three most westerly openings. Bank not in operation.

60. *Old Peach Orchard* bank (Grove & Co.), about 3 miles southwest of Centerville, or about 3 miles southeast of Jacksonville. Sample consisted of 121 pieces taken from ore in place, also from wash-ore lying around mine. Bank not in operation.

61. *Peffer* bank, 2 miles west of Papertown. Sample consisted of 152 pieces taken from ore lying around mine. Bank not in operation.

62. *Wild Cat* openings (South Mountain Mining and Iron Company), about 2½ miles southwest of Pine Grove. Sample consisted of 60 pieces selected from ore taken out of several openings or shafts.

63. *Pine Grove* ore-bank (South Mountain Mining and Iron Company), at Pine Grove furnace. Sample consisted of 154 pieces taken c from ore in place at different parts of bank. Ore mined for use at Pine Grove furnace.

64. *Laurel No.* 2 bank (South Mountain Mining and Iron Company), about 1 mile south of Laurel forge. Sample consisted of 160 pieces taken from ore-pile at bank. Bank not in operation at date of visit.

65. *Laurel No.* 1 bank (South Mountain Mining and Iron Company), at Laurel forge. Sample consisted of 112 pieces taken from ore lying in and around mine. Bank not in operation. Samples selected independently by Mr. Daniel King, superintendent Pine Grove furnace, and analyzed by him, corroborated the above results.

66. *Henry Clay No.* 3 bank (Seyfert & McManus), 2½ miles northeast of Laurel. Sample consisted of 70 pieces taken from ore lying around mine. Bank not in operation.

67. *Henry Clay No.* 2 bank (Lanigan & Wynkoop), about 2¼ miles northeast of Laurel. Henry M. Watts & Son, lessees. Sample consisted of 101 pieces taken from ore in place and also from that lying around mine. Bank not in operation at date of sampling.

68. *Henry Clay No.* 1 bank (Guiterman & Robinson), 3 miles northeast of Laurel. Mount Holly Ore Bank Company, lessees. Sample consisted of 90 pieces taken from ore lying around mine. Bank not in operation at date of sampling.

68*a*. *Henry Clay No.* 1 bank (Guiterman & Robinson), 3 miles northeast of Laurel. Mount Holly Ore Bank Company, lessees. Samples of lump-ore selected by Mr. Ethelbert Watts since bank has been operated. d

69. *Diven* tract openings (McCormick & Co.), 3½ miles northeast of Laurel. Sample consisted of 106 pieces taken from ore found at eleven different pits or trial-shafts.

70. *Koontz & Myers'* bank, about 3½ miles northeast of Laurel. Wash-ore. Sample consisted of 174 pieces selected from ore-pile. Ore from which sample was taken was prepared by the so-called "dry-washer", so that analysis practically represents the ore unwashed.

71. *Grove* bank, about one-half mile south of Hunter's Run station, South Mountain railroad. Wash-ore. Bank adjoins the Lehman No. 2 tract. Sample consisted of 410 pieces taken from ore-pile at washer.

71*a*. *Grove* bank, about one-half mile south of Hunter's Run station. Lump-ore. Sample of the lump-ore selected by Dr. E. A. Grove, at my request.

72. *J. C. Lehman No.* 2 bank (Eisenhower & Gill), about three-quarters of a mile south of Hunter's Run station, South Mountain railroad. Wash-ore. Sample consisted of 192 pieces taken from pile of ore prepared for shipment. This bank has been quite recently e leased by Messrs. Henry M. Watts & Son.

73. *Mount Holly* (Medlar) bank (Mount Holly Ore Bank Company), about 1 mile southwest of Mount Holly. Two-thirds lump- and one-third wash-ore. Sample consisted of 230 pieces taken from ore in place at different parts of bank; wash-ore from ore-pile.

73*a*. *Mount Holly* (Medlar) bank (Mount Holly Ore Bank Company), about 1 mile southwest of Mount Holly. Sample represents the dark-brown cellular lump-ore from northeast end of bank, analyzed separately.

74. *Mullen* bank, about 1 mile west of Mount Holly. One-fourth lump- and three-fourths wash-ore. Mr. Daniel King, lessee. Sample consisted of 640 pieces taken from pile of ore prepared for shipment.

75. *Strickler* bank, 1 mile east of Mount Holly, or 3 miles southwest of Boiling Springs. Sample consisted of 130 pieces taken from ore in place, also from ore lying around mine. Bank not in operation.

76. *Pepper* bank ("Old mine"), 2 miles southwest of Boiling Springs. Sample consisted of 123 pieces taken from ore lying around mine. Bank not in operation.

77. *Ege* bank (Philadelphia and Reading Coal and Iron Company), 1 mile southeast of Boiling Springs. Lump-ore. Sample consisted f of 177 pieces taken from ore-pile at mine.

77*a*. *Ege* bank (Philadelphia and Reading Coal and Iron Company), 1 mile southeast of Boiling Springs. Wash-ore. Sample consisted of 345 pieces taken from ore-pile at mine.

78. *Beltzhoover* bank (Philadelphia and Reading Coal and Iron Company), 2 miles southeast of Boiling Springs. Lump-ore. Sample consisted of 195 pieces taken from ore-pile at mine.

78*a*. *Beltzhoover* bank (Philadelphia and Reading Coal and Iron Company), 2 miles southeast of Boiling Springs. Wash-ore. Sample consisted of 320 pieces taken from ore-pile at mine.

79. *Leidig & Hoffer* bank, about 3½ miles southeast of Boiling Springs. Sample consisted of 186 pieces selected from ore lying around mine. Bank not in operation.

a The following twelve analyses of limonite from *Cumberland county* have not before been published:

	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.	12.
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
Sesquioxide of iron	66.857	55.285	77.571	73.000	72.142	74.000	79.214	74.000	62.928	71.000	79.214	81.500
Sesquioxide of manganese	1.376	1.095	0.361	0.372	0.186	0.403	0.185	0.320	0.237	Trace.	0.113	0.081
Sesquioxide of cobalt	0.040	.....	.....	.....	0.170	.....	0.050	.....	0.290	0.160	0.200	0.160
Alumina	2.081	1.492	0.528	0.852	1.310	2.385	0.448	1.723	2.096	2.878	0.577	0.263
Lime	1.160	0.680	0.910	0.810	0.840	0.760	0.900	0.500	2.010	1.060	1.390	1.520
Magnesia	0.609	0.526	0.558	0.389	0.374	0.457	0.389	0.526	0.515	0.497	0.497	0.389
Sulphuric acid	0.025	0.057	0.110	0.130	0.072	0.010	0.027	0.155	0.017	0.087	0.060	0.052
b Phosphoric acid	0.552	0.467	0.439	0.373	0.378	0.428	0.318	0.325	1.436	0.602	0.169	0.194
Water	12.696	10.544	12.500	11.056	11.658	9.764	11.986	12.496	10.378	12.836	10.980	11.248
Silicious matter	14.350	29.810	7.260	13.210	12.540	11.620	6.410	10.140	20.140	10.570	6.200	4.730
Total	99.746	99.956	100.287	100.192	99.670	99.827	99.927	100.185	100.047	99.690	99.400	100.137
Metallic iron	46.800	38.700	54.300	51.100	50.500	51.800	55.450	51.800	44.050	49.700	55.450	57.050
Metallic manganese	0.958	0.763	0.252	0.259	0.130	0.281	0.129	0.223	0.165	Trace.	0.079	0.057
Sulphur	0.010	0.023	0.044	0.052	0.029	0.004	0.011	0.062	0.007	0.035	0.024	0.021
Phosphorus	0.241	0.204	0.192	0.163	0.165	0.187	0.139	0.042	0.627	0.263	0.074	0.085
Phosphorus in 100 parts iron	0.514	0.527	0.353	0.319	0.326	0.361	0.250	0.274	1.423	0.529	0.133	0.148

c 1. *Gorgas* bank, one-half mile west from White Hill station, Cumberland Valley railroad. Sample, 175 pieces, from loose ore lying around opening.

2. *Raapp* bank, three-quarters of a mile west from White Hill station, Cumberland Valley railroad. Sample, 96 pieces, from loose ore around opening.

3. *Best's* bank, 2 miles east-southeast from Shiremanstown. Sample, 138 pieces, from loose ore around opening.

4. *Weaver* bank, one-half mile west from Shepardstown. Sample, 118 pieces, from loose ore around opening.

5. *Carey Ahl's* bank, 1 mile east from Carlisle. Sample, 273 pieces, taken from ore-pile at washer.

6. *Sterrett Wood's* bank, 2½ miles southeast of Carlisle. Pipe-ore. Sample, 197 pieces, from loose ore around bank.

7. *Myer's* bank, 4 miles south from Greason. Sample, 225 pieces, from ore-pile at opening and from loose ore around opening. Pipe-ore.

8. *McKeehan's* bank, 2½ miles northwest from Greason. Sample, 235 pieces, from loose ore around opening. Pipe-ore.

9. *Charles Mullen's* bank, 1 mile south-southwest from Mount Holly. Sample, 168 pieces, represents the ore from 10 trial-shafts.

10. *Shopp* bank, about 1 mile northeast from Shiremanstown. Sample, 178 pieces, from loose ore around opening.

d 11. *Heike's* bank, 2 miles north-northwest from Greason. Sample, 293 pieces, from loose ore around opening. Pipe-ore.

12. *Bear's* bank, 1½ miles north from Greason. Sample, 283 pieces, from loose ore around opening. Pipe-ore.

Franklin county.—Product of limonite in census year, 36,558 tons. The following notes and analyses are from Report MM, pp. 207 and 208, and Report M³, pp. 1 to 14:

e

	186.	432.
	Per cent.	*Per cent.*
Sesquioxide of iron	76.571	77.571
Sesquioxide of manganese	0.392	0.103
Sesquioxide of cobalt	.....	.....
Alumina	5.010	0.042
Lime	0.200	0.160
Magnesia	0.281	0.076
Sulphuric acid	0.185	0.040
Phosphoric acid	0.409	0.185
Water	10.980	10.874
Insoluble residue	6.100	9.775
Total	100.128	99.726
Metallic iron	53.000	54.300
Metallic manganese	0.273	0.072
Sulphur	0.074	0.016
Phosphorus	0.179	0.081

f

186. *Michael Good's* ore-bank, 1½ miles northwest from Fayetteville. From ore-bank back of mill (see CC, p. 247). Somewhat cellular, botryoidal; dark brown and reddish brown. (D. McC.)

432. *Michael Good's* ore-bank, 1½ miles northwest from Fayetteville. Cellular, botryoidal; brittle; light and dark brown.

	No. 3.	No. 4.	No. 5.	No. 6.	No. 6a.	No. 7.	No. 8.	No. 12.	No. 13.	No. 14.	No. 15.	No. 16.[a]
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
Protoxide of iron	None.	None.					None.					
Bisulphide of iron										0.133		
Sesquioxide of iron	67.857	60.571	58.643	64.714	52.000	62.285	68.857	63.857	56.428	75.500	75.642	57.785
Sesquioxide of manganese	3.352	2.069	0.508	1.582	2.543	0.342	1.531	0.290	6.881	0.113	0.579	1.469
Sesquioxide of cobalt	0.200	0.130	0.030	0.170	0.280	0.280	0.390	0.510	0.390	0.120	0.180	0.130
Alumina	2.887	3.470	3.923	2.723	5.709	2.020	2.573	3.277	2.874	3.363	2.166	2.985
Lime	0.740	0.700	0.760	0.450	0.620	0.560	0.670	0.710	0.630	0.830	0.640	0.590
Magnesia	0.612	0.547	0.378	0.796	0.904	0.493	0.522	0.290*	0.670	0.338	0.432	0.331
Sulphuric acid	0.130	0.112	0.157	0.120	0.137	0.012	0.175	0.135	0.105	0.197	0.065	0.072[b]
Phosphoric acid	0.776	0.646	1.704	0.813	0.611	3.394	0.950	1.456	1.388	0.128	0.492	0.123
Arsenic acid										0.022		
Water and organic matter	12.080	11.572	11.885	11.610	10.668	11.132	11.592	11.840	12.120	12.908	11.928	10.510
Silicious matter	11.070	19.530	22.000	16.280	26.050	18.500	12.040	17.250	18.810	6.890	8.500	25.476
Total	100.254	99.847	100.048	99.258	99.612	99.618	100.200	99.624	100.296	100.542	100.624	99.465
Metallic iron	47.500	42.400	41.050	45.300	36.400	43.600	48.200	44.700	39.500	52.912	52.950	40.450
Metallic manganese	2.334	1.441	0.396	1.102	1.758	0.238	1.066	0.202	4.791	0.079	0.403	1.023
Sulphur	0.052	0.045	0.063	0.048	0.055	0.005	0.070	0.054	0.042	0.150	0.026	0.029
Phosphorus	0.339	0.282	0.744	0.355	0.267	1.482*	0.415	0.636	0.606	0.056	0.215	0.054
Phosphorus in 100 parts iron	0.713	0.665	1.812	0.783	0.733	3.399	0.861	1.422	1.534	0.105	0.406	0.133

*Average of two determinations. [c]

	No. 17.	No. 18.	No. 19.	No. 20.	No. 21.	No. 22.	No. 23.	No. 24.	No. 25.	No. 26.	No. 27.	No. 28.
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
Sesquioxide of iron	53.928	62.428	67.000	52.928	68.928	60.642	69.214	66.214	77.428	68.214	75.428	67.857
Sesquioxide of manganese	0.133	0.237	0.135	0.558	0.258	3.652	2.287	1.825	0.817	1.252	0.889	2.266
Sesquioxide of cobalt	0.190	Trace.	0.160	0.090	0.240	0.250	0.250	0.220	0.370	0.280	0.260	0.070
Alumina	1.980	1.500	1.567	3.035	1.927	2.695	1.695	2.126	1.248	1.182	1.866	2.663
Lime	0.600	0.116	0.780	0.590	0.870	0.700	0.650	0.510	0.600	0.670	0.730	0.360
Magnesia	0.576	0.305	0.371	0.450	0.230	0.681	0.486	0.490	0.324	0.252	0.414	0.353
Sulphuric acid	0.065	0.087	0.032	0.055	0.188	0.110	0.047	0.065	0.169	0.100	0.070	0.047
Phosphoric acid	1.074	0.602	1.012	0.950	1.005	0.043	0.501	0.540	0.229	0.774	0.432	0.160[d]
Water and organic matter	8.858	9.392	10.102	9.665	10.056	11.065	11.515	10.020	10.607	11.860	11.780	11.284
Silicious matter	32.560	25.570	18.250	31.700	15.200	18.870	13.070	16.750	7.870	14.990	8.020	14.510
Total	99.064	100.321	99.409	100.021	99.502	99.368	99.625	99.660	99.657	99.574	100.289	99.570
Metallic iron	37.750	43.700	46.900	37.050	48.250	42.450	48.450	46.350	54.200	47.750	52.800	47.500
Metallic manganese	0.093	0.165	0.094	0.389	0.180	2.546	1.592	1.271	0.569	0.872	0.619	1.578
Sulphur	0.026	0.035	0.013	0.022	0.075	0.044	0.019	0.026	0.067	0.040	0.028	0.019
Phosphorus	0.469	0.263	0.442	0.415	0.439	0.281	0.219	0.236	0.100	0.338	0.189	0.070
Phosphorus in 100 parts iron	1.242	0.601	0.942	1.120	0.909	0.661	0.452	0.509	0.184	0.708	0.357	0.147

	No. 29.	No. 30.	No. 31.	No. 32.	No. 33.	No. 34.	No. 35.	No. 36.	No. 37.	No. 38.	No. 39.
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*[e]
Sesquioxide of iron	67.642	68.642	73.714	66.071	69.428	72.214	54.785	68.714	75.000	61.285	78.000
Sesquioxide of manganese	1.075	2.545	0.082	0.620	3.094	0.441	4.501	3.694	0.952	0.775	0.483
Sesquioxide of cobalt	0.160	Trace.	Trace.	0.120	0.320	Trace.	0.230	0.170	0.050	Trace.	Trace.
Alumina	1.458	3.250	1.650	2.620	1.027	1.044	4.381	1.605	2.150	3.143	1.982
Lime	0.700	0.740	0.830	0.630	0.800	0.940	0.280	0.830	0.480	0.720	0.470
Magnesia	0.166	0.309	0.137	0.295	0.277	0.324	0.454	0.299	0.216	0.306	0.248
Sulphuric acid	0.165	0.040	0.030	0.082	0.120	0.135	0.037	0.092	0.047	0.022	0.092
Phosphoric acid	0.451	0.252	0.229	1.000	0.135	0.362	1.944	0.091	0.261	1.062	0.238
Carbonic acid							0.046	None.	None.		
Water and organic matter	11.586	11.692	11.522	12.062	12.062	12.630	11.742	11.200	11.812	10.788	12.610
Silicious matter	16.020	12.100	11.910	15.940	11.680	11.520	21.510	12.790	9.110	21.480	5.775
Total	99.423	99.571	100.104	99.449	99.543	100.210	99.910	99.485	100.078	99.581	99.898[f]
Metallic iron	47.350	48.050	51.600	46.250	48.600	50.550	38.350	48.100	52.500	42.900	54.600
Metallic manganese	0.749	1.772	0.057	0.432	2.154	0.309	3.134	2.572	0.663	0.540	0.336
Sulphur	0.066	0.016	0.012	0.033	0.048	0.054	0.015	0.036	0.019	0.009	0.037
Phosphorus	0.197	0.110	0.100	0.437	0.059	0.157–.158	0.849	0.040	0.114	0.464	0.104
Phosphorus in 100 parts iron	0.416	0.228	0.193	0.944	0.121	0.312	2.213	0.083	0.217	1.081	0.190

a	No. 40.	No. 41.	No. 42.	No. 43.	No. 44.	No. 45.	No. 46.	No. 47.	No. 48.	No. 49.	No. 50.
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
Protoxide of iron					Trace.	Trace.	Trace.				
Sesquioxide of iron	68.517	78.500	75.714	78.785	64.214	55.142	67.142	65.071	53.142	62.500	60.214
Sesquioxide of manganese	0.685	0.405	0.081	0.235	1.728	1.002	1.800	1.045	2.358	1.947	2.017
Sesquioxide of cobalt	Trace.	0.210	0.010	0.030	0.050	0.070	0.090	0.110	0.080	0.110	0.570
Alumina	2.968	1.754	1.968	0.550	2.100	1.625	1.471	3.150	5.352	3.664	1.511
Lime	0.440	0.530	0.350	0.730	0.380	0.370	0.500	0.280	0.580	0.700	0.480
Magnesia	0.349	0.227	0.216	0.281	0.396	0.138	0.183	0.360	0.756	0.558	0.388
Sulphuric acid	0.092	0.092	0.067	0.060	0.100	0.072	0.075	0.032	0.072	0.070	0.032
b Phosphoric acid	0.250	0.199	0.268	0.261	0.316	0.407	0.678	1.578	1.400	1.216	0.575
b Water and organic matter	12.190	12.440	11.760	11.222	10.812	11.078	12.004	11.660	11.468	12.360	11.838
Silicious matter	14.320	4.950	8.770	7.780	19.470	29.070	15.650	16.460	24.250	16.080	13.270
Total	99.811	99.367	99.204	99.934	99.566	99.874	99.602	99.746	99.464	99.895	100.095
Metallic iron	47.962	54.950	53.000	55.150	44.950	38.600	47.000	45.550	37.200	43.750	43.450
Metallic manganese	0.477	0.324	0.057	0.165	1.203	0.698	1.260	0.728	1.642	1.356	2.031
Sulphur	0.037	0.030	0.027	0.024	0.040	0.029	0.030	0.013	0.029	0.028	0.013
Phosphorus	0.109	0.087	0.117	0.114	0.138	0.178	0.296	0.689	0.614	0.531	0.251
Phosphorus in 100 parts iron	0.227	0.158	0.220	0.206	0.307	0.461	0.629	1.512	1.650	1.213	0.518

3. *Old Mount Pleasant* bank, near Richmond furnace. Lump- and wash-ore. Sample consisted of 445 pieces taken from pile of ore
c prepared for shipment.

4. *Beaver* bank, about 2 miles northwest of Richmond furnace. Lump- and wash-ore. Sample consisted of 450 pieces taken from pile of ore prepared for shipment.

5. *Jennings Jones'* bank, 4 miles north of Richmond furnace. Sample selected by Mr. William Burgess, consisted of 30 pieces taken from different parts of mine.

6. *Old Carrick Furnace* bank, 1¼ miles west of Fannettsburg, Metal township. Lump-ore. Sample consisted of 149 pieces taken from ore-pile at furnace.

6a. *Old Carrick Furnace* bank. Unwashed fine ore. Sample consisted of 185 pieces taken from ore-pile at furnace.

7. *Railroad* bank, about 1¼ miles west of Fannettsburgh, Metal township, 200 feet north of Old Carrick Furnace bank. Sample consisted of 78 pieces taken from ore-pile at furnace.

8. *George Weinman's* bank, 1½ mile northwest of Fannettsburgh, Metal township. Surface-ore. Sample consisted of 156 pieces taken from ore found around opening.

12. *Webster* bank (Smith, Duncan & Avery), 2 miles west-northwest of Mercersburg. Sample consisted of 83 pieces taken from ore-
d pile at bank.

13. *Squire Stinger's* old bank, 1 mile east of Loudon, Peters township. Sample consisted of 138 pieces taken from dump of five or six shafts.

14. *Garlick* bank, 2½ miles southwest of Saint Thomas. Sample consisted of 63 pieces taken from ore found around opening.

15. *Robert McCleary's* bank, 1½ mile north of Mount Hope, Quincy township. Sample consisted of 244 pieces taken from ore lying around bank.

16. *George Rook's* bank, 3 miles south of Mont Alto, or 1 mile southeast of Quincy. Sample consisted of 63 pieces taken from ore in place at different parts of the bank. Mine not in operation at date of visit. Bank about 50 feet in diameter, and from 4 to 10 feet deep.

17. *Pass Orchard* bank, 1½ mile east of Quincy, in Bissecker gap, Mont Alto estate. Sample consisted of 165 pieces taken from ore at various pits sunk prior to 1864. Bank not worked.

18. *Wyeth Douglas* bank, 1 mile northeast of Quincy, near Mount Airy. Sample, selected by Mr. A. E. Lehman, consisted of several large pieces. No fresh sample was taken from this bank, as upon examination it was thought that the above analysis, made in 1879, fairly
e represented the character of ore.

19. *David Mentzer* opening, 1½ mile southwest of Altodale (Funkstown). Sample consisted of 91 pieces selected from ore lying around openings.

20. *Smith, Duncan & Avery's* bank, 1 mile west of Mont Alto. Lump- and wash-ore. Sample consisted of 478 pieces taken from ore-pile as prepared for shipment. Mine worked by open cut. Has probably shipped over 5,000 tons ore.

21. *Mill* bank (Mont Alto Iron Company), about 300 yards west of furnace at Mont Alto. Sample consisted of 125 pieces taken from ore-pile at washer. This bank is an open excavation, 20 feet deep from surface, 60 by 80 feet. About 1,500 tons of ore mined from it prior to January, 1881.

22. *Mine No.* 3 (Mont Alto Iron Company), one-fourth mile east of Mont Alto furnace. Sample consisted of 200 pieces taken from ore in place at different parts of shaft. Mine both open and underground work. Opened prior to 1864, but idle from 1865 to 1879. Capacity, about 70 tons per day.

23. *Mine No.* 4 (Mont Alto Iron Company), three-fourths mile east-northeast of Mont Alto furnace. Sample consisted of 210 pieces taken from pile of ore mined for furnace-use at Mont Alto. This mine is both open and underground work. It has supplied over 100,000 tons of ore to Mont Alto furnace. Deepest point of work below surface, 230 feet; length of mine, 1,800 feet; width of mine, 35 feet.

24. *Mine No.* 5 (Mont Alto Iron Company), three-fourths mile east-northeast of Mont Alto furnace. Sample consisted of 75 pieces
f taken from ore lying around mine. This mine is worked both open and underground; worked to 50 feet deep from surface. Has furnished about 5,000 tons of ore.

25. *Mine No.* 8 (Mont Alto Iron Company), 1½ mile north, 38° east, from Mont Alto furnace. Sample consisted of 197 pieces taken from pile of ore at mine. Excavation 200 feet long, 50 feet wide, and 25 feet deep.

26. *Benjamin George* deposit, 1½ mile northeast of Altodale. Surface-ore. Sample consisted of 41 pieces selected from surface-ore of deposit.

27. *John Small* bank, 1¾ mile north of Mont Alto furnace; 500 yards east of the Shiery farm. Sample consisted of 74 pieces taken from ore lying around opening. Open excavation 35 feet long, 25 feet wide, and 10 feet deep. Product about 250 tons.

28. *Thomas Calliman* bank, about one-half mile east from Pond No. 1 bank. Sample consisted of 75 pieces taken from ore lying around openings. Four pits sunk on this deposit to test the quantity and quality. No large quantity mined. a

29. *Jacob Rock's* bank, 3 miles north of Mont Alto furnace. Lump- and wash-ore. Sample consisted of 288 pieces taken from pile of ore prepared for shipment. Mine worked by a shaft 105 feet deep. Has furnished about 2,000 tons of ore.

30. *Lucy* mine (Mont Alto Iron Company), 2¼ miles north from Mont Alto. Sample consisted of about 50 pieces taken from ore mined from a number of test-pits. Private analysis made for Mont Alto Iron Company, and published by permission of Mr. George B. Wiestling, superintendent.

31. *Ruth* mine (Mont Alto Iron Company), one-half mile west of the Lucy mine. Sample consisted of about 50 pieces taken from ore mined from various test-pits. Private analysis published by permission of Mr. George B. Wiestling, superintendent Mont Alto iron-works.

32. *McNeal* bank (McCormick & Co.), about 3 miles north of Mont Alto. Sample consisted of 131 pieces taken from ore lying at opening and near it. Mine not in operation.

33. *Pond No.* 2 bank, 3 miles north-northeast of Mont Alto, on Mont Alto estate. Sample consisted of 218 pieces taken from ore lying around mine. Mine not in operation at date of visit. Open excavation 110 feet by 90 feet, and about 10 feet deep. Worked prior to 1864, and ore used at Mont Alto furnace. Since 1864 a shaft was sunk and about 2,000 tons of ore mined at depth of 90 feet from surface. b

34. *Pond No.* 1 bank, 3 miles north-northeast of Mont Alto, on Mont Alto estate. Sample consisted of 175 pieces taken from ore lying around mine. Not in operation at date of visit; 163 pieces selected by Mr. George B. Wiestling since mine has been operated gave—Metallic iron, 48.500; phosphorus, 0.149; water, 11.935; silicious matter, 13.930; phosphorous in 100 parts iron, 0.306. This is an open excavation 300 by 150 feet, and varying in depth from 8 to 30 feet. Quantities of ore were mined here prior to 1864. Laid idle from 1864 until the fall of 1880, when work recommenced.

35. *English* mine, 2 miles southeast of Greenwood. Sample consisted of 138 pieces taken from ore in place at various parts of mine. Opening about 150 by 100 feet by 20 feet deep.

36. *Lime Kiln* bank, 2¼ miles north of Mont Alto furnace. Sample consisted of 125 pieces taken from ore lying around opening. Open and underground. Open work say 25 feet diameter and 8 feet deep; underground 40 feet deep. Probably about 400 tons taken from mine.

37. *Guilford* bank, 2½ miles south of Greenwood, 2½ miles northeast of Altodale, or 2½ miles north, 25° east of Mont Alto. Sample consisted of 128 pieces taken from ore lying in and around bank. Open excavation 75 feet long, 30 feet wide, and 18 feet deep. This is surrounded with probably 10 test-pits. c

38. *Hope* mine (Mont Alto Iron Company), 200 yards west of the Promise mine, or about 3 miles north, 20° east of Mont Alto. Sample consisted of about 50 pieces taken from ore-pile mined from pits to test quality. Private analysis made by me for Mont Alto Iron Company, and published by permission of Mr. George B. Wiestling, superintendent.

39. *Promise* mine (Mont Alto Iron Company), 3 miles north, 20° east from Mont Alto. Sample consisted of about 50 pieces taken from ore mined to test quality. Worked open and underground 40 feet deep. Private analysis published by permission of Mr. George B. Wiestling, superintendent of Mont Alto iron-works.

40. *White Rock* mine (Mont Alto Iron Company), 2¼ miles north, 20° east from Mont Alto. Sample consisted of about 50 pieces taken from several pits or shafts over an area of say 2,000 feet square. Private analysis published by permission of Mr. George B. Wiestling.

41. *Wiestling* mine, 3 miles north, 25° east of Mont Alto, or 1½ mile south of Greenwood. Sample consisted of 99 pieces selected from ore taken out of several pits or shafts sunk to test quantity and quality. d

42. *William L. Chamber's* opening, on farm about 1 mile north of Scotland. Sample consisted of 75 pieces taken from surface ore near shaft.

43. *Ahl's* bank, 1½ mile southwest of Shippensburg, Southampton township. Pipe-ore. Sample consisted of 115 pieces taken from ore lying around and in opening. Bank not in operation.

44. *McHose* bank (old "Neikirk" bank), 3 miles west-southwest of Shippensburg. Wash-ore. *Sample consisted of 227 pieces taken* from pile of ore at washer.

45. *Joseph Cressler* bank, about 3 miles south-southwest of Shippensburg, Southampton township. Wash-ore. Sample consisted of 878 pieces taken from pile of ore at washer.

46. *Jacob Koser* bank, about 3 miles south-southwest of Shippensburg, Southampton township. Wash-ore. Sample consisted of 325 pieces taken from pile of ore at washer. This is the same opening as the Joseph Cressler bank, but ore is mined from a higher level.

47. *Old Southampton* bank, 3 miles south of Shippensburg, on old furnace property. Owned by George H. Stewart. Leased to Moses Taylor, New York. *Sample consisted of 213 pieces taken from ore lying around mine. Bank not in operation.*

48. *Ruby* or *Plaster* bank, 3½ miles south of Shippensburg, near Old Southampton furnace. Sample consisted of 275 pieces taken from ore lying around mine. Bank not in operation. e

49. *Gochenauer & Rohrer* bank, 3 miles south of Shippensburg, on Clever farm, near Old Southampton furnace. Sample consisted of 160 pieces taken from ore lying around mine. Bank not in operation at date of visit.

50. *Means* bank, about 3 miles southeast of Shippensburg, near county line. Sample consisted of 121 pieces taken from ore dump. Bank not in operation.

Montgomery county.—Production of limonite in census year, 94,387 tons. No analyses of the limonite from this county have yet been published by the Second Geological Survey.

Chester county.—Production of limonite in census year, 5,031 tons. No analyses of this ore are available.

Lancaster county.—Production of limonite in census year, 78,850 tons. The following analyses are from Report MM, pp. 209 and 210: f

	No. 642.	No. 651.	No. 652.	No. 641.	No. 797.
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
Sesquioxide of iron	64.571	78.571	78.857	76.428	76.714
Sesquioxide of manganese	1.450	0.657	1.302	1.456	0.723
Sesquioxide of cobalt	0.185	0.130	0.047	0.066	0.045
Alumina	2.633	2.367	2.112	1.260	2.791
Lime	0.054	0.170	0.210	0.230	0.030
Magnesia	0.047	0.187	0.335	0.147	0.198
Sulphuric acid	0.008	Trace.	0.095	0.008	0.027
Phosphoric acid	1.026	0.847	0.581	0.602	1.475

	No. 642.	No. 651.	No. 652.	No. 641.	No. 642.
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
Water	10.970	12.468	12.075	12.733	13.472
Insoluble residue	10.015	4.770	4.765	7.200	4.385
Total	99.959	100.167	100.379	100.220	99.860
Metallic iron	45.200	55.000	55.200	53.500	53.700
Metallic manganese	1.010	0.457	0.908	1.015	0.504
Sulphur	0.003	Trace.	0.038	0.003	0.011
Phosphorus	0.448	0.370	0.254	0.263	0.644

a 642. *Chestnut Hill* ore-mines, about 3 miles northeast from Columbia. Mined by Chickies Iron Company in the bank of Edward B. Grubb's heirs. From eastern series of mines; one-third lump, two-thirds fine ore. Generally compact and fine-grained, but with numerous cavities filled with ochreous iron ore. Bombshell ore lined with fibrous, botryoidal brown oxide of iron. Fine ore carries considerable quartz.

651. *Chestnut Hill* ore-mines; mined by Chickies Iron Company in the bank of Edward B. Grubb's heirs. All lump-ore. Stalactites; bombshell ore, with fibrous, botryoidal brown oxide of iron. Specimens show some specks of quartz. Color, generally dark brown.

652. *Chestnut Hill* ore-mines; Clement B. Grubb's bank. All lump-ore. A mixture of bombshell ore, with walls of shell lined with fibrous iron oxide with velvety surface; and cellular, dull earthy-looking ore. Portions of the ore have a distinctly laminated structure. Generally coated with a yellowish-white clay.

641. *Chestnut Hill* ore-mines; Chestnut Hill Iron Company's bank; C. J. Nourse, superintendent. One-fourth fine ore; three-fourths lump-ore. Nodular; stalactitic; bombshell; with considerable fibrous brown oxide of iron. Color, generally dark brown. Some masses of
b quartz throughout specimens.

797. *Chestnut Hill* ore-mines; float-ore from Chestnut Hill Iron Company's bank. Fibrous, brittle; dark brown.

York county.—The limonites of York county are of more than one age. Some of the deposits occur at the contact of the slates and limestones of Formation II, while others are the "decomposed outcrops of the ferriferous beds in the Azoic rocks". In Report MM, Mr. McCreath has collected their analyses under a different heading from that of the limonites of Formation II; but it appears from the position of the mines that the greater part of the limonite produced in this county in the census year came from this formation, so that in these notes it seems as well to include them under this head. York county produced 28,165 tons of limonite in the census year. The following notes and analyses are from Report MM, pp. 220 to 221, and Report M³, pp. 24 to 26:

c

	No. 111.	No. 353.	No. 429.
	Per cent.	*Per cent.*	*Per cent.*
Sesquioxide of iron	65.000	60.857	56.143
Sesquioxide of manganese	1.712	2.038	0.201
Alumina	2.365	1.912	2.321
Lime	0.390	0.160	0.140
Magnesia	0.356	0.407	0.324
Sulphuric acid	0.105	0.057	0.073
Phosphoric acid	3.295	2.691	0.616
Water	11.790	11.560	6.286
Insoluble residue	14.880	19.115	34.330
Total	99.883	99.397	100.434
Metallic iron	45.500	42.600	39.300
Manganese	1.192	1.337	0.139
Sulphur	0.042	0.023	0.027
Phosphorus	1.439	1.175	0.269

d

111. *Henry L. Bauman's* ore-bank, one-half mile east of York Road station, Hanover Junction railroad. *Sprenkel's* opening. See Report C, p. 39. Arenaceous, seamed with quartz; dark brown. (D. McC.)

353. *Henry L. Bauman's* ore-bank, one-eighth mile east of York Road station, Hanover Junction railroad. *Kraber & Ness'* opening. See Report C, p. 40. Arenaceous, brittle; seamed with quartz; ore carries considerable argillaceous slaty gangue. Color, generally dark brown.

c 429. *Bollinger's* bank, at Kaufman's siding, one-fourth mile east from York Road station, Hanover Junction railroad. See Report C, p. 38. Compact, brittle; carries a large amount of adhering yellow and white clay. Color, various shades of red and brown.

Adams county.—Only 560 tons of iron ore was produced in this county in the census year. This was limonite, and was mined near Littlestown; it probably belongs to Formation II.

Clinton county.—No ore was mined in this county in the census year. The following analyses are from Report M³, p. 44. The ore is referred, provisionally, to Formation II:

f

	No. 136.	No. 137.		No. 136.	No. 137.
	Per cent.	*Per cent.*		*Per cent.*	*Per cent.*
Sesquioxide of iron	77.071	74.785	Water and organic matter	12.650	11.978
Sesquioxide of manganese	0.030	0.030	Silicious matter	8.380	9.780
Sesquioxide of cobalt	Trace.	Trace.	Total	99.045	100.003
Alumina	0.593	2.053			
Lime	0.630	0.640	Metallic iron	53.950	52.350
Magnesia	0.468	0.508	Metallic manganese	0.021	0.021
Sulphuric acid	0.087	0.097	Sulphur	0.035	0.039
Phosphoric acid	0.036	0.132	Phosphorus	0.016	0.058
			Phosphorus in 100 parts iron	0.029	0.110

136. *Salona* ore-bank, Nittany valley, Porter township. Lump- (kidney) ore.

137. *Salona* ore-bank, Nittany valley, Porter township. Wash-ore. Limonite, botryoidal; dark brown; small masses of quartz throughout specimens.

Centre county.—Product in census year, 8,935 tons. The ore was mined principally from the vicinity of the Eagle and Howard furnaces. The following analyses, from Report T_4, pp. 142 and 178, show the character of the census year's product. a

	No. 1.	No. 2.
	Per cent.	*Per cent.*
Sesquioxide of iron	56.642	75.821
Sesquioxide of manganese	0.288	0.258
Alumina	1.470	0.850
Lime	2.520	0.500
Magnesia	1.131	0.724
Sulphuric acid	0.052	0.077
Phosphoric acid	0.236	0.320
Water	10.932	12.340
Insoluble residue	24.020	9.330
Total	100.201	100.220
Iron	41.750	53.075
Manganese	0.201	0.180
Sulphur	0.021	0.031
Phosphorus	0.103	0.144
Phosphorus in 100 parts iron	0.246	0.271

b

1. *Curtin Brothers' Fishing Creek* bank. Sample consisted of 10 pounds of ore, and was collected in 1881. c
2. *Howard* bank, three-eighths of a mile northeast of Hecla. Sample consisted of 20 pounds of ore.

Huntingdon county.—Limonite has been mined in this county at the following geological horizons: Siluro-Cambrian (Formation II), Medina (Formation IV), Lower Helderberg and Oriskany (Formations VI and VII), Marcellus (Formation VIII), and Mauch Chunk Red Shale (Formation XI). In the census year a total of 10,186 tons were produced, and of this 10,080 tons were mined in Warriors' Mark township (in the northeastern corner of the county) from the Siluro-Cambrian. Reference will be made hereafter to the ores of the younger formations.

Blair county.—In this county, as in Huntingdon, limonite occurs at several geological horizons. The ores of Formation II are, however, by far the most important; and, with the exception of 6,720 tons from the S. C. Baker mine, in Logan township, from the Lower Helderberg limestone, it is probable that no limonite was mined in the census year in this county from any other horizon. In the census year 114,278 tons of limonite were produced in the county. The following notes and analyses are from Report MM, pp. 199 to 206: d

	No. 565.	No. 566.	No. 567.	No. 788.	No. 789.	No. 603.	No. 466.	No. 640.	No. 644.	No. 639.	No. 583.	No. 468.
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
Sesquioxide of iron	60.000	65.571	69.428	79.714	80.428	78.428	78.428	62.714	70.143	72.857	75.571	78.143
Bisulphide of iron												0.024
Sesquioxide of manganese	3.517	0.033	0.270	0.061	0.184	0.102	0.356	0.345	0.123	0.173	0.081	0.103
Sesquioxide of cobalt				None.	None.	Trace.	Trace.	Trace.	Trace.	Trace.		Trace.
Alumina	2.321	3.796	1.891	1.320	1.636	2.204	1.886	2.655	2.069	3.239	3.426	2.146
Lime	0.270	0.390	0.270	0.260	0.460	0.050	0.030	0.350	0.020	0.320	0.680	0.030
Magnesia	0.398	0.302	0.010	0.392	0.598	0.511	0.097	0.292	0.158	0.338	0.073	0.493
Sulphuric acid	0.102	0.091	0.092	0.030	0.050	0.025	0.060	Trace.	Trace.	Trace.	Trace.	0.147 e
Phosphoric acid	0.822	2.153	1.021	0.224	0.286	0.174	0.306	0.311	0.238	0.504	0.513	0.137
Water	11.188	12.020	12.304	11.050	11.700	11.958	11.248	10.113	10.218	11.391	12.595	11.886
Insoluble residue	20.590	15.030	13.660	7.560	5.165	5.700	7.410	23.450	17.240	11.325	7.010	6.845
Total	99.218	99.786	99.615	100.611	100.507	99.152	99.911	100.230	100.204	100.147	100.549	99.954
Metallic iron	42.000	44.500	48.600	55.800	56.300	54.900	54.900	43.900	49.100	51.000	52.900	54.710
Metallic manganese	2.449	0.650	0.191	0.043	0.128	0.072	0.248	0.240	0.085	0.120	0.057	0.072
Sulphur	0.065	0.036	0.037	0.012	0.020	0.010	0.024	Trace.	Trace.	Trace.	Trace.	0.072
Phosphorus	0.359	0.040	0.446	0.098	0.125	0.076	0.178	0.136	0.104	0.220	0.224	0.060

565. *Henrietta* mines, 4 miles southeast from Martinsburg. Mine No. 1; the large open cut. Sample taken from washed-ore pile. Ore from top of Formation No. II in Utica slate. Nearly all fine ore; sandy, brittle; dark brown.

566. *Falkner* ore-shaft, south of Henrietta mine, in Leathercracker Cove. Lump-ore taken from pile. Top of Formation No. II. f
Compact, botryoidal, with velvety surface; light brown and reddish brown.

567. *Hoover* bank, 1 mile south of Henrietta main mine. Hoover open cut. Top of Formation No. II. Compact, with laminated structure; also cellular, with considerable yellow and white clay in cells; color, dark brown and reddish brown.

788. *Robeson Farm* ore-bank, 2 miles south-southwest from Birmingham station. Outcrop-ore. Cellular, brittle; dark brown and yellowish-brown. Some masses of quartz throughout specimens.

789. *Clark Farm* ore-bank, near Etna furnace. Cellular, brittle; dark brown.

603. *Ore bank* near Etna furnace, Catherine township, Canoe valley. Stalactitic, botryoidal; somewhat coated with a yellowish clay; color, generally dark brown.

466. *Short Mountain* mines, Catharine township, 1¼ miles northwest from Franklin forge. Etna Iron-Works; Isett & Brothers. Compact; also cellular, botryoidal, mammillary, with radiated, fibrous, brown oxide. Generally hard and tough, with light and dark brown color.

a	No. 467.	No. 526.	No. 525.	No. 643.	No. 604.	No. 606.	No. 607.	No. 612.	No. 963.	No. 973.	No. 608.	No. 609.
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
Sesquioxide of iron	84.428	73.714	52.428	74.143	65.713	78.000	77.143	76.214	59.428	69.857	72.143	51.571
Bisulphide of iron	0.004	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Sesquioxide of manganese	0.368	0.610	1.344	0.205	0.551	0.195	0.093	0.011	1.758	0.509	1.273	0.548
Sesquioxide of cobalt	Trace.	Trace.	.....	.....	.....	Trace.	.....	.....	.....	.....	0.011	Trace.
Alumina	2.617	1.970	2.042	3.010	3.908	2.348	2.438	2.491	3.024	3.176	2.457	3.906
Lime	0.070	Trace.	Trace.	0.150	0.240	0.220	0.130	0.020	0.080	0.130	0.170	0.075
Magnesia	0.227	0.309	0.129	0.255	0.260	0.396	0.464	0.386	0.331	Trace.	0.457	0.209
Sulphuric acid	0.237	0.072	0.075	Trace.	0.115	0.102	0.041	0.020	0.062	0.138	0.195	0.057
Phosphoric acid	0.123	0.137	0.080	0.238	0.219	0.462	0.194	0.259	0.128	0.057	0.103	0.185
b Water	8.672	10.510	9.375	10.805	11.876	11.880	10.104	12.486	8.795	10.280	11.276	9.811
Insoluble residue	3.400	12.260	34.700	11.360	17.500	6.805	9.260	7.470	25.855	16.350	11.970	32.890
Total	100.206	99.501	100.173	100.295	100.382	100.408	99.927	99.357	99.461	100.497	99.995	99.282
Metallic iron	59.100	51.600	36.700	51.900	40.000	54.600	54.000	53.350	41.600	48.900	50.050	36.100
Metallic manganese	0.256	0.425	0.936	0.181	0.384	0.136	0.065	0.007	1.224	0.353	0.886	0.382
Sulphur	0.096	0.029	0.030	Trace.	0.046	0.041	0.017	0.008	0.025	0.055	0.054	0.023
Phosphorus	0.054	0.060	0.035	0.104	0.096	0.202	0.085	0.113	0.056	0.025	0.045	0.081

640. *Brower* mine, 2½ miles northwest of Williamsburg. Compact, fine-grained, jaspery, brittle; reddish-brown and liver-brown.

644. *Patterson* mine, 1 mile south from Williamsburg. Compact, brittle, arenaceous, with masses of quartz throughout the specimen.

c Color of ore, dark brown.

639. *Red Bank* mine, 2 miles south from Williamsburg. Generally cellular, with cells partially filled with reddish-brown ochreous earth. Comparatively soft; reddish brown, showing spangles of quartz.

583. *Dean's* mine, 2 miles southeast of Williamsburg, Woodberry township. Cellular, with cells filled with a yellow clay; generally dark brown. (D. McCreath.)

468. *Springfield* mines, 1 mile south of Springfield. Bank No. 3, two-thirds of a mile west of bank No. 2. Lump- and wash-ore. Nodular, cellular, with cells partially filled with a yellow clay. Shows small kernels of pyrite, without crystalline form; also rhombic dodecahedron crystals of hydrous iron oxide. Color of ore generally dark-brown.

467. *Springfield* mines, bank No. 2, Lykens mine, one-half mile south of bank No. 1. Bombshell-ore. Bombshell-ore, the bombs partially filled with clay and lined with fibrous, botryoidal iron oxide. Exceedingly hard and tough; dark brown and reddish brown.

526. *Springfield* mines, bank No. 2. Ore as taken from washer and used by Cambria Iron Company. Specimen consists of small masses of brown hematite iron ore with admixture of bombshell-ore. (D. McCreath.)

525. *Springfield* mines, bank No. 1, generally known as Davis' bank. At north end of line of mines. Wash-ore. Lump- and fine-

d ore; structure of lumps somewhat laminated. Fine ore carries considerable quartz. (D. McCreath.)

643. *McPheese* bank, 1½ mile south of Springfield. Brittle, argillaceous; somewhat cellular; dark brown and reddish brown.

604. *Rebecca* mine, 4 miles northeast of Henrietta post-office. Brittle, arenaceous; cellular, with cells lined with göthite; considerable adhering white clay. Color of ore generally light brown.

606. *Thompson* mine, 2 miles west from Fredericksburg. Cellular, nodular, brittle; dark brown.

607. *Red Ore* bank, one-third mile from Millerstown. Ore for the most part coated with a reddish-brown clay; exceedingly hard and tough. On fresh fracture the color is dark brown.

612. *Soister* mine, 3½ miles north from Woodberry, near county line. Abandoned mines. Exceedingly hard and tough; generally very compact; carries considerable quartz. Color, various shades of dark brown, reddish brown, and vermilion.

963. *Sarah Furnace* ore-bank (Springfield mines), about 2 miles south of Springfield. Hard and tough, with considerable quartz; color dark brown and brownish black; fracture irregular, rough.

973. *Sarah Furnace* ore-bank, about 2 miles south of Springfield. So-called "burnt ore." Somewhat cellular, with considerable

e quartz; dark brown to reddish brown. (S. S. Hartranft.)

608. *Bloomfield* mines, about 3 miles south from Roaring Springs. Lump-ore. Generally compact; also cellular and bombshell, the walls of the bomb lined with fibrous, botryoidal iron ore. Color, light and dark brown. Considerable adhering yellowish-white clay.

609. *Bloomfield* mines, about 3 miles south of Roaring Springs. Wash-ore. Specimens consist of a mixture of small masses of brown hematite iron ore, with a considerable amount of argillaceous iron ore, ferruginous clay, and quartz pebbles.

	No. 708.	Percentages.
	Per cent.	
Sesquioxide of iron	75.071	= 52.550 per cent. iron.
Binoxide of manganese	3.760	= 3.004 per cent. manganese.
Protoxide of manganese	0.779	
Sesquioxide of cobalt	0.030	
Alumina	2.678	
Lime	0.240	
Magnesia	0.295	
Sulphuric acid	0.182	= 0.073 per cent. sulphur.
Phosphoric acid	0.071	= 0.031 per cent. phosphorus.
Water	13.330	
Insoluble residue	3.948	
Total	100.324	

f

708. *Bloomfield* mines, about 3 miles south from Roaring Springs. Bombshell-ore. Bombshell-ore, the walls of the shell lined with nodular lumps, consisting mainly of oxide of manganese. The ore is generally fibrous and brittle; also partially foliated, with irridescent surface. a

	No. 709a.	No. 709b.
	Per cent.	*Per cent.*
Iron	22.700	40.250
Manganese	37.611	11.870
Sulphur	0.018	0.015
Phosphorus	0.043	0.033
Alumina	1.144	1.050
Lime	0.470	0.157
Magnesia	0.271	0.210
Silica	2.850	11.360

b

709a. *Bloomfield* mines, about 3 miles south of Roaring Springs. Manganese ore. Hard and tough; minutely crystalline; steel gray.
709b. *Bloomfield* mines. Manganese ore. Analysed for Pennsylvania Steel Company in 1874, and published by permission.

Analyses of Bloomfield wash-ore made for Pennsylvania Steel Company, and published by permission.

Date of analysis.	Iron.	Phosphorus.
	Per cent.	*Per cent.*
July, 1873	32.25	0.053
March, 1874	39.06	0.041
April, 1874	33.50	0.039
April, 1874	35.00	0.059
May, 1874	36.60	0.053
Average	35.28	0.049

c

Bedford county.—The principal ore of this county is the fossil ore of Formation V; but some deposits of limonite of Formation II exist, though none were worked in the census year. The character of the ore is shown by the following analyses from Report MM, p. 206:

d

	No. 613.	No. 605.
	Per cent.	*Per cent.*
Sesquioxide of iron	56.214	80.000
Sesquioxide of manganese	0.073	0.207
Sesquioxide of cobalt	None.	Trace.
Alumina	4.855	3.069
Lime	0.015	0.310
Magnesia	0.335	0.562
Sulphuric acid	0.012	0.082
Phosphoric acid	0.451	0.201
Water	10.390	12.106
Insoluble residue	27.960	3.970
Total	100.305	100.507
Metallic iron	39.350	56.000
Metallic manganese	0.050	0.144
Sulphur	0.005	0.033
Phosphorus	0.197	0.088

e

613. *Baker's* mine, 1 mile south from Bloomfield furnace. Cambria Iron Company. Brittle, sandy, argillaceous; generally compact; dark brown and liver-brown.
605. *R. Hoover's* mine, 1 mile north from Woodberry. Surface pipe-ore. Stalactitic, brittle, dark-brown. Considerable yellow clay in cells. f

LIMONITE ORES IN THE HUDSON-RIVER SLATES (FORMATION No. III).

In the preface to Report M³, Mr. McCreath thus refers to these ores: "There are found near Mercersburg, and at other localities in Franklin county, important deposits of *bog-ore*, which are now being quite extensively worked, From 1876 to 1880 nearly 10,000 tons of this ore were mined, nearly 4,000 tons of it during 1880. The ore is generally found in the slates of Formation No. III, and has evidently resulted from the decomposition of iron pyrites.

a the large percentage of sulphuric acid which they invariably contain going to confirm this view. They are characterized by an almost uniformly *low percentage of phosphorus*, and by being practically free from manganese."

The following analyses are from Report M³, pp. 1 and 3:

Franklin county.	No. 2.	No. 9.	No. 10.	No. 11.
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*
Protoxide of iron	0.337	0.176	0.192	0.128
Sesquioxide of iron	57.554	50.090	58.142	50.928
Sesquioxide of manganese	Trace.	Trace.	Trace.	Trace.
Sesquioxide of cobalt	Trace.	Trace.	Trace.	Trace.
b Alumina	2.100	5.700	3.049	5.520
Lime	0.120	0.300	0.720	0.640
Magnesia	0.115	0.342	0.371	0.421
Sulphuric acid	0.925	0.872	0.742	0.887
Phosphoric acid	0.082	0.105	0.084	0.199
Water and organic matter	14.518	13.896	15.378	14.680
Silicious matter	24.530	27.840	20.030	26.720
Total	100.281	99.411	99.508	100.123
Metallic iron	40.550	35.200	40.850	35.750
Metallic manganese	Trace.	Trace.	Trace.	Trace.
c Sulphur	0.370	0.349	0.297	0.355
Phosphorus	0.036	0.046	0.037	0.087
Phosphorus in 100 parts iron	0.088	0.130	0.090	0.243

2. *Richmond* furnace bog-bank, about 1 mile northwest of furnace. Bog-ore of III. Sample consisted of 79 pieces taken from ore-pit at different places.

9. *Leib* bank (J. S. Whitmer & Co.), 2 miles east of Mercersburg. Bog-ore in III. Sample consisted of 94 pieces taken from ore-pile.

10. *Jacob Stouffer's* bank, 1 mile east of Mercersburg, Montgomery township. Bog-ore in III. Sample consisted of 129 pieces taken from ore-pit at different places.

11. *R. P. McFarland's* bank, 1½ mile east of Mercersburg, Peters township. Bog-ore in III.

LIMONITE ORES OF THE MEDINA FORMATION.

d Regarding these ores Mr. McCreath says, in Report MM, p. 198:

Some of the sandstones of the Medina are highly ferruginous, and blocks coated with a crust of limonite sometimes line the crest of the mountains of IV. Local deposits of a coarse limonite are sometimes found along the outcrop, but are never of much value.

West of Orbisonia, in Huntingdon county, a large deposit of limonite fills a cross fissure in the top of the Black Log mountain. (See F, p. 257.)

Huntingdon county.	No. 94.	No. 93.	No. 97.
	Per cent.	*Per cent.*	*Per cent.*
e Iron	35.500	40.700	44.700
Manganese	3.566	2.260	.....
Sulphur	None.	None.	0.031
Phosphorus	0.478	0.709	0.197
Insoluble residue	29.575	18.100	18.820

94. Iron ore found scattered upon the terrace of the northwest side of Black Log mountain, 1 mile southwest from Beaver gap, and 7 miles from Fort Littleton. (See F, p. 239.) Compact, brittle, sandy; dark brown and reddish brown.

93. Same ore, from the surface on Alexander Ramsey's property, 4 miles northeast from Fort Littleton. (See F, p. 139.) Hard, arenaceous, somewhat cellular; color, various shades of light and dark brown.

97. *William Stambach's* ore-opening, 5 miles northeast from Fort Littleton, on the northwest side of Black Log mountain. (See F, p. 128.) Cellular; the cells for the most part filled with yellow clay; brittle, and of a light-brown color. (D. McCreath.)

f LIMONITE ORES OF THE LOWER HELDERBERG AND ORISKANY FORMATIONS.

The following notes and analyses of these ores are from Report MM, pp. 196 to 198, and Report M³, pp. 33 and 34:

Accumulations of limonite, quite local and usually insignificant, but sometimes, as at Blair's and Baker's mines in Blair county, of vast width and depth, occur along the many outcrops of the Oriskany sandstone and Lewistown limestone in middle Pennsylvania. For a description of some of these, see Report F, 1878, and Report T, 1879.

713. *Baker's* ore-bank, at Blair furnace, near Altoona. Pipe-ore. Formation No. VI. Brittle, dark-brown pipe-ore; somewhat coated with a yellow clay; pipes very distinct.

728. *Baker's* ore bank, at Blair furnace, near Altoona. Pipe-ore. Brittle, dark-brown pipe-ore; pipes somewhat obliterated.

729. *Baker's* ore-bank, at Blair furnace, near Altoona. Limonite, cellular, brittle, dark brown.

Blair county.	No. 713.	No. 728.	No. 729.	No. 714.
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*
Sesquioxide of iron	83.071	83.000	68.286	67.214
Sesquioxide of manganese	0.350	0.312	1.405	0.985
Sesquioxide of cobalt	Trace.	Trace.	0.116	0.102
Alumina	2.124	1.980	3.534	4.440
Lime	0.215	0.210	0.220	0.290
Magnesia	0.312	0.302	0.456	0.479
Sulphuric acid	0.115	0.127	0.257	0.282
Phosphoric acid	0.455	0.673	0.660	0.506
Water	11.772	12.314	11.950	9.660
Insoluble residue	1.675	1.430	13.630	16.120
Total	100.089	100.348	100.454	100.078
Metallic iron	58.150	58.100	47.800	47.050
Metallic manganese	0.244	0.217	0.978	0.685
Sulphur	0.046	0.051	0.103	0.113
Phosphorus	0.199	0.294	0.262	0.221

714. *Baker's* ore-bank, at Blair furnace, near Altoona. Bombshell-ore. Hard, tough, arenaceous; dark brown and liver-brown. The walls of the bombs are coated with a sandy clay of a pinkish-gray color.

Perry county.	No. 108.
	Per cent.
Sesquioxide of iron	60.928
Sesquioxide of manganese	0.100
Alumina	*a* 3.746
Lime	0.660
Magnesia	0.216
Sulphuric acid	0.155
Phosphoric acid	0.185
Water and organic matter	9.390
Silicious matter	24.620
Total	100.000
Metallic iron	42.650
Metallic manganese	0.070
Sulphur	0.062
Phosphorus	0.081
Phosphorus in 100 parts iron	0.189

a By difference.

108. *Rinesmith's* mine, 1 mile southwest of Rinesmith's farm, in Sandy Hollow, northeast of Gibson rock. Brown hematite of VII. Hard and compact; some portions of sample shaly; irridescent; carries some adhering yellow clay; various shades of brown. (J. M. S.)

LIMONITE ORES OF THE DEVONIAN—CHIEFLY OF THE MARCELLUS FORMATION.

A continuous outcrop of more or less ferriferous calcareous clay-bed runs through the middle counties of Pennsylvania, carrying, on Yellow creek, in Blair county, on Aughwick creek, in Huntingdon county, and on the affluents of the Juniata river, in Juniata and Perry counties, large deposits of brown hematite, the full width of the bed, which sometimes amount even to 20 or 25 feet. Slopes are sunk on the bed to depths of 100 or 200 feet in the ore, when nuts and masses of rough carbonate replace the limonite, and, finally, further down, the whole bed turns to a dark pyritous clay. For descriptions, see Report of Progress F.—(Report MM, p. 193.)

Perry county.—In this county 12,734 tons of limonite were mined in the census year, the greater part, if not the whole, of which came from the Marcellus ore-bed, "which underlies the black slates of No. VIII, and overlies the green calcareous shales. Although the thickness of the ore-deposit is extremely variable, yet a large quantity of ore has been mined at different localities from this horizon. The quality is usually quite good, the ore being almost uniformly low in its contents of phosphorus. A small quantity of ore has also been mined in the *Corniferous shales;* but the quality of the ore is usually inferior, although occasional deposits are met with which are quite rich in iron" (Report M³, pp. 29 and 30). The following notes and analyses are from Report M³, pp. 32 and 33:

100. *Washer* ore-pit, about 2 miles southwest from Newport, on Limestone ridge. From the clay in the ore-pit near the surface. Corniferous brown hematite. Generally compact and fine-grained; appearance, shaly; color, reddish brown.

101. *Washer* ore-pit, about 2 miles southwest from Newport, on crest of Limestone ridge, at Newport and Duncannon road. In synclinal of Oriskany sandstone, in the upper part of the Corniferous shale. Corniferous brown hematite. Compact and fine-grained; dark brown and reddish brown; some of the ore has a shaly appearance.

a

	No. 100.	No. 101.	No. 102.	No. 103.	No. 104.
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
Sesquioxide of iron	50.285	61.143	62.000	59.500	54.214
Sesquioxide of manganese	0.051	0.072	0.072	0.120	0.083
Alumina	*a* 5.101	2.037	4.191	*a* 5.072	2.044
Lime	1.070	0.050	0.090	0.720	0.090
Magnesia	0.342	0.288	0.324	0.324	0.327
Sulphuric acid	Trace.	0.107	0.135	0.100	0.047
Phosphoric acid	0.146	0.176	0.270	0.469	2.072
Water and organic matter	7.465	0.980	9.925	10.495	8.065
Silicious matter	35.540	24.040	22.570	23.260	31.870
Total	100.000	99.093	100.096	100.000	99.332
Metallic iron	35.200	42.800	43.400	41.650	37.950
Metallic manganese	0.035	0.050	0.050	0.083	0.058
Sulphur	Trace.	0.043	0.054	0.040	0.019
Phosphorus	0.064	0.077	0.122	0.205	0.905
Phosphorus in 100 parts iron	0.181	0.179	0.281	0.492	2.384

a By difference.

102. *Washer* ore-pit, about 2 miles southwest from Newport, on crest of Limestone ridge. Corniferous brown hematite. Appearance, sandy; very brittle; dark brown and yellowish brown.

c 103. *Limestone Ridge Mining Company*, 2 miles from Newport, on Limestone ridge; east end of long ore-pit, east of Washer ore-pit. Corniferous brown hematite. Bombshell-ore, with considerable clay in bomb; very brittle; color dark brown.

104. *Limestone Ridge Mining Company;* from first opening northeast of east ore-pit; on crest of Limestone ridge, south of Newport; on the road leading off from the Newport and Bailey Station road. In the synclinal of the Oriskany sandstone. A few hundred tons mined by the Limestone Ridge Mining Company. Corniferous brown hematite. Generally compact and fine-grained; somewhat shaly; dark brown.

Juniata county.—All the ore mined in this county in the census year was reported to be fossil-ore. The Devonian limonite exists, but it was apparently not worked.

Mifflin county.—This county produced 24,366 tons of limonite in the census year, which presumably was all mined from the Devonian. The following notes and analyses are from Report M, p. 64:

d

	II.
	Per cent.
Iron	42.500
Sulphur	0.044
Phosphorus	0.078
Insoluble residue	23.800

II. *McVeytown Gap*, Ross ore-opening. Ore from upper opening. Limonite, compact, argillaceous; of a light-brown color.

Huntingdon county.—The following notes and analyses are from Report M, pp. 66 to 68; Report MM, p. 194; Report M³, p. 40:

e

	XV.	XVI.	XVII.	XVIII.	XIX.
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
Iron	47.500	47.500	47.300	45.000	51.700
Sulphur	Trace.	0.013	Trace.	0.032	0.023
Phosphorus	0.402	0.111	0.491	0.187	0.068
Insoluble residue	17.260	14.100	17.900	26.580	10.490

XV. *Lane* ore-bank, Hill valley, 5 miles northwest from Orbisonia. Ore in Oriskany sandstone, lower portion Chestnut ridge. Lane property. Limonite, sandy, with large admixture of ochreous earth.

XVI. *Hick's* ore-bank, between Logan ore-bank and Stewart's ore, 5 miles from Orbisonia, Chestnut ridge. Rockhill Coal and Iron Company. Limonite, cellular, cells for the most part filled with ochreous ore.

f XVII. *Douglas* ore-bank, opposite Lane ore-bank, 5 miles northwest from Orbisonia. Limonite, compact, silicious and cellular.

XVIII. *Mountain* ore-bank, 4 miles southwest from Orbisonia, in crevice of Medina sandstone, Blacklog mountain. Rockhill Coal and Iron Company. Limonite, compact, botryoidal, somewhat cellular; color, various shades of brown.

XIX. *Sandy Ridge* ore, 2 miles north from Orbisonia. Rockhill Coal and Iron Company. Limonite, very hard and compact, containing considerable ochreous iron ore; dark-brown color.

	No. 563.	No. 125.	No. 126.
	Per cent.	*Per cent.*	*Per cent.*
Protoxide of iron	25.714	.....	.....
Sesquioxide of iron	27.000	53.857	66.571
Bisulphide of iron	0.429	.....	.....
Sesquioxide of manganese	0.289	0.275	0.510
Sesquioxide of cobalt	0.580	.....	.....
Alumina	2.002	*a* 2.861	*a* 1.606
Lime	1.143	0.090	0.710
Magnesia	0.832	0.313	0.285
Sulphuric acid	0.502	0.100	0.075
Phosphoric acid	0.137	0.114	0.323
Carbonic acid	15.938	.....	.....
Carbonaceous matter	2.681	.....	.....
Water	6.460	.....	.....
Water and organic matter	.....	13.200	13.580
Silicious matter	.....	28.500	16.940
Insoluble residue	16.211	.....	.....
Total	99.918	100.000	100.000
Metallic iron	30.100	37.700	46.600
Metallic manganese	0.201	0.191	0.355
Sulphur	0.430	0.076	0.080
Phosphorus	0.060	0.050	0.141
Phosphorus in 100 parts iron	.....	0.132	0.302

a By difference.

563. *McCarthy's* ore-bank, near Saltillo. Marcellus iron ore. See F, p. 237. Altered carbonate ore; generally compact, with laminated structure. Color, various shades of brown.

125. Property of Dr. J. A. Shade, 2 miles southwest from Shade gap, Shade valley. Outcrop of Marcellus ore-bed. Brittle; cellular; full of seams of ochreous iron ore; color, generally light brown. Ore carries a large amount of carbonaceous matter.

126. Property of Isaac Taylor, 3 miles southwest from Shade gap. Marcellus ore-bed. Cellular; brittle; light and dark brown; ore carries considerable carbonaceous matter.

Fulton county.—The following analysis is from Report M³, p. 42:

	No. 132.
	Per cent.
Sesquioxide of iron	66.428
Sesquioxide of manganese	0.132
Alumina	*a* 2.024
Lime	0.720
Magnesia	0.270
Sulphuric acid	0.170
Phosphoric acid	0.121
Water and organic matter	11.315
Silicious matter	18.820
Total	100.000
Metallic iron	46.500
Metallic manganese	0.092
Sulphur	0.068
Phosphorus	0.053
Phosphorus in 100 parts iron	0.113

a By difference.

132. From the land of P. Awl & Brother, on the northwest side of Sidney Knob, three-fourths of a mile northwest of Burnt Cabins. Marcellus brown hematite. Generally fine-grained and compact; hard and brittle; color various shades of dark brown and reddish brown.

a *Franklin county.*—The following analysis is from Report M³, p. 1:

	No. 1.		No. 1.
	Per cent.		*Per cent.*
Protoxide of iron	None.	Water and organic matter	11.754
Sesquioxide of iron	67.142	Silicious matter	17.280
Sesquioxide of manganese	0.589	Total	100.389
Sesquioxide of cobalt	0.390		
Alumina	1.998	Metallic iron	47.000
Lime	0.500	Metallic manganese	0.410
b Magnesia	0.252	Sulphur	0.116
Sulphuric acid	0.290	Phosphorus	0.085
Phosphoric acid	0.194	Phosphorus in 100 parts iron	0.180

1. *Bower's Furnace* ore-bank, on Mrs. Eliza Furray's farm, 9 miles southwest of Mercersburg, Warren township. Brown hematite of VIII.

LIMONITE ORES OF THE MAUCH CHUNK RED SHALE.

The following note is from Report MM, p. 192:

These ores are merely the decomposed outcrops of beds of carbonate ore underlying the conglomerate. Only one specimen has thus far been analyzed.

c

Huntingdon county.	No. 949.
	Per cent.
Iron	25.240
Sulphur	0.029
Phosphorus	0.100
Insoluble residue	48.240

949. *Jos. Diggin's* ore-opening, 1¼ mile east of Broad Top City. Hard, botryoidal; yellowish brown to dark brown. (S. S. Hartzanft.)

IV. CARBONATE ORES.

d

The limonite ores of the Coal Measures occur along the outcrops of limestone-beds, and are, in general, simply the weathered outcrops of seams of carbonate ore. In classifying the output of iron ore in the census year, it was found impossible to separate the altered from the unaltered ores of the Coal Measures, and they will be referred to in these notes under the comprehensive heading of *Carbonate Ores of the Coal Measures and their Derivatives.* The older carbonate ores will, however, be first considered.

CARBONATE ORES OF THE SILURO-CAMBRIAN FORMATION.

The following, in regard to these ores, is from Report MM, pp. 187 and 188:

One theory of the origin of the limonites of our limestone valley derives them from intercalated beds of carbonate of iron and lime;
e and this view is supported by the frequent presence of rough carbonate of iron below or back of outcrop deposits of limonite in the beds of the Hamilton No. VIII, limiting the practical working of the limonite to a certain depth beyond which it does not exist.

Such carbonates have been found in the limestones of No. II, on the surface of which such vast accumulations of limonite exist, as at Ironton, Trexlerville, Moselem, Pine Grove, Mount Alto, Pennsylvania furnace, Springfield, Bloomfield, etc.

Northampton county.	No. 995.	Percentages.
	Per cent.	
Protoxide of iron	54.385	=43.050 per cent iron.
Sesquioxide of iron	1.071	
Protoxide of manganese	3.254	=2.521 per cent. manganese.
Protoxide of cobalt	0.010	
f Alumina	1.457	
Lime	0.540	
Magnesia	0.540	
Sulphuric acid	0.112	=0.045 per cent. sulphur.
Phosphoric acid	0.263	=0.115 per cent. phosphorus.
Carbonic acid	35.310	
Water (by difference)	0.923	
Insoluble residue	2.105	
Total	100.000	

995. *Saucon Iron Company's Wharton* mine, 2 miles east of Hellertown, Northampton county. Carbonate ore from shaft 126 feet deep. See analysis of limonite from this mine, § 13, No. 967. Fine-grained; hard and tough; fracture, conchoidal, inclining to rough; color, teel-gray on fresh surface.

CARBONATE ORES OF THE MARCELLUS FORMATION.

It is from these ores that the limonites of this formation are derived; on sinking through a seam of limonite a the carbonate is invariably encountered. The following notes and analyses are from Report M, pp. 70 and 71, and Report M³, pp. 31 and 39:

Mifflin county.	I.	II.
	Per cent.	*Per cent.*
Iron	33.500	42.500
Sulphur	0.734	0.260
Phosphorus	0.110	0.135
Insoluble residue	18.870	8.390

b

I. *Ross* ore-bank, McVeytown gap, 1 mile north of McVeytown. Black carbonate ore; lower depths of vein. Here this specimen alternates with shale, and, including the yellow hematite, measures from 24 to 28 feet. Carbonate ore, exceedingly hard and compact, surface somewhat hematitic and botryoidal, structure laminated, and fracture conchoidal; color, various shades of black. The ore carries considerable carbonaceous matter.

II. *Ross* ore-bank, McVeytown gap, 1 mile north from McVeytown. Carbonate ore; upper portion in layers divided by black shale. Whole thickness of measures, including alternations, 24 to 28 feet. Carbonate ore, hard and compact; color, bluish black; crust, hematitic; fracture, conchoidal, showing small crystals of pyrites. Ore carries considerable carbonaceous matter, and when thoroughly roasted yields 60 per cent. metallic iron and 5 per cent. insoluble silicious residue.

Mifflin county.	III.
	Per cent.
Protoxide of iron	48.857
Sesquioxide of iron	0.825
Bisulphide of iron	0.262
Alumina	2.240
Protoxide of manganese	1.625
Lime	4.536
Magnesia	0.569
Phosphoric acid	1.314
Sulphuric acid	0.133
Carbonic acid	32.650
Water	0.308
Organic matter	0.360
Insoluble residue	6.410
Total	*100.149*
Iron	38.700
Sulphur	0.102
Phosphorus	0.574

c d

III. *Lewistown* section, 1 mile northwest of Lewistown. Carbonate ore, taken from near the surface. Clay iron ore; steel-gray color; hard and compact, with conchoidal fracture.

Mifflin county.	No. 124.
	Per cent.
Metallic iron	28.325
Sulphur	0.306
Phosphorus	0.036
Silicious matter	30.170
Phosphorus in 100 parts iron	0.127

e

124. *Robert McCormick's* ore-opening, in Oliver township, 4 miles southwest from McVeytown. Carbonate ore of VIII(?). Soft; fine-grained; argillaceous; pearl-gray color.

CARBONATE ORES OF THE POCONO (?) FORMATION.

f

In *Sullivan county*, near Ganoga lake (Long pond), deposits of carbonate ore of uncertain age have been found; they do not appear to be of much commercial importance. No iron ore was mined in Sullivan county in the census year.

a

CARBONATE ORES OF THE MAUCH CHUNK RED SHALE FORMATION.

The following notes and analyses are from Report MM, pp. 184 to 187, and Report M³, p. 46:

Everywhere throughout Pennsylvania, where the great Conglomerate exists, one or more plates of carbonate ore exist in the shales beneath it. Sometimes the shales are merely studded with balls of ore. In many places local lenticular deposits of solid grayish-blue carbonate extend for hundreds of yards, or a mile or more, with a maximum thickness of 3 or 4 feet, as on the Tangascootac and Queen's run, in Clinton county. At Ralston, in Lycoming county, there are several beds, which have been extensively stripped for long distances under the conglomerate escarpment at the summit of the mountain walls of Lycoming creek. Around the Tioga mountain the bed is 1 foot thick. In the gaps of the Conemaugh, Loyalhanna, and the Youghiogheny rivers, in Westmoreland and Fayette counties, the ore appears, and has been worked in certain places. It spreads in patches over the back of Laurel Hill, in Somerset county, and is seen in many places along the front of the Allegheny mountain, and around Broad Top mountain, in Huntington and Blair counties.

b Sometimes the beds have been decomposed into brown hematite for a certain distance back from the outcrop. Bogs of loose limonite have formed on the terraces in front of the outcrop, some of them many acres in extent, and a few of them removed for use in furnaces.

The best description of this extensive deposit is to be found in Professor Stevenson's Report KK (see Index to KK, p. 422), where the ores are described under the names Big and Little Honeycomb, Kidney, Big Bottom of XI, and Red Belt of XI.

The analyses given under this section show the ores to be of excellent quality, generally very rich in iron, and containing only a comparatively small amount of phosphorus.

Fayette county.	No. 56.	No. 55.	No. 551.	No. 550.
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*
Iron	41.000	31.200	41.400	36.200
Sulphur	0.191	0.253	0.184	0.107
Phosphorus	0.120	0.129	0.151	0.154
Insoluble residue	6.810	21.030	6.430	12.980

c

56. *Vernon* mines, near old Mount Vernon furnace, Bullskin township. Pin-vein ore. (See KK, p. 128.) Compact, fine-grained, brittle, bluish-gray; shows small specks of pyrite.

55. *Vernon* mines, near old Mount Vernon furnace, Bullskin township. Lower big-bottom ore. (See KK, pp. 129, 131.) Structure somewhat flaggy; brittle; dark bluish gray.

551. *Lemont Furnace* mines, northeast from Uniontown, North Union township. Big honeycomb ore. (See KK, p. 127.) Cellular; exceedingly brittle; spotted with pyrites; generally bluish gray. (D. McCreath.)

550. *Lemont Furnace* mines, northeast from Uniontown, North Union township. Lower big-bottom ore. (See KK, p. 131.) Brittle, rather coarse-grained; bluish gray. (D. McCreath.)

d

Fayette county.	No. 549.	Percentages.
	Per cent.	
Protoxide of iron	49.885	= 38.800 per cent. iron.
Protoxide of manganese	0.799	= 0.619 per cent. manganese.
Alumina	1.092	
Lime	1.240	
Magnesia	1.203	
Sulphuric acid	1.020	= 0.408 per cent. sulphur.
Phosphoric acid	0.440	= 0.195 per cent. phosphorus.
Carbonic acid	31.204	
Water	1.575	
Carbonaceous matter	0.080	
Insoluble residue	10.605	
Total	99.833	

e

549. *Lemont Furnace* mines, northeast of Uniontown, North Union township. Kidney-ore. (KK, p. 129.) Fine-grained; hard and tough; fracture, conchoidal; color, generally bluish gray. (D. McCreath.)

Fayette county.	No. 730.	No. 740.	No. 731.
	Per cent.	*Per cent.*	*Per cent.*
Iron	42.800	42.500	42.500
Sulphur	0.227	0.484	0.153
Phosphorus	0.128	0.160	0.130
Insoluble residue	9.040	5.190	7.110

f

730. *Center Furnace* mines, Wharton township. Big honeycomb ore. (See Report KKK, pp. 218, 219, 220.) More or less oxidized throughout; color, light brown and bluish gray; fracture, irregular, rough. Shows numerous small drussy cavities.

740. *Center Furnace* mines, Wharton township. Little honeycomb ore. (See KKK, p. 218.) Crust hematitic; spotted with pyrites; hard and tough. Fracture, conchoidal; color, generally bluish gray on fresh surface.

731. *Center Furnace* mines, Wharton township. Little honeycomb ore (?). Crust hematitic; irregularly seamed with calcareous matter; brittle; bluish gray on fresh surface; fracture, conchoidal.

CARBONATE ORES OF THE POTTSVILLE CONGLOMERATE.

The following notes and analyses are from Report MM, p. 183:

The ores of this horizon are best described in Professor Stevenson's Report KK, under the head of the Mount Savage ore-group (see index to KK, pp. 421, 422), because the beds have been extensively mined in southern Fayette county, under the names Stratford ore (KK, pp. 110, 124, 196), Carr's ore (p. 140), Jude ore (p. 124), and Mahan ore (pp. 124, 160).

In the upper part of the conglomerate No. XII occur abundant deposits of ore-balls and lens-shaped plates along Shade creek, near Old Shade furnace, in Somerset county. (See HHH, p. 147.)

Ore of the same horizon occurs about one-quarter of a mile east of Listonville, in southern Somerset county. (See HHH, p. 271.)

In the conglomerate along the Beaver waters ore is often found. (Q, pp. 225 and 69.)

In many other counties of western Pennsylvania carbonate ball-ore has been noticed at this horizon, at the base of the Coal Measures, but nowhere in quantity justifying mining operations. b

Lawrence county	No. 759.	No. 760.
	Per cent.	*Per cent.*
Iron	37.250	35.200
Manganese	0.655	0.807
Sulphur	0.154	0.335
Phosphorus	0.145	0.178
Lime	3.020	4.120
Magnesia	1.747	2.223
Insoluble residue	9.790	11.190

c

759. *Neshannock* iron-ore opening, near Neshannock Falls, Wilmington township. From the horizon of the Mercer limestone. Crust hematitic; exceedingly hard and tough, with irregular fracture and reddish-gray color.

760. *New Castle* iron-ore opening, 2 miles north from New Castle, in Neshannock township. From the horizon of the Mercer limestone. Exceedingly hard and tough, with irregular fracture and dark bluish-gray color.

CARBONATE ORES OF THE COAL MEASURES AND THEIR DERIVATIVES.

A.—Of the Lower Productive Coal Measures (Freeport, Kittanning, and Clarion Groups).

The following notes and analyses are from Report MM, pp. 174 to 191; Report M³, pp. 48 to 53:

Over the Freeport upper coal, a calcareous ore occurs locally in Hampton township, Allegheny county. (Q, p. 159.) d

The irregular bed of ore mined at Springfield, in Fayette county, comes directly under the Mahoning sandstone. It thins away to nothing northward; and southward reappears on Decker's creek, in West Virginia. (KK, pp. 121, 122.)

Over the Freeport upper coal, ore in ferruginous shale occurs at Hooversville, and at Lohr's, and elsewhere on Stony creek, Somerset county. (See HHH, p. 121.)

Ore overlying the Freeport upper coal (?) was extensively worked for Ritter furnace, on Black lick, and at Lamoreaux's, in Cambria county. (HH, pp. 161, 163.)

The Freeport upper limestone has large quantities of ore associated with it at Brady's bend, on the Allegheny river, where it has been extensively worked. (HHHH, p. 204; and HHHHH, 1879.)

On the lower waters of Yellow creek, in Indiana county, D. Griffith's bed, 2 feet thick, in two layers 3½ feet apart, lies under one limestone and over another. (See HHHH, p. 205.)

Huge lumps of handsome ball-ore are scattered through the *Bolivar fire-clay, under the Freeport upper limestone, between Cucumber* and Jonathan's run, Stewart township, Fayette county (KKK, p. 89). And again, 10 feet from the bottom of the 30-foot plastic clay e deposit over the Freeport lower coal-bed, on Tub Mill run, Fairfield township, Westmoreland county, is a persistent stratum of them. (See KKK, p. 160, section Fig. 64, p. 158.)

The Freeport upper limestone has often been mistaken for iron ore along Jacob's creek, in Westmoreland county; and in Tyrone township, of Fayette county, it actually has a top layer of pretty fair ore, 16 to 20 inches thick; 10 inches thick on Dunbar creek; a foot thick at Springfield furnace, changing to limestone. It is known as "coal-bank" ore on Jacob's creek. (See KK, p. 122.) This is the excellent ore of Pridevale and Decker's creek, and Booth's creek, in West Virginia.

In the Freeport upper limestone, some layers are a calcareous iron ore in Big Beaver township, Beaver county. (Q, p. 224.)

Under the Freeport upper limestone, ore occurs on Pine creek, Hampton township, Allegheny county. (Q, p. 161.)

Between the Freeport upper and lower coals is a persistent bed of rich ore, at Pinkerton point, on Castleman's river, Somerset county; and the same (?) appears at Castleman station. (HHH, p. 185.)

Ball-ore occurs over the Freeport lower coal on Black creek, Cambria county, at Big Bend. (Moore's.) (See HH, p. 161.)

On the Freeport lower limestone, ore occurs at various places, and ore-balls everywhere in the Beaver-river district. (Q, pp. 49, 93, 96, 138, 187, 219, 221, 241.) f

Under the Johnstown cement bed, 10 feet thick, in the Conemaugh bluffs, above the mouth of Tom's run, Indiana county, a persistent bed of carbonate, 8 inches thick, has been worked. (See HHHH, pp. 178 and 179, Fig. 44.)

The Johnstown cement bed under the Freeport lower coal is represented at Anderson's bridge, Forward township, Butler county. (Q, pp. 111, 112.)

The Johnstown cement bed ore is probably represented in Fayette county by "the furnace ore" of Jacob's creek. (See KK, p. 123.)

Under the Darlington (Kittanning upper) coal-bed ore-balls are abundant in north Allegheny, south Butler, and north Beaver counties. (Q, pp. 117, 184, 194, 200, 222, 245, 263.)

Shales carrying carbonate ore replace the Kittanning upper limestone on Laurel run, Fayette county. (See KKK, pp. 109, 110.)

Below the Kittanning (?) coal in Fayette county, Springfield township, nests of ore replace the clay. (See KK, p. 140.)

a Above the Kittanning lower coal (C), 10 feet on the Conemaugh at Lockport and Bolivar, occurs a 6-inch (local?) bed of carbonate ore. (See HHHH, p. 65, Fig. 5.)

This horizon is represented on Schlimmer's run, in western Indiana county, by 50 feet of shales, through which ball-ore is disseminated in lumps of all sizes, and a plate of the ore reported under the fire-clay of the Kittanning upper coal (D). (See HHHH, p. 267.)

Over the Clarion coal (B) on Simpson's creek, in Indiana county, ball- and plate-ore occur, but not workable. (See HHHH, p. 191.)

A persistent outcrop of carbonate ore over the Clarion coal, but of unknown value, occurs along Fallen Timber run, Cambria county. (HH, p. 82.)

Between the Clarion and Brookville beds (A and B) occurs the persistent carbonate ore-bed of Hooversville, Somerset county, opened at Clark's, in two bands, 2 feet thick, and with only 0.3 phosphorus. (See HHH, p. 120.)

This is probably the same ore horizon as that at the forks of Paint creek, Somerset county, where at least 2 feet of good carbonate plate- and ball-ore exists at water-level. (See HHH, p. 133, and *Geology of Pennsylvania*, vol. 2, p. 655; 1878.)

Excellent carbonate ore in three layers occurs at Silver diggings, in Well's creek, Somerset county, at some undetermined horizon b (low?) in the lower productive Coal Measures. (HHH, p. 18, plate 2.)

Below the Clarion coal, 20 feet, ball-ore is very abundant throughout 6 feet of shale at Lloydsville, Cambria county. (HH, p. 87.)

Immense balls of carbonate ore, in shales, between the Clarion and Brookville coals, occur on Levi run, Cambria county. (HH, pp. 91, 92.)

A lean silicious ore is found between the Clarion and Brookville coals on Moore's hill, on Black creek, Cambria county. (HH, p. 160.)

Over the Brookville coal ball-ore is abundant at New Brighton, Beaver county. (Q, p. 250.)

Armstrong county.—This county produced 31,557 tons of ore in census year. The following notes and analyses are from Report M³, pp. 48 to 52, and Report MM, p. 178:

The principal iron ores of Armstrong county are found at the horizon of the ferriferous limestone. These ores have long been mined and have been the principal source of supply for the blast-furnaces of the county. The ore occurs both as a brown hematite and as a carbonate. The former is usually very rich in iron, averaging, when properly mined, nearly 50 per cent. metallic iron; and as the c percentage of phosphorus is not excessive, a very good quality of mill-iron can be made from its use. The average thickness of the ore is only about 8 inches; but as it occurs directly in contact with the ferriferous limestone—which is the flux used in the furnace—it can be easily and profitably mined. The carbonate ore is always roasted before being smelted, and at some of the furnaces it is customary to roast both varieties of the ore. For this purpose the slack coal is generally used. Besides adding by its ash a considerable percentage of silicious matter to the roasted, ore it not unfrequently carries quite a large percentage of phosphorus, which materially affects the quality of the pig-iron produced. This question has already been discussed by Mr. William G. Platt in his report on Armstrong county, volume H⁵, pp. lvii to lxiii, so that no further reference to it is here necessary.

	No. 151.	No. 152.	No. 153.	No. 154.	No. 966.	No. 965.	No. 156.	No. 155.	No. 157.	No. 158.	No. 159.
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
Protoxide of iron	None.	None.	None.	None.	41.400	40.285	.....	None.	41.464	38.378	42.428
d Sesquioxide of iron	73.143	70.714	73.928	68.928	2.000	1.428	.....	65.928	10.310	2.646	2.233
Sesquioxide of manganese	1.986	2.421	1.344	2.048	.....	.....	.....	1.563	.....	.....	.....
Sesquioxide of cobalt	Trace.	0.010	0.020	Trace.	.....	.....	.....	0.020	.....	.....	.....
Bisulphide of iron	.....	.....	.....	.....	0.041	0.118	.....	.....	0.062	0.090	0.187
Protoxide of manganese	.....	.....	.....	.....	1.896	1.655	.....	.....	2.353	1.153	0.799
Protoxide of cobalt	.....	.....	.....	.....	.....	.....	.....	.....	Trace.	Trace.	0.010
Oxide of cobalt	.....	.....	.....	.....	Trace.	Trace.	.....	.....	.....	.....	.....
Alumina	1.691	1.491	1.532	1.358	1.184	0.823	14.328	2.088	1.949	1.223	0.916
Lime	4.920	7.630	1.610	8.670	8.920	7.080	0.630	7.710	4.090	10.840	7.150
Magnesia	0.800	0.547	0.501	0.576	1.801	1.484	0.691	0.991	2.054	2.666	1.881
Silica	.....	.....	.....	.....	.....	.....	31.800	.....	.....	.....	.....
Sulphuric acid	0.010	0.010	Trace.	0.012	Trace.	Trace.	.....	0.580	Trace.	Trace.	0.030
Phosphoric acid	0.636	0.765	0.740	0.584	0.346	0.400	.....	1.074	0.623	0.480	0.334
e Carbonic acid	3.980	5.280	None.	6.980	34.208	35.358	.....	} 5.365	{ 31.450	32.074	32.622
Water	8.800	7.465	12.615	6.000	.....	.....	.....		{ 1.315	1.910	1.950
Silicious matter	4.800	3.860	8.060	4.370	.....	.....	.....	14.520	3.760	8.540	0.460
Insoluble residue	.....	.....	.....	.....	0.430	3.150	.....	.....	.....	.....	.....
Water and carbonaceous matter	.....	.....	.....	.....	1.774	2.010	.....	.....	.....	.....	.....
Total	100.166	100.143	100.350	100.126	100.000	100.900	.....	100.340	100.000	100.000	100.000
Metallic iron	51.200	49.500	51.750	48.250	33.620	37.050	24.600	46.150	30.500	31.750	34.650
Metallic manganese	0.965	1.686	0.936	1.420	1.460	1.282	1.232	1.088	1.823	0.893	0.619
Sulphur	0.004	0.004	Trace.	0.005	0.022	0.063	0.528	0.232	0.029	0.042	0.112
Phosphorus	0.278	0.334	0.323	0.255	0.151	0.262	0.544	0.469	0.272	0.224	0.146
Phosphorus in 100 parts iron	0.542	0.674	0.624	0.528	.....	.....	2.211	1.016	0.688	0.705	0.421

f

151. At *Stewardson* furnace, 1 mile east from mouth of Mahoning creek, in Madison township. F. B. & A. Laughlin. Ferriferous limestone ore. [Limonite.] Very compact and fine-grained; exceedingly brittle, with rough irregular fracture. Irregularly seamed with calcite. Numerous pits filled with white pulverulent silicate of alumina. Reddish brown.

152. At *Stewardson* furnace, 1 mile east from mouth of Mahoning creek, in Madison township. F. B. & A. Laughlin. Ferriferous limestone ore. "Red ore." [Limonite.] Very compact and fine-grained; exceedingly brittle, with rough irregular fracture. Irregularly seamed with calcite. Generally reddish brown.

153. At *Stewardson* furnace, 1 mile east from mouth of Mahoning creek, in Madison township. F. B. & A. Laughlin. Ferriferous limestone ore. "Brown ore." [Carbonate.] Cellular, also fine-grained; dark brown and yellowish brown.

154. *Campbell & Barrett*, 1 mile northwest of Centreville, Madison township. Ferriferous limestone ore. [Carbonate.] Exceedingly compact and fine-grained; hard and tough, with rough, irregular fracture; somewhat conchoidal; numerous pits of pulverulent silicate of alumina. Reddish brown. **a**

966. *Brown & Musgrove's* ore-opening, at Slabtown, on north fork of Pine creek, 4 miles southeast of Templeton. Buhrstone iron ore. Somewhat oxidized; fine-grained. Color bluish gray to reddish brown; fracture irregular.

965. *Pine Creek Furnace* ore opening, 6 miles northeast of Kittanning. Buhrstone iron ore. Somewhat oxidized; fine-grained. Color, bluish gray to reddish brown; fracture irregular, rough.

156. *Stewardson* furnace, 1 mile east of mouth of Mahoning creek, in Madison township. F. B. & A. Laughlin. Ore-screenings. [Limonite.]

155. *Stewardson* furnace, 1 mile east from mouth of Mahoning creek, in Madison township. F. B. & A. Laughlin. Ferriferous limestone ore. "Mixed ores roasted."

157. *J. A. Colwell*, one-half mile northwest of Mahoning furnace, in Madison township. Ferriferous limestone ore. [Carbonate.] Rather coarse-grained and porous; more or less oxidized throughout; mottled with calcite; color generally reddish gray. **b**

158. *Brady's Bend Iron Company*, in Brady's Bend township, 1 mile southwest of Brady's bend. Ore from Phillip's hill. Ferriferous limestone ore. Crust hematitic; exceedingly hard and tough; rather fine-grained; fracture irregular, rough; color, reddish gray.

159. *Stewardson* furnace, 1 mile east from mouth of Mahoning creek, in Madison township. F. B. &. A. Laughlin. Blue carbonate ore. Rather hard and tough; coarse-grained; bluish gray.

Butler county.—Product in census year, 2,318 tons. The following notes and analysis are from Report M³, p. 54:

	No. 566.	Percentages.
	Per cent.	
Protoxide of iron	34.200	=34.50 per cent. of iron.
Sesquioxide of iron	11.285	
Alumina	4.326	
Lime	4.720	
Magnesia	2.854	
Sulphuric acid	0.120	=0.048 per cent. sulphur.
Phosphoric acid	0.849	=0.371 per cent. phosphorus.
Carbonic acid	28.670	
Water	2.500	
Insoluble residue	10.765	
Total	100.289	

c

556. Iron-ore opening near Denny's mill, 1¼ mile west from Old Winfield furnace, Winfield township. Ore 60 to 70 feet below the Freeport Upper coal. (See Report Q, p. 92.) Carbonate ore, considerably oxidized; reddish brown. (D. McCreath.) **d**

Clarion county.—In the census year 15,705 tons of Coal-Measures ore were mined in this county. The following analyses are from Report M³, pp. 52 and 53:

	No. 161.	No. 162.	No. 163.
	Per cent.	*Per cent.*	*Per cent.*
Bisulphide of iron	0.109	0.491	0.009
Protoxide of iron	44.357	48.535	38.571
Sesquioxide of iron	2.857	1.101	2.142
Protoxide of manganese	2.101	1.282	1.756
Protoxide of cobalt	Trace.	Trace.	Trace.
Alumina	0.743	0.528	1.027
Lime	6.380	5.650	6.750
Magnesia	2.248	2.306	1.992
Sulphuric acid	Trace.	Trace.	Trace.
Phosphoric acid	0.643	0.277	2.333
Carbonic acid	33.333	36.109	29.403
Water	1.789	0.711	2.137
Silicious matter	5.440	2.920	13.880
Total	100.000	100.000	100.000
Metallic iron	36.550	38.750	31.500
Metallic manganese	1.628	0.994	1.361
Sulphur	0.058	0.262	0.005
Phosphorus	0.281	0.121	1.019
Phosphorus in 100 parts iron	0.768	0.312	3.234

e **f**

161. *Sligo Furnace* bank, Piney township. Ferriferous limestone ore. [Carbonate.] Specimen more or less oxidized; calc-spar in thin plates; somewhat cellular; bluish gray and reddish gray.

162. *Fox* farm, Piney township. Ferriferous limestone ore. Plate-ore. [Carbonate.] Very fine-grained; full of little pits partially filled with calc-spar; rather hard and tough; bluish gray.

163. *Hindman's* quarry, Clarion township. Ferriferous limestone ore. Ore occurs in balls. [Carbonate.] Hard and tough; rather coarse-grained; surface somewhat oxidized; bluish gray.

a *Fayette county.*—This county produced 76,140 tons of ore in the census year. This was chiefly mined near the horizon of the Pittsburgh coal-seam. The following analyses of ore from the Lower Productive Measures are from Report MM, p. 180:

	No. 741.	No. 738.
	Per cent.	*Per cent.*
Iron	33.900	38.100
Sulphur	0.333	0.150
Phosphorus	0.302	0.115
Insoluble residue	18.690	9.250

b 741. *Fayette* furnace property ore, 2 miles east of Springfield, Springfield township. Ore above the Kittanning coal. (See Report KKK, p. 216.) Hard and tough; minutely crystalline; fracture irregular; color, light bluish gray.

738. *Fayette* furnace property ore, 2 miles east of Springfield, Springfield township. Iron ore under the Kittanning coal. (See Report KKK, p. 217.) Exceedingly hard and brittle; fracture, irregular; color, bluish gray.

	No. 150.
	Per cent.
Bisulphide of iron	0.052
Protoxide of iron	37.607
Sesquioxide of iron	3.214
Protoxide of manganese	1.776
c Protoxide of cobalt	Trace.
Alumina	1.034
Lime	0.600
Magnesia	2.594
Sulphuric acid	Trace.
Phosphoric acid	0.572
Carbonic acid	30.791
Water	1.350
Silicious matter	13.810
Total	100.000
Metallic iron	31.524
d Metallic manganese	1.376
Sulphur	0.028
Phosphorus	0.250
Phosphorus in 100 parts iron	0.793

150. *J. S. Magiffin*, 2½ miles southwest of Brookville, Rose township. Buhrstone iron ore. [Carbonate.] Exceedingly hard and tough plate-ore; full of small drusy cavities; fracture irregular, slightly conchoidal; color, brownish gray.

Lawrence county.—In the census year 70,296 tons of ore were mined in this county, principally at the horizon of the ferriferous limestone. The following analyses are from Report MM, pp. 189, 190, and 191:

	No. 753.	No. 752.	No. 750.	No. 751.	No. 754.	No. 756.	No. 755.	No. 757.
e	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
Sesquioxide of iron	79.000	76.428	76.500	83.142	85.571	71.000	49.571	69.714
Bisulphide of iron	0.056	0.041	0.123	0.197	0.041	0.060	0.054	0.038
Sesquioxide of manganese	0.517	1.034	0.950	0.673	0.692	1.240	0.845	1.304
Alumina	2.980	1.331	0.914	0.732	1.775	1.321	1.720	1.410
Lime	0.480	0.710	2.160	0.510	0.380	0.070	19.950	5.500
Magnesia	0.396	0.564	0.940	0.360	0.432	0.979	0.540	0.945
Sulphuric acid	Trace.	Trace.	Trace.	0.007	Trace.	0.007	0.007	0.007
Phosphoric acid	0.572	0.831	0.936	0.346	0.600	0.625	0.190	0.238
Carbonic acid	None.	None.	1.697	None.	None.	4.770	15.370	4.100
Water	13.566	13.000	13.234	12.736	8.536	11.010	6.060	12.720
Insoluble residue	2.708	5.995	2.385	1.568	2.256	3.273	5.715	4.300
f Total	100.275	99.934	99.839	100.271	100.283	100.356	100.031	100.276
Metallic iron	55.326	53.519	53.607	58.292	59.919	49.728	34.729	48.818
Metallic manganese	0.360	0.720	0.663	0.469	0.482	0.864	0.576	0.968
Sulphur	0.030	0.022	0.066	0.108	0.022	0.035	0.032	0.021
Phosphorus	0.230	0.363	0.409	0.151	0.262	0.273	0.087	0.104

753. Ferriferous limestone ore, near Rose Point, 8 miles east from New Castle, Slippery Rock township. Bombshell-ore, used at Hope furnace. Hard, brittle bombshell-ore, the walls of the bombs being lined with fibrous, botryoidal, dark-brown iron oxide.

752. Ferriferous limestone ore, near Rose Point, 8 miles east from New Castle, Slippery Rock township. Ore used at Hope furnace. Generally compact and brittle, with dark-brown color; structure laminated; fracture irregular. Surface of specimen coated with light-brown, botryoidal iron oxide. a

750. *Houck & Granniss'* mines, 4 miles northeast of Chewton, Wayne township. Ferriferous limestone ore. Brittle; full of seams of ochreous iron ore; color, dark brown and yellowish brown; fracture irregular, rough.

751. *Houck & Granniss'* mines, 4 miles northeast of Chewton, Wayne township. Ferriferous limestone ore. Specimen curiously honeycombed; the cells partially filled with ochreous iron oxide; generally hard and brittle, with irregular fracture, showing kernels of pyrite.

754. *Houck & Granniss'* mines, 4 miles northeast of Chewton, Wayne township. Ferriferous limestone ore; keel-ore. The specimen consists of hard and tough deep-red ore, with thin (surface) layer of brown oxide; generally very compact and earthy-looking; fracture irregular.

756. *Houck & Granniss'* mines, 4 miles north of Chewton, Wayne township. Ferriferous limestone ore. Exceedingly hard and tough, with reddish-brown color and somewhat conchoidal fracture; irregularly seamed with brown oxide of iron. b

755. *Mr. Ziegler's* mines, 4 miles northeast of Chewton, Wayne township. Ferriferous limestone ore. Hard and tough, reddish-brown ore, with conchoidal fracture.

757. *Mr. Ziegler's* mines, 4 miles northeast of Chewton, Wayne township. Ferriferous limestone ore. Specimen irregularly seamed with brown oxide of iron; is exceedingly hard and tough, with reddish-brown color and conchoidal fracture.

Somerset county.—No ore was mined in this county in the census year. The following analysis is from Report MM, p. 181:

	No. 406.
	Per cent.
Protoxide of iron	44.357
Sesquioxide of iron	2.857
Bisulphide of iron	0.247
Protoxide of manganese	0.873
Alumina	3.220
Lime	1.210
Magnesia	1.690
Sulphuric acid	0.040
Phosphoric acid	0.338
Carbonic acid	29.860
Water	0.990
Carbonaceous matter	0.930
Insoluble residue	12.403
Total	99.015
Metallic iron	30.500
Metallic manganese	0.677
Sulphur	0.148
Phosphorus	0.148

c

d

406. *G. W. Clark's* ore-opening, at Hooversville. (See Report HHH, p. 120.) Carbonate ore; hard, compact, minutely crystalline; bluish gray. (D. McCreath.)

Westmoreland county.—No ore was mined in this county in the census year. The following analyses are from Report MM, pp. 179 and 180:

	No. 58.
	Per cent.
Protoxide of iron	51.271
Sesquioxide of iron	0.943
Bisulphide of iron	0.515
Protoxide of manganese	2.352
Alumina	2.050
Lime	1.344
Magnesia	0.814
Sulphuric acid	0.007
Phosphoric acid	0.537
Carbonic acid	33.980
Water	0.910
Carbonaceous matter	0.710
Insoluble residue	5.120
Total	100.553
Metallic iron	40.750
Metallic manganese	1.822
Sulphur	0.278
Phosphorus	0.220

e

f

58. Furnace-ore, on Jacob's creek, Mount Pleasant township, 2½ miles southeast of Jacob's Creek station. (See Report L, p. 105; also, Report KK, p. 123.) Compact, somewhat flaggy; irregularly seamed with white crystalline carbonate of lime; exceedingly brittle; bluish gray.

a

	No. 49.	No. 50.	No. 53.	No. 737.
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*
Iron	28.300	26.500	27.700	32.500
Sulphur	0.079	0.090	0.160	1.288
Phosphorus	0.137	0.046	0.679	0.152
Carbonate of lime	13.680	23.120	7.040	.....
Carbonate of magnesia	7.870	5.600	4.517	.....
Insoluble residue	13.885	13.810	25.240	15.130

b 49. Forge-ore, on Jacob's creek, 2½ miles southeast from Jacob's Creek station. (See Report L, p. 106.) Compact; bluish gray, with conchoidal fracture.

50. Coal-bank ore, on Jacob's creek, 2½ miles southeast of Jacob's Creek station, on the Pittsburgh and Connellsville railroad. (See Report KK, p. 122.) Crust hematitic; fresh fracture bluish gray, showing considerable calcite.

53. Bridge-ore, on Jacob's creek, 1½ miles northeast from Jacob's Creek station. Crust hematitic; bluish gray on fresh fracture; brittle; seamed with white crystalline carbonate of lime.

737. Iron-ore opening, on the Bedford pike, near old Washington furnace, 5 miles east from Ligonier, Ligonier township. About 25 feet above the Pottsville conglomerate. (See Report KKK, p. 217.) Crust hematitic, hard and tough; much spotted with pyrites; fracture irregular; color, bluish black.

B.—Of the Lower Barren Measures.

c

1. The Johnstown Ore-bed.

The following notes are from Report MM, pp. 170 and 171:

The Johnstown ore lies in the lower rocks of the Barren Measures, and is an extensive ore-horizon of western Pennsylvania. It is minutely described in HH (pp. 118, 119, with analyses), and its place among the members of the great Mahoning sandstone group is indicated in Fig. 54, p. 111, where it is represented as 2 feet thick, as mined extensively by the Cambria Iron Company in the hills around Johnstown, east of the Conemaugh river.

It overlies the Freeport upper coal about 52 feet, as measured by Mr. Fulton (HH, p. 112), and is therefore to be placed between the lower and middle members of the Mahoning sandstone.

The Lamoreaux-ore on Black creek (HH, p. 163), in the Armagh valley, may be the same bed; but it is rather identified by Mr. Platt with the Ritter furnace bed just overlying the Freeport upper coal (HH, p. 161, section p. 162).

d In Somerset county the Johnstown ore is recognized on Castleman's river (HHH, pp. 185, 186), resting on the upper of two members of the Mahoning sandstone, but only in nodules. It was worked once for Ben's Creek furnace along Mill creek (HHH, p. 216). Scarcely a trace of it is to be found around Ursina.

In the Ligonier Valley the Johnstown ore may be recognized perhaps in a bastard limestone over the Mahoning sandstone in Salt Lick township, Fayette county (KKK, p. 116); as a lean black shale ore *in* the Mahoning sandstone in Fairfield township, Westmoreland county (KKK, p. 163); as a ferriferous shale, 35 feet above the Freeport upper coal, in Saint Clair township (KKK, p. 175); and generally as a calcareous horizon *in* the Mahoning sandstone along the east flank of Chestnut ridge, and *on top* of it west of Chestnut ridge (allowing for the absence or presence of one or other member of the sandstone); like the Stewart ore near Meadow run; the Springfield mines ore on the Youghiogheny; the Weaver ore north from Falls city; the rich, good ore on the Clay pike in Mount Pleasant township, Westmoreland county; or as a dark ferruginous shale along the base of Laurel hill, like that once mined for Laurel Hill and Ross furnaces, always lean, and unaccompanied by limestone. (KKK, p. 215.) It was mined for Mount Pleasant furnace, on Jacob's creek, and also below the mouth of Indian creek.

The Johnstown calcareous ore lies directly on the Mahoning sandstone, in the region south of the Youghiogheny river and west of e Chestnut ridge. It is the Fairchance ore. (KK, p. 149.) On Cove run it is called the "limestone ore", 2 feet thick; and it is 2½ feet thick at Beattie's in North Union township. (KK, p. 120.) On Redstone it is in four layers in 5 feet of clay. It seems to be Hardman's 4-foot ore-bed in Preston county, West Virginia (see KK, p. 121); and the Haines' ore of Pride Vale furnace; and it seems to extend far south of the Baltimore and Ohio railroad. (See also KK, pp. 138, 165, 172, 186, 265, 318.)

In Indiana county the Johnstown ore is recognized 100 feet above the Freeport upper coal, in Fry's Hill section, on Rayne's run, a few miles from Marion, Indiana county (see HHHH, p. 257); and perhaps in the form of a ferruginous limestone at Five Points, on Plum creek, Indiana county. (See HHHH, p. 280.)

A regular and persistent bed of carbonate ore exists on Mill creek, Cambria county, and worked extensively for Schoenberger's furnaces on Mill and Ben's creeks. It is doubtless the Johnstown ore-bed. (HH, 132.)

Specimens representing the Johnstown ore have been analyzed from Cambria, Fayette, Westmoreland, and Indiana counties. The amount of iron varies from 11.10 to 35.93 per cent.

f

2. Carbonate Ores over the Mahoning Sandstone.

The following notes are from Report MM, pp. 167 to 169:

There are numerous ball ore-bearing shales in the (lower) Barren Measures, between the Philadelphia coal-bed and the Freeport upper coal.

In the country between the Chestnut ridge and the Monongahela river, ores show themselves at many places in the 300-foot interval between the Pittsburgh coal and the Green crinoidal limestone, but only in one place (below New Geneva, 115 feet beneath the Pittsburgh bed) as likely to be valuable. (See KK, p. 119.)

Over the Morgantown sandstone, and 155 feet beneath the Pittsburgh coal-bed, a stratum of calcareous ore from 1½ to 3 feet thick was once extensively stripped for the old Hermitage furnace, in Ligonier township, Westmoreland county. (KKK, pp. 140, 141.)

Connected with the Elk Lick coal and limestone at Elk Lick falls, Somerset county, is an excellent local deposit of carbonate ore, in three benches, 20 inches of ore in 4 feet of interval, more than 200 feet below the Pittsburgh coal. (HHH, p. 70.)

In Greene county, also, there are some low-grade ores about 200 feet beneath the Pittsburgh coal.

A very fair ore occurs about 325 feet beneath the Pittsburgh coal, below the mouth of Cheat river. (K, p. 384.) This is about the middle of the Barren Measures, near the Green crinoidal limestone. a

Under the Green crinoidal limestone ball-ore is abundant in Hampton township, Allegheny county. (Q, p. 160.)

Between the Green crinoidal limestone and the Mahoning sandstone are several horizons of ball-ore in the country between Chestnut ridge and the Monongahela river, one of which, lying higher than the Mahoning sandstone or Johnstown ore, is the Snake-den ore, on Georges creek, a fair-looking carbonate, 8 to 14 inches thick, and once extensively mined for Springfield furnace. (See KK, pp. 119, 120.) It has been stripped along Cove run, North Union township, Fayette county, for Lemont furnace.

About 400 feet below the Pittsburgh coal theoretically, or 220 feet above the Freeport upper coal actually, lies the Black Lick ore (described in HHHH, pp. 99, 102–106, 114), once mined for Black Lick and Buena Vista furnaces in eastern Indiana county. It lies just underneath the black fossil limestone, which itself becomes a lean and poor iron ore along the eastern edge of the Ligonier valley, north from the Loyalhanna, and was mined for Laurel Run furnace and old Washington furnace. (KKK, pp. 214, 215.) b

This ore may be represented in Cambria county by the siliceous ore-bed 150 feet above the Johnstown ore-bed (200 feet above the Freeport upper coal.) (See HH, p. 112.)

In the Pine Creek limestone, 450 feet below the Pittsburgh coal, ore occurs in East Deer and Indiana townships, Allegheny county. (Q, pp. 149, 154.)

In the Brush Creek limestone, 510 feet below the Pittsburgh coal, ore occurs on Davis run, Economy township, Beaver county. (Q, pp. 34, 183.) This may correspond to the Johnstown ore horizon of Cambria county.

C.—Of the Upper Productive Measures.

1. Of the Pittsburgh coal horizon.

The following notes and analyses are from Report MM, pp. 162 to 167:

Under the Pittsburgh coal-bed (from 4 to 6 feet) occurs, in southern Fayette county, an important deposit of ore formerly supposed to be confined to the Connellsville-Uniontown basin, but recently found along the Monongahela river in the trough next west, sinking below water-level near Gray's distillery, above the mouth of Dunkard's creek. (See K, pp. 304, 383.) c

In Washington and Allegheny counties no traces of this ore have been found. (K, p. 384.) But in Fayette county, on the contrary, it is a most important horizon of ore, on which a number of furnaces have been and still are running with great success. Under the name of "the Pittsburgh Iron-Ore Group," with its various beds of blue-lump, condemned flag, big-bottom, red-flag, and yellow-flag ores, at Oliphant's, Springfield, and Lemont furnaces; at Fairchance, Monroe, Frost's station, New Geneva, Braddock's, on Scott's run, Cat's run etc., it is fully described in Report KK, on pages 111–118, 149, 170–181, 234–255, and 385, to which the reader is referred. (See index of iron ores, KK, p. 420.)

The analyses given under this section speak in sufficiently strong terms of the excellent quality of the ores. They show them to be generally very rich in iron and comparatively free from phosphorus:

Fayette county.	469.	35.	36.
	Per cent.	*Per cent.*	*Per cent.*
Protoxide of iron	46.671	49.500	44.742
Sesquioxide of iron	8.285	0.700	0.818
Bisulphide of iron	0.034	0.020	0.272
Protoxide of manganese	1.311	1.636	1.059
Oxide of cobalt	Trace.	Trace.	Trace.
Alumina	1.606	1.153	2.795
Lime	1.740	1.859	3.119
Magnesia	1.001	2.018	3.870
Sulphuric acid	0.057	Trace.	Trace.
Phosphoric acid	0.161	0.204	0.096
Carbonic acid	31.790	34.000	34.450
Water	1.727	1.395	1.000
Carbonaceous matter	1.040	0.730	0.640
Insoluble residue	4.415	5.790	7.450
Total	99.838	99.905	100.401
Metallic iron	42.116	39.000	35.500
Metallic manganese	1.016	1.267	0.820
Sulphur	0.041	0.011	0.145
Phosphorus	0.070	0.089	0.042

d

e

469. *Dr. Fuller's* mines, about 3 miles southeast of Uniontown, in South Union township. Blue lump-ore. (See Report KK, p. 114.) Generally compact; minutely crystalline. Irregularly seamed with brown oxide of iron. Color, bluish gray.

35. *Oliphant Furnace* mines, in Georges township. Blue lump-ore. (See Report L, p. 99; also KK, p. 114.) Exceedingly hard and compact; minutely crystalline; color, bluish gray; fracture, conchoidal. f

36. *Oliphant Furnace* mines, in Georges township. Big-bottom ore. (See Report L, p. 99; also KK, p. 114.) Hard and compact, with thin seams of brown oxide of iron. Fracture, conchoidal; color, bluish gray.

Fayette county.	37.	38.	39.
	Per cent.	*Per cent.*	*Per cent.*
Iron	37.500	35.800	35.400
Sulphur	0.041	0.047	0.319
Phosphorus	0.505	0.083	0.069
Insoluble residue	5.670	9.560	10.450

a 37. *Oliphant Furnace* mines, in Georges township. Condemned flag-ore. (See Report L, p. 100; also KK, p. 111.) Compact and fine-grained; color, blue; fracture, subconchoidal.

38. *Oliphant Furnace* mines, in Georges township. Red flag-ore. (KK, p. 115.) Compact, fine-grained, reddish gray.

39. *Oliphant Furnace* mines, in Georges township. Yellow flag-ore. (KK, p. 115.) Crust hematitic; structure, flaggy; color, yellowish brown; on fresh fracture, bluish gray.

b

Fayette county.	No. 732a.	No. 732b.	No. 732c.	No. 552.
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*
Iron	31.000	37.500	38.150	29.200
Manganese	1.030	0.691	0.691	0.612
Sulphur	0.932	0.512	0.342	0.415
Phosphorus	0.151	0.123	0.121	0.268
Lime	4.080	3.530	3.860	3.380
Magnesia	5.405	3.459	2.828	3.012
Insoluble residue	8.855	4.735	3.360	19.240
Metallic iron in roasted ore	47.880	56.020	57.220	

732a. *Lemont Furnace* mines, 3 miles northeast of Uniontown. Ore immediately under the Pittsburgh coal-bed. Upper layer. (See Report KK, p. 116; also Report KKK, p. 228.) Comparatively soft and crumbling; structure laminated; color, grayish black. Specimen shows numerous small rounded pebbles consisting of the carbonates of iron, lime, and magnesia. Has the general appearance of a dried mud.

c 732b. *Lemont Furnace* mines. Pittsburgh coal ore Middle layer. Rather hard and tough; irregularly seamed with calcspar; contains small pits of white, pulverulent silicate of alumina. Fracture slightly conchoidal, inclining to rough; color, dark bluish gray.

732c. *Lemont Furnace* mines. Pittsburgh coal ore. Lower layer. Rather hard and tough, with irregular fracture and bluish-black color. Irregularly seamed with carbonate of lime, and white, pulverulent silicate of alumina.

552. *Lemont Furnace* mines, 3 miles northeast of Uniontown. Pittsburgh coal ore. Upper, middle, and lower layers, with a silicious layer, which is always rejected in mining.

By an error in labeling, these samples were analyzed as one. The analysis is merely given to show the utterly worthless character of the silicious layer. Analyzed by D. McC. (See Report KK, p. 116; also Report KKK, p. 228.)

d

	No. 700b.	No. 701b.	No. 702b.
	Per cent.	*Per cent.*	*Per cent.*
Iron	29.000	33.000	28.800
Sulphur	0.603	0.473	0.492
Phosphorus	0.208	0.112	0.135
Carbonate of lime	14.875	11.803	18.035
Carbonate of magnesia	6.485	4.691	4.601
Insoluble residue	9.540	5.540	10.030

700b. *Hoggsett, Watt & Co.'s* mines, at Braddock's station. Ore under the Pittsburgh coal. Upper layer. Second specimen obtained at 1,100 feet from the outcrop. (See KKK, p. 229.) Exceedingly hard and tough, with irregular fracture and grayish-black color. Spotted with pyrites; shows considerable calcareous matter.

701b. *Hoggsett, Watt & Co.'s* mines. Middle layer. Second specimen obtained at 1,100 feet from the outcrop. Exceedingly hard and tough; irregularly seamed with white crystalline carbonate of lime. Fracture conchoidal; color, grayish black and bluish black.

e 702b. *Hoggsett, Watt & Co.'s* mine. Lower layer. Second specimen obtained at 1,100 feet from the outcrop. Hard and tough, with irregular fracture and grayish-black and bluish-black color.

D.—Of the Upper Barren Measures (partly Permian).

The following notes are from Report MM, pp. 159 to 160:

There is scarcely a farm in Greene and Washington counties on which nodules of carbonate of iron are not plowed up. The ore-balls have been set free from the shales by the action of the air and frost, and there is hardly a stratum of shale or sandstone in the Barren Measures through which they are not disseminated, but no continuous beds are known to exist. (See K, p. 386.)

There is a local deposit of ore in the shales overlying the roof shales of the upper Washington limestone (No. VI of Stevenson's section to page 45, K), in Centre township, Greene county, near the headwaters of Pursley creek. (See K, p. 385.) The area is 2 miles long, and the amount of ore large; the ore is full of phosphorus, but otherwise good. This horizon of ore is about 800 feet over the f Pittsburgh coal-bed. It was carefully examined all over the two counties, but yielded no ore elsewhere.

Below limestone No. V (of Stevenson's section to page 45, K), at many localities in Greene county, a good deal of ore occurs (K, p. 385), but the ore is rendered worthless by the large percentage of phosphorus.

Under the Washington lower limestone, and on the Washington coal-bed in Fayette county, at A. Struble's, in German township, is a considerable deposit of lean ball-ore. (KK, pp. 27, 245.)

Immediately above the little Washington coal-bed, in Greene county (525 feet above the Pittsburgh coal-bed), a little ore occurs in black shale, and a specimen was analyzed. (K, p. 384.) On Smith's creek, near Waynesburg, a moderate amount of ore was found also immediately above this coal-bed.

In the body of the Waynesburg coal-bed (375 feet above the Pittsburgh coal) are 5 feet of shales holding ball-ore loosely scattered. (KK, pp. 33, 228.)

Under the Waynesburg coal-bed in Greene county the shales contained very moderate quantities of ball-ore. (K, p. 384.) Some of it was once dug, at various points in Morgan township, for the old Clarksville furnace. This ore-horizon seems persistent.

V.—FOSSIL ORES.

OF THE CLINTON FORMATION.

A belt of these ores extends in a southwesterly direction through the middle counties of the state from Columbia county to the Maryland border. They have been largely mined along the Juniata river. The following notes and analyses are from Report MM, pp. 234 to 235; Report M, pp. 60 to 63, and Report M³, pp. 37, 38, 39, 41, 43, 45:

A detailed description of these beds will be found in Report of Progress F, on the Juniata district.

1. The Sand Vein ore-bed, the uppermost of the group, overlying the sand-rock or upper member of the ore sandstone. It is a hard, lean, calcareous ore below the drainage-level, but soft and comparatively rich from drainage-level up to outcrop. Sometimes it is represented by loose sand. Fossil impressions are numerous. (See F preface, pp. xxxv to xxxviii.)

2. The Danville ore-group of three or four beds underlying the ore sandstone and about 25 or 30 feet beneath the sand-vein ore. These beds are very variable, calcareous, fossiliferous, and from 4 to 8 inches thick. Sometimes they lie near enough together to allow 40 inches of ore to be taken out of a drift. They are softened into rich ore at the surface of the ground, and for 100, 200, or 300 feet down to drainage-level. (F preface, pp. xxxix to xl.)

3. The block-ore lies 150 feet beneath the Danville ore-group, and is called also the iron sandstone. It separates the Clinton upper from the Clinton lower shales. (F, p. xli.)

4. The Boyer block-ore lies 250 to 300 feet beneath the iron sandstone, and is 6 feet thick in Mahontongo gap.

5. The Bird-Eye fossil ore-bed occurs 100 to 150 feet above the base of the Clinton formation No. V, in the Clinton lower shales, and varies from 6 to 14 inches. (F, p. xlv.)

6. The Shot-Block ore-bed lies still lower, and if it be the same with R. H. Powell's ore-bed, southwest of Huntingdon, it lies close upon the Medina sandstone and sometimes attains a thickness of more than 20 feet, of which from 2 to 6 feet is soft ore. This may be the dye-stone ore of the southern states. (F, p. xlvii.)

Columbia county.—This county produced 22,588 tons of fossil ore in the census year. No analyses of the ore have been published in the reports of the second geological survey.

Montour county.—Product in census year, 33,890 tons. No analysis of an average sample is available.

Lycoming county.—The chief ore of this county is the fossil ore of the Chemung formation. The Clinton fossil has been mined here too, however. The following analyses are from Report M³, p. 44:

	138.	139.	140.
	Per cent.	*Per cent.*	*Per cent.*
Sesquioxide of iron	30.00	42.857	43.928
Sesquioxide of manganese	0.145	0.248	0.300
Alumina	5.051	5.975	4.568
Lime	1.100	1.720	1.300
Magnesia	1.116	1.037	1.000
Sulphuric acid	0.015	0.022	0.005
Phosphoric acid	0.439	0.868	0.604
Carbonic acid	1.227	1.289	1.075
Water	2.778	3.971	3.925
Silicious matter	58.120	41.980	42.520
Total	100.036	99.967	99.365
Metallic iron	21.000	30.000	30.750
Metallic manganese	0.101	0.173	0.209
Sulphur	0.006	0.009	0.002
Phosphorus	0.192	0.379	0.303
Phosphorus in 100 parts iron	0.914	1.263	0.985

138. *J. Young's* ore-bank, on the south side of the Susquehanna river, near Antes Fort, opposite Jersey Shore, and about 2 miles south from it. Fossil ore of V. Upper layer. Compact, fine-grained, sandy, with lenticular masses of slate; reddish brown.

139. *J. Young's* ore-bank, on the south side of the Susquehanna river, near Antes Fort, opposite Jersey Shore, and about 2 miles south from it. Fossil ore of V. Middle layer. Compact, fine-grained, sandy, with numerous shot-like phosphatic pebbles.

140. *J. Young's* ore-bank, on the south side of the Susquehanna river, near Antes Fort, opposite Jersey Shore, and about 2 miles south from it. Fossil ore of V. Lower layer.

Union county.—Only 663 tons of ore were mined in this county in the census year. The following analysis is from Report MM, p. 245:

	723.
	Per cent.
Iron	33.800
Sulphur	0.004
Phosphorus	0.358
Carbonate of lime	39.142
Carbonate of magnesia	2.497
Insoluble residue	3.851

723. *Union Furnace Company's* mines, at Winfield. Hard fossil-ore; Danville ore-bed. Exceedingly hard and tough, carrying small lenticular masses of slate; color, reddish brown and reddish gray.

a *Snyder county.*—Production of iron ore in the census year, 31,426 tons. The following analyses are from Report MM, pp. 242 and 245:

	103.	104.	99.	126.
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*
Iron	52.300	52.900	50.300	29.400
Sulphur	Trace.	0.011	0.006	0.056
Phosphorus	0.378	0.514	*a* 0.488	0.726
Insoluble residue	10.550	9.070	14.270	32.660

a My test for phosphorus in this specimen gave 0.485 per cent.

b 103. *Dr. J. D. Conrad's* ore-opening, 1¼ miles southwest of Beavertown. Sand-vein ore-bed, 24 inches thick, with 6 inches of jack in the middle; top bench of the vein. Compact, coarse-grained, showing spangles of quartz; color, iron rust. (D. McCreath.)

104. *Dr. J. D. Conrad's* ore-opening; upper part of lower bench. Compact, coarse-grained, wi h spangles of quartz. (D. McC.)

99. *Dr. J. D. Conrad's* ore-opening; lower part of vein. Compact, coarse-grained, with spangles of quartz. (D. McC.)

126. *Dr. J. D. Conrad's* ore-opening; jack of the vein. Specimen carries considerable intermingled slate, is very compact, and of a dark-brown and iron rust color.

c

	610.	
	Per cent.	
Sesquioxide of iron	77.714	=54.400 per cent. iron.
Sesquioxide of manganese	0.325	=0.226 per cent. manganese.
Alumina	5.054	
Lime	0.740	
Magnesia	0.410	
Sulphuric acid	0.065	=0.026 per cent. sulphur.
Phosphoric acid	0.771	=0.337 per cent. phosphorus.
Water	5.822	
Insoluble residue	8.315	
Total	99.816	

d 610. *Dr. J. D. Conrad's* ore-opening, 1 mile southwest of Beavertown, on the property of J. F. Middlesworth; sand-vein ore-bed, 26 inches thick, with 6 inches of jack in the middle. This specimen from the bottom bench of vein. (See F, p. 37.) Represents clean ore. Compact, rather coarse-grained; reddish brown and iron rust.

	125.	127.	100.	925.	102.	725.
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
Iron	43.100	52.600	40.900	52.100	42.750	48.800
Sulphur	0.010	0.023	0.006	0.032	0.021	0.028
Phosphorus	0.243	0.521	0.196	0.396	0.113	0.326
Insoluble residue	21.800	11.560	15.100	12.960	27.430	15.230

125. *Bloomsburg Iron Company's* ore-opening, 1 mile southwest of Beavertown, on the property of J. F. Middlesworth; sand-vein ore-bed. (See F, p. 37.) Compact, coarse-grained; reddish brown.

e 127. *John Earnest's* ore-opening, three-fourths of a mile southwest of Beavertown; sand-vein ore-bed. Vein 24 inches thick, with 6 inches jack. (Bloomsburg Iron Company.) Compact, coarse-grained; reddish brown.

100. *John Earnest's* ore-opening; jack of the vein. (See F, p. 35.) Block fossil ore, showing spangles of quartz and specular iron ore; color, iron rust. (D. McC.)

925. *Bloomsburg Iron Company's* ore-opening, on property of Jacob Gross, southeast of Adamsburg; sand-vein ore-bed. Soft; reddish brown, spotted with quartz. (S. S. Hartranft.)

102. *Bloomsburg Iron Company's* ore-opening, on property of Jacob Gross, 1 mile southwest of Adamsburg. Ore comparatively soft, with considerable specular iron oxide; reddish brown. (D. McC.)

725. *Swengle & Dunning* ore-opening, on the property of Reuben Dreese, 1 mile southwest of Adamsburg; sand-vein ore-bed. Rather friable, argillaceous; reddish brown; shows numerous small spangles of quartz.

	724.	926.	128.
	Per cent.	*Per cent.*	*Per cent.*
Iron	45.125	32.455	50.500
Sulphur	0.015	0.094	0.024
Phosphorus	0.407	1.975	0.257
Carbonate of lime	10.928	.....	.....
Carbonate of magnesia	2.497	.....	.....
Insoluble residue	12.855	29.635	15.220

724. *Cruikshank & Brother's* ore-opening, on the property of Emanuel Duck, 2 miles from Smithgrove; bird-eye fossil ore. Compact, coarse-grained, brittle; fracture irregular; color, reddish brown.

926. Ore-opening 2 miles southeast of Smithgrove, on road leading to Freeburg; block-ore. Hard; reddish brown, with shot-like pebbles of impure phosphate of lime; spotted with quartz. (S. S. Hartranft.)

128. *Andrew Bickle's* ore-opening, 2 miles north of Freeburg, and 2½ miles southeast of Smithgrove; bird-eye fossil ore. Coarse-grained, brittle; reddish brown.

Mifflin county.—In the census year 29,333 tons of fossil ore were mined in this county. The following analyses are from Report M, pp. 60 to 63; Report MM, p. 242; and Report M³, p. 39:

	II.	III.	IV.
	Per cent.	*Per cent.*	*Per cent.*
Iron	36.400	44.400	34.000
Sulphur	0.017	0.028	0.018
Phosphorus	0.184	0.145	0.124
Insoluble residue	35.200	28.880	35.480

b II. *George M'Kee's* ore-bank, Ferguson valley, 7 miles west of Yeagertown; top portion of ore-vein good; whole vein about 18 inches thick. This part analyzed about 10 inches thick. Compact, silicious fossil ore of a dark-brown color.

III. *George M'Kee's* ore-bank, Ferguson valley, 7 miles west of Yeagertown; fossil ore vein 12 inches thick; this part (top) 8 inches thick; north dip in vein. Balance 4 inches in jack. Compact, sandy fossil ore of a reddish-brown color.

IV. *North of George M'Kee's* ore-bank, near James Shehan's house, in the meadow foot of Jack's mountain. Ore-vein about 12 inches thick; second specimen taken from heap of ore, being ore from shaft. Specimens mixed in proper proportions previous to analysis. Compact, sandy fossil ore of a deep-red color.

	V.
	Per cent.
Sesquioxide of iron	42.857
Alumina	7.816
Sesquioxide of manganese	0.093
Lime	0.448
Magnesia	0.738
Phosphoric acid	0.547
Sulphuric acid	0.122
Water	5.500
Insoluble residue	41.510
Total	99.631
Iron	30.000
Sulphur	0.048
Phosphorus	0.239

c **d**

V. *George M'Kee's* ore-bank, Ferguson valley, 7 miles west of Yeagertown. Top bench of vein 6 to 12 inches thick; bottom part of vein, lower bench, 2 to 6 inches thick; face of gangway, 8 to 12 inches thick; top bench, south dip, average of vein. The analysis represents the above ores mixed in proper proportions. Compact, coarse, sandy fossil ore of a deep-red color, somewhat slaty.

	VI.	VII.
	Per cent.	*Per cent.*
Iron	30.800	42.300
Sulphur	0.011	0.010
Phosphorus	0.231	0.516
Insoluble residue	31.560	25.930

e

VI. *John Kinzer's* ore-bank, 5 miles northeast from M'Veytown. Soft fossil ore (medium); north dip, south anticlinal of ore-ridge; vein 1 foot thick. Fossil ore, compact, iron-rust color, with a tendency to break up into blocks.

VII. *Ferguson Valley* ore-ridge, 6 miles northeast from M'Veytown. Fossil ore (medium soft); John M'Cord ore-bank, No. 2 gangway. Fossil ore, compact and very hard, reddish-brown color, slaty structure, with much slaty gangue.

	XIII.	XIV.
	Per cent.	*Per cent.*
Iron	41.700	50.000
Sulphur	0.034	0.024
Phosphorus	0.212	0.606
Insoluble residue	27.640	14.784

f

XIII. *Ferguson* valley, 6 miles northeast of M'Veytown. John Rotherick ore-bank (soft medium fossil). In same ravine as John M'Cord ore-bank, on east side of ravine; north dip of ore-ridge; vein from 16 to 18 inches thick. Fossil ore, hard and compact, slaty structure; reddish-brown color, containing numerous particles of specular iron ore. Analyzed by S. A. Ford.

XIV. *Matilda* furnace, 1 mile north from Mount Union. Medium fossil taken from third level; vein 20 to 22 inches thick; vein overlying the ore sandstone. Fossil ore, compact, with slaty gangue; color, brownish red; ore has a tendency to break up into blocks. Analyzed by S. A. Ford.

a

	721.	722.
	Per cent.	*Per cent.*
Iron	26.100	46.900
Sulphur	0.051	0.005
Phosphorus	0.544	0.310
Carbonate of lime	47.018	.....
Carbonate of magnesia	2.240	.....
Insoluble residue	9.610	22.880

b 721. Iron-ore opening on property of J. H. Mann, Logan Gap. Hard fossil ore from Danville ore-bed. (See Report F, p. 17.) Hard, compact, coarse-grained; reddish brown and reddish gray.

722. Iron-ore opening on property of J. H. Mann, Logan Gap. Fossil ore from sand-vein ore-bed. (See F, p. 18.) Generally compact, and rather earthy; sparkles with scales of specular iron oxide. Color, pink and reddish brown.

c

	123.
	Per cent.
Sesquioxide of iron	71.571
Sesquioxide of manganese	0.682
Alumina	4.493
Lime	0.560
Magnesia	0.342
Sulphuric acid	0.035
Phosphoric acid	0.614
Water and organic matter	4.753
Silicious matter	16.950
Total	100.000
Metallic iron	50.100
Metallic manganese	0.475
Sulphur	0.014
Phosphorus	0.268
Phosphorus in 100 parts iron	0.534

d

123. *J. J. Dull's* ore-opening, in Oliver township, about 1½ mile north of Dunkard church, on old mountain road, Jack's mountain. Fossil ore of V. Samples selected by Mr. Dull. Coarse-grained; oölitic; reddish brown. A portion of the specimen was in fine powder and rather argillaceous.

Juniata county.—Production in census year, 35,729 tons of fossil ore. The following analyses are from Report MM, pp. 229 to 241, and Report M³, p. 38:

e

	22.	928.	13.	19.	20.	21.
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
Iron	44.600	41.273	46.000	47.900	51.900	24.800
Sulphur	0.012	0.020	0.009	0.008	0.005	0.005
Phosphorus	0.496	0.348	0.200	0.279	0.215	0.562
Insoluble residue	18.080	25.775	24.220	17.760	14.080	43.010

22. *Henry Aughey's* ore-opening, 4 miles northwest of Mifflintown and 3 miles west of the Juniata river. Hirsh & Hiestand, lessees. Block-ore; compact, rather coarse-grained; reddish brown.

928. *Samuel Aughey's* ore-opening, 2 miles southwest of the Juniata river. Specimen analyzed consisted of one-half jack and one-half ore, this being about the proportions in which they occur in the bed. Comparatively soft, reddish brown, with numerous small pebbles and some micaceous iron ore. (S. S. Hartranft.)

13. *Hirsh & Hiestand* ore-opening, south side of Lost Creek ridge. Sand-rock ore. Very hard and compact, with slaty structure and dark-brown color.

19. *Graham* ore-bank (No. 1), 4 miles northeast of Mifflintown, east of Juniata river. (Toll & Williams.) Vein 20 inches thick with 5 inches jack. Specimen analyzed consisted of three-fourths ore and one-fourth jack. Block-ore; compact, light brown, with some
f intermingled slate.

20. *Graham* ore-bank (Nos. 2 and 3), 4 miles northeast of Mifflintown and 1 mile east of Juniata river. Vein 2 feet thick. Ore specimen analyzed, 18 inches thick. Leased by Glamorgan Iron Company. Block-ore; coarse-grained; light brown and reddish brown, with numerous specks of quartz and specular iron ore.

21. *Graham* ore-bank (Nos. 2 and 3), jack from the vein. Compact, slaty; iron rust and various shades of brown.

	941.	29.	14.	23.	18.
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
Iron	20.775	42.100	16.500	32.100	45.450
Sulphur	0.112	Trace.	0.249	0.010	Trace.
Phosphorus	0.351	0.338	0.122	0.257	0.246
Carbonate of lime	38.375	.....	12.172	34.250	.....
Carbonate of manganese	0.802	.....	2.662	3.465	.....
Insoluble residue	9.340	23.050	49.748	11.360	21.600

941. *William Nankwell's* ore-opening, 5 miles north from Mifflintown, on south slope of Lost Creek ridge. Hard fossil-ore from sand vein ore-bed. Hard, tough; reddish brown. Sparkles with calcareous matter. (S. S. Hartranft.) a

29. *William Nankwell's* ore-opening, 3½ miles west of the Juniata river. Block-ore; compact, coarse-grained; reddish brown.

14. *William Nankwell's* ore-opening, on A. Guss' property, 3 miles from Juniata river, Licking Creek valley. Vein 10 inches thick. Hard, sandy, calcareous; chocolate brown.

23. *William Nankwell's* ore-opening, on A. Guss' property, 3 miles from Juniata river, Licking Creek valley. Vein 14 inches thick. Hard, compact; reddish brown.

18. *Richard Nankwell's* ore-opening, Licking Creek valley. Compact; brownish black and reddish brown.

In the shot block-ore lying below the Bird-eye fossil-ore, and about 150 feet above the Medina sandstone, occur small rounded, shot-like pebbles. These consist for the most part of an impure phosphate of lime, as shown by the following analysis:

	17.	
	Per cent.	
Lime	20.825	
Magnesia	0.486	
Phosphoric acid	16.208	= 35.38 per cent. phosphate of lime.
Oxide of iron	18.143	
Alumina	9.029	
Silica	35.540	
Total	100.141	

b

17. Phosphatic pebbles found in shot block-ore, on land of John Robinson, Lost Creek ridge, Licking Creek valley, Juniata county. (Report MM, p. 368.) c

Perry county.—Twenty-six thousand six hundred and fifty tons of fossil-ore were mined in this county in the census year. The following analyses are from Report M³, p. 37. The analyses represent the clean ore:

	117.	118.	119.
	Per cent.	*Per cent.*	*Per cent.*
Sesquioxide of iron	78.571	73.714	55.285
Sesquioxide of manganese	0.021	0.021	0.051
Alumina	4.927	5.702	7.553
Lime	0.510	0.390	0.650
Magnesia	0.213	0.209	0.400
Sulphuric acid	0.042	0.050	0.030
Phosphoric acid	1.502	1.784	0.382
Water and organic matter	6.015	9.075	5.690
Silicious matter	8.170	8.870	30.490
Total	99.971	99.815	100.531
Metallic iron	55.000	51.600	38.700
Metallic manganese	0.015	0.015	0.036
Sulphur	0.016	0.020	0.012
Phosphorus	0.656	0.779	0.167
Phosphorus in 100 parts iron	1.192	1.509	0.431

d

e

117. *B. G. Mush & Co.*, southeast side of Tuscarora mountain, one-fourth mile north from Millerstown, on the northeast side of the Juniata river. Sand-vein fossil-ore. Sample represents the quality of the greater part of the ore-bed, 10 to 12 inches thick. Rather coarse-grained and friable; reddish brown.

118. *B. G. Mush & Co.*, southeast side of Tuscarora mountain, one-fourth mile north from Millerstown, on the northeast side of the Juniata river. Sample represents the character of ore 3 to 4 inches thick in bed. Hard and tough; rather fine-grained; dark brown and reddish brown; small masses of shale in specimens.

119. On southeast side of Tuscarora mountain (Michael's ridge), one-fourth mile northwest of Millerstown, and a few hundred rods northeast of Juniata river. Fossil-ore of V, 8 inches thick; from ore sandstone, 7 feet from top. Compact; specimen consists of a mixture of hard and soft ore; reddish brown. (J. M. S.)

Huntingdon county.—This county produced, in the census year, 15,927 tons of fossil-ore. The following analyses and notes are from Report M, p. 63; Report MM, pp. 237 and 238, and Report M³, p. 41: f

	a XV.	*a* XVI.		*a* XV.	*a* XVI.
	Per cent.	*Per cent.*		*Per cent.*	*Per cent.*
Sesquioxide of iron	72.571	72.428	Water	3.440	4.620
Alumina	4.723	4.211	Insoluble residue	18.650	17.000
Sesquioxide of manganese	0.320	0.269	Total	100.443	99.560
Lime	0.174	0.319			
Magnesia	0.309	0.432	Iron	50.800	50.700
Phosphoric acid	0.256	0.281	Sulphur	Trace.	Trace.
Sulphuric acid	Trace.	Trace.	Phosphorus	0.112	0.123

a The analyses represent the clean ore.

a XV. South side of Blacklog gap, No. 1 gangway, large underlying fossil-ore; vein 20 inches in thickness. Rockhill Coal and Iron Company. Compact; coarse fossil-ore; reddish-brown color.

XVI. South side of Blacklog gap, small overlying fossil-ore vein, Gangway No. 1. Rockhill Coal and Iron Company. Hard, compact fossil ore; chocolate-brown color, with somewhat laminated structure.

b

	XVII.	XVIII.	930.	929.
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*
Iron	28.800	27.250	46.500	34.300
Sulphur	Trace.	Trace.	0.025	0.038
Phosphorus	0.238	0.203	0.475	0.132
Carbonate of lime	30.132	36.007	17.550	None.
Carbonate of magnesia	6.976	1.180	1.551	None.
Insoluble residue	12.850	16.610	6.880	40.080

XVII. *Blacklog* gap, near Orbisonia. No. 1 north gangway. Hard fossil-ore. Fossil-ore, hard, compact; reddish color.

XVIII. North side of Blacklog gap, near Orbisonia. Bottom vein, Drift No. 1, 20 inches thick. Fossil-ore, hard, compact, with numerous small crystals of calcite, of a reddish-brown color.

930. Iron-ore opening, 1 mile northwest of McAleavy's fort. From old workings of Little furnace. Compact; showing considerable calcareous matter; fracture irregular; color, reddish gray and reddish brown.

929. Iron-ore opening, 3 miles west of McAleavy's fort. Surface specimen from old workings of Monroe furnace. Sandy, coarse-grained; dark brown and yellowish brown. Fracture rough, irregular.

c

	787.	
	Per cent.	
Sesquioxide of iron	71.500	= 50.050 per cent. iron.
Sesquioxide of manganese	0.643	= 0.448 per cent. manganese.
Alumina	5.825	
Lime	1.715	
Magnesia	1.248	
Sulphuric acid	0.069	= 0.028 per cent. sulphur.
Phosphoric acid	1.285	= 0.561 per cent. phosphorus.
Water	4.979	
Insoluble residue	12.385	
Total	99.649	

d

787. Iron-ore opening, 4 miles from Greenwood furnace. Fossil-ore from outcrop in ridge back of J. Barr's. Dip, southeast. Brittle, fossiliferous, reddish brown. Emits a strong argillaceous odor when breathed upon. (S. S. Hartranft.)

e

	128.	129.
	Per cent.	*Per cent.*
Sesquioxide of iron	71.571	42.928
Sesquioxide of manganese	Trace.	0.403
Alumina (by difference)	4.512	1.363
Lime	1.630	24.380
Magnesia	0.619	1.895
Sulphuric acid	Trace.	Trace.
Phosphoric acid	0.998	1.021
Carbonic acid	None.	19.710
Water	4.040	1.900
Silicious matter	15.730	6.400
Total	100.000	100.000
Metallic iron	50.100	30.050
Metallic manganese	Trace.	0.281
Sulphur	Trace.	Trace.
Phosphorus	0.436	0.440
Phosphorus in 100 parts iron	0.870	1.484

f

128. On property of Dull & Bradley, three-quarters of a mile south of Mapleton. White and red. Fossil-ore of V. Soft fossil. Comparatively soft; shows small scales of specular iron ore; color, various shades of brown. (J. M. S.)

129. On property of Dull & Bradley, three-quarters of a mile south of Mapleton. White and red. Fossil-ore of V. Hard fossil. Compact; brittle; dark brown and reddish brown. (J. M. S.)

Blair county.—In the census year 40,636 tons of fossil-ore were mined in this county. The following analyses are from Report MM, pp. 235 to 237:

	646*a*.	646*b*.
	Per cent.	*Per cent.*
Sesquioxide of iron	30.857	19.285
Sesquioxide of manganese	0.053	0.046
Alumina	2.850	1.828
Lime	31.530	38.160
Magnesia	0.865	0.840
Sulphuric acid	0.060	0.085
Phosphoric acid	1.092	0.417
Carbonic acid	23.778	30.205
Water	1.885	1.015
Insoluble residue	7.090	8.315
Total	100.000	100.202
Metallic iron	21.600	13.500
Metallic manganese	0.035	0.032
Sulphur	0.024	0.034
Phosphorus	0.477	0.182

646*a*. *Hollidaysburg* double fossil-ore, upper layer. Compact, fossiliferous, showing considerable calcareous matter; reddish brown.
646*b*. *Hollidaysburg* double fossil-ore, lower layer. Compact, fossiliferous; reddish gray and reddish brown.

	645.	712.	962.
	Per cent.	*Per cent.*	*Per cent.*
Sesquioxide of iron	74.285	67.285	69.357
Sesquioxide of manganese	0.072	0.278	0.014
Alumina	7.392	7.044	6.285
Lime	0.960	0.550	0.910
Magnesia	0.552	0.569	0.551
Sulphuric acid	0.077	0.082	0.008
Phosphoric acid	0.758	0.398	0.768
Carbonic acid	Traces.	Traces.	None.
Water	4.962	6.190	5.167
Insoluble residue	11.115	17.855	17.230
Total	100.173	100.251	100.290
Metallic iron	52.000	47.100	48.550
Metallic manganese	0.050	0.194	0.010
Sulphur	0.031	0.033	0.003
Phosphorus	0.331	0.174	0.327

645. *Hollidaysburg and Gap Iron Company's* mine, McKee's Gap. Lump-ore. Compact and tough; full of seams of ochreous iron ore and spangles of specular iron oxide. Color, generally reddish brown.

712. *Hollidaysburg and Gap Iron Company's* mine, McKee's Gap. Second sample, consisting of two-thirds lump-ore and one-third fine ore. Lump-ore has the general appearance of first specimen. Fine ore is for the most part a yellowish ochreous mud, rather lean in iron.

962. *Sarah Furnace* ore-bank, on Dunning's mountain, near Sarah furnace. Dark reddish brown; brittle; full of fossil pits, for the most part filled with specular iron ore. Emits a strong argillaceous odor when breathed upon.

OF THE CHEMUNG FORMATION.

These have been long known as the Mansfield ores of Tioga county, reported on first in 1841 by J. P. Lesley (published in 1858, *Geology of Pennsylvania*, vol. 1, p. 311), and then in greater detail in 1875 by Mr. Sherwood (published in 1878, *Report of Progress G*, pp. 33 to 37, 41, 42, 67).

The series consists of three beds: 1. *Upper* or *Spirifer* bed; 2. *Middle* or *Fish* bed; and, 3. *Lower* ore-bed.

The *Upper* or *Spirifer* bed is full of shells, but contains no fish remains. It lies about 200 feet below the base of the Catskill red rocks of Formation No. IX. Near Mansfield it is from 2 to 3 feet thick; on Lamb's creek, from 1 to 3 feet thick. (G, pp. 60, 61.)

The *Middle* or *Fish* bed is oölitic, and very similar to the Clinton fossil ores of middle Pennsylvania, yields remains of *fish* (*Diplodus*; *Heliodus*), and is ground for paint. It lies 200 (?) feet beneath the upper ore-bed at Wilcox's, on Mann's creek (G, p. 61), and is opened in many places, as at Roseville (4 feet thick); Whipple's hill; Bixby's hill; on Elk run, at Covington; Oak hill; Clark's hill; Austenville (where it thickens to 6 and 7 feet); Columbiana, etc. (G, p. 66.)

The third or *Lower* ore-bed, on Tioga river, back of Shaw's, is described on p. 61, G, as from 100 to 200 feet beneath the Middle bed. It contains small flattened pebbles of quartz.

At Canton Corners, Bradford county, two beds, separated by 8 feet of shale, yield 5 feet of ore, under a roof of shaly Chemung limestone, 10 feet thick, full of fossils. (G, p. 41.)

Mr. Sherwood discovered one of the Mansfield ore-beds on a sharp anticlinal in Lycoming county, in front of the Alleghany mountain; and traces of this deposit have been seen elsewhere in middle Pennsylvania, as in Huntingdon county (see Report F, p. 235), where they have been referred to the Larry's creek ore; and, since they lie 13 feet beneath the bottom of the *transition* layers of IX and VIII, they may represent, under a very much changed aspect, the upper Mansfield ore-bed. (Report MM, pp. 229 and 230.)

a The following analyses are from Report MM, pp. 231 to 232, and Report M³, pp. 34 to 36, 41 and 45:

Tioga county.	319.	198.	318.	335.	317.
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
Iron	42.800	38.900	32.400	43.100	35.300
Sulphur	0.018	0.063	0.065	0.018	0.026
Phosphorus	0.903	0.608	0.585	0.657	0.215
Lime	.....	13.100	9.170	1.800	4.740
Magnesia	.....	2.140	2.918	0.922	.....
Insoluble residue	21.670	11.565	23.890	20.910	28.845

b

NOTE.—Dr. McCreath writes: "These analyses may serve to show the character of the Mansfield ore-beds, but it is doubtful if the samples represent the average ore to be mined."

319. *Upper* or *Mansfield* ore-bed, on Andrew Shaw's farm, 2 miles northeast of Mansfield, Richmond township. Upper vein, 3 feet thick. (See G, p. 61.) Compact, coarse-grained; reddish brown.

198. *Upper* or *Mansfield* ore-bed, about 3 miles west of Mansfield. (See G, p. 60) Compact; deep red; shows considerable calcareous matter.

318. *Upper* or *Mansfield* ore-bed, on lands of G. R. Wilson, 3 miles northwest of Mansfield, Lamb's creek, Richmond township; 18 inches thick. (See G, p. 60.) Compact, coarse-grained; reddish brown.

335. *Lower* or *Third* ore-bed, 1 mile northwest of Mansfield. Outcrop in the bed of the Tioga river. (See G, p, 61.) Hard and compact, with small flattened quartz pebbles; color, generally reddish brown. (D. McCreath)

c 317. *Middle* or *Second* ore-bed, 1½ miles south of Mansfield, on Bixby's hill. Fine-grained; reddish brown. (D. McCreath.)

Tioga county.	324.	323.	322.	321.
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*
Iron	39.300	31.300	37.000	28.900
Sulphur	0.027	0.018	Trace.	0.015
Phosphorus	0.184	0.220	0.241	0.208
Insoluble residue	34.400	44.420	36.370	44.980

Ore-openings on the lands of Mr. Hermon and Mr. Meetem, 1 mile southeast of Ogden's Corners, Union township. (See G, pp. 33, 34.)

324. Ore from the top band, 4 feet thick. Compact, fine-grained; dark reddish brown.

d 323. Ore from the second band, 1 foot 5 inches thick. Compact, fine-grained; reddish brown.

322. Ore from third band, 8 inches thick. Compact, fine-grained; reddish brown and reddish gray.

321. Ore from bottom band, 1 foot thick. Compact, sandy; reddish brown (D. McCreath)

Perry county.	112.
	Per cent.
Metallic iron	35.775
Sulphur	0.010
Phosphorus	0.731
Silicious matter	31.740
Phosphorus in 100 parts iron	2.043

e

112. *Cumbler* property, Miller township, one-half mile northwest from the Cook property, on left side of ravine. Dr. Harry Stites, Newport. Montebello fossil ore. Rather coarse-grained, argillaceous; reddish brown.

Perry county.	113.	114.	115.	116.
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*
Sesquioxide of iron	41.714	33.428	44.143	40.714
Sesquioxide of manganese	0.110	0.220	0.352	0.042
Alumina	9.037	12.143	9.381	3.704
Lime	0.560	0.610	0.570	0.230
Magnesia	0.428	0.536	0.407	0.583
Sulphuric acid	0.025	0.025	0.037	0.029
Phosphoric acid	1.399	0.719	1.376	0.478
Water and organic matter	10.745	7.385	9.685	4.485
Silicious matter	35.620	44.690	34.070	48.980
Total	99.638	99.756	100.021	99.305
Metallic iron	29.200	23.400	30.900	28.250
Metallic manganese	0.079	0.158	0.253	0.030
Sulphur	0.010	0.010	0.015	0.011
Phosphorus	0.611	0.314	0.601	0.209
Phosphorus in 100 parts iron	2.092	1.341	1.945	0.739

f

NOTE.—Mr. McCreath writes: These samples "represent the fossil ore of VIII, and the analyses show about what the average ore yielded in the furnace. Not much of the ore used."

113. *George Peterman's* land, Duncannon Iron Company, lessees; Polecat valley, in Mahonoy valley, on the southeast side of Mahonoy ridge, 3 miles southwest of Juniata river. Montebello ore. Top division of ore, upper bed 8 inches to 10 inches thick. Soft, crumbling, shaly; dark brown; structure somewhat laminated. a

114. *George Peterman's* land, Duncannon Iron Company, lessees; Polecat valley, in Mahonoy valley, on the southeast side of Mahonoy ridge, 3 miles southwest of Juniata river. Montebello ore. Middle division of ore = the bottom division of the upper ore-bed; 8 to 10 inches thick. Soft, crumbling, very shaly; reddish brown.

115. *George Peterman's* land, Duncannon Iron Company, lessees; Polecat valley, in Mahonoy valley, on the southeast side of Mahonoy ridge, 3 miles southwest of Juniata river. Montebello ore. Top bed of ore. Soft ore, 18 inches thick. Comparatively soft, shaly; reddish brown.

116. *George Peterman's* land, Duncannon Iron Company, lessees; Polecat valley, in Mahonoy valley, on the southeast side of Mahonoy ridge, 3 miles southwest of Juniata river. Montebello ore. Bottom bench of ore = lower of the two ore-beds, 8 inches thick. Rather coarse-grained and sandy; full of fossil casts; somewhat porous; reddish brown. b

Lycoming county.	141.	142.	143.	144.
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*
Sesquioxide of iron	40.714	46.643	49.857	42.857
Sesquioxide of manganese	0.103	0.300	0.248	0.186
Alumina	5.260	5.476	3.774	4.000
Lime	1.620	1.760	0.270	1.450
Magnesia	0.828	1.030	1.093	0.881
Sulphuric acid	Trace.	Trace.	Trace.	Trace.
Phosphoric acid	0.907	1.101	1.759	0.863
Carbonic acid	None.	None.	2.590	None.
Water	3.710	4.310	4.060	3.705
Silicious matter	56.630	30.220	20.130	44.830
Total	99.781	99.840	99.381	99.402
Metallic iron	28.500	32.650	34.900	30.000
Metallic manganese	0.072	0.209	0.173	0.130
Sulphur	Trace.	Trace.	Trace.	Trace.
Phosphorus	0.396	0.481	0.768	0.377
Phosphorus in 100 parts iron	1.389	1.473	2.200	1.256

c

141. *McGowan* mine, Piatt township, 2 miles northeast from Jersey Shore, Stewart's run. Fossil-ore of VIII. Generally compact, highly fossiliferous, with some phosphatic pebbles; color, reddish brown. d

142. *Quiggleville* mine, at Quiggleville, 1 mile northwest from Perryville, Lycoming township, just south of Mr. Stiber's house. Chemung fossil-ore. Rather compact and fine-grained; fossiliferous, with some phosphatic pebbles; color, reddish brown.

143. *Hayes* mine, on Lycoming creek, Hepburn township, one-third mile north of Cogan Station, Northern Central railroad. Chemung fossil-ore. Rather coarse-grained; highly fossiliferous; carries numerous phosphatic pebbles; color, reddish brown and reddish gray.

144. *Furnace Run* mines, on the north side of Furnace run, close to the south line of Watson township, and near the old Safe Harbor furnace, 6 miles northwest of Jersey Shore. Chemung fossil-ores. Rather fine-grained, fossiliferous, shaly; reddish brown.

REPORT ON CERTAIN MAGNETITES IN EASTERN PENNSYLVANIA.

By Bailey Willis.

Within the area of Mesozoic red sandstone in eastern Pennsylvania there are several deposits of magnetic ore of great economic value and peculiar geologic relations. Their chemical composition, the associated minerals, and the wall-rock are essentially different from those of the neighboring magnetites of New Jersey, and afford a distinct set of geologic facts worthy of much more detailed study than has been given them. c

The deposits thus referred to are the Dillsburg magnetic mines; the Great Cornwall mine, near Lebanon, Lebanon county; the Jones mines, near Springfield, Berks county; the Hopewell, Saint Mary's, and French Creek, in western Chester county; the Wheatfield and Fritz' Island, near Reading, and the Boyertown mines.

Of these the Cornwall mine is the largest and best known, and what little study the deposits have received has centered in that.

The description given by Professor Rogers, in the *Report of the First Geological Survey of Pennsylvania* (Vol. II, page 718), the paper by Professor T. Sterry Hunt (*Proc. Am. Inst. of M. E's.*, Vol. IV, page 319), and an account by Professor Hans Höfer, in the *Report of the Austrian Commission to the Centennial Exposition*, called "Die Kohlen und Eisenerz-Lagerstätten Nordamerikas" (page 241), are the only publications relating to these mines I have seen. My own observations were made in June and July, 1881, while visiting the mines to collect samples for d the Tenth Census. They are by no means as detailed as I could desire, but some of the facts noticed and the maps of the mines obtained are of importance.

The three writers on these deposits differ greatly in their opinions. Professor Rogers says, under the heading "Iron Ores of the Metamorphic or Gneissic Rocks" (Vol. II, p. 713):

> The magnetic iron ore occurs only in the form of true veins of injection or genuine mineral lodes.

And in the same paragraph:

> These iron ores evidently reached the positions in which we thus find them while in a melted state.

Writing of the French Creek deposits, near Knauertown, he says (Vol. II, p. 706):

> The predominant metalliferous injections are veins or lodes of magnetic oxide of iron.

And on page 707, of the Leighton mine: e

> A large surface excavation, embracing two veins of igneous magnetic iron ore.

On page 708, however, he says of the Warwick mine, near Saint Mary's:

> This extensive and interesting body of iron ore is in reality not a genuine lode or igneous intrusive vein, though the ore derives some of its characters from intrusive igneous action, but is a bed or deposit at the base or very near the base of the middle secondary red sandstone, which here laps upon the gneiss.

At the bottom of the same page he refers to the ore as having been originally a hematite, but altered by igneous action.

On page 718 he describes the ores of the primal series as follows:

> The slates of the primal series, especially the upper primal slates, yield two classes of iron ore—one a very ferruginous variety of f the rock itself, under conditions of more or less metamorphism; the other a class of rich brown hematite iron ore of superficial formation. To the first class belong the valuable and noted mines of Cornwall, in Lebanon county, the Jones mine, in Berks, and partially the Chestnut Hill mine, near Columbia, and some of the ore-diggings near Safe Harbor.

Referring particularly to the Cornwall mine, he goes on:

> At this locality the actions collecting the oxide of iron into its present conditions have been somewhat complicated. The ferruginous primal slate has been metamorphosed, and its oxide of iron segregated and crystallized through the influence, probably, of highly-heated volcanic steam, and the same influence has produced a very general cleavage structure. During the same action, or subsequently, numerous injections of molten hot lava, resulting in dikes of trap-rock, have invaded the stratum, and have still further changed the condition of the mass, infusing among it, probably by sublimation, some trappean mineral matter, and especially some sulphuret and carbonate of copper; and since these subterranean influences, the atmosphere, through its rains, has exerted itself through countless ages to modify still further the chemical and physical conditions of the shattered and fissured mass and its contained oxide of iron.

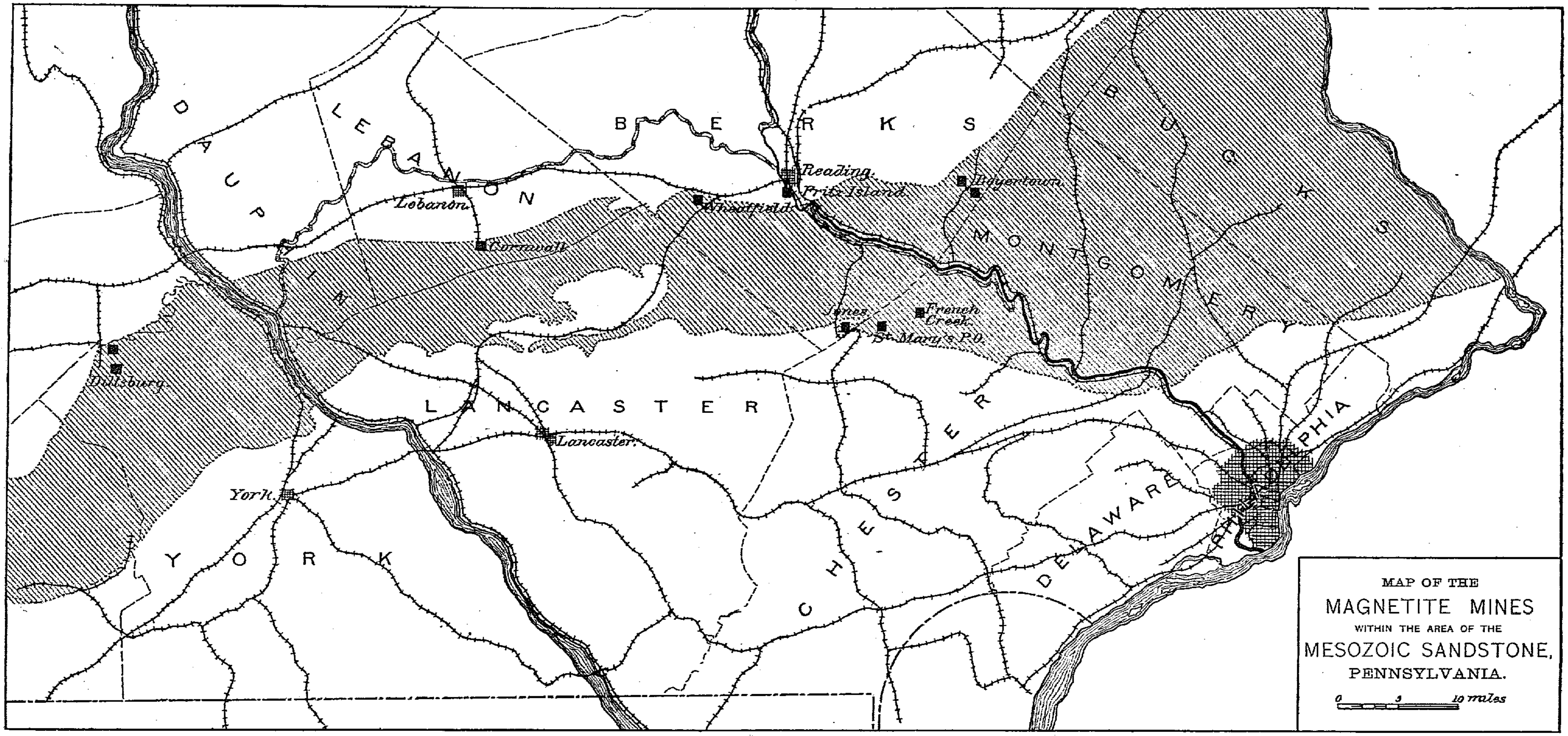

MAP OF THE
MAGNETITE MINES
WITHIN THE AREA OF THE
MESOZOIC SANDSTONE,
PENNSYLVANIA.
0 5 10 miles
DAUPHIN
LEBANON
BERKS
BUCKS
MONTGOMERY
LANCASTER
CHESTER
DELAWARE
PHILADELPHIA
YORK
Reading
Fritz Island
Boyertown
Wheatfield
Lebanon
Cornwall
Jones
French Creek
St. Mary's P.O.
Dillsburg
Lancaster
York

FIG. 57.

Professor Rogers thus considers some of these magnetites to be of igneous origin, and some to be metamorphic; a the Warwick mine, at Saint Marys, he assigns to the Mesozoic, the Cornwall and Jones mines to the upper primal slates, which directly overlie the primal white sandstone or Potsdam sandstone.

Professor T. Sterry Hunt, in his paper on these ores, says (*Transactions of American Institute of Mining Engineers*, Vol. IV, p. 319):

These ores were, by Professor H. D. Rogers, referred to what he designates as the primal slates, which he regarded as the lowest member of the Paleozoic series; though by some later observers the Cornwall mine and certain related deposits west of the Susquehanna have been referred to the Mesozoic sandstone. It would be foreign to my present purpose to set forth the reasons which lead me to conclude that they are, all of them, really contemporaneous deposits included in the primal slates, which correspond to a portion of the Lower Taconic series of Emmons, and belong, in my opinion, to a lower horizon than the Potsdam sandstone of the New York system. b

Professor Hunt thus refers the ores to the lower primal slate, which is separated from the upper by the Potsdam.

Professor Höfer considers the trap at Cornwall not an eruptive rock.

The almost constant associates of these ores are a light-green slate, which is interstratified with them, a crystalline limestone, the Mesozoic red sandstone, and trap- (dolerite) dikes. The constantly-occurring intermingled minerals are pyrite, chalcopyrite, and carbonates of copper and calcite. Dr. Genth gives many others in his report on the mineralogy of Pennsylvania for the second geological survey, but they are not of sufficient consequence to be cited here.

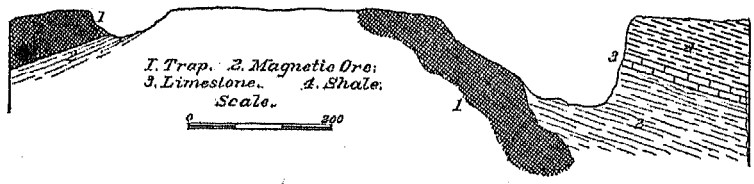
The French Creek mines and those near Saint Mary's differ from the others by the absence of stratified limestone, and the bedding of the ore in gneiss, which is not seen in Boyertown, Fritz island, Wheatfield, Cornwall, or Dillsburg. At all the latter the limestone is an important associate. Professor Rogers, in his description of Cornwall, has the c following (Vol. II, p. 720):

In the pit large masses of light-blue, flinty, and magnesian limestone are found imbedded with and surrounded by ore; they are devoid of regular form. In like manner masses of quartz are found as bunches in the bedding of the slaty ore. The limestone is evidently not *in situ*.

The developments made at Cornwall since Professor Rogers' observations show that the limestone is distinctly stratified, and occurs as indicated in the section of that mine. At Jones' the limestone is conformable to the stratified underlying ore, which becomes more calcareous as it approaches it, and there is no marked line of division. At Boyertown a limestone bed 175 feet thick lies between the Warwick and the old Gable workings. At Fritz island and Wheatfield the ore is associated with the Potomac marble, a limestone breccia; and at Dillsburg the limestone forms the foot-wall of the ores. The relative position of the limestone to the ore may be open to d discussion; but that it had a definite stratigraphical position which, disturbed as the deposits are, may yet be determined, hardly seems doubtful.

The following is a description of the individual mines, with such observations on their geology as the writer was able to make:

Jones' mine, 1 mile north of Springfield, Berks county, presents the simplest structure. There are two open-cut workings on stratified ore, both dipping away from a body of trap which lies between.



e

Approximate Section of the Jones' Mine.

FIG. 58.

In the northern pit the ore dips 16° N. 55° W. The contact between the ore and the underlying trap has been well exposed in the south side of the cut. Above the ore is a limestone-bed conformable to it, about 12 to 15 feet thick, and above that still is a conformable light-green, earthy shale. If it should prove that this shale belongs to the Mesozoic sandstone, the ore is probably of the same age; but this shale has no resemblance to any of Mesozoic f age that the writer has seen, and it seems more probable that it corresponds to an overlying ore-stratum found in some of the other mines, but here devoid of magnetite.

The conformability between the ore, limestone, and shale points to their having a common geological age. The body of the ore is a black magnetite, interstratified with light-green slate, and containing pyrites, calcite, and chalcopyrite. The upper layers pass from this into a crystalline marble with grains of magnetite, and these become fewer as the limestone is approached, pointing to the deposition of the ore as a sediment in a shallow sea, which gradually deepening, afforded the conditions for the formation of limestone.

In the southern opening, about 300 yards from that just described, the ore lies beneath a trap-dike, dipping about 25° to the southeast. The foot-wall has not been reached. The ore is much oxidized and contains much less pyrites than that from the northern cut.

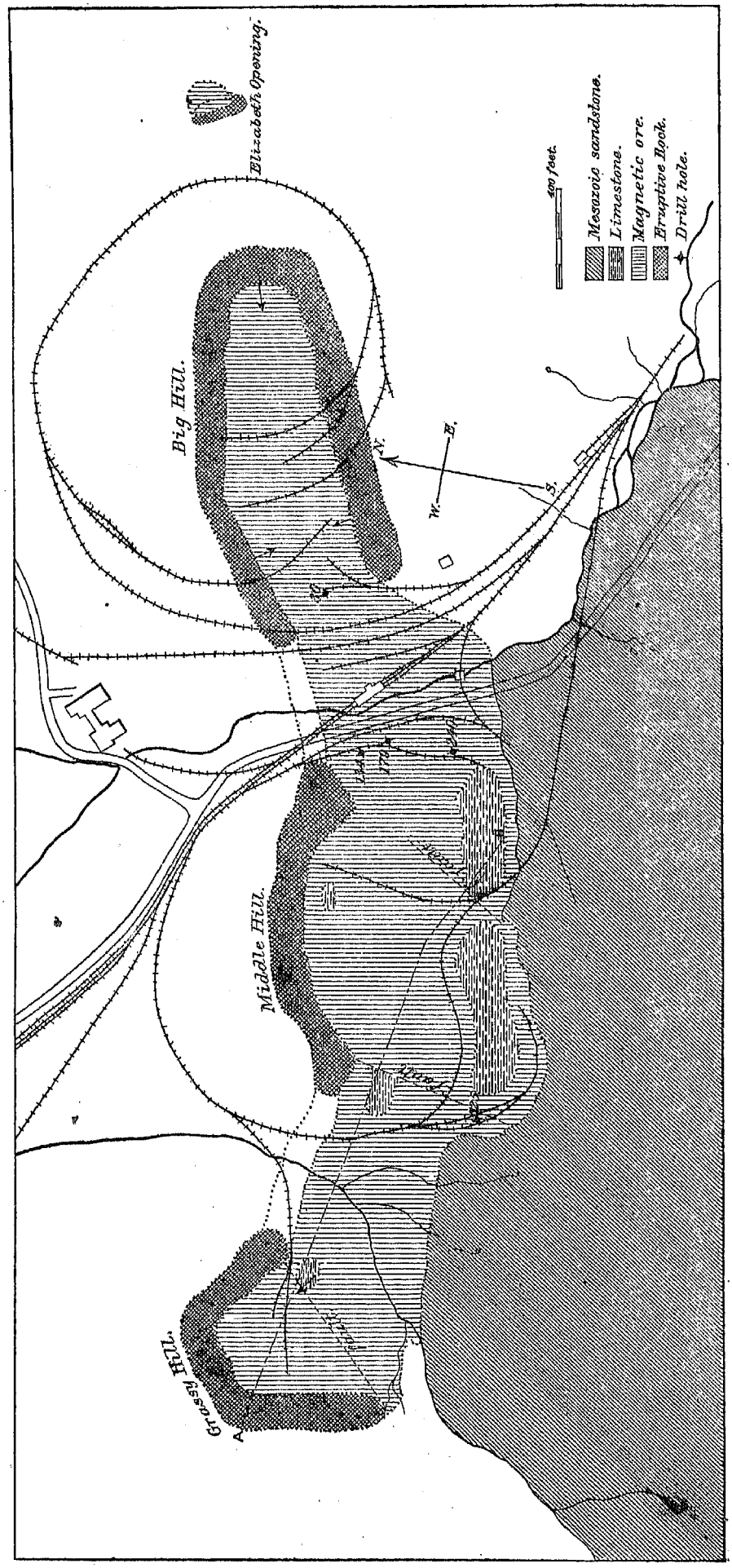


FIG. 59.—MAP OF THE CORNWALL MINE, LEBANON COUNTY, PENNSYLVANIA.

The structure of the entire deposit is that of an anticlinal, broken through at the top of the arch by the trap. a
The following are the analyses of the samples taken from the ore on stock-pile at the two openings:

	North cut.	South cut.
	1424.	1425.
	Per cent.	*Per cent.*
Metallic iron	45.26	51.32
Phosphorus	0.027	0.025
Phosphorus in 100 parts iron	0.060	0.049

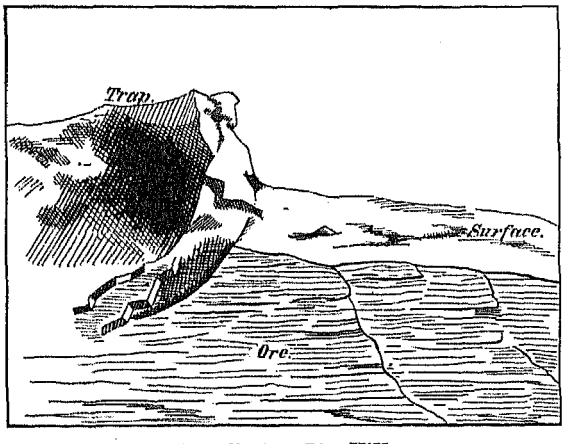
b

The Cornwall mine is opened on an enormous deposit of magnetic ore, 4,500 feet in length from east to west and 400 to 900 feet in width from north to south. On the west, north, east, and southeast it is bounded by a wall of trap; on the remaining south side, 3,200 feet in length, the ore disappears under the Mesozoic sandstone.

Two streams, flowing northward across the deposit, have cut it into three hills—Big hill on the east, Grassy hill on the extreme west, and Middle hill between. Big hill is 312 feet above the creek at its base; Middle hill, 98 feet; and Grassy hill, 78 feet (Rogers, Vol. II, p. 719).

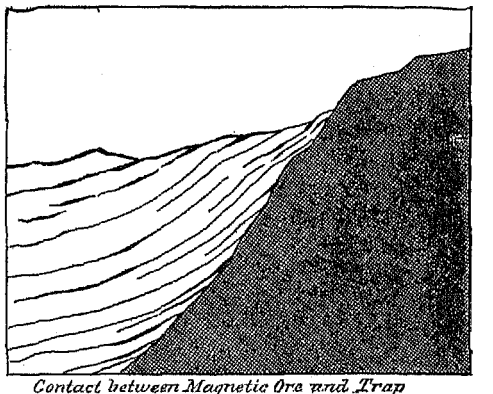
Surrounded on the south, east, and north by converging walls of trap, the ore of Big hill lies in a basin like the bowl of a spoon; a hole sunk at the western part of the hill struck trap after passing through 30 feet of ore. The southern rim of this basin sinks beneath the surface just west of Big hill, while the northern edge, notched c by the little stream, reappears north of Middle hill, and again on the north and west of Grassy. The basin deepens going westward from Big hill; east of Middle hill the trap was found in three holes sunk 134 feet, 179 feet, and 240 feet below the level of the creek, the deepest being nearest the sandstone on the south. On the western slope of Middle hill a hole was sunk 325 feet through ore, and, according to Mr. J. T. Boyd, the engineer in charge, no trap was found.

The structure of the ore throughout the entire exposure is that of a stratified deposit. In Big hill the strata



Trap Dyke, Big Hill.
FIG. 60.

d



Contact between Magnetic Ore and Trap Big Hill, Cornwall, Pa.
FIG. 61.

e

are essentially horizontal, though in places the intrusion of small trap-dikes has disturbed the mass, and along the sides the stratification is bent upward parallel to the great bounding walls of trap.

In Middle hill the dip is about 30° to the north, but it is much disturbed. A piece of the slate which occurs interstratified with the ore is shown in the accompanying sketch:

f

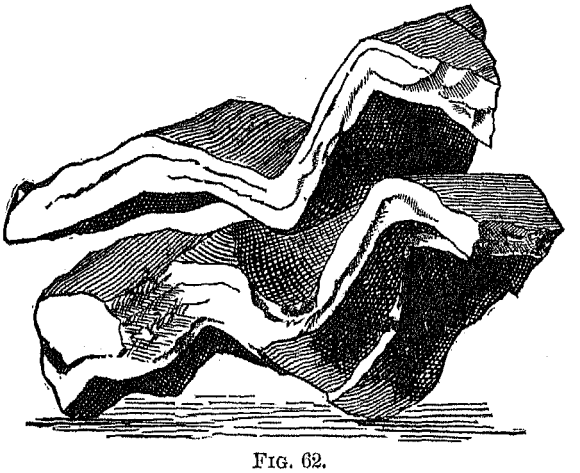


FIG. 62.

a The limestone, associated with the ore, occurs in isolated areas on Middle and Grassy hills; there is none on Big hill. In the accompanying section (Fig. 59) the principal occurrences of limestone are shown. Descending from the trap and crossing the ore-deposit on Grassy hill, one comes upon the limestone apparently dipping 30° under the ore toward the trap. Crossing the little knoll of limestone, it is seen conformably overlying the ore. Hence, this limestone either lies in the ore, between two separate strata, or it lies upon the ore, and the apparent dipping under is really a fault. Crossing the little brook to Middle hill, one finds a limestone near the foot of the slope. It ends abruptly near a steep ascent to the top of the hill, which is here covered by pebbles of the decomposed red sandstone; but south of the section-line a considerable area of the summit is formed of limestone, overlying the highest ore.

b Coming down to the southeast side of Middle hill, there is an outcrop of limestone, which appears, as on Grassy hill, to dip under the ore, but from beneath which the ore has been mined in a long drift.

Comparing this deposit with the very similar one at the Jones' mine, and considering the large areas over which the limestone lies above the ore, it seems probable that it was laid down upon it; that at Grassy hill a triangular prism of ore, bounded on the north and west by the fissures now filled with trap and on the southeast by a fault, was carried up in the outburst and placed in its apparent position above the limestone; and that a similar uplifted area forms the greater part of Middle hill, bounded on the west by a nearly north and south fault, on the north by the trap, and on the southeast by a fissure, partly located by the apparent dipping of the limestone under the ore.

At the foot of the eastern slope of Big hill, about 300 yards from the summit, is an old ore-pit, called the c "Elizabeth opening". This ore lies east of the trap, which surrounds the deposit on Big hill, and it cannot be ascertained definitely whether the great dike extends all the way between the two ore-beds or not. The fragments on the surface indicate that it probably does, and that the Elizabeth ore is a small pocket, separated from the main body in the upheaval.

A mile still farther east is another old ore-pit, now caved in. Of it Professor Rogers says (Vol. II, p. 720):

> A small ore-pit, from which no ore is at present extracted, known as the Dover mine, is situated 1½ mile east of Cornwall. The ore, though of the magnetic variety, appears in irregular bunches and nests. No trap interjections are found in the vicinity. The deposit is quite near the limestone, and is intermixed with sand and gravel.

It is much to be regretted that this deposit, apparently so distant from the trap elsewhere intimately associated with these ores, cannot be carefully examined.

d The Cornwall ores are represented by seven samples, two from Big hill, one from Grassy, and three of magnetite and one of copper ore from Middle hill. The latter represents the ore which is picked from the magnetite, in which it occurs in irregular pockets, and sold to smelting-works as it accumulates:

Analyses of Cornwall ores.

	1401.	1402.	1405.	1403.	1404.	1406.	1407.
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
Metallic iron	49.53	50.93	59.74	56.07	44.56	53.80	.....
e Phosphorus	0.013	0.017	Trace.	0.011	0.019	0.009	.....
Phosphorus in 100 parts iron	0.026	0.033	.....	0.019	0.043	0.017	.....
Copper (not analyzed for Fe)	.....	.....	.....	.....	.....	.....	11.62

In the neighborhood of Reading, in Berks county, are two mines, opened on ores essentially like that of Cornwall, but in much more disturbed deposits. These are the Fritz Island mine, 1 mile south of Reading, in the Schuylkill, and the Wheatfield mine, 7 miles southwest of Reading.

An attempt is made to indicate the character of the Wheatfield deposit in the accompanying section based on approximate measurement by pacing across five of the seven ore deposits.

f

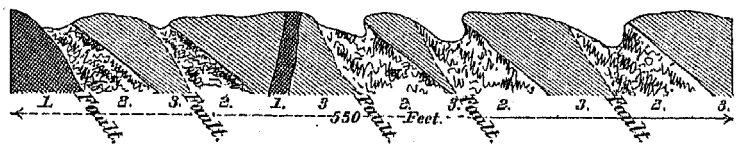


FIG. 63.—APPROXIMATE SECTION OF PART OF THE WHEATFIELD MINE.
1 TRAP, 2 MAGNETIC ORE AND LIMESTONE, 3 MESOZOIC RED SANDSTONE.

The strike is nearly north and south. The dip is about 40° to the west. Going westward from a low hill on the east one crosses in 300 yards seven outcrops of the Mesozoic red sandstone with the same number of marble- and ore-beds apparently interstratified. The sandstone is metamorphosed to a dense quartzite, which at times resembles the trap. The ore occurs in irregular deposits between the marble and the over and underlying sandstone, and in the marble itself; the latter is formed of angular fragments, readily distinguished by form and coloring from the inclosing matrix of calcite; the whole mass is a breccia.

Professor T. Sterry Hunt, speaking of the association of these magnetic ores with trap-dikes, says (*Transactions American Institute of Mining Engineers*, Vol. IV, p. 323): a

The Dillsburg ores are interposed in granular silicious rocks, and are associated in most cases with eruptive traps, not unlike those of the Cornwall mine—a fact which has served to confirm the popular notion that these ore-deposits are in some way dependent upon the eruptive rock. It is, however, found, in some cases where these traps cut across and interrupt the ore-deposit, that this is continued unchanged on the farther side of the dike, and at Wheatfield, where similar ores are mined, these traps are wanting, although the miners, firm in the conviction that trap-rock is an indispensable condition of a successful mine, maintain that the granular detrital quartzite, with which the ore is here interstratified, is itself a trap.

Undoubtedly the quartzite is not trap; but a body of trap appears to form the eastern boundary of the deposit, and a very distinct dike cuts across the beds with a northeast and southwest course. Specimens from this dike cannot be distinguished from those from Cornwall, Jones', French Creek, Fritz Island, or Dillsburg. b

The Fritz Island mine is worked through an incline, sunk, it is said, 275 feet from the surface in ore. The body thus opened extends about 400 feet eastward under the Schuylkill, and 75 or 100 feet westward from the incline; at both ends it is pinched out by the meeting of the hanging-wall and foot-wall. A small dike of trap runs through the ore, dipping, conformably with it, toward the north, and sometimes expanding so as almost to cut it out. Both walls are formed of a breccia indistinguishable from the marble at Wheatfield, and called by the miners "allsorts". From the western end of this ore-body a drift was driven southward 90 feet into the foot-wall, and a parallel deposit of ore found. This extends eastward from the cross-cut about 80 feet; its western limit has not been reached. The hanging-wall is the "allsorts" that fills the space between the two veins, while the foot-wall is an unbroken dike of trap. c

Two samples were taken from the Wheatfield and Fritz Island mines: One from a car-load of Wheatfield ore on the track, the other from 800 tons of Fritz Island ore at the Reading Iron Works. The analyses are—

	Fritz Island.	Wheatfield.
	1411.	1420.
	Per cent	*Per cent.*
Metallic iron	41.84	37.88
Phosphorus	0.029	0.025
Phosphorus in 100 parts iron	0.069	0.066

d

After the Cornwall the most extensively worked of these deposits are those of Boyertown. There are here four distinct mines—the Phœnix, the California, the Warwick, and the Gable. The two former are worked by the Phœnix Iron Company, of Phœnixville, the third by the Warwick Iron Company, of Pottstown, and the latter by the owners.

I am much indebted to Mr. J. H. Hardin, superintendent for the Phœnix company, for maps and information; to Mr. J. Fegley, superintendent of the Warwick mine, for the very recent map of the workings under his control; and to Captain Polkenhorn, of the same mine, for assistance in making my observations.

The owners of the Gable mine permitted me to go through their workings, but I was unable to plat my observations with the same accuracy as in the other cases.

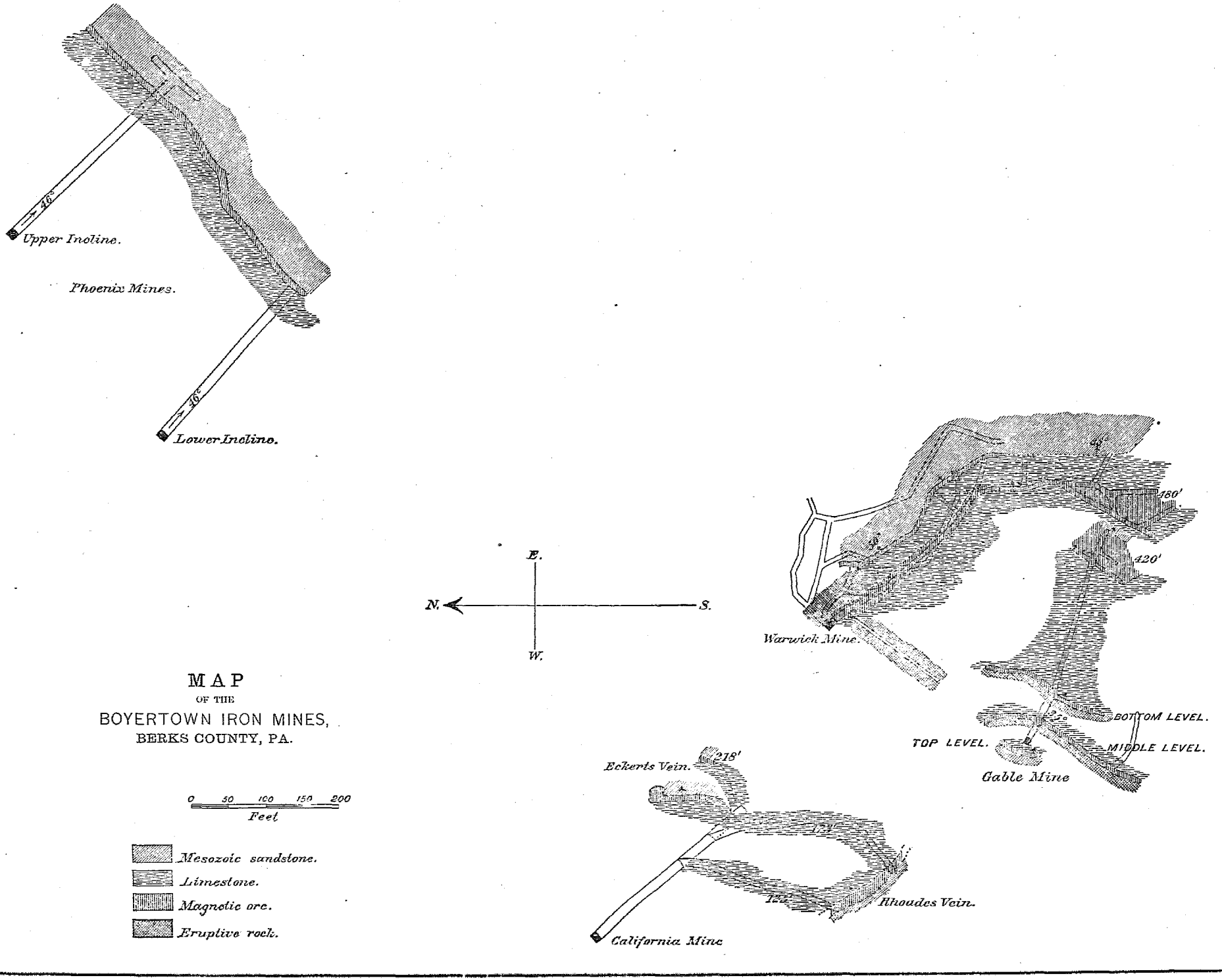
The Phœnix mines present the simplest structure. Two inclines, having an average slope of 46°, are sunk on e the ore, between a hanging-wall of Mesozoic red sandstone and a foot-wall of dark-gray limestone. Drifts, of which only the lowest is shown on the map, have been driven off on either side of the incline, and the ore removed by stoping. The bed varies from 7 to 12 feet in thickness, and near the hanging-wall there is usually a selvage of chloritic slate, which comes down in mining. The strike is quite regular, about northeast and southwest, and the beds have the apparent prospect of continuing indefinitely in either direction; just southwest of the lower incline the bed is pinched out, however, and no exploration has been made to ascertain whether it continues or not.

A shaft, known as Eckert's, and not down on the map, was sunk a short distance northeast of the California incline, and "Eckert's vein" was opened by it. The Phœnix company owns part of the mineral right on this "vein", and the California incline was sunk through rock to develop it and "Rhoades' vein", which was known by surface workings. f

As will be seen from the map, the northeast drifts of the California mine reach the southwest end of Eckert's ore; while two long cross-cuts have been driven through limestone to Rhoades' deposit. Eckert's is like the Phœnix in geological relations, but strikes nearly north and south, with a dip to the east.

Rhoades' vein strikes at right-angles to the Phœnix, southeast and northwest, and dips northeast; it has a hanging-wall of limestone and foot-wall of trap, and in this resembles the deposit opened by the Gable shaft; the ores obtained from the two openings are also very similar, and the differences of strike and dip are hardly sufficient in so disturbed a corner to render it improbable that they belong to the same deposit.

The lowest working in the California mine, on Eckert's vein, is 218 feet from the surface at the top of the incline; the dip is about 45° toward the east. This drift is 240 feet from the Warwick shaft, measured on the



MAP
OF THE
BOYERTOWN IRON MINES,
BERKS COUNTY, PA.

FIG. 94.

map. Ore was first struck in that shaft at a depth of about 400 feet, probably 425 feet below the top of the a California incline.

A dip of 38° to 40° would place a southern extension of Eckert's vein in the position of that cut in the Warwick shaft. It does not follow that the ore-body is continuous from the Warwick workings up to the California drifts. In fact, the trap which lies east of the Warwick shaft, and that penetrated in the long cross-cut toward the Gable mine, render it very improbable that there is an undisturbed body of ore here; but it does seem probable that the Warwick, the Eckert, and perhaps the Phœnix beds, which all have a red sandstone hanging-wall and a limestone foot-wall, are disturbed portions of the same originally-connected bed.

A special map is herewith given of the Warwick mine (Fig. 65).

It is opened in the most disturbed portion of the belt, and the apparent development of two parallel ore-beds, b together with the exceptional facilities afforded by the kindness of Captain Polkinhorn, led to careful study of it. In the long drift on the middle level, toward the south, there is a well-defined limestone foot-wall. The hanging-wall of red sandstone is also uninterrupted; but between the two, and especially in the northern end of the mine, the limits of the ore are very ill-defined. The wall is usually mixed limestone and ore, and mining is left off simply when the proportion of ore to limestone becomes too small to pay.

As the owners of the mine use their own product the quality is kept at a high standard.

Where the ore-body turns southward the upper bed of ore approaches the lower bed, and it will probably be found that there is but one extending southeastward, beyond the next turn in the Gable property. The variations in the thickness of the ore-bed and the positions of the associated limestone, red sandstone, and trap are given in c the accompanying special map.

Accepting the inference that the Warwick, Eckert, and Phœnix deposits have originally formed parts of one bed, though now disturbed and separated by "pinches", it is difficult to understand how the Gable and Rhoades veins can ever have been part of that bed.

The foot-wall of the Phœnix and the Eckert mines is apparently tilted, but otherwise a little disturbed, and continuous stratum. Away from the trap, which has confused the deposit near the Warwick shaft, the limestone foot-wall is in that mine also well defined. The long cut driven from the Gable bed to the large deposit in the south end of the Warwick mine passes through 175 feet of limestone. The same material lies uninterruptedly between the Eckert and the Rhoades beds. Hence it seems highly probable that there are here two distinct deposits of ore. With this in view, it would be interesting to know the results of exploration north of the Phœnix d mines.

Turning to the other similar mines, one finds at Fritz island two beds with 90 feet of limestone between them. But the deposit is so disturbed and the development is so insufficient, that this fact can hardly be accepted as confirmatory evidence. At Wheatfield the ore lies above and below and in the limestone; but that deposit is also too confused to base any judgment on.

I have already given my opinion, that the limestone at Cornwall was deposited above the ore now to be seen there. If another bed has at any time existed it has apparently been eroded.

At Jones' mine alone do we find the strata above the limestone undisturbed. The light-green shales conformable to it resemble the slates elsewhere interstratified with the ore. It is possible that they represent a stratum here locally so poor in iron that it has all been metamorphosed to a silicate; while at Boyertown the reducing action e has resulted in the formation of similar minerals, mingled with magnetic ore.

A very peculiar form of magnetite is not uncommon in the Warwick and Phœnix mines, and occurs frequently in the French creek and Hopewell deposits. This ore has a black streak and is distinctly magnetic, but it is crystallized in thin plates, having the appearance of micaceous specular ore. The immediate inference is that this is a pseudomorph, after specular ore. In Blum's *Nachtrag zu den Pseudomorphosen* (1847, pages 100–102), he describes pseudomorphs of magnetite, after siderite, specular ore, and limonite. In his *Vierter Nachtrag* (1879, pages 11, 12) he mentions two other instances of pseudomorphism of magnetite after specular ore, and says of one specimen: "The pseudomorphs are iron-black, with metallic luster; are magnetic, and have a black streak." The description applies exactly to specimens from Hopewell, French Creek, and Phœnix mines. In the latter several hundred tons of ore of this character were found in a mass. f

The occurrence of eruptive rock in the Boyertown mines is shown on the accompanying map; but the great dike, which is exposed for half a mile southwest of Gable's mine in the railroad cuts, is not mapped, as the writer had neither time nor means for a careful survey of the surface-geology.

The trap, which forms the foot-wall of Rhoades and Gable's ores, closely resembles that of Cornwall; but, macroscopically, there is but little similarity between it and the great dike above referred to. The latter is much more coarsely crystalline, and possibly owes its lighter color and different appearance more to that fact than to difference of composition.

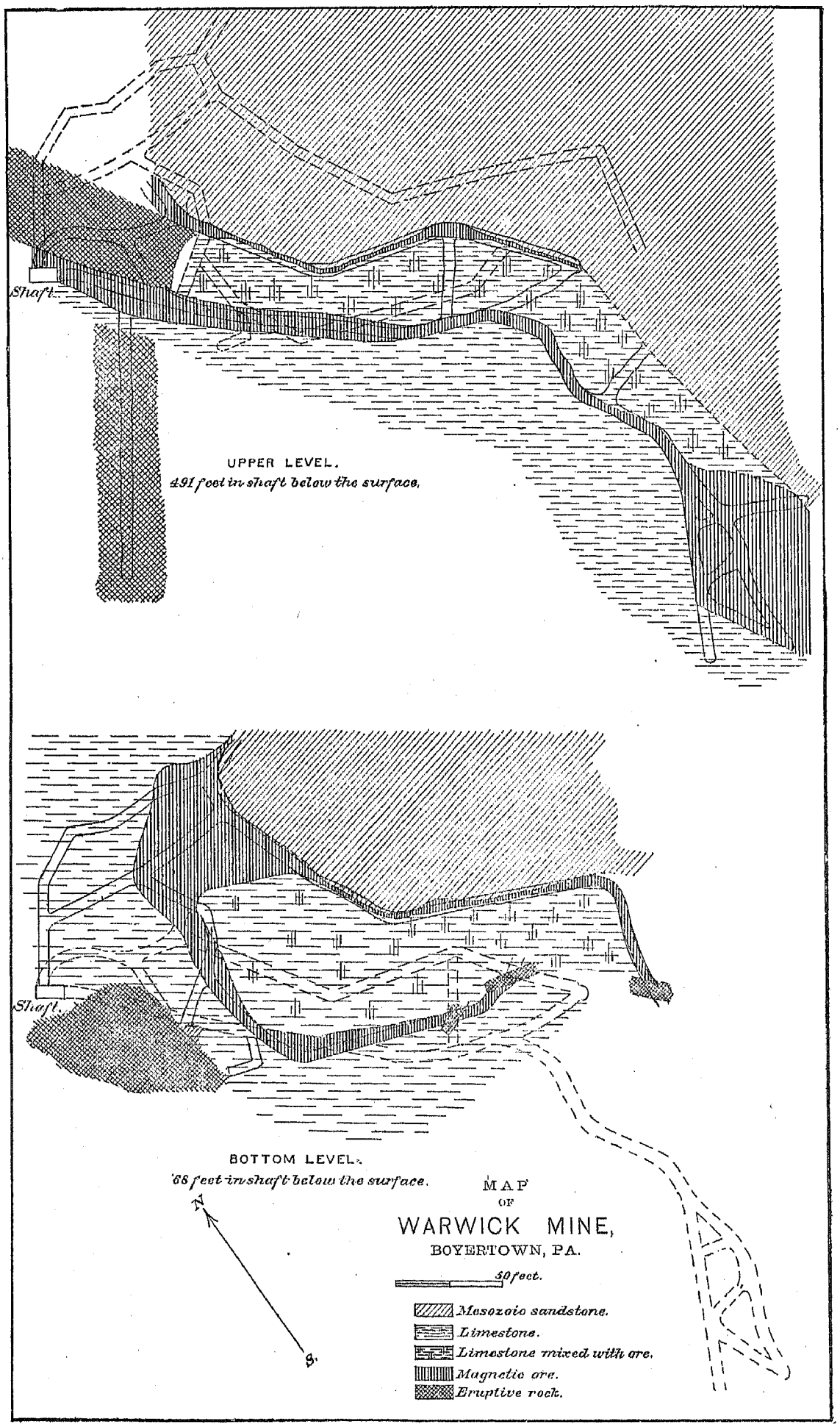

Shaft.
UPPER LEVEL.
491 feet in shaft below the surface.
Shaft.
BOTTOM LEVEL.
668 feet in shaft below the surface.
MAP
OF
WARWICK MINE,
BOYERTOWN, PA.
50 feet.
Mesozoic sandstone.
Limestone.
Limestone mixed with ore.
Magnetic ore.
Eruptive rock.

FIG. 65.

The ores of the Boyertown mines are represented by six samples: One from Warwick, two from Gable, one from Phœnix, and two from the California mine.

The analyses are:

	Warwick.	GABLE.		Phœnix.	CALIFORNIA.	
		New vein.	Old vein.		Eckerts.	Rhoades.
	1413.	1414.	1415.	1416.	1417.	1418.
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
Metallic iron	45.10	47.43	37.73	48.68	54.97	37.57
Phosphorus	0.069	0.038	0.039	0.022	0.037	0.045
Phosphorus in 100 parts iron	0.153	0.080	0.103	0.045	0.067	0.119

The Dillsburg magnetites are very similar in many respects to those already described; their chemical composition, associated minerals, and accompanying strata are essentially the same, but they differ in important geologic particulars. The trap which occurs in the mines a mile east of Dillsburg overlies the ore, with sometimes a layer of Mesozoic sandstone between it and the ore-bed; the foot-wall is sometimes limestone, sometimes sandstone. Hence the ores lie apparently more in the Mesozoic sandstone, less distinctly beneath it than elsewhere.

Professor Frazer says of these ores (*Report of Progress, Second Geological Survey of Pennsylvania*, 1877, p. 317):

> That they in their present state belong to the horizon of the Mesozoic series, and to no other, seems to be beyond question; first, because the same variety of that micaceous ore, which is so eminently characteristic of the deposits, can almost always be traced in any iron-mining locality of this formation from massive plates filling more or less regular interstices between sand-rocks, altered mud-rocks, traps, and shales; to scattered plates of the same ore spread slightly over the inner surfaces of joints and cracks in the sedimentary beds of the above; second, nowhere else is an exactly similar series to be found.

The decision between Professor Rogers and Professor Hunt on the one side, and Professor Frazer on the other, must be decided by those whose thorough acquaintance with all the facts fits them to judge.

Three of the mines east of Dillsburg are represented by samples taken from the ore loaded onto the cars at the depot. The analyses are:

	Bell.	Longnecker.	Underwood.
	1432.	1433.	1434.
	Per cent.	*Per cent.*	*Per cent.*
Metallic iron	39.55	43.63	44.10
Phosphorus	0.016	0.016	0.018
Phosphorus in 100 parts iron	0.040	0.037	0.041

The facts which separate the French Creek and Hopewell mines from all the others examined have already been referred to. The ores are bedded on gneiss; they are not associated with stratified limestone.

The deposit opened in the French Creek No. 1 Shaft is a peculiar formation.

The ore-body measures about 140 feet east and west by 70 feet north and south; the foot-wall, a dark-gray fine-grained gneiss, is nearly vertical; the hanging-wall dips 60° to 70° toward the north, and consists of a fine light-colored granite or gneiss. On the east a vertical wall of trap (?) cuts the ore square off, while on the west a wall of coarsely crystalline marble interrupts it, dipping 50° to the southeast. This marble incloses masses of granite, and is cut through by dikes of close-grained trap. Half a mile south of the mine a very large dike forms part of a ridge and apparently extends some miles westward.

In Shaft No. 2, within 200 yards of No. 1, a bed of very similar ore but very irregular formation has been developed. The dip here varies from 90° to 30°; at the depth of 150 feet the ore-body is about 120 feet long, and varies very greatly in thickness. The strike is nearly east and west, and the general dip northward, as in No. 1.

It seems probable that these ores have formed part of one bed, that they have been separated in the eruption of the trap, and that the peculiar form of the bed opened in No. 1 is the result of two fissures, the one of which filled with trap (?), the other with crystalline limestone. It should be stated, however, that the limestone of the western wall is coarsely granular, and the crystals are without regular form, while in the ore-mass large well-formed rhombohedra of calcite are very common. If the two have a common origin in crystallization from solution in thermal waters, which accompanied or followed the eruption of trap, the conditions of formation of the crystals have been essentially different.

Two samples taken from the chutes at the two shafts represent the French Creek ores.

	FRENCH CREEK.	
	No. 1 Shaft.	No. 2 Shaft.
	1421.	1422.
	Per cent.	*Per cent.*
Metallic iron	52.64	56.13
Phosphorus	0.033	0.040
Phosphorus in 100 parts iron	0.083	0.092

a In the neighborhood of Saint Mary's post-office there are a number of old mines from which magnetic ores of the character here described have been obtained for many years. Of these only the Hopewell was working in July, 1881; the Saint Mary's had lain idle for some time, and nothing could be seen of the deposits.

The old Hopewell workings were very extensive, both open-cut and underground; the ore dips 30° to 60° between walls of gneiss, and was followed downward with inclines until a persistent trap dike, which cuts the bed off, dipping in the same direction but with smaller inclination, was met with.

Hopewell Shaft No. 4 was working; this is sunk 150 feet through a coarse-grained gneiss, and the ore-bed has been followed 70 feet on a slope of 30°. The outcrop of the trap lies parallel with the old workings, about 50 yards south of them, the dike and ore both dipping northward.

b Fine specimens of magnetite crystallized in octahedra and of micaceous magnetic ore in arborescent forms were obtained from this mine. The ore as shipped is represented by the following analysis:

	Hopewell Shaft No. 4.
	1423.
	Per cent.
Metallic iron	57.29
Phosphorus	0.030
Phosphorus in 100 parts iron	0.068