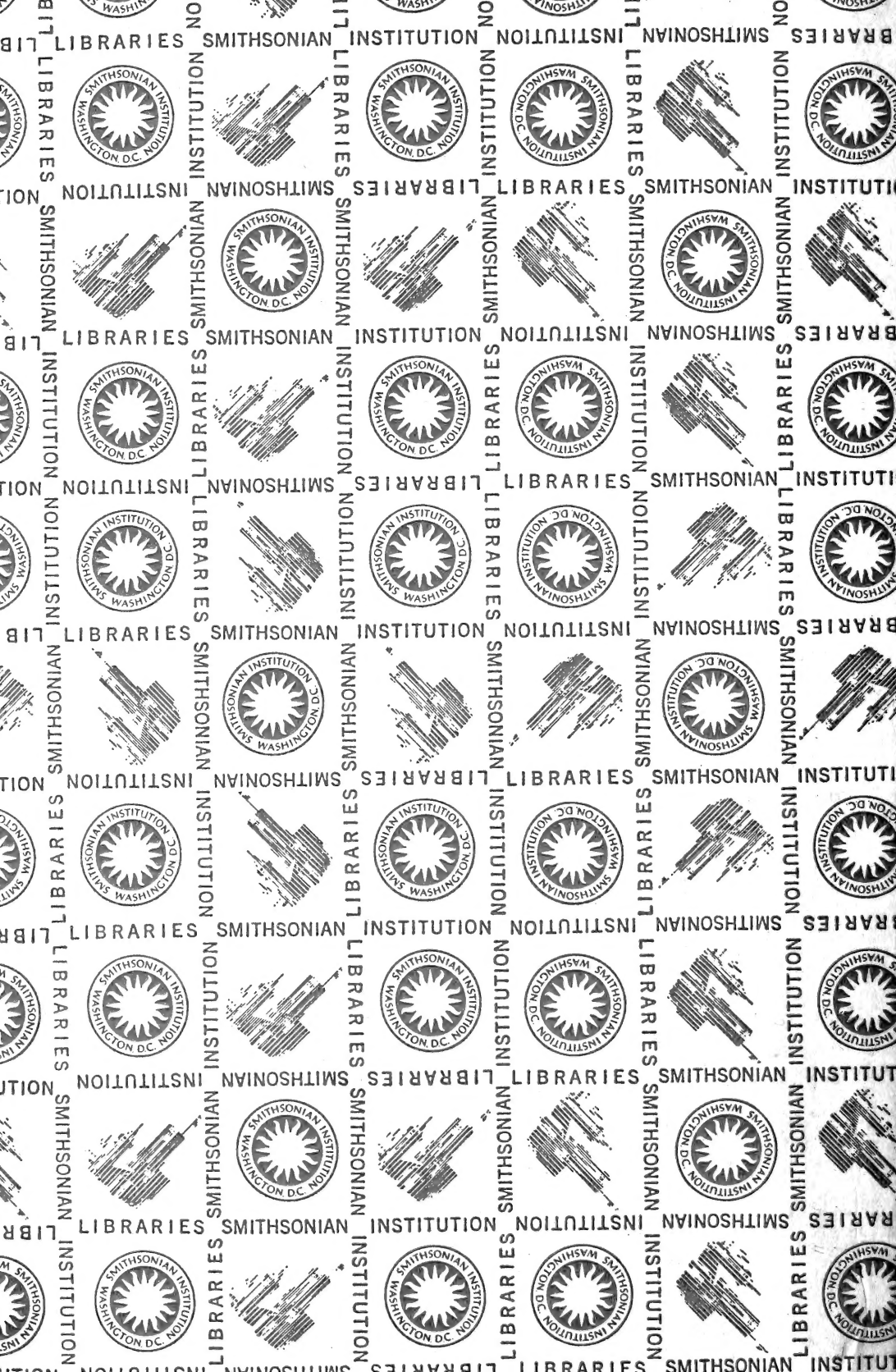
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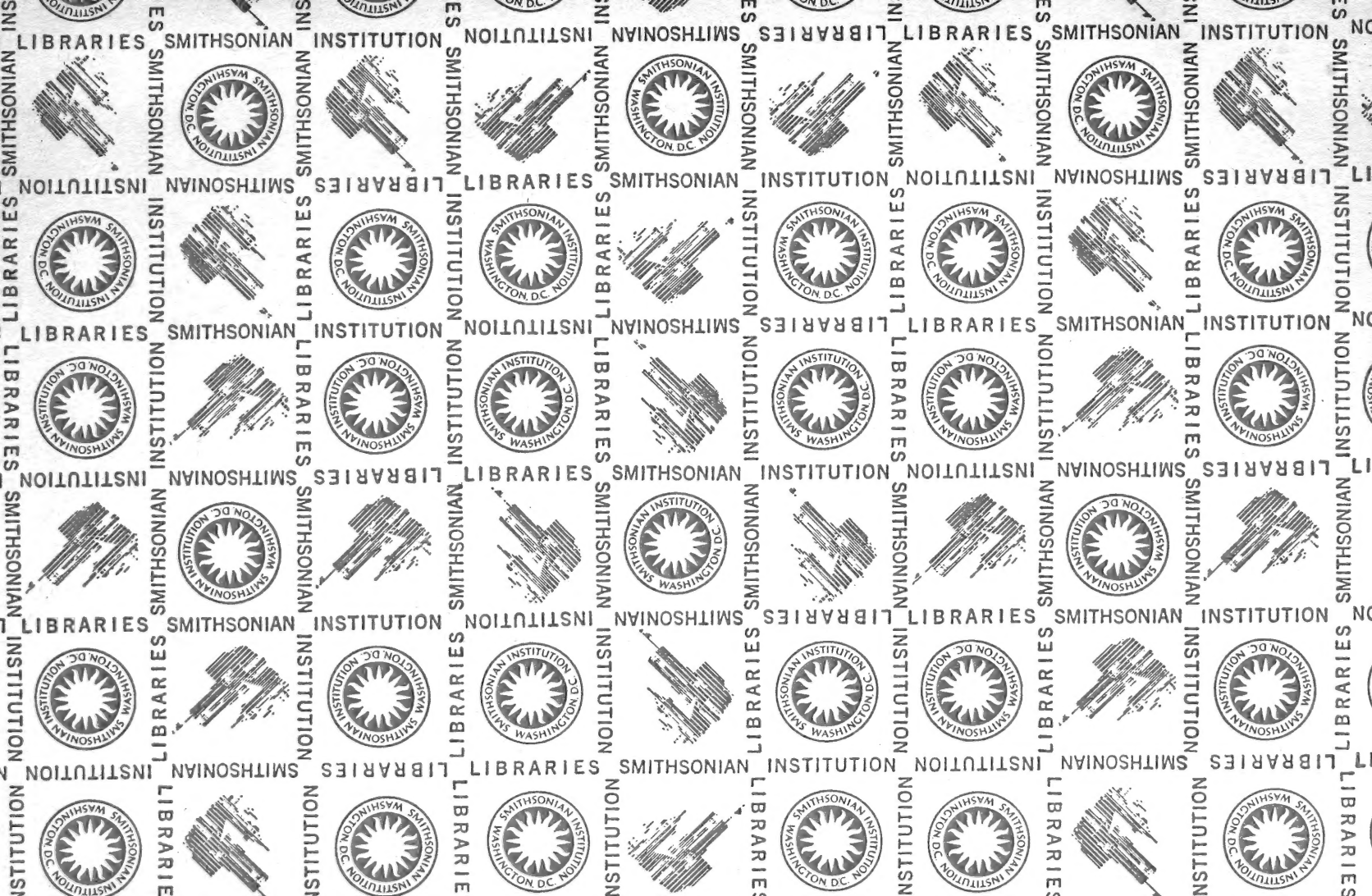
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BULLETIN

OF THE

NEW YORK STATE MUSEUM

OF

NATURAL HISTORY.

No. 7.

JUNE, 1889.

FIRST REPORT

ON THE

Iron Mines and Iron-Ore Districts in the State of New York.

By JOHN C. SMOCK,

DEPARTMENT OF MINERALOGY AND ECONOMIC GEOLOGY,

AND IN CHARGE OF THE

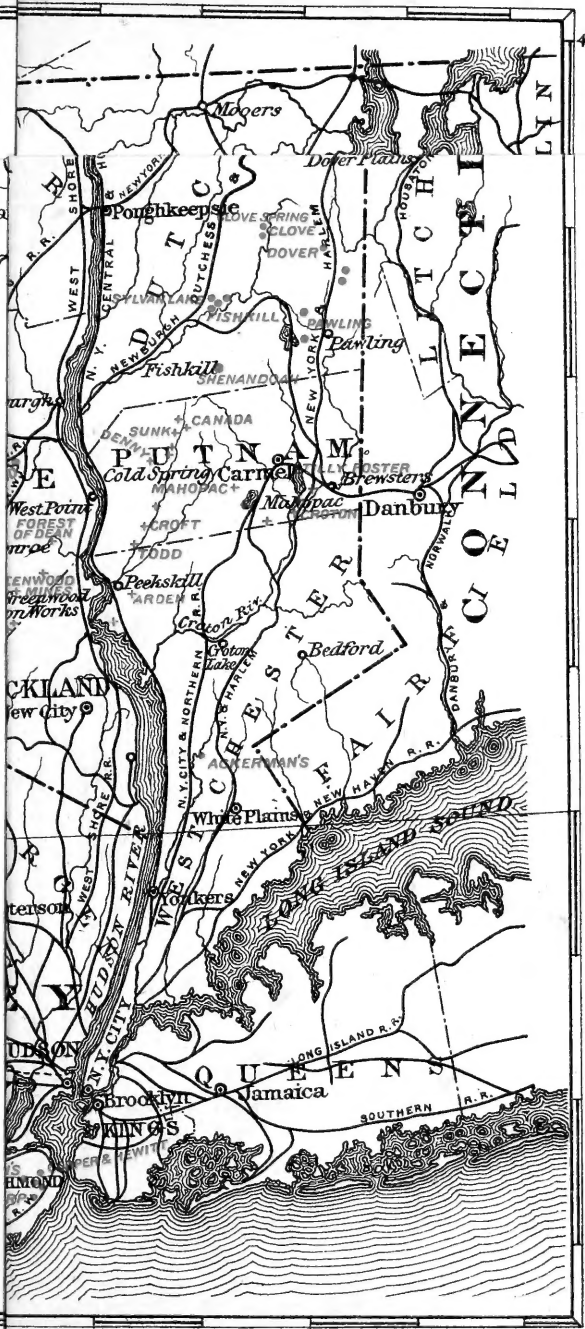
NEW YORK STATE MUSEUM.

PRINTED FOR THE MUSEUM.

ALBANY:

CHARLES VAN BENTHUYSEN & SONS,

1889.


45°
Towa
Poughkeepsie
Fishkill
Cold Spring
Carmel
Brewsters
Mahopac
Danbury
West Point
Peekskill
Croton Riv.
Bedford
White Plains
Yonkers
Brooklyn
Jamaica
KINGS
QUEENS
PUTNAM
DUTCHESS
WESTCHESTER
FAIRFIELD
LITCHFIELD
LONG ISLAND SOUND
HUDSON RIVER
N.Y. CITY
NEW YORK
HARLEM R.R.
N.Y. & NEW HAVEN R.R.
N.Y. CITY & NORTHERN R.R.
LONG ISLAND R.R.
SOUTHERN R.R.
41°
74°


MAP
OF
NEW YORK
SHOWING LOCATION OF IRON MINES
1889.
SCALE IN MILES
SCALE IN KILOMETERS
LAKE ONTARIO
LAKE ERIE
LEGEND
The Iron-Ore Mines are indicated thus:
+ MAGNETITE — Magnetic Iron Ore.
○ HEMATITE — Red Hematite "Fossil Ore."
• LIMONITE — Brown Hematite.
▪ CARBONATE OF IRON — Carbonate Ore.
Vermeule & Birn
Civil & Mining Engineers.

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PREFACE.

The work of preparing a report on the iron mines and iron-ore districts of New York was begun in the summer of 1888. A circular letter, with questions asking for information relative to their location, extent, statistics of mining plant, output and markets, analyses of ores, and historical notes of working, was sent to all of the mine owners or managers. A personal survey of the several iron-ore districts and a short visit to each mine were planned. The field work was continued through the autumn and into December, until the close of the season. Nearly all of the mines were visited and notes on their geographical situation and geological relations were obtained. Specimens of the ores of some of the more characteristic, associated rocks, illustrative of the occurrence, were collected for the Museum exhibition.

The letters of inquiry were answered, with two exceptions only, and valuable data about the mines, especially in their relations to the iron-mining and iron-manufacturing industries of the country, were received. The notes of the field survey, supplemented by the information furnished by the mine owners and managers, constitute the greater part of the material used in making this report. Short notices of the older mines and of some of the abandoned mine localities, chiefly of a historical nature, have been incorporated in it. The authorities for these references are given in all cases.

The original plan of the work has been followed, and the descriptive notes have been limited to the generalizations and details of a practical nature. The constant aim has been to make it a useful guide to the iron mines of the State; and not for the miner and prospector only, but for the public generally. The statistics of the extent and of the mine equipment and output are on the authority of the company or mine officials. The analyses show the chemical composition of the higher grades of ore and the percentage of metallic iron is above the average of the ore shipments. In many cases the yield of iron in the furnace, or the percentage guaranteed, is stated.

The full descriptions of the mines, the discussion of the structural features of the ore beds and deposits, and their geological relations, with notes on the geology of the districts in which they are found, are omitted. The season was too short for the additional work of studying the varying modes of occurrence of the several kinds of ore in all of the iron-ore districts. They may make the subject of a second report, in a future bulletin.

It is proper and pleasant to refer here to the prompt and uniformly kind courtesy of all the mine owners, superintendents and other officials, and of the furnace managers also, who have responded so fully to the circular letters sent to them, and to acknowledge their generous aid in affording every facility for seeing the mines under their care, without which the preparation of this report would have been an impossibility.

JOHN C. SMOCK.

DEPARTMENT OF MINERALOGY
AND ECONOMIC GEOLOGY,
N. Y. STATE MUSEUM.

ALBANY, JUNE, 1889.

CONTENTS.

INTRODUCTION.

The ores of iron, which occur in beds and deposits of workable size, in the State of New York, may be classified, according to their chemical composition, into oxides and carbonates of iron, and these classes may be subdivided, following the mineralogical characters, into the several species and varieties. The following tabular arrangement shows the natural grouping of the species in these two great divisions:

NOTE. *Pyrite* and *Pyrrhotite*, known commonly as iron pyrites and magnetic pyrites, *menaccanite* or titanic iron and other compounds of iron, some of which are found in large deposits, or are widely distributed, are not put in this table, because they cannot be used economically as sources of iron.

CHEMICAL GROUPS.		MINERALOGICAL SPECIES AND COMMON NAMES.	
Oxides	Anhydrous Ferric Oxide. Sesquioxide of Iron.	Hematite	Red Hematite. Specular Ore. Clinton Ore.—Fossil Ore. Red Ochre.
	Ferric and Ferrous Oxides. Proto-sesquioxide of Iron.	Magnetite	Magnetic Iron Ore. Titaniferous Iron Ore.
	Hydrated Ferric Oxide. Sesquioxide of Iron.	Limonite	Brown Hematite. Brown Ochres. Bog Iron Ore.
Carbonates	Ferrous Carbonate. Carbonate of Iron.	Siderite	Carbonate Ore.
		Spathic Iron Ore	Clay Iron Stone. "White Horse."

A general law of occurrence of iron ores is that certain ore species occur in, or are characteristic of, definite geological horizons. For example, the magnetic iron ores are found in the crystalline rock areas of the Laurentian series; the red hematite appears to mark the Huronian; the fossil ore the Clinton epoch; the limonite, or brown hematite the formations of the Trenton Period; the carbonate the Marcellus shale, and the bog iron ore the more recent formations of Tertiary and Post Tertiary ages.* There are, as might be expected,

*See paper by the author in *Trans. of Am. Inst. Min. Eng.*, Vol. xii, pp. 130, *et seq.*

many exceptions; but in the greater number of these apparently exceptional cases, the surface alteration, due to weathering or other atmospheric agencies, explains the occurrence.

This relation between the geological formation and the mineralogical species or *kinds* of iron ore, indicates the areas in which they may occur, and determines roughly their limits. Hence, a geological map of the State shows approximately correct boundaries of the several iron-ore districts, and is, as it were, an iron-mines map. The geology of a county or district, gives the clue in searching for ore; and its importance cannot be too strongly stated, both as a guide, suggesting exploration, and warning against unnecessary and fruitless surveys and wasteful outlays of time and money. Thus, for example, the magnetites belong in the crystalline rock districts, and the search for them in the later, sedimentary rocks of the adjacent territory would be a hopeless task; or, again, the exploration of the Highlands or Adirondacks, for carbonate ores, would be equally unscientific and destitute of results.

The geological formations, which are characterized as definite ore horizons, become the basis of a natural arrangement of the ore districts of the State. They are well marked geographically also, as can be seen by reference to the map accompanying this report. This map is on a scale of twenty miles to an inch, or $\frac{1}{1267200}$, and shows by its signs the location of the several mines, the kinds of ore, and indirectly, the groups or iron-ore districts.

Following this geologico-geographical arrangement, the groups and iron-ore districts are:

I. THE HIGHLANDS OF THE HUDSON.—MAGNETIC IRON ORES.
II. THE ADIRONDACK REGION, INCLUDING THE LAKE CHAMPLAIN MINES.—MAGNETIC IRON ORES.
III. THE HEMATITES OF JEFFERSON AND ST. LAWRENCE COUNTIES.
IV. THE CLINTON OR FOSSIL ORES.
V. THE LIMONITES OF DUTCHESS AND COLUMBIA COUNTIES.
VI. THE LIMONITES OF STATEN ISLAND.
VII. THE CARBONITE ORES OF THE HUDSON RIVER.

A few isolated mines cannot be thus classified, as the hematite near Canterbury, Orange county, Ackerman's mine near Unionville, Westchester county, the Napanock and Wawarsing mines, in Ulster county, the hematite of Mt. Defiance in Ticonderoga, and the bog

iron ores, which are scattered in all of the great divisions of the State. The iron sands of the shores of Long Island are left out, as not properly a natural source of iron.

In the descriptions of the iron-ore districts and mines, which here follow, the arrangement is a geologico-geographical one, that is, the order of succession is first, that of the geological series as given above, and second, in the several districts it is geographical. The general description of the districts precedes and is introductory to the notes of the mines. The location in town and county, the nearness to railway or water transportation lines, the extent of opening and depth of deepest pits or shafts, the geological structure, including strike, (or course) and dip of the ore deposits, the nature of the ore, the mining equipment and machinery, dates of first opening, statistics of production, markets and names of proprietors and lessees, make up the subjects of the notes on each mine and mine group.

—THE—

Iron-Ore Districts of New York.

I.—THE HIGHLANDS OF THE HUDSON.—MAGNETIC IRON ORES.

Magnetite is one of the common minerals in the crystalline rock region of the Highlands. It occurs as an accessory constituent in the granitic and gneissic strata; and by itself, forms beds of considerable extent and thickness. Accordingly as it is more or less free from foreign minerals it is rich or lean, varying from the pure magnetic iron ore to rock with traces only of iron in its mineralogical composition. The beds of ore show lamination and planes of bedding and are faulted, folded and contorted as the enclosing strata of rock; and have the same general strike and dip in common with the latter. They are generally of irregular form, in places widening into thick deposits or lenticular-shaped masses, in others, contracted in thin sheets, which are not mined profitably. The ore is found in some cases to separate into thin layers; and masses of rock ("horses") are met with, entirely surrounded by the ore. The phases of variation are as many almost as there are mines, where they can be studied. In the larger and older mines the ore has been followed for thousands of feet in the line of strike or on the course of the ore, and for hundreds of feet in depth (on the line of dip) without reaching its limits. Owing to the unprofitable nature of working so thin ore beds, they are often not followed to the end, and the real extent of few of these ore deposits is known. In general, it may be stated that in this region the ore beds stand nearly on edge and have a north-east and south-west strike and a descent or dip at a steep angle to the south-east. In consequence of their highly inclined position and their irregular shape, these ore bodies are called "veins"; less frequently, "chimneys" and "shoots" of ore.

The magnetic iron ore has not been found distributed uniformly throughout the Highlands. There appear to be certain ore *ranges* or belts, in which the larger and more productive mines are opened. There are mine groups also, as the Sterling Iron and Railway Company's mines, the Greenwood mines, in Orange county; the Todd-Croft and Sunk mines, and the Croton-Brewster ranges in Putnam county. The boundaries of these ore-bearing belts and the intermediate barren territory, have not been determined, since the exploration has been largely made by individual effort and without any general plan covering the whole area. It is probable that a geological survey of the Highlands would enable us to trace the limits of an iron-bearing group, as has been indicated by the surveys of the New Jersey Highlands.*

Mines have been opened in Orange, Rockland, Westchester and Putnam counties in this iron-ore district and from the New Jersey line, at the south-west, to the Connecticut boundary on the east. Their locations and names are shown on the map which accompanies this report. Some of the largest and most productive mines in Orange county have been worked more than a century.† This county was famous for its iron manufacture during the Revolutionary war.‡ The greatest development of the iron mines in Putnam county has been since the opening of the Tilly Foster and Mahopac mines or during the last twenty-five years. The distance from public lines of transportation, the increased cost of working the smaller "veins" at greater depths, the low prices for iron ore and the competition with the richer ores of other parts of our country have necessitated the suspension of work in some of the mines and led to the permanent abandonment of those most unfavorably situated. Of the forty separate mines, which have been ore producers, ten only were in operation during a part or the whole of the year 1888. Their aggregate output for that year amounted to 114,000 gross tons. The ores of the Highlands district are the hard, crystalline magnetites. They are generally rich, free from titanium, but contain a slight excess of phosphorus above the limit for the manufacture of Bessemer iron, excepting the Mahopac and Tilly Foster mines which have yielded

* See "*Ann. Report of the State Geologist for the year* 1886." Trenton, 1887, pp. 82-85.

† Ore was discovered on the Sterling tract as early as 1750; the Forest of Dean mine was opened about the same time.

‡ See "*History of the Manufacture of Iron in all ages*," by James M. Swank, Philadelphia, 1884, pp. 102-106.

a large amount of Bessemer ore, and a few small mines, but which are no longer worked.

II.—THE ADIRONDACK REGION, INCLUDING THE LAKE CHAMPLAIN MINES.—MAGNETIC IRON ORES.

The Adirondack region, the great mountain plateau of Northern New York, is bounded by the valleys of Lake Champlain on the east, of the St. Lawrence river on the north and north-west, of Black river on the west, and the Mohawk on the south. It occupies nearly all of Warren, Hamilton and Essex counties, the western and southern parts of Clinton, the southern parts of Franklin and St. Lawrence, the eastern part of Jefferson and Lewis, the northern towns of Oneida, Herkimer, Hamilton and Saratoga, and the north-west corner of Washington counties. Its area has been estimated to be at least 10,000 square miles. Dr. Emmons, in his Survey of the Second Geological District, described the rock formations of this territory as gneisses and hypersthene rock principally; and the former he regarded as the prevailing rock, excepting in a large triangular area in Essex county, where the outcropping rocks are hypersthene.* The gneissic rocks resemble closely the rocks of the Highlands of the Hudson, and they have been recognized by geologists generally as Lower Laurentian.

The so-called "hypersthene rocks" of Dr. Emmons consist of labradorite and pyroxene or labradorite with hypersthene and some pyroxene, and hence are often designated as a Labrador series. In an article on the "Laurentian Magnetic Iron Ore Deposits in Northern New York," Charles E. Hall has grouped the magnetites in three series, or horizons; the lowest, the Laurentian magnetites; second, the Laurentian sulphurous ores; and highest, the Labrador group, with its titaniferous ores.†

Magnetite is one of the common minerals in the Adirondacks, and is widely distributed, both as a constituent or accessory mineral in rocks, and in beds of workable extent. Mines have been opened in all parts of the region, but the greatest development has been in the valley of Lake Champlain, and hence the ores are known in the market as Lake Champlain ores. In it are the famous Port Henry mines and others. The Chateaugay range cannot be said to lie in

* EMMONS: Survey of the Second Geological District, Albany, 1842, pp. 27–33 and 75–78.

† Thirty-second Annual Report, N. Y. State Museum, pp. 133–140.

the Champlain valley. Therefore the grouping by geological rather than by geographical lines alone, is more definite, and the larger district of the Adirondacks is better than any subdivisions according to our present knowledge. It is a notable fact that nearly all of the mines are on the borders, and that comparatively few ore localities have been found in the interior. A reference to the map of the State, with this report, shows the location of the mines and mine groups. The explanation of their distribution is the greater accessibility of the outer part of the region to lines of transportation and its more thorough exploration. Prospecting for iron ore in the forested and more distant interior is difficult, and besides, is not stimulated by any hope of adequate return, excepting in case of large deposits which, from their extent and character of ore might warrant the construction of branch railway lines, as at Chateaugay, Clifton, Jayville and Little River. Future explorations will, doubtless, discover many iron-ore beds, and result in the development of other mining centres in what now appears as barren ore-territory. The construction of additional railways, affording facilities for reaching the markets, will do much to open and develop new mines.

The titaniferous nature of the magnetites, which have been found in the Labrador series, as for example, at Splitrock, in Westport, and at Adirondack, in the town of Newcomb, Essex county, has retarded mining in the localities where they occur.

The difficulty and expense of reducing the ores containing considerable titanium, and the failures in the way of practically separating the titanic minerals from the magnetite, have shut them out of the iron-ore market, and the mines having such ores only, have been idle for years. That all the magnetic iron ore occurring in this geological horizon is alike titaniferous, does not appear to be proven by the comparatively few ores analyzed from limited areas; and there is hope that ores sufficiently low in titanium for successful working, may be found.

The strike or course of the iron-ore beds in so large a district is affected by all the local variations in the positions of the enclosing strata. In general, the direction is north-east and south-west. The dip is also at all angles, varying from a horizontal to a vertical. Much further study of the geological structure is needed to explain the features which the mines have exposed to view. The immense deposits at the Port Henry mines, the many separate beds of the Crown Point mines, the dikes and faults at Palmer Hill, the parallel

shoots of the Arnold Hill mine, the bends and faults at Chateaugay are interesting features for study.

The magnetite, as it occurs in the Adirondack region, varies much in the degree of crystallization, in texture and color. In the Port Henry mines it is, as a rule, rather coarsely crystalline and lustrous black. At Palmer Hill and at Arnold Hill martite, a hematite crystallizing as magnetite, appears to replace the latter mineral. The titaniferous ores are noted for their hardness, dull black fracture surfaces and general fineness of grain. In the nature of the associated minerals also, there is much variation. The more commonly occurring rock constituents are found everywhere. Apatite also, is a common associate, as in some of the ore at the Port Henry mines. In general, the iron ores of this region average high in the percentage of metallic iron, especially the non-Bessemer ores; and on account of their richness the Port Henry magnetites are widely known and esteemed. Bessemer ores are obtained in quantity at Crown Point, in the western range at Mineville (Port Henry), at Chateaugay, and at other localities, given in the notes of mines, further on in this report.

The beginnings of iron-ore mining in the Lake Champlain valley were early in the present century. Some of the forges were in operation in 1801 and 1802, and they were run upon the ores in their vicinity.* But the output was small, in the aggregate a few thousands of tons. The rapid increase was after 1840. In 1868 the town of Moriah, Essex county, produced 230,000 tons. The tenth census reported 742,865 tons from all of the mines in the Adirondack region. In 1888 the output was 812,000 gross tons, of which 418,000 tons came from the Port Henry mines. In the course of the last ten years a notable change has been in the suspension of work at the mines which supplied the ores for the forges, or bloomaries. All of the bloomaries are idle, excepting those belonging to the J. & J. Rogers Iron Company and the Chateaugay Ore and Iron Company. The mines away from railway or lake navigation lines have all been closed. The capacity of production in the few mines, which are in operation, has been increased greatly by their better equipment and improved facilities for sending their ores to market. Another characteristic of the region is the great size of some of the ore beds. The great sheet, as it were, opened in the Chateaugay slopes, the thick beds or shoots of ore at Mineville (Port Henry), the great outcrops at Adirondack

* SWANK: "History of the Manufacture of Iron in All Ages," Philadelphia, 1888, p. 106.

and the ridge of lean ore at Little River, are almost inexhaustible, and, with the advent of practicable, concentrating processes, all of them can produce cheap ores and compete with other iron-ore districts of the country.

III.—THE HEMATITE ORES OF ST. LAWRENCE AND JEFFERSON COUNTIES.

The hematites, or red hematites, as distinguished from the brown hematites (limonites) are mined in a narrow belt, scarcely thirty miles long, stretching from Philadelphia, in Jefferson county, northeast into Hermon, in St. Lawrence county. The ore deposits are found associated with a so-called *serpentine* rock, and lying between the Potsdam sandstone and the crystalline rocks of the Archæan age. The geological horizon appears to be below the Potsdam, and it is probably Huronian, although it has not been so recognized by Dr. T. S. Hunt in his references to * the hematites of Canada and Northern New York. The deposits are found to be very irregular in shape, due apparantly to the way in which the "serpentine" rock is mixed with the hematite, but their general structure is that of stratified bodies. The cap rock is a sandstone; the bottom rock, slaty beds, underlain by a white, graphitic, crystalline limestone. From the variations in the ore, as tested by borings with the diamond drill at the Caledonia mines, it seems reasonable to assume the existence of two classes of deposits—one, the originally stratified sheets, and the other, secondary deposits in smaller and irregular shaped pockets.

The hematite of these mines is generally firm and massive, of a deep red color, soiling whatever it touches. In some of the mines there is a specular ore, which has a crystalline structure, metallic lustre and is of a steel-gray to black color. Calcite, carbonate of iron, ferruginous quartz, pyrite and millerite occur in the ore. These ores average from 48 to 53 per cent. of metallic iron. They contain an excess of phosphorus above the limit demanded by furnace managers for making Bessemer iron. For mixing with more refractory ores they are sought after, being almost self-fluxing. In the market they are often known as "Antwerp red hematites" and "Rossie hematites."

* "On the Mineralogy of the Laurentian Limestones of North America," in the 21st Ann. Report of the Regents of the University of New York, Albany, 1871, pp. 88–89.

Charcoal furnaces were built early in this century at Rossie, St. Lawrence county, and at Sterlingville and Antwerp, in Jefferson county, for smelting these ores. Of the older mines the Shirtliff and Tate and Polly have been abandoned. Two new mines have becomes producers, the Clark and Pike. The total production of the district was 110,000 gross tons in 1888.

IV.—THE CLINTON OR FOSSIL ORES.

The red hematite of the Clinton group bears several names; thus: from its aggregated grains it is termed "oolitic ore" or "lenticular iron ore;" from its fossiliferous character, it is widely known as "fossil ore," and, from its place in the geological series, it is often called "Clinton ore." It is remarkable for the thin, yet persistent beds over wide areas, which lie between green shales and calcareous strata. Following the outcrop, of the Clinton group, the ore has been found in Herkimer, Oneida, Madison, Cayuga, Wayne and Monroe counties. West of the Genesee river Prof. Hall reports that it was not seen.* There are two beds, generally about twenty feet apart, according to Vanuxem's report on the Clinton group, thin, averaging little more than a foot, and distinguished by the more abundant oolitic particles in the lower bed and by the larger grains and concretions in the upper bed.† Very little mining has been done, excepting in the towns of Clinton, Oneida county, and Ontario, in Wayne county. The average thickness of the beds in these mines is 30 inches, and one bed only is worked. They lie almost horizontal, dipping slightly to the south; and in the extraction of the ore a part of the overlying shales has to be removed and the roof supported by timbering.

This ore consists of lenticular-shaped grains, closely aggregated in a firm, solid mass, which has to be broken up by blasting and heavy sledging. It is more friable and soft on the outcrop. It is brownish red in color and soils like a paint. The percentage of metallic iron varies less than in the magnetic iron ores and in the brown hematites. The average is 44 to 48 per cent. The phosphorus is above the Bessemer limit. It is well adapted for making foundry iron and is used for that class of iron mainly. Local furnaces take nearly all the output of the mines. The first lease for digging Clinton ore was

*See Prof. Hall's report on "Survey of the Fourth Geological District," Albany, 1843, p. 61.

†Vanuxem's report on "Survey of the Third Geological District," Albany, 1842, p. 83.

given in 1797.* The last U. S. census reported the total production to be 85,442 gross tons of ore. In 1888 it amounted to 75,000 tons.

V.—THE LIMONITES OF DUTCHESS AND COLUMBIA COUNTIES.

The ore deposits and mines, as here grouped, are in two principal ranges and limestone valleys. First, the Fishkill-Clove belt, stretching north-east, from the Highlands of the Hudson, across the towns of Fishkill, East Fishkill, Beekman and Unionvale; second, the north-south valley, traversed by the New York and Harlem railway, from the Highlands across Duchess county, and to Hillsdale in Columbia county. The limonite, or brown hematite ore, is found in small pockets of irregular shape, and also in large deposits, which are associated with ochreous clays, and in some cases, with a gray carbonate of iron, in beds underlying it. These ore bodies are wholly in the limestone, or between the limestone and the adjacent slate or schist formations, or they are in the latter, and as a rule of occurrence they are found on or near the dividing line between these formations. Near Fishkill and at Shenandoah the deposits are at the border of the Potsdam sandstone and at the foot of the Archæan ridges. The existence of the carbonate ore in the deeper parts of some of the mines and interstratified with the limestones, is suggestive of the origin of the oxide (limonite) by the decomposition of the ferriferous beds through oxidation and the agency of carbonated waters, and of the great masses of colored clays, also, through the disintegration and decay of the slaty rocks and more argillaceous limestone.† The limestone of these valleys and the overlying slaty rocks have been studied by Prof. Dana, and are referred by him to the Trenton Limestone and the Hudson river slate formations. ‡

The ore occurs (1) in large masses, somewhat cellular, having the interstices filled with clays or sandy earths (2) in cavernous and hollow "bombs," often with beautiful mamillary or stalactitic incrustations on the interior, and (3) in irregularly shaped, fragmentary masses, distributed unevenly through the ochreous clays ("ochres") and sandy

* BIRKINBINE; "The iron ores east of the Mississippi River," in *Mineral Resources of the United States for the calendar year* 1886, *p.* 50.

† For a clear and concise statement of the origin of these ores see "*Note on the making of Limonite ore beds,*" by PROF. JAMES D. DANA, in *Am. Jour. of Science* (3), vol. XXVIII: pp. 398-400.

‡ *Am. Jour. Science* (3), vol. XVII: pp. 375-388 and vol. XXIX: pp 205 *et seq.*

earths. The more solid ore has to be broken down by blasting; in the more earthy parts of the deposit it can be picked down and nearly all of the ore be sorted by hand. In mining, pits are sunk and worked open, or drifts are cut from the pit, horizontally into the ore, and much of it is won by underground work. In this district nearly all of the ore is mined from open pits; and some of them have reached vertical depths of over 100 feet. The ore is commercially known as "rock ore" or "lump ore," that which is sorted by hand, and "wash ore," which is the residue after the earths and sands have been removed by washing. The brown hematite ores of Dutchess and Columbia counties vary considerably in their chemical composition, all containing more or less silica, little or no sulphur, but are rarely low enough in phosphorus to answer for Bessemer pig-iron manufacture. Although there have been many ore localities discovered in these counties, twenty-four only have been developed into working mines, deserving of enumeration in this report.

The earliest iron manufacture in the State was in Columbia county, on Ancram creek, and was probably on these ores. The Salisbury mines in Connecticut, properly a part of this iron-ore district, were opened more than 150 years ago. The causes which have operated in the Highlands, have been effective here also in closing many of the mines, so that, in 1888, there were but nine at work, and four of them were closed during the year. The aggregate output has declined from 144,878 gross tons for the census year, 1879–80, to 43,000 tons in 1888.

VI.—THE LIMONITES OF STATEN ISLAND.

The group of iron mines on Staten Island is described on a succeeding page, and under the descriptions of iron ores and iron-ore mines.

VII.—THE CARBONATE ORES OF THE HUDSON RIVER.

The mines of spathic iron ore, or carbonate ore, are in the valley of the Hudson river, in Columbia county, south of the city of Hudson, and in Ulster county near Napanock. The mines south of Hudson are known as the Burden iron mines; and, on account of their extent and productiveness, and the comparative insignificance of the Ulster county mines, they may be considered as practically the whole of this group. The range in which the Burden mines are opened is

between one and two and a half miles east of the river, opposite Catskill, and is four miles in length, from north to south. It lies partly in the town of Greenport and partly in Livingston. The ore crops out in the western face and near the crest of Plass Hill at the north, and in Cedar Hill and Mt. Thomas at the south. It is stratified, and its beds dip at angles of 20° to 40° to the east. South of Mt. Thomas and in mine No. 2, at Burden, a synclinal fold has been mined out. The thickness of the ore varies considerably, and for the greater part of the distance the average is from ten to twenty feet. In the Burden mines as much as thirty feet of ore has been found; in mine No. 2 and in Mt. Thomas upwards of forty-five feet. The underlying beds are shaly and are probably of the Hudson river slate formation. Above the ore there is a siliceous conglomerate, which is succeeded by a shale, and that by a gray sandstone, and that, in turn, by a calcareous conglomerate.

The ore varies in composition from a siliceous and lean ore at the north, which contains generally too much phosphorus for making Bessemer pig-iron, to a rich, Bessemer ore at the south. Quartz in fine grains, calcite in small, crystalline nests, and pyrite are common in it. All of it has to be roasted before smelting. The Burden mines are reached by a railway three and a half miles long, from the Hudson river, near Catskill station.

The first mining of considerable extent done on this range was in 1874. Next year the Hudson River Spathic Iron Ore Company was organized, and the mines were worked by that company for about two years. In 1882 the property came into the possession of the Hudson River Ore and Iron Company, and a large establishment was at once set up. There are ten roasting kilns on the river at the Burden docks; and the ore is shipped to Troy, Scranton, Pa., and Franklin Furnace, New Jersey.

DESCRIPTIVE NOTES

OF THE

IRON MINES.

I.— THE HIGHLANDS OF THE HUDSON.— MAGNETIC IRON ORES.

WARWICK MINE, TAYLOR MINE, FERRO HILL MINE, Warwick, Orange County. — This cluster of mines is near the New Jersey line, and two miles south-east of Warwick. The Warwick belongs to the Parrott Iron Company, and is the largest of the three mines. It has not been in operation since 1880. The Taylor and Ferro Hill are comparatively small ore bodies. They, also, have been idle for the same time.

SNYDER MINE, Warwick, Orange County. — One of the Ringwood group of mines, and the property of Cooper & Hewitt, of New York city. It has not been worked in many years.

STERLING IRON AND RAILWAY COMPANY'S MINES, Warwick and Monroe, Orange County. — This company owns a large tract of land in the towns of Warwick and Monroe, in Orange county, and on it are opened the following: Crawford, Behring, Moorhead, California, Sterling, Clarke, Lake, Red Back (or Spruce Swamp), Hard, Cook, Scott and Oregon, Mountain, Causeway, Long and Augusta mines. The oldest and most famous of this group is the Sterling mine, near Sterling Pond and at the terminus of the Sterling Mountain Railroad. It was opened in 1750, and a furnace was built in 1751, according to the report of Dr. William Horton, in Mather's "Third Annual Report on the First Geological District." No ore was raised from it last year, although the pumps

were kept going and the mine was in order. It is remarkable for the large size of the ore body, the undulating foot-wall, the "rolls," which run north-west and south-east, or at right angles to the dip, and for the fault at the south side, by which the ore is displaced vertically 10 feet. Its slope is 600 feet long. A large amount of ore was taken from the original outcropping bed, on the hillside, and the total output of this mine is a large part of the aggregate raised by the company from all of its mines. From the Sterling levels to the nearest levels in the Lake mine the unopened space is 75 feet.

The Lake mine has reached a vertical depth of 130 feet, and extends under the Sterling lake. The ore body is marked by the same structural features as that of the Sterling mine, and it varies from 4 to 20 feet in thickness. The dip averages 15° to north-northeast. The axes of the rolls run nearly in the direction of the dip and the intervals, from roll to roll, are generally a few yards only, or less than in the Sterling. The hoisting slope runs down the foot-wall obliquely to the line of dip, and from it the levels each way penetrate the ore. Pillars are left conveniently where the pinches occur. The walls are of gneissic rock, clean and firm. The ore is rich and medium fine-crystalline.

The Clarke mine (formerly Tip-Top) on the hill west of the Sterling mine is no longer worked.

The ore raised in mine cars from the Lake and Sterling levels is dumped at the surface into the company's railway cars and shipped thence, without further handling, to its destination. Over the ridge and about one mile east of the Sterling, in the town of Monroe, are the Cooke and the Scott mines. The latter mine is near the old Oregon, its openings almost connected, and being to the south of the old pits and workings. The Scott "vein" is apparently a few feet above, that is, in the hanging-wall side of the Oregon. There is a third bed in the foot-wall side. The Scott mine has reached a depth of 430 feet on the slope, and its levels have an extreme length on the course of the "vein," of 900 feet. The ore is from 4 to 18 feet thick. The wall rocks are fine-crystalline gneisses. The ore is quite fine-grained and contains in places some hornblende and feldspar, in coarse-crystalline masses. The Cooke mine is south of the last named and in lower ground; much the same structural features are seen in it as in the Scott mine. The shaft has a vertical depth of 250 feet; there is more water; the ore is more crystalline and not as close-

grained as that of Scott mine. None of these ores are suitable for making Bessemer pig-iron. A narrow guage road connects the Scott and Cooke with the Sterling Mountain railway at the Lake mine.

The ore mined by the Sterling Iron and Railway Company goes to its Sterling Furnace (on this tract), and to furnaces in Eastern Pennsylvania. The annual output is large and constitutes the greater part of the total production of the magnetic iron-ore region of the Highlands,— an example of efficient and economic administration.

AUGUSTA MINE, Monroe, Orange County.—This mine, east of Augusta, was opened in 1878–9 and worked a short time. On the same (Lorillard) property, three-quarters of a mile west of Sloatsburg, a mine was worked in 1877. They are idle.

MOUNT BASHA MINE, FORSHEE MINE, O'NEIL MINE, CLOVE MINE, Monroe, Orange County.—These mines are situated between one and three miles south of the village of Monroe and west of Arden (Greenwood Iron Works formerly). They have not been worked since 1880, and then for the supply, in part, of the Greenwood furnaces.

East of the N. Y., Lake Erie and Western railway are the following-named mines, the property of the Parrott Iron Company:

HOGENCAMP MINE, SURE-BRIDGE MINE, PINE SWAMP MINE, GREENWOOD MINE, CUNNINGHAM MINE, Monroe, Orange County.—Of these mines the Hogencamp is the only one which has been in operation in the past decade.

BULL MINE, Blooming Grove, Orange County.—The Bull mine is named from Bull Hill, a narrow ridge of gneissic rocks, 870 feet high, in which it is sunk. The Parrot Iron Company worked it until the summer of 1880.

All of these mines on the old Greenwood tract (Parrot Iron Company) are away from railroad lines, from one to three miles; and the cartage over hilly roads adds to the cost of mining. Since the furnaces at Greenwood (now Arden) were dismantled they have been closed. Excepting the Hogencamp and Forshee they produced a non-Bessemer ore. They were opened at an early day. Dr. Beck described them in his Mineralogy of New York in 1842.*

* Natural History of New York, Mineralogy, pp. 7–9.

FOREST OF DEAN MINE, Monroe, Orange County. — The Forest of Dean mine is five miles west of Fort Montgomery on the Hudson. It is opened on a large ore-body or "shoot," which pitches north-east at an angle of 27°. The walls dip steeply south-east. The slope is 1,350 feet long and descends on the bottom rock at the angle of 27°. A "horse" of rock divides the ore at the roof, the rock of which, unlike that of the walls, indicates the synclinal fold structure. The ore is medium fine-crystalline and rather friable, inclining to a shot-like structure. Calcite, red and white, occurs in it, in scattering, crystalline masses. It is a rich, non-Bessemer ore. An analysis, communicated by A. Tower, of Poughkeepsie, shows:

Silica	5.00 per cent.
Alumina	Traces
Lime	5.51
Magnesia	1.19
Oxide of Manganese	.63
Oxides of Iron	83.56
Phosphoric Acid	2.30
Carbonic Acid	1.05
Water	.20

The ore is sold to furnaces on the Hudson river and in the Lehigh Valley, Pennsylvania. The mine water is raised in a vertical shaft, which is located 900 feet north-east of the slope; and there are two (10-inch and 8-inch) 5 feet drawing-lift, and one 12-inch plunger pumps. The hoisting and pumping are done by means of water power. There are two overshot water wheels 40x6 feet. One air compressor supplies compressed air to the power drills. The ore is run direct from the mine on a tramway, three miles to the dump, where it is transferred to wagons and thence carted two miles to Fort Montgomery. It is shipped over the West Shore railroad and by boats.

The Forest of Dean is one of the oldest mines in the State and was worked, as reported by Dr. Beck, 21 years previous to 1777. It is the property of the Forest of Dean Iron Ore Company, of Poughkeepsie. Its output since 1865 is reported to be 430,756 tons.

DUNDERBERG OR HERBERT MINE, Stony Point, Rockland County. — An iron mine was opened many years ago on the north side of Dunderberg mountain, one and a half miles west of Iona Island. The ore is said to be lean and to contain pyrite. No work has been done recently.

QUEENSBOROUGH MINE, Monroe, Orange County. — The mine at Queensborough has been idle for nearly thirty years. It is the property of the Forest of Dean Iron Ore Company.

KRONKHITE MINE, Highland, Orange Co. — The Kronkhite mine also belongs to the Forest of Dean Iron Ore Company. It is about two miles west of Cranston's-on-the-Hudson. The vein is said to be small; and the mine has been idle for a long time.

Magnetic iron ore has been mined in small quantities at three or four other localities in the Highlands north of West Point and in the towns of Highland and Cornwall. None of them have been developed into productive mines.

CORTLANDT MINES, Cortlandt, Westchester County.—Under this head may be grouped several openings on magnetic iron ore in the town of Cortlandt, south and south-east of Peekskill.

The "mines" near Cruger's station and west of the H. R. R. line are properly trial pits, and the ore found there is either in thin beds or is too lean for profitable working.

South-east of Peekskill, three to four miles, larger deposits of irregular shape have been opened in surface diggings, made in searches for emery. The magnetite occurs with corundum and in the Courtlandt rocks as described by Prof. Jas. D. Dana.* According to analyses, these ores contain from 34 to 35 per cent of metallic iron and 34 to 44 per cent of alumina, and this high percentage of alumina has attracted attention to them as a blast furnace flux.† No work has been done at any of these Cortlandt localities in the last ten years.

TODD MINE, Phillipstown, Putnam County.—This mine is six miles northeast of Peekskill, in the Canopus Hollow. It was opened about thirteen years ago and worked until 1880.

CROFT MINE, Putnam Valley, Putnam County.—In the same valley (Canopus Hollow) and nine miles from the Hudson river, the Croft Mine is opened in the western hill-side. It was one of the earliest opened mines of Putnam county, and was worked until in 1881. A narrow-gauge railroad runs from the mine to the Hudson river. The ore is suited for Bessemer iron.

*Am. Jour. Science (3) vol. XX., pp. 199-200.

†Dr. Jas. P. Kimball. A "Flux for Rolling Mill, Cinder and Silicious Iron Ores in the Blast Furnace." *Trans. Am. Inst. Min. Eng.*, vol. IX., pp. 18–19.

WILLIAMS MINE, Putnam Valley, Putnam County. — This opening is two miles north-east of the Croft Mine and in the same valley. It was worked a short time about twenty-five years ago.

DENNY MINE, Putnam Valley, Putnam County.— The Denny Mine is an old opening on top of the hill, west of Canopus Hollow and at the side of Cold Spring road. It was last worked by the Thomas Iron Company in 1880.

PRATT MINE, SACKETT MINE, SUNK MINE, Putnam Valley, Putnam County. — These mines are the property of the Philadelphia and Reading Coal and Iron Company. They have lain idle since 1880. The principal mine is known as the Stewart or Sunk, and is opened in the eastern face of a steep ridge, and on the west side of the Canopus Hollow. It is seven miles east of Cold Spring. The Pratt and Sackett are smaller mines, south-west of the Sunk. The CANADA MINE belongs to the same company, and is on the same range, two miles to the north-east and stretching into Phillipstown.

The mines of this property produce a non-Bessemer ore. Their distance from railway lines is against their development and working. An extension of the Croft Mine railroad, up the valley, is entirely feasible.

BLACKBERRY OR GRAND ISLAND MINE, Carmel, Putnam County.—A bed of iron ore was opened and worked on the westernmost island in Lake Mahopac for a few months in 1879–80.

TRAVIS' MINE, Carmel, Putnam County.—Near Union Valley, north-east of Croton Falls, there are openings from which a small quantity of ore has been taken. The locality has not developed into a productive mine.

MAHOPAC MINES, Carmel, Putnam County.—The Mahopac, or German Flats mines, as they are locally known, are opened in the western part of the town of Carmel, and one and one-third miles north of Red Mills and four miles from Baldwin station, on the New York and Northern railroad.

Although the existence of ore was known many years ago, and a little work in exploring had been done, there was no regular and thorough prospecting and mining until the autumn of 1879, when the present owners, the Mahopac Iron Ore Company, of New York

city, began operations. Four parallel "veins," or ore beds, have been found within a breadth of ninety feet, from foot-wall to the hanging-wall. The course, or strike, of the ore is about north 18° east, and the dip at an angle of 39°–40° to the east–south-east. The beds of ore are irregular and of varying thickness, and coalesce into two and, in places, into one bed. The longest slope is 1,200 feet in length, and has reached a point beyond the Kent Cliffs road. There are three slopes, from which drifts run each way into the ore, and the ore-body has been opened for a length of 450 feet. The vertical depth is 490 feet. According to the observations of E. A. Le Wald, the manager, there are no distinguishing characteristics in the ore of the several "veins." In general it is medium fine-grained, compact and hard. An analysis by A. McCreath of a sample representing 10,000 tons shows:

Metallic iron	54.22 per cent.
Manganese	.141
Phosphorus	.012
Sulphur	.014

It is sold on a basis of fifty-two per cent of metallic iron, and is used at Franklin Furnace, New Jersey, at Scranton, Pa., and by other iron works in Pennsylvania and New York. The plant consists of ten power drills, one diamond drill, one 24x36 duplex compressor, four small hoisting engines, one 150-horse-power engine, and four 75-horse-power boilers. The company's office is at 69 Wall street, New York city.

CROTON MAGNETIC IRON MINES, South-east, Putnam County.—The Theall and McCollum are the two principal openings on this range of ore. The McCollum, at the south-west, exposes strata of ore and ore-bearing rock, although no walls are reached. It is an open cut with a shaft sunk sixty feet deep. The breadth of the ore is nearly 100 feet.

The Theall mine, at the north-east end of the same hill, penetrates 600 feet, on the course of the ore, into the hill, and its lower level is 160 feet below the main adit tunnel. The ore-bearing strata here have been tested from 60 to 110 feet in breadth, and openings have proved the ore body to be 2,500 feet in length. A small part of the ore only is rich enough for furnace use; the larger part is too lean, and needs concentrating. According to analysis, the selected, furnace ore contains fifty per cent of metallic iron and one-fifth of one per cent

of phosphorus. About 30,000 tons of ore have been shipped to furnaces in Pennsylvania, and there are, it is estimated, at least 100,000 tons of lean ore on the dump. Concentrating works, equipped with crushers and Conkling jigs were put up in 1883. During the past season experiments in separating the magnetite and the rock by a magnetic separator have been carried on, and it has been decided to set up a plant to concentrate the ore in this way. So far the results prove that the average of the dump containing thirty-eight per cent of iron, can be concentrated to sixty-two per cent. The Ramel Carburetted Iron Company has built a small mill near the mine and reduced the fine concentrated ore in Conley patent retorts. Their product is sold to open hearth steel furnaces. These mines are the property of the Croton Magnetic Iron Mines Company, J. D. Cheever, treasurer, 51 Park Row, New York. A wire tramway connects the mines with the New York and Harlem R. R. line about two miles south-west of Brewster.

This range of ore was described by Prof. Mather as one of great extent, in his report on the *First Geological District of the State.**

BREWSTER MINE, Southeast, Putnam County.— The mine in the village of Brewster has not been in operation since 1880. Its workings run under the New York and Harlem railroad. The "shoots" of ore were small and irregular in form, and are said to be exhausted.

TILLY FOSTER MINE, Southeast, Putnam County. — This large and well-known mine is on the line of the New York and Northern railroad, two miles north-west of Brewster. The extensive mining operations here have proven the existence of a large body of valuable ore, and brought to light some notable facts in the geological structure of the ore body, indicative of great changes in its shape and position, and affording excellent illustrations of the way in which these Archæan rocks have been uplifted and disturbed. The strike of the enclosing gneissic strata is, in general, a few degrees north of north-east, and the dip is at a high angle (70°) to the east-south-east. The ore has been exploited for a length of 1,500 feet, and a depth of 630 feet, in the deepest (middle or Cheever slope). The breadth of ore is 160 feet in the middle, narrowing to 80 feet towards either end. This great breadth of ore is explained by a

* *Geology of the First Geological District*, by Wm. W. Mather, Albany, 1843, pp. 560–561.

fault whose plane dips east, and whose course is nearly due north, or oblique to the strike of the ore.*

The polished slickensides surfaces, which traverse the ore, indicate fractures and movements to an unusual extent. The presence of numerous pseudomorph minerals also points indirectly to a vast amount of fracturing.† The ore is fine-crystalline, and consists of magnetite, mixed with some chondrotite and serpentine. It is a Bessemer ore. As shipped it averages 50 per cent of metallic iron.‡ Owing to the shaky condition of the roof, and the difficulty of supporting it by pillars of ore and of masonry, the gigantic feat of removing the whole of the superincumbent rock from an area of about 400 by 300 feet, to a depth of 300 feet, was begun in 1887. In this way the ore in the pillars can be won, and the mine worked as an open pit to a depth of 600 or 650 feet.

As this work is done under a special contract, the company is not mining any ore.§ The lean ore, which occurs interstratified with the rich, is being stocked in huge dumps at the side of the great pit for future concentration. The rich, furnace ore is used at the furnaces of the Lackawanna Iron and Coal Company, at Scranton, Penn., and Franklin Furnace, N. J.

A mill for the concentration of the lean ores, equipped with Blake crushers, Michigan stamps and Conkling jigs, has been erected north of the mine, at the side of the railroad, but is not fairly in operation. The total production of this mine, to the end of 1888, is 620,162 tons. It was opened in 1864. Since 1879, the "Tilly Foster Iron Mine Co." have been owners of the property.

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* A full description of the geology of the Tilly Foster Mine, is given by Ferdinand S. Ruttmann, of New York city, in the *Trans. Am. Inst. Min. Engineers*, Vol. XV, pp. 79–90. See also paper by A. F. Wendt, in Vol. XIII, pp. 478–34, same series.

† "On Serpentine, Pseudomorphs and other kinds, from the Tilly Foster Iron Mine Putnam Co., N. Y., by James D. Dana." *Am. Jour. Science* (3), Vol. VIII, pp. 371–381, and 447–459.

‡ An analysis shows the ore to contain:

Oxides of iron	67.42 per cent.
Oxide of Manganese	.54
Alumina	3.85
Lime	1.44
Magnesia	13.30
Sulphur	0.11
Phosphoric acid	0.128
Silica	13.23
	100.018

Communicated by S. P. Tompkins, Superintendent.

§ For an account of this work of uncovering, see paper by F. H. McDowell, of New York city, to appear in Vol. XVII., *Trans. Am. Inst. Min. Eng.*

HOBBY OPENING, Patterson, Putnam County. — A pyritiferous ore was discovered on this property, two miles south-west of Towner's Station, in 1882. It has not been developed into a productive mine.

II.—THE ADIRONDACK REGION, INCLUDING THE LAKE CHAMPLAIN MINES.—MAGNETIC IRON ORES.

MT. HOPE, FORT ANN AND POTTER MINES, Fort Ann, Washington County.— These mines are in the western part of the town of Fort Ann, and five miles north-west of Fort Ann station on the New York and Canada railroad. They are opened on parallel "veins," which dip at an average angle of 30° to the north-east. The Mt. Hope is on a ridge of the same name, and a half mile north-west of the Potter. It has been opened for a length of 50 to 60 rods, and to a depth of 100 feet. The Fort Ann has been sunk to a maximum depth of 300 feet, and has been opened for 80 rods on the course of the ore. The Potter is only 30 rods in length and 75 feet deep. These mines have been idle for several years, owing to the low price of ore and the cost of carting it to Fort Ann — a distance, by wagon road, of seven miles. The ores are all Bessemer, containing on an average, .034 of phosphorus. The Mt. Hope is rather lean, as compared with the Potter and Fort Ann. The Potter mine was first opened in 1879 ; the Fort Ann at least twenty years, and the Mt. Hope more than thirty years ago. The total production is estimated to have been 350,000 tons. The mines are owned by Hon. Joseph Potter, of Whitehall, and Hon. John F. Winslow, of Poughkeepsie.

WARRENSBURGH MINE, Warrensburgh, Warren County.— Iron ore was mined near this village more than fifty years ago. It has not been in operation for many years.

VINEYARD MINE, BURLEIGH SHAFT, Ticonderoga, Essex County.—The Lake Champlain Ore and Transportation Company opened the ore bed on this old iron-ore property in 1887. The Vineyard mine was opened about forty years ago, and worked in a small way. The mine is one and a half miles west of Lake Champlain, and four miles north-west of Ticonderoga. The ore cropped out originally in a glaciated ledge. The course of the ore bed is north, 30° east, and its dip 52° to the north-west. The greatest depth

reached is 132 feet; the opening on the ore bed is about 100 feet, and the average thickness of the ore in the mine is sixteen feet. The walls are not, however, well defined. The ore is rich, analyses showing 54 per cent. of metallic iron and little sulphur. It is rather fine-crystalline, and has a tendency to a prismatic structure. Pyrite occurs in scattering, nodular masses, particularly near the walls. The ore is carted to Ticonderoga and Crown Point. A Bleichert tramway is proposed, to run direct to the railroad and lake shore from the mine, which is about 300 feet higher than the lake. The plant consists of one Copeland & Bacon hoisting engine, one air compressor, three steam pumps, power drills, etc. B. W. Burleigh, of Ticonderoga is the manager.

MT. DEFIANCE ORE BED, Ticonderoga, Essex County.—Hematite occurs at the foot of Mt. Defiance, and about 50 rods from the shore of Lake Champlain. The vein is eight feet wide, and dips at a high angle south-west. A pit 50 feet deep has been sunk, and some ore has been shipped to Port Henry and to Chatham. The place was opened in 1888 by B. W. Burleigh, of Ticonderoga.

PARADOX LAKE MINE, HARRIS MINE, Schroon, Essex County.—These mines were first opened many years ago, and were worked a few months during 1879–80, since which time they have been idle. The first named is on the south side of Paradox Lake; and the other on the north-west of the same water. Their production has not been more than a few hundred tons.

SKIFF MINE, Crown Point, Essex County.—The Horicon Iron Company, and later, its successor, the Lake Champlain Ore and Transportation Company, have done some work at the Skiff mine. It is situated on a hillside, two miles southerly from Hammondville. The same company owns the Schofield mine, an old opening in the town of Schroon, one-third of a mile south of the Paradox mine.

All of these mines have been idle since 1880.

CROWN POINT MINES, Crown Point, Essex County.—The group of mines belonging to the Crown Point Iron Company is in the western part of the town of Crown Point, and thirteen miles from Lake Champlain. There are many openings on the tract owned by the company, but the principal working mines are near

the mine village, which is known as Hammondville. The surface is rocky, and the mean elevation is 1,300 feet above the level of Lake Champlain. The varying strike and dip and the faults in the rock outcrops are evidence of much disturbance in the strata and the ore beds and deposits enclosed by them. The general direction of the strike of the ore bodies is north-east and south-west, and their dip is in nearly all cases to the south-east; but there are several notable exceptions. During the past year the mining of ore has been confined to mines No. 4, at the north-east and near the road to the old furnace; No. 2, north-west of the office; No. 7, south of the railroad; the West End, a continuation of the old Penfield mine; and on the western hill, mines Nos. 26, 27 and 38. In addition to the regular mining work, searching for new ore beds, by sinking trial shafts and pits, and boring with a diamond drill, is carried on almost continously. The once famous Hammond and Penfield mines, from which over 500,000 tons of ore have been taken, are no longer in operation. The West End is on the normal (south-east) dip of the Penfield ore-body, and is remarkable for its irregular walls and the "slips" which traverse it. The slope is about 900 feet long and, vertically, 300 feet deep. The openings on the western hill are extensive and, in part, open cuts in the ore which dips 30° to the south-east. At the south-west the ore bed turns to the south and south-east, and has a dip of 40° to the north-east, showing the existence of an endfold. Mine No. 7 is the only one south of the railway which is in operation. The dip of the ore is 35° to south-southeast. The slope which follows down the foot wall, in the line of the dip, is nearly 1,000 feet in length. From it the workings have been driven each way, a total length, varying from 300 to 600 feet. The thickness of the ore has been found to vary from one to twenty feet. Two faults, or offsets, have been encountered in the mine, displacing the ore in one, 10 feet, and in the other, from 11 to 22 feet. At the bottom a rock has been struck, beyond which no ore has been found. Mine No. 4 is on the south slope of Hammond hill and near the old furnace road. Its shaft has a vertical depth of 250 feet to the ore; and it is one of the best mines on the property.

The Crown Point mines yield, in general, a medium fine-crystalline ore, which is compact and withal quite friable, and often falls to pieces in a shot-like mass. The commonly occurring foreign minerals are; white quartz, feldspar and a green (pyroxenic) mineral. The percentage of metallic iron runs close to 50, and the small

amount of phosphorus makes it a Bessemer ore. An analysis, communicated by Mr. A. L. Inman, gives the composition as follows:

Peroxide of Iron	47.38 per cent.
Protoxide of Iron	21.32
Protoxide of Manganese	.10
Alumina	1.97
Lime	1.18
Magnesia	.36
Phosphoric Acid	.08
Sulphur	.02
Silica	27.48
Metallic Iron	49.74
Phosphorus	.035

The several mines are connected by narrow gauge tracks with the company's railroad, which runs to the furnaces and the lake at Crown Point. This branch is a 3-foot gauge and, when ore has to be sent over the Del. & Hud. Canal Co.'s road it has to be re-loaded in their cars at the junction.

The mine equipment consists of large Rand compressors, four winding engines, which operate nine drums, fourteen boilers of about 700-horse-power, and twenty-five pumps.

The ore is used at Scranton and Bethlehem, Pa., and at Troy, and at the company's furnaces at Crown Point.

This company owns 32,000 acres of land in a belt, ten miles long, from north to south, in the towns of Ticonderoga, Crown Point, Schroon, and North Hudson, and has several small ore openings outside of the Hammondville mines proper. North of Hammondville, there is on Moose Mt. an extensive deposit of titanic iron ore, which carries 55 per cent. of metallic iron. It is not worked.

These mines have been opened and worked for 60 years, but the development has been mostly since 1873.* The total output for the past thirteen years, up to Jan. 1, 1889, is reported by Mr. Inman to amount to 1,041,015 gross tons.

The officers of the company are, A. L. Inman, Plattsburgh, general manager; H. L. Reed, Crown Point, assistant general manager; and Thomas Montague, Hammondville, superintendent of mines.

* The Hammond ore bed was known in 1827, but it was not worked to any extent until 1845. The forge at Irondale was built in 1828. [See Watson's "History of Essex County," Albany, 1869, p. 383.]

The most important group of mines in this district is that at Mineville, in the town of Moriah, Essex county, seven miles west of, and at a mean elevation of 1,300 feet above Lake Champlain. The mines are in two ranges, whose general strike is north-east. They have been referred to an upper and a lower horizon by geologists.* The eastern range includes Mine 21, Bonanza, Little Joker, Mine 23, Brinsmade shaft, Old Bed and Miller Pit. These openings are in a drift-covered, gently south-sloping area 2,500 feet long, from north-east to south-west, and about 1,000 feet wide.

The western range includes the mines opened at the south end and in the eastern side of the Barton Hill ridge, and is about a half mile west of the other range.

Two companies work these mines at Mineville; the Port Henry Iron Ore Company and Witherbees, Sherman & Co. The former has Brinsmade shaft, and Mine 23, and a part of Old Bed and the 21 mine; the latter, Miller Pit, Bonanza and Little Joker, and the western part of Old Bed and Mine 21, the property line running across the ore bodies without reference to their position and geological relations. The mines of the western range belong to Witherbees, Sherman & Co., excepting those on Fisher Hill.

The geological structure, revealed in the great openings on this eastern or lower horizon of iron ore, appears to have been complicated by faulting, folding and compressing agencies, which have resulted in a serious distortion of the original beds. Hence the relations of the several parts, and the correct shape of this great ore deposit are not yet fully made out.

The general direction of the *dip* of these ore masses is south-south-west, but it is highly probable that the dip is westerly and that the south-west inclination represents the *pitch* of the huge lenses of ore.†

MINE 21 is south of the railway and consists of an open pit, 300 by 250 feet, and 250 feet deep and underground workings to the south and east, which are reached through Nolan's shaft, slopes 1, 2, 3 and 4, and Tefft's shaft at the west.

The angle of the pitch as indicated in the rock on the east side is about 30° to the south-west. The west side wall is quite irregular and curving, as it were, the bounding wall of a great shoot of ore. The

* Report of Charles E. Hall on "Laurentian Magnetic Iron Ore Deposits in Northern New York," in *Thirty-second Annual Report N. Y. State Museum*, p. 135.

† According to a well-known rule of occurrence in the magnetic iron ores of the Highlands region of New York and New Jersey, the pitch is to the north-east when the dip is easterly, and south-west when westerly.

roof in the south workings of 21 dips at a moderately low angle to the south-west. The extreme south-west face in this mine is 100 feet only horizontally from the Bonanza mine, but is 100 feet higher. The roof is held up by large pillars of ore. The vertical depth of the mine is 340 feet in Nolan's shaft and about 300 feet at the south-west. As the foot wall is not yet reached, the whole vertical thickness of the ore is not known. The ore is generally coarsely crystalline and contains scarcely any foreign minerals. Apatite occurs in reddish grains to a considerable extent in some of the Nolan shaft ore, whence the name of "red ore." Some of the most beautiful cabinet specimens of splendent, crystalline masses of magnetite are found in this mine. A large part of the rich ore is sold for "fettling" in puddling furnaces.

BONANZA SHAFT is on the property of Witherbees, Sherman & Company, 300 feet south of 21 pit. It is vertical to the ore, then it runs at an angle of about 40° in a south-west course. The limit of working is at least 150 feet beyond the foot of the shaft. The roof is clean and dips 10° south-west. No foot wall has yet been reached. The ore is stoped down from the roof, then quarried back in benches, 10 ft. thick, to the foot of the incline. Pillars 40 to 50 feet square are left to support the roof. The ore is, in general, coarse-crystalline, resembling that of mine 21, and also that of the Little Joker shaft.

THE LITTLE JOKER SHAFT is about 400 feet south of the Bonanza. It was sunk seven years ago. For a distance of 90 feet it passes through drift earth. It descends at a steep angle to the south-west, and *bottoms* in the ore. There are two levels, 100 feet apart, vertically. The roof has an average dip of 20° to the south-west, varying, however, considerably on account of the rolls in it. The foot wall found north of the foot of the slope shows a steep, southward dip, indicating a great thickness of ore. The bottom is over 500 feet below the surface and over 200 feet lower than the floor of the Bonanza. The vertical thickness of the ore in this mine exceeds 100 feet everywhere, and the maximum is yet unknown. The workings are of much greater extent than in the Bonanza mine. Mine 21, Bonanza, and Little Joker are, apparently, all openings in one continuous ore-body or in connected shoots of the same *vein*. The rapid extension of the limits of these mines will soon connect their workings and show their true relation to one another. The

general character of the ores is much alike in them. Both Bonanza and Little Joker are owned and worked by Witherbees, Sherman & Company.

On the north side of the railway, MINE 23 or WELCH SHAFT and the BRINSMADE SHAFT are on an ore bed whose dip is to the west. Their depth is 240 feet. This bed is pinched north of the Brinsmade Shaft and is not worked far in that direction. The ore is coarse-crystalline and resembles that of Mine 21. But the relation to the latter is all as yet conjectural. The ores of 23 mine are sold as "chunk" ore for fettling.

OLD BED, west of the last named, and also north of the railway, is in part, a great open pit, which has fallen in somewhat. It is believed to be a separate ore-body, and not connected with 21 mine; on the west there may be an ore connection with that of the Miller Pit. A north and south property line crosses the pit.

MILLER PIT is an extensive mine west of the Old Bed and Mine 21, stretching 500 to 600 feet south-west of the railway. It is on the property of Witherbees, Sherman & Company, but is not in operation.

The equipments of the Port Henry mines are extensive and first class. The Port Henry Iron Ore Company has one central station whence all the motive power for hoisting and pumping, and compressed air are distributed to the several mines. There are three large hoisting engines, one pumping engine, one shop engine, four duplex air compressors, three lift pumps, sixteen steam pumps, air drills, etc., etc.

Witherbees, Sherman & Company have of necessity separate plants at New Bed, and on Barton Hill. They use four 150-horse-power, one 125-H. P., two 100-H. P., two 75-H. P., and two 50-H. P. engines, forty pumps, air compressors, etc. Electric lights are used in all of these mines. The hoisting is all done in mine cars, which dump the ore on platforms, at top of slopes, where it is sorted and loaded into the company's cars, and which run thence to the lake at Port Henry.

Owing to the extraordinary thickness of the beds in these mines, the ore can be broken down in huge blocks, and by great blasts; and the cost of mining is thus reduced. The relatively small proportion of dead work and the dryness of the mines, also assist in lowering the expenses. The richness of the ore is another important favoring element, enabling these companies to produce a large amount

of ore annually, and to put it in distant markets, in successful competition with other ores, and other iron-ore districts. They find their way to blast furnaces in all the Eastern and Middle States, and even further west and south, for use in puddling furnaces. An ideal composition is afforded in the following analysis of Witherbees, Sherman & Co.'s ores from Old Bed 21 ore.

Metallic iron	66.18
Oxygen with iron	25.25
Insoluble, silicious matter	1.94
Phosphoric acid	2.45
Alumina	.76
Lime	2.27
Magnesia	.14
Potoxide of Manganese	.36
Loss and undermined	.07
	100.00
Metallic iron	66.18
Phosphorus	1.07

The western range, or belt of ore, at Mineville is opened in the New Bed mines, the Barton Hill and Fisher Hill mines. It is a half mile west of the 21 mine and Little Joker mines. Through the New Bed and Barton Hill mines the range has been exploited and proven to be continuous. In the character of the ore also there is a proof of the oneness of the deposit or ore body.

NEW BED MINES.— These mines are at the south-west end of the range. Beginning at the south-west, there are : the Roe shaft, Big pit, Wasson shaft, Dalton shaft and North pit. The first named is a vertical shaft, sunk through the overlying rock to the ore. At the Big pit three well defined ore beds crop out. They have been followed — the lower one, to the south-west, about 1,800 feet, on the dip of the ore bed ; the upper one, for 400 feet. About ten feet of rock separates the lower and the middle beds ; from the latter to upper there is rock for six to fifteen feet.

The dip at the mouth of Big pit is 20° to south-west. The ore occurrence in these several workings is marked by *pinches* and *shoots*, by *slips* or faults, and by rolls and offsets in the wall rocks. Another marked feature is a dike eight feet wide, which crosses the ore beds

vertically, running a north-west and south-east course. By reason of irregularities in the course of the foot-wall, the ore breadth varies considerably, and the *pinches* are from a few feet to 75 feet long. Generally, magnetite is found in scattered grains in the mass of rock, both in the foot and in the hanging walls. The ore is all quite rich, but varies in the texture. Much of it is rather fine-crystalline. On account of its excellence and its value for Bessemer iron it is sought after, and the mines are worked at a great depth, and on comparatively small *veins*. The ore is hoisted through the Roe shaft and Big pit mainly. There is little water, excepting near the surface, and that is collected in the upper levels and raised by small pumps. There are two engine houses from which power for hoisting, pumping, compressing air and the electric light are furnished, one near the Roe shaft and the other, north-east of the Big pit.

The chemical composition of New Bed ore is, according to an analysis, from W. C. Witherbee:

Metallic iron	68.97
Oxygen with iron	26.29
Lime	.03
Alumina	.09
Magnesia	trace
Silicious matter (insoluble)	4.23
Phosphoric acid	.082
Water	.26
Undetermined and loss	.048
	100.000
Metallic iron	68.97
Phosphorus	.036

BARTON HILL MINES.—Two slopes with their connected workings and open pits on the outcrop, constitute the Barton Hill mines. They are on the eastern side of the ridge, and within 200 feet, vertically, of the crest. The strike of the ore is north and the dip to the west, at varying angles, due to the inequalities in the foot and in the hanging wall. Hence the thickness varies greatly, in places being pinched to a few inches; in others broadening to five and up to eighteen feet. At the north side of the north slope the ore is found abutting against rock, as it were, a longitudinal fault, which

makes a slightly oblique angle with the foot wall. The mine has reached a depth of 800 feet, measured on the slopes, or a vertical depth of 200 feet. The ore varies in texture from fine-crystalline to a coarse-grained, shot-like mass. Vitreous quartz is common with the magnetite. It is a Bessemer ore. Fine cleavage specimens occur in places, as also large crystals of magnetite. The roof is supported by pillars and scarcely any timbering is necessary. The volume of water is remarkably small, enough for the boilers only. The two slopes are worked from one engine house standing between them. The ore is hauled by teams to the railroad, near the New Bed, three-quarters of a mile distant.

FISHER HILL MINE.—Four slopes are opened in the ore-body on Fisher Hill, a half-mile north of the Barton Hill mine. The dip of the ore is at a moderately steep angle to the south-west. The ore is about five feet thick. It is lean, but answers for Bessemer iron. The Port Henry Iron Ore Company owns this mine.

O'NEIL, COOK AND THOMPSON SHAFTS. — These mines are a half mile east of Fisher Hill. Their workings are connected. They belong to Witherbees, Sherman & Co. For several years they have been idle.

Magnetic indications of the existence of iron ore in this part of the town of Moriah were noted as early as 1810, at the time of the survey of the Iron Ore Tract. The first openings were as early as 1824. Mine 21 was discovered in 1829; New Bed in 1844.* There was not much ore raised before 1846, when openings were made on lots 23 and 25. Dr. Emmons and Prof. Beck described the mines in 1842.† Since 1852 these mines have been opened extensively and their producing capacity has been increased, so that they rank with the largest iron mines of the country. The output has aggregated as much as 428,000 tons in a single year, and 8,846,000 gross tons in the period, 1840–1888, inclusive.‡

BURT HILL MINE, Elizabethtown, Essex County. — The Champlain Iron Company owns the Burt Hill mine, on lot No. 55 of

* WATSON: "History of Essex County," Albany 1869, pp. 391–2 and 398.

† EMMONS: "Survey of Second Geological District," pp. 237–244.
BECK: Mineralogy, pp. 15–16.

‡ Statistics communicated by Mr. Walter C. Witherbee, of Port Henry (of Witherbees, Sherman & Co.

the Iron Ore Tract. It was opened in 1842, and was worked to a depth of 180 feet. The ore is said to be rich, Bessemer, carrying 67.7 per cent. of metallic iron and .018 per cent. of phosphorus. There is an engine at the mine, but no work has been done lately.

NOBLE MINE, NIGGER HILL, Elizabethtown, Essex County. — Another mine of the Champlain Iron Company on lot No. 136 of the North Riverhead Tract. The ore has been opened for 150 feet, on a side hill, on the out-crop. The vein is eleven feet wide. The ore bed was first discovered in 1825. No mining has been done in fifteen years.

The distance of these mines from lines of public transportation, low prices, and slack demand for iron ore, prevent their further development at present.

GATES MINE, Elizabethtown, Essex County. — Two iron mines have been opened on lot No. 138, of Iron Ore Tract, south of New Russia. One is owned by H. A. Putnam of Elizabethtown. The ore has been opened a length of about twenty rods, and in one shaft to a depth of 140 feet, and has been found to range from two to sixteen feet in width. The strike is north-northeast, and the dip of the ore bed 60° westerly. The ore is fine-crystalline, and averages about 50 per cent. of metallic iron. North-west of the above-described opening, and in the lower ground, the Vulcan Iron Company of Boston, opened a vein of ore, which was 12 to 20 feet wide. The ore was remarkably fine-grained. The greatest depth reached was 70 feet. The ores from these mines were used mostly in the forge at New Russia. About 10,000 tons were obtained from the Gates mine. No work has been done in them since 1882.

Iron ore has been mined on the O'Donnell lot in this town by L. H. Roe, of Mineville.

On lot 209 of the Iron Ore Tract, and two miles south-east of Elizabethtown a titaniferous-ore bed was opened years ago, but not much ore was raised.

West of the Bouquet river in this town magnetic iron ore in workable extent has been discovered on what is known as the Castaline place, north of New Russia, and in the Wakefield, Post and Ross veins. A titanic iron ore is reported on lots Nos. 115 and 116, one mile south of Kingdom forge. Since the stopping of the forges these mines have lain idle. The Castaline bed is one of the oldest open-

ings in the county. Watson, in his history of Essex county, says that ore was taken out of it about 1800 and used in forges.

KEENE MINE, Keene, Essex County. — Magnetic iron ore has been mined on two adjoining lots, one mile south-west of the village of Keene. The first opening was made on the Wood lot in 1847. The Hale mine was opened in 1880. Both have lain idle since 1880. The notable features of these mines are: the occurrence of the ore in a crystalline limestone, and the presence of some calcite and epidote with the magnetite. The ores were concentrated and used in Weston's forge at Wilmington.

PILFERSHIRE MINE, Moriah, Essex County.—This mine is one and a half miles south-east of Mineville and east of the L. C. & M. R. R. It has been idle for about fifteen years. G. Rowley Sherman, of Port Henry, is the owner.

CHEEVER MINE, Moriah, Essex County.—This famous mine is near the shore of the lake, two miles north of Port Henry. It has been opened for nearly seventy years, but systematically worked since 1853.* It is owned by the Cheever Ore Bed Company and leased by the New York Mining and Developing Company, O. S. Presbrey, manager. The old workings have been abandoned, and the mining has been limited to two slopes, a few rods south-east of the old outcrop and mine. The relation of these bodies of ore to that of the old mine has not been fully ascertained, but from descriptions given of them, they appear to be smaller shoots of ore. The ore is rich, friable and shot-like, so that much of it is fine. The mine is operated by power carried from the engine-house west of the main road. The plant consists of two Corliss engines, each of 105-horse-power, with air compressors attached, pumps, etc. The ore is carted by teams to the furnaces at Port Henry. The total production of this mine from its first opening to the present time is estimated to be 800,000 tons.

GOFF'S MINE, Moriah, Essex County.—This mine is north of the Cheever Ore bed and three miles from Port Henry. It has been idle for several years.

SPLITROCK MINE, Westport, Essex County.—Splitrock ridge gives name to the openings for iron ore in its southern face, on the

* The great outcrop of magnetite attracted attention necessarily at an early date, and the first lease is reported to have been given in 1820.

shore of the lake, about five miles north-east of Westport. The ore crops out in the steep and rocky bluff from the water up, nearly to the top of the hill. The openings are 90 to 120 feet above the lake. The ore is very hard and fine-grained, and is reported to contain a considerable percentage of titanium. There are three drifts which follow the ore into the hillside. The ore was run down in chutes to the separating works, which are on the lake, below the mines. The equipment comprises crusher, rolls, magnetic separator, with engines for driving the machinery, and all in fairly good repair, although no work has been done in mining or concentrating in the past six years. The mines are owned by a New York and Albany company.

In the extreme western part of the town of Westport an iron-ore bed was opened in 1845–1850, on Campbell Hill, and on lots 166 and 168 of the Iron Ore tract. The locality was not visited. The ore is reported to be lean and titaniferous. It is four miles from the New York and Canada railway.

CHESTERFIELD, Essex County. A titaniferous iron ore is reported in this town. It is in the south-west corner and too far from rail communication to prompt much work in further searches or opening.

MINERVA MINE, Minerva, Essex County.—A vein of magnetite was opened in this town, north-west of Olmsteadville, by the Burden Iron Co., of Troy, and exploited subsequently in 1881, by the same company, but the small size of the veins and the distance from railroad prevented the further development of the property.

ADIRONDACK MINES, Newcomb, Essex County.—A remarkable group of magnetic iron-ore outcrops is exposed to view near Lake Sanford on the head waters of the Hudson river. They attracted the attention of geologists and iron makers half a century ago, and Dr. Emmons' clear description of these large deposits is so well known that reference to it without quotation is sufficient.* The discovery of the ore was in 1826.† The mines were opened in 1832–3, and a charcoal furnace was built, which was in blast until 1846, when a second furnace 56x12 feet was built and was run at short intervals until 1858, since which date it has been out of blast and the mines have been idle.

* EMMONS: *Survey of the Second Geological District*, Albany, 1842, pp. 244–255.

† WINSLOW E. WATSON: *Agricultural Survey of the County of Essex*, Trans. N. Y. State Ag. Soc., vol. XII., p. 772.

In 1888, a part of the tract was surveyed by Wm. H. Scranton and Uno Sebenius, under the direction of James McNaughton, of Albany. Their surveys indicate the extent of the Sanford ore bed as much greater than the outcrop (the outcrop exposed in the opening is over 500 feet wide and 1,600 feet long). Four long and persistent lines of regular attraction were found, crossing Lake Sanford in a north-east and south-west course, and were traced for considerable distances each side of the lake. In the bed of Calamity brook a fine-grained ore outcrops, 30 feet wide, and is traced north-east from this stream. One hundred yards north there is an outcrop 20 feet wide, of fine-grained ore. It can be followed for 100 yards north-east. Further north there are two more "veins" with 10 and 30 feet outcrops, respectively. All of these ores are reported to have the same general character as the "fine-grained ore" (of Emmons' report), which is on the hill, opposite the Upper Club House. The Cheney bed, on the west side of the lake, has been exposed in mining for a width of 40 feet, without reaching the walls. It is traceable half a mile toward the lake. Like the Sanford, it appears to be practically inexhaustible. Chemical analyses made of the specimens of ore collected in 1888 show that they are rich in iron, contain very little phosphorus, but all are titaniferous. In some of them the titanium is so low and is so combined that it can be largely eliminated by the use of a magnetic separator. Trials of these ores, using the Norton and the Edison separators, prove that it can be done. The iron and steel made from these ores, exclusively, were of the best quality, as was shown by tests made by the U. S. Government.* These mines are 32 to 38 miles from the Adirondack railway at North Creek, from which point there is a practicable route for its extension to them. There is a large fuel supply in the heavily-timbered lands all about the mines, and excellent water power; and the manufacture of charcoal iron on the property seems to be indicated by its natural advantages. It is hoped that these great beds of ore can be made productive mines, and the "deserted village" again become the centre of a busy population. The Adirondack tract, on which the mines are located, covers 100,000 acres of territory, and is held in trust by Jas. McNaughton, of Albany, in behalf of the heirs of the original owners.

PALMER HILL MINES, Black Brook, Clinton County.—These mines are on the southern end of Palmer Hill, one and a half miles north of Au Sable Forks.

* See report loc. cited.

There are two companies at work, viz.: the J. & J. Rogers Iron Company and the Peru Steel Ore Company (limited). The Big pit is the principal mine of the first named company. Its slope is 1,500 feet long and 400 feet deep, vertically. The extent of the opening on the course of the ore, from the Big pit, north-east to the opening on lot No. 29, is abont 2,000 feet. The shoots of ore pitch to the north at a low angle. The dip varies on account of rolls in the walls, and in places, the ore stands almost vertical. A notable feature is in the cutting of the ore by dikes. The largest is 16 feet wide, and is traced across both companies' mines and in an easterly course on the slope of the hill. Another, five feet wide, thinning out west in the open cut, crosses the mine of the Peru Company, near their engine house. The larger part of the ore is fine-granular and carries some vitreous quartz, orthoclase and a greenish mineral. The coarser-crystalline variety has orthoclase with the magnetite. No apatite is found and little pyrite. In the mass it has a bluish shade; crushed, the powder is red. An analysis, communicated by Hon. H. D. Graves, president of the company, gives:

Metallic iron	51.47
Oxygen	19.62
Alumina	1.86
Lime	.08
Magnesia	.62
Water	.43
Phosphoric acid	.042
Silica	25.42
	99.542

The ore is run down a gravity road to the dump, south of the mine; thence it is carted to the separating works on a stream near Au Sable Forks. It is all roasted and separated, and is made into billets in the catalan forges of the company at Black Brook, Au Sable Forks. and at Jay.* The product is sold to makers of crucible steel; nearly all of it goes to Pittsburgh, Penn. This mine was opened about the year 1844. The total output amounts to nearly 1,000,000 tons of ore.

*This company owns 80,000 acres of land in Essex and Clinton counties and uses annually 1,000,000 bushels of charcoal, for which about 1,000 acres of wood have to be cut over. In their separating works Blake crushers and stamps reduce the ore; the separating is done by means of jigs.

The mine of the Peru Steel Ore Company is on the south-east side of the hill. It supplies ore to that company's forges at Clintonville, three miles east of the mine. Little ore has been raised from it for several years past.

North-east of Palmer Hill is the Jackson Mine, which was worked up to about 1873.

WINTER MINE, Clinton County.—Dr. Emmons, in his Report on the Second Geological District, describes the *Jackson*, *Burt*, *Mace*, *Finch* and *Winter Veins.** They are opened in the towns of Au Sable and Black Brook, north and north east of Palmer Hill. They have been idle for many years.

ARNOLD HILL MINES, Au Sable, Clinton County. — These mines are situated on the north-east slope of Arnold Hill, and one and one-half miles west of Ferrona, a station on the Au Sable branch railroad. Three parallel veins of ore are worked; known as "the Grey," "the Black," and "the Blue." The strike is north-north-east. The dip is 60° to 70° west-north-west. The "shoot" structure is very marked, and the "pitch" of these lenticular bodies of ore is north-north-east, at an average angle of 40°. Another remarkable feature in the occurrence is the clean and smooth walls; and the rare presence of any slabs of rock on roof or foot wall. The veins are separated by rock — in places as much as 40 feet — between the "Grey" and the "Black."

The ore in the "Grey," or lowest bed, is medium fine-crystalline, and carries some greenish mineral in it. That of the "Black" is rather more friable and finer grained; a shot ore, although some of it is coarse-crystalline. It contains some apatite in small grains. The blue ore is named from its bluish shade of color. It also is a rich ore. Its crushed powder has a red color. There are two working slopes, each about 500 feet long and 500 feet apart. The whole working length is nearly 700 feet. Cross drifts connect the levels on the three veins. The "shoots" of ore are from three to twenty feet thick. Where the pinches occur, pillars of ore are left. The vertical depth, according to aneroid barometer, is 440 feet.

The lower, or Barton mine, 1,800 feet to the north-east (Nelson Bush mine of previous reports), is no longer worked. It is a large ore body, whose dip is nearly vertical, west-north-west. The magnetite occurs in thin, alternate layers with rock, so as to be

* *Geology of the Second Geological District*, Albany, 1842, pp. 304–306.

separable by sorting. It is about 100 feet deep. The plant of the Arnold Hill mine comprises one 100-horse-power hoisting engine, with friction drums for two slopes, two 8-inch Cornish plunger pumps, two Allison air compressors, Sargent drills, cars, etc.

Automatically dumping cars of $1\frac{1}{2}$ tons capacity are used in the mine; and 5-ton cars carry the ore from the shaft, on a gravity road to the head of the plane, which is 3,500 feet long, ending at the dump at Ferrona. A stationary engine controls the movement of the cars up and down this plane. The ore is shipped via Au Sable Branch railway and Plattsburgh to furnaces in New York, Pennsylvania and Ohio. It is a rich, non-Bessemer ore. The total output since the first opening in 1830 is estimated to be 400,000 tons. Since 1881 these mines have been the property of the Arnold Ore Company, J. N. Vance, president; Jno. N. Glidden, secretary, Cleveland, Ohio, and Joseph Payette, manager, Ferrona.

COOK MINE, Au Sable, Clinton County.—This mine is one and a half miles east of Ferrona station. It has lain idle for nearly twenty years. The Arnold Ore Company owns it.

WILLIAMSBURG MINE, Black Brook, Clinton County.—This mine was worked up to 1887, by Bowen and Signor, in which year it became the property of E. A. Carpenter, of Cambridge, Mass., and F. M. Vilas, of Buffalo. The mine has been opened 1,200 feet on the course of the "vein," and 160 feet in depth. There is a large body of ore, but it is nearly all lean and requires to be concentrated. The mine was first opened in 1855, and was worked for the supply of the forges of Bowen and Signor, at Redford, Russia, and Saranac. Its total production is reported to amount to 260,000 tons.

TREMBLAY'S MINE, Saranac, Clinton County.—Peter Tremblay's mine is on lot No. 72, Township 4, at Peterburgh, in the town of Saranac. It was opened in 1867, and worked for the supply of forges of Tremblay and others, in the neighborhood; it has been idle since 1885. The greatest depth reached was 80 feet.

DANNEMORA, Clinton County.—The mine of iron ore on the state property at the Dannemora prison has been idle for nearly twenty years. The ore bed dips northward; the ore is lean and sulphurous.

The Skinner and Averill mines in this vicinity were worked for

the State prison supply of forge ore, before the opening of the mine on the State property. They have since been idle.

CHATEAUGAY MINES, town of Dannemora, Clinton county. —These mines are situated on the north slope of Lyon Mountain, which gives name to the railway station at the mines. They are 34 miles west of Plattsburgh, and are reached by the Chateaugay railroad. There are two *veins* of ore, whose course is north-east and south-west, and whose dip is, at high angles, to the north-west. The ore has been opened almost continuously on the main *vein* for a length of 2,500 feet, and in twenty-two slopes. The principal working slopes are numbers 16, 15 and 14 at the north-east, and near the separating works, and at the western end of the line, slopes Nos. 7, 6, 5, 4, 3, the New or Hall shaft, No. 1, and the Cannon shaft, on the back or Burden *vein*. In the eastern slopes the depth ranges from 500 to 600 feet, and the ore is rather softer and coarser-grained. A notable feature of the range is the uniformity in the wall rocks, which carry some magnetite in the coarse-crystalline aggregate of orthoclase, vitreous quartz and hornblende. More or less feldspar and quartz occur in the ore, either in thin laminae with the magnetite or in scattered grains through the mass. The lean ore of the *vein* between slopes Nos. 14 and 7 is not now mined. The western slopes are from 1,000 to 1,100 feet long and 650 to 700 feet deep, vertically. The strike near slope No. 4 becomes west, and the average dip at the west, is 45° north ; at the eastern slopes, it is 70° north-east. A breadth of 20 feet of ore is won in the western slopes, leaving lean ore in the hanging and foot walls. In consequence of rolls in the walls the slopes are not at uniform angles of descent, and the tracks have to follow the undulations of the foot wall. Trap dikes traverse the ore, crossing it in sheets which are as much as 20 feet thick in some cases, and, in the western slopes, dipping steeply southward. Wherever encountered they are left as pillars to hold up the roof. Near slopes Nos. 14 and 16 they strike transversely across the *vein* and are vertical.* The ore at the western slopes is rather fine-crystalline and harder than that at the east, although in breaking it down there is much fine ore. All of the ore is suitable for Bessemer, and the average composition is shown by the following analysis : †

* There was no opportunity when at the mines to note carefully the mode of occurence and collect specimens of these rocks for study.

† Communicated by Mr. A. L. Inman, of Plattsburgh, general manager of the Chateaugay Ore and Iron Company.

Peroxide of iron	49.98
Protoxide of iron	22.49
Oxide of manganese	.17
Alumina	1.36
Lime	4.04
Magnesia	1.97
Silica	18.44
Phosphoric acid	.06
Sulphur	.05
Metallic iron	52.47
Phosphorus	.029

A new slope, between Nos. 2 and 3, at the west end of the line, is to be the main hoisting way, and several of the slopes near it are to be abandoned, thus increasing the efficiency of the working power.

The ore, as mined, is sorted into furnace and separating ore. The latter is concentrated in the mill near the mines.* These works have a capacity of 300 tons a day; and, in 1888 the product of separated ore amounted to 55,000 tons. This separated ore or concentrates averages sixty-five per cent. of metallic iron, and is used largely at their furnaces at Standish and at Plattsburgh. The company has another separating works at Standish, and a third near a lake north-east of the mines.

The mining plant here is of necessity extensive, and includes four Dickson Manuf. Co.'s duplex winding engines with 20 drums; 22 boilers with an aggrgate of 1,600-horse-power; three large Rand and one Clayton air compressors; 70 power drills and 40 pumps of various sizes. The main line of the Chateaugay railroad runs close to and nearly a parallel course with the *vein*, and there are branch tracks to all of the docks.

The extent of this ore belt has been proven by boring three miles to the north-east, where the Parkhurst shaft is in course of sinking, and to the north, under the village, in bore holes 1,800 feet deep.

The outcrop of ore at Chateaugay was discovered many years ago, but no mining worthy of note was done until the railroad was extended to the mines, from Dannemora, in 1879. The present owners, the Chateaugay Ore and Iron Company, came into possession in May,

* For a description of the mill see paper by Ferdinand S. Ruttmann in the *Transactions of the Am. Inst. of Mining Engineers*, Vol. XVI., pp. 609–623.

1881, and their output up to January 1. 1889 — a period of 7 years and 8 months — amounted to 1,519,520 gross tons.

MINE 81, Belmont, Franklin County.— The openings on lot No. 81, are one mile north-east of Standish. The ore bed here occurs with a dip of 70° to 75° to south-east. The wall rocks are a coarse-crystalline, syenitic gneiss. The ore was worked in the deepest shaft to a depth of 130 feet. It was carted by teams to separating works and furnace at Standish. The mine has been idle four years. This mine also belongs to the Chateaugay Ore and Iron Company.

In Franklin county magnetic iron ore has been mined at two localities in the town of Duane and in Malone, but for many years the mines have been abandoned.* These mines are too far from transportation lines to be of importance at present prices for ores.

CLIFTON MINES, St. Lawrence County.—Extensive beds of magnetic iron ore were opened about forty years ago on Grasse river, 20 miles south-east of De Kalb Junction, by the Clifton Mining Company, and costly preparations made to do a large business. A charcoal furnace on Grasse river near the mines, was run for a time on these ores exclusively.† The ore is reported to contain some titanium.

JAYVILLE MINES, Fine, St. Lawrence County. — The existence of iron ore at this locality was known at least 20 years ago, and some mining was done before the present company took possession. In 1886 the Carthage and Adirondack railroad was built as far as the mines and they were worked until the autumn of 1888, producing 25,000 tons of ore in that time. The openings are on the north-west and north-east slopes of a low rocky ridge of hornblendic gneiss. The eastern side hill is opened in slope known as Hart No. 1, which is 300 feet deep, on a shoot of ore 20 feet wide and 10 feet thick. At the north end of the hill are New York No. 1, Benson No. 1, Benson No. 2 slopes. Fuller No. 2, is located at the south-west end of the western range of ore. The dip of the strata and of the ore beds averages about 60° to the north-west. In Benson No. 1, the ore was said to have been from four to twenty feet wide for a length of 400 feet. The greatest depth reached was 350 feet

*Dr. Emmons' Report on *Geology* of the *Second District*, Albany, 1842, pp. 327–331.

†*Trans. Am. Inst. Mining Engineers*, Vol. I, pp. 364–371. *On the Magnetites of Clifton*, by Prof. B. Silliman.

on the angle of slope; and the length on ore, 600 feet. The ore is not very rich, but it does for Bessemer metal. The product was shipped to furnaces in this state, and to Scranton and Bethlehem, in Pennsylvania. The mines are equipped with three hoisting engines, five boilers, two air compressors, twelve pumps, a washer, and branch tracks from the several slopes to the main line of railroad. The proprietors are the Magnetic Iron Ore Company, office 12 Broadway, New York city.

LITTLE RIVER MINES, Fine, St. Lawrence County.—The Magnetic Iron Ore Company is developing the mines at Little River, 14 miles south-east of Jayville. Dr. Emmons described the locality as one of the largest ore beds in the county, and as having been worked twenty-two or three years prior to his report.* A mass of iron ore rising 60 to 100 feet above the valley of Little River, 800 to 1,500 feet wide and two miles long, in a general north-east and south-west direction, has here been tested by diamond drill to a depth of 182 feet without getting through to rock. The ore is lean and must be concentrated in order to its enrichment, and the possible separation of the apatite. The natural ore averages about 42 per cent of metallic iron. The Carthage and Adirondack railway terminus is to be at the mines, on its completion in 1889. It is hoped that by means of concentrating, the product can be used for Bessemer metal. The successful development of these mines, like that of other large ore bodies in the State, is dependent upon the economic concentration of the lean ore by magnetic separating machines.

PORT LEYDEN MINE, Lewis County. — The iron mine in the village of Port Leyden has been idle for about twelve years. The ore is titaniferous.†

III.—THE HEMATITES OF JEFFERSON AND ST. LAWRENCE COUNTIES.

SHIRTLIFF MINE, Philadelphia, Jefferson County.— The Shirtliff mine was first opened in 1838‡ for the supply of the Sterlingville furnace. It produced a large quantity of ore, and was worked

* *Geology of the Second Geological District.* Albany, 1842, page 347.

† Iron ores east of the Mississippi River, John Birkinbine in "*Mineral Resources of the United States for* 1886," p. 47.

‡ HOUGH: "History of Jefferson County," Albany, 1854, p. 558.

until the deposit was exhausted a few years ago. The mine has been dismantled.

In the town of Antwerp there is a range of ore deposits owned by the Jefferson Iron Company. They are, beginning at the south-west: *Colburn, Ward, Dickson, White and Old Sterling* mines. The company is working the Dickson and Old Sterling only; the others are idle.

THE DICKSON MINE was first opened in 1858. It is 120 feet deep, and worked wholly as an underground mine. The geological relation of the ore is much the same as in the Old Sterling mine.

THE WHITE MINE is a small pit on the White farm, between the Dickson and Old Sterling. It has been idle for many years.

THE OLD STERLING MINE is one mile north-east of the Dickson mine, and three miles from Antwerp. First opened by George Parish in 1836, it has been in operation ever since. For years it was in the possession of the Sterling family who used the ore in their furnace, and refused to sell any of it. In 1869 it became the property of the Jefferson Iron Company, which was organized in that year. The open pit at the north-east is 115 feet deep, and approximately, 500 by 175 feet. The underground workings are south and south-west of it, and the ore has been followed for a distance of 900 feet, and to a depth of 185 feet. This deposit lies between the gneissic rocks on the south-east, 400 feet distant, and the sandstone (Potsdam) on the west side of the mine, but no walls have as yet been reached in the mine. A serpentine rock occurs with the ore, apparently without any order in its relations to it. The ore varies from a specular ore of metallic lustre and steel-gray shade of color to amorphous, compact masses of deep red. The crushed powder answers well as a paint, and stains deeply all with which it comes in contact. The chemical composition is shown by the following analysis:

Sesquioxide of iron	79.52
Oxide of manganese	0.07
Alumina	1.12
Lime	2.49
Magnesia	1.07

Phosphoric acid	0.263
Sulphur	0.08
Silica	9.80
Water	0.68
Metallic iron	55.66
Phosphorus	0.115

The ore stands up well, and, by leaving pillars, with arched roof in the galleries and drifts, no timbering is necessary. There is comparatively little water in the mine. The serpentine is not so firm as the ore, and is full of slickensides surfaces. Small mine cars are used on the narrow gauge tramways in the mine drifts. A skip track runs to the bottom of the open pit. A branch railroad three miles long, connects this mine and the Dickson with the main line of the R. W. & O. R R., near Antwerp, although in a due east course the latter is less than a mile away.

The Dickson and Old Sterling ores are sold to furnaces on the Hudson river and in Eastern Pennsylvania, and some to Ohio. The ease with which the Old Sterling ore is smelted, being almost self-fluxing, creates a demand for it in mixtures with other more refractory ores, and even where the freights make it expensive. The total output of these mines is estimated by Mr. E. B. Bulkley, president of the company, at 750,000 tons.

KEENE MINE, Antwerp, Jefferson County.—This mine is the property of the Rossie Iron Works, Chas. S. Westbrook, manager. It is less than a mile west of Keene station on the R. W. & O. R. R., and near the county line. Sandstone here caps the ore, and the floor is a siliceous conglomerate in part, with some serpentine. It has been worked over 500 feet on the line of strike and is 400 feet deep, and the ore has been on an average twelve feet thick. Work at raising ore stopped in the autumn of 1887, but the water is still kept out.

CALEDONIA AND KEARNEY MINES, Rossie, St. Lawrence County.—The mines of the Rossie Iron Works are in the south-eastern part of Rossie, near the Jefferson county line, and six miles from Gouverneur village. The southern workings constitute the Caledonia; the Kearney mine lies north and north-east and a part of it is in the town of Gouverneur.

The Caledonia mine has two shafts. At the south-west shaft (No. 1) explorations with the diamond drill have discovered a second bed, 47 feet below the bottom of the shaft, of a rich, soft hematite, 33 feet thick, and resting on a white, graphitic, crystalline limestone. Shaft No. 2 is north-east of No. 1 and is vertical, 98 feet in sandstone, overlying the ore. The diamond drill borings at this shaft in 1886 went through 59 feet of ore; then in serpentine and mixed ore. The old Caledonia mine is near the foot of the hill, several rods north of shaft No. 2. It is full of water. Near it a new opening in the side hill exposes the ore in two beds with sandstone between them. The dip in the Caledonia mine varies somewhat, but is, in general, quite flat.

The Kearney mine consists of a large open pit and extensive underground workings on the hill north of the Caledonia. The ore bed dips to south-east and east, under sandstone strata (Potsdam). Near the surface and at the outcrop the cap of sandstone was replaced by earth and the ore quarried out in an open pit, to a depth of nearly 100 feet. A skip road runs down the west side of the pit into the mine. In this mine the ore occurs associated with the serpentine in large irregular-shaped bodies, somewhat as in the Old Sterling mine. The foot wall has not been reached. The ore of the Caledonia mine approximates to a true, specular ore in its color, lustre and texture; that of the Kearney is of a deep red color and more nearly an amorphous mass. The average percentage of metallic iron in the ore shipped from these mines is 52 to 53; the phosphorus is 0.2 per cent. The mining plant consists of hoisting and pumping engines, located between the Kearney and Caledonia No. 1 shaft, and working them, and another at Caledonia No. 2. Branch railroads connect all with the main line of the Rome, Watertown and Ogdensburg railroad, which is about a quarter of a mile east of the mines.

Ore was discovered in the Caledonia outcrop in 1812; the Kearney bed was opened in 1825, the Keene in 1837.*

The company employs from 90 to 200 men, and sells a large amount of ore yearly to furnaces on the Hudson river, in the Lehigh and Schuylkill regions in Pennsylvania and some to Ohio. These mines were first opened and worked by Geo. Parish about sixty years ago, and were known as the Parish mine.† They were purchased in 1865 by the Rossie Iron Works, and have been worked steadily since

* Hough's history of St. Lawrence and Jefferson counties, Albany, 1853, pp. 450–51 and 683.

† EMMONS: *Geology of Second Geological District*, Albany, 1842, pp. 93–96.

that time. The total product is estimated by Mr. Chas. S. Westbrook, manager, to amount to 500,000 tons.

CLARK AND PIKE MINES, Rossie, St. Lawrence County.—One-fourth of a mile north-east of the Kearney mine the Gouverneur Iron Ore Company has opened on adjoining properties what are known as the Clark and Pike mines. They are on opposite sides of a low ridge of sandstone (Potsdam) and in a synclinal fold of this formation. The first openings consisted of pits sunk on the north-east slope of the ridge. The Pike shaft is situated a few rods to the north-west of the old workings: the three slopes of the Clark mine are at the south-west border of the hill and on the north-east dipping ore bed. The greatest depth reached is 120 feet — on the slope. The ore has been found to vary in thickness, because of the undulating foot wall, the hanging wall being more nearly uniform in its dip. Some hematite occurs in the latter, in thin layers in the sandstone, and the workings are not carried to the ore limit in that direction. The three slopes are located within a length of 300 feet on the course of the ore bed. The average dip is stated to be 38°. The ore of this mine has a more laminated structure than the ores of the district in general. It is reported to run as high as 50 per cent. of metallic iron, and to make a good foundry iron. The Pike shaft is idle. It is not as deep as the Clark mine. The mining plant is comparatively extensive, including two hoisting engines, one Cornish pump, two steam pumps; and branch railroads connect the mines with the main line of the R. W. & O. R. R., 100 rods to the south-east. These mines were opened by John Webb, Jr., of Gouverneur, the present manager, in 1880, and, excepting two years, have been worked to the present time. The total out-put is reported by Mr. Webb to be 45,000 tons.

LOWDEN MINE, Hermon, St. Lawrence County.—This locality was abandoned in 1877 by the owner, A. Pardee, of Hazleton, Pa., after a thorough search for a workable deposit of ore.

IV.—THE CLINTON OR FOSSIL ORES.

In the town of New Hartford the Clinton ore bed has been opened at the DAVIS MINE, one mile east of Washington Mills, and at Chadwick's, four miles south of East Utica. A little ore was dug at the latter place last summer (1888). The Sauquoit Creek has eroded the formation and its continuity is broken, going west.

THE WELLS MINE, in the eastern part of Kirkland is idle.

Thence the outcrop is traceable west and south-west to the openings near Clinton village.

ELLIOTT AND PADDON MINES, Kirkland, Oneida County.—North-east of the mines of the Franklin Iron Manufacturing Company and east of Clinton, James Paddon and Frank Elliott own ore banks. They have lain idle for several years. The bed of ore is reported to have been four feet thick at one point in the Paddon mine, but the roof was poor, on account of the thin layers of shale and heavy bearing of earth.

The MINES of the FRANKLIN IRON MANUFACTURING COMPANY are near Clinton, on the east of a small stream. The ore beds descend about one foot in 100 feet, to the south-west. The overlying material is dark-colored shales and shaly sandstones, and is from twenty to thirty feet thick. The upper ore bed is thirty inches thick, and shale twelve to eighteen inches thick, separates the upper and lower ore beds. The upper bed alone is now worked. The long-wall system of mining is followed and drifts have a height of four feet, being cut two feet up into the roof. Two main adit levels are cut in the ore eastward and east-north-east, more than half a mile. The working face has a length of 4,200 feet, and the ore has been removed from an area of sixty-four and one-half acres. A part of the mine has a natural drainage. The ore is loaded on cars of a capacity of 2,800 to 3,000 pounds, which are drawn by mules to the dump, whence it is taken on a branch railway to the company's furnaces, two miles south of the mine.

The chemical composition of the average ore is shown in the following analysis: *

Oxide of iron	69.17
Alumina	3.92
Lime	5.80
Magnesia	2.27
Oxide of manganese	0.19
Phosphoric acid	1.726
Silica	11.57
Carbonic acid	4.75
Sulphur	0.28
Metallic iron	48.42
Phosphorus	0.754

* Communicated by C. H. Smyth, Jr., Chemist of the Franklin Iron Works.

The mining plant consists of two Ingersoll air compressors, twenty power drills, two ventilating fans, two Knowles steam pumps, etc. A large force of men is employed, and the annual output has averaged over 50,000 tons since the mine was opened in 1880; the total output to the end of 1888 amounting to 392,321 tons. The ore is all smelted in the company's furnace and makes a good foundry iron. A small fraction, about ten tons a day, is ground into paint by the Clinton Metallic Paint Company.

The old mine south of the road has not been in operation since the opening on the present location.

THE CLINTON MILLS or FERMAN MINE of the Kirkland Iron Company was opened in May, 1888. When visited, the bank section showed:

Glacial drift, with imbedded boulders	18–30 feet
Greenish-gray shale	20 inches
Ore bed	24–30 inches
Floor of ferruginous sandstone.	

The inclination of the ore bed is at the rate of three feet in 100 feet and to the south-west. The floor is uneven; and offsets of six inches occur. The ore is red and fine-oolitic, with scattering small pebbles, in places. Pyrite is found occasionally, in thin laminæ, as shale and ore partings. The mine has thus far been worked as an open pit, and an acre or more of the ore has been uncovered. The ore is carted by teams to the company's furnace, one and a half miles north of the mine. It is used with magnetic iron ore and Antwerp red hematite.

THE NORTON ORE BED, adjoining that of the Kirkland Iron Company, on the north, is no longer worked.

The Clinton ore bed is traced in a west-north-west direction from Clinton Mills, through Westmoreland and Verona; and there are several mines on its outcrop, none of which have been in operation since 1882.

Ore was dug on the same outcrop in the town of Lenox, Madison county, for the Lenox furnace when in operation many years ago.

These localities were referred to by Vanuxem in his report in 1842.* They have been abandoned.

*Geology of the Third Geological District, Albany, 1842, pp. 88–89.

STERLING, Cayuga County. — The Clinton ore bed has been opened about 100 rods west of the R. W. & O. R. R. and north of the Southern Central line, and worked by the Furnaceville Company of Ontario county. The ore is found covered more deeply as the quarrying moves southward, in the line of dip. There are two ore beds "or tiers," each about 18 inches thick. In the lower one the ore is mixed with some "flint."

WOLCOTT MINE, Wolcott, Wayne County. — Fossil ore was formerly mined in this town for the supply of the Wolcott furnace, six miles west of the mine. The furnace went down years ago, and the mine was then closed.

The Clinton ore crosses the towns of Sodus and Williamson, west of Wolcott; and it was dug near the mouth of Salmon creek in the first named town for the supply of the Sodus furnace. The locality has been abandoned for many years.

ONTARIO MINES, Ontario, Wayne County. — The outcrop of the oolitic ore of the Clinton formation stretches across the town of Ontario, in a nearly due east-west course and dipping southward at the rate of ten inches in 100 feet. The country is level and the workings reach the profitable limit for the removal of the overlying rock and earth (10–12 feet) within comparatively short distances.

The Bennet estate owns the easternmost outcrop and mine, on the east of the Ontario station and furnace road. It has lain idle nearly ten years. The mines west of the Bennet property are opened on a line about one-half mile north of and parallel to the R. W. & O. R. R.

At present the Jones & Bean farms are producing ore; the Hurley, Le Frois and Bundy openings are not worked. All are controlled by the Furnaceville Company, Samuel Raymore, manager. On the Bean farm the ore is covered by drift earth and a greenish-grey shale, varying up to 12 feet in thickness. The ore bed is twenty to twenty-two inches thick, and has a slightly wavy upper surface. Under it there is greenish shale, which falls to pieces on exposure to the air.

The Jones mine adjoins the above, on the west, and in one continuous opening. Near the outcrop the covering is earth with lumps of ore in it; south, the rock appears, first in thin layers, increasing to six and eight feet thick at the present face of working. The lumps of

ore in the surface layer are of a deep brownish-red color and make an excellent paint material. The bedded ore has a steel-blue shade, and is a strongly cemented mass of lenticular and ovoidal grains, which are much larger than those of the Oneida county ore. The crushed powder is red and stains as a paint. In working, the cap rock is broken up by drills and by powder. The ore is hard and must be blasted, to break it into blocks for handling. One pump raises the water from the whole mine, whose length of face is now 100 rods. A branch track from the R.. W. & O. R. R. runs into the mine. The ore is shipped to Charlotte, Syracuse, Elmira and other points. Its percentage of phosphorus is high. It is made into foundry iron. The westernmost mine is near the west line of this town. A branch railway runs into it, but it is not worked. The Ontario mines were first opened fifty years ago.* They have produced a large amount of ore (at the rate of 4,000 tons a month in some years). Work was suspended in the spring of 1888 and resumed in November of same year.

V.—THE LIMONITES OF DUTCHESS AND COLUMBIA COUNTIES.

MASE'S MINE, Fishkill, Dutchess County.—A bed of brown hematite, two miles south of Fishkill village, was opened by S. H. Mase, of Matteawan, in 1885, and some ore raised.

SHENANDOAH MINE, East Fishkill, Dutchess County.—The Shenandoah mine has not been worked since 1879, when it was re-opened and, after an unsuccessful attempt to find ore in quantity to justify further mining, was abandoned. The locality is three miles from the N. Y. & N. E. R. R. line at Stormville.

SYLVAN LAKE MINES, Beekman, Dutchess County.—Four mines are opened in the valley of the Fishkill Creek, near Sylvan Lake. On the north-west the HORTON MINE, which has been idle for years; south of the Horton is the old Fishkill Company's pits, not worked in forty years; next, eastward and on the south side of the lake, the Fishkill mine of A. Tower, of Poughkeepsie, and adjoining it, to the north-east, the Sylvan Lake Mine. The FISHKILL MINE is the only one which has been in operation for the past six years. It

*See report by Prof. James Hall on the Fourth Geological District, Albany, 1843, pp. 60–62 and 419.

forms with the Sylvan Lake Mine a connected opening about a quarter of a mile long, and has an average breadth of 200 feet. The vertical depth is about 90 feet. The ore is covered by drift earth. In places it has been found within a few feet of the surface; at other points as much as 30 feet of glacial drift, boulder clay and ochreous earths are found over the ore. No rock in place has been encountered in the excavations; and the nearest outcrop is that of a light blue limestone 20 rods south-east of the mine. The same formation appears to the north, near the lake. Both blue and yellow "ochres" occur with the ore, in masses of irregular shapes and of varying extent. About ten per cent. of the ore is lump or "rock;" the rest is wash material. The former is picked out in the mine. The "ochres" also are separated as far as possible, in the digging. "Bombs," stalactitic, and compact masses occur. Thus far no carbonate or "white horse" has been found. There are two slopes on the north side of the pit, 400 and 384 feet long, respectively. The ore is reported to average 47 per cent. of metallic iron, eight per cent. of silica, with traces of manganese and no sulphur; phosphorus, .07 per cent. It is a non-Bessemer ore. The mining plant consists of two hoisting engines; one 13x24″ and one (Corliss) 14x30″; two 75-horse-power boilers; two steam-pumps; two Cornish, plunger pumps, and two ore-washers. A track runs from the washer to the Clove Branch railway. The mine makes a large volume of water, draining the adjacent Sylvan Lake pit, and the pit water serves for washing the ore.

The market for the ore is at Troy and Poughkeepsie, and in the Lehigh region of Eastern Pennsylvania. A. E. Tower & Bro., of Poughkeepsie, are the lessees.

The SYLVAN LAKE MINE has been idle for six or seven years. It is owned by the proprietors of the Clove Iron Works. The geological relations of the ore are similar to those of the Fishkill mine, excepting the greater thickness of the overlying drift and ochreous earth. At present the pit is drained through Tower's mine. In these Sylvan Lake mines the exploitation is done by driving horizontal drifts into the ore, in advance of the mining, and its extent ahead is ascertained. In mining, the overlying earth and ore are thrown down in large sections, by great blasts, and then roughly sorted into lump or rock ore, wash ore and waste dirt and stone. The volume of water is large—from the large drainage surface of pit area, as well as underground water. The bottom of the mine is considerably lower than the level of the lake.

BEEKMAN MINE, Beekman, Dutchess County.—The mine in the village of Beekmanville is named from the town in which it is situated. It is opened on the north-west of the village street 100 yards, and within a quarter of a mile of the Clove Branch railroad. The mine is 500x300 feet and 70 to 90 feet deep. The *stripping* is a glacial drift, which is five to twenty feet thick, underlain by an ochreous clay, in which there is some ore. At the north-west there is a crumbling, slaty rock exposed by the excavation, which dips east-southeast steeply. The ochreous earths on the south and west sides show south-dipping layers — the lines of original stratification in the rock. The ore is quite firm and has to be blasted down. A large proportion is rock ore which is sorted out in the mine from the wash ore. For washing, water from a stream 3,500 feet northward and with a good head, is led to the washer at the south side of the mine. The hoisting is in cars, pulled up a slope 350 feet long by a slide valve engine 8x24″. Two tubular boilers, one Knowles steam pump, one Plunger pump and one Bradford washer are in use. The pit water is raised to a drain west of the mine. The ore is shipped to Poughkeepsie furnaces. This mine has been in operation continuously for 19 years, since it was first opened. It is owned by A. Tower, and worked by A. E. Tower & Bros., all of Poughkeepsie.

CLOVE MINE, Unionvale, Dutchess County.—Two mines have been opened in the Clove Valley, three miles north-east of Clove Spring Iron Works, the terminus of the Clove Branch railroad. The mine at the south-west is the property of A. Tower, of Poughkeepsie. It was opened about 1834, and was worked until February, 1888. The ore was found bounded on the south-east by an irregular wall of grey limestone, and covered by ochreous clay and glacial drift. On the west the rock was not reached, but further west, the valley is bounded by the Scott mountain — a rocky ridge of hydro-mica slate. The ore was carted to the Clove Branch railroad, and thence shipped to Poughkeepsie furnaces.

THE CLOVE SPRING MINE is separated from the above by an unbroken surface of about 500 feet. It is similarly situated and apparently in the same body of ore. The pit is nearly 900 feet long, from north-east to south-west, 200 feet wide and 130 feet deep. The slope on the west side is 200 feet long. The "stripping" consists of drift, with many large boulders, from 6 to 30 feet thick, and under it ochreous earths, in which there is more or less ore. A gray lime-

stone has been met with on the east side of the pit; also in the west and south-west of the present working, and on a higher level. A horizontal drift on the west was cut 92 feet into the ore and no wall was reached. The overlying blue and yellow ochreous earths ("or ochres," of the miners) stand up well when not weighted by too much top earth. The ore is compact and must be blasted down. In places the "ochres" occur in irregular-shaped masses, with the ore, and to such an extent as to make their removal add largely to the expenses of working. The ore is hoisted in cars and is sorted into lump and wash ore. The mining plant consists of one 40-horse-power engine, three boilers, two pumps and one Newbold washer. The ore is carted to Clove Spring Iron Works station, and thence shipped to Copake Iron Works. This mine is owned by Hon. Frederick Miles, of Salisbury, Conn., who purchased it in October, 1888. It was first opened in 1871 and was worked several years for the supply of the Clove Spring Iron Works. The total production is estimated to be 150,000 tons.

PAWLING MINE, Pawling, Dutchess County. — The Pawling mine is two and a half miles west-north-west of the village of Pawling, and at the eastern foot of a ridge of mica-schist rock. This rock bounds the ore body on the west; on the east, limestone strata crop out near the mine. The mine was first opened in 1870, and was worked as an open pit until 1884; from that time till the stoppage in the autumn of 1888 the workings were underground. The two main openings are on the opposite sides of the Poughquag turnpike, but the ore has been exploited for a distance of 1,200 feet to the north-east. The greatest depth reached was 130 feet. The mining plant includes, in addition to office and houses, one 80-horse power engine, with two drums, three boilers and four pumps, and a Carter washer. The ore contains, according to an analysis communicated by the company:

Metallic iron	46.45	per cent.
Silica	14.10	
Phosphorus	0.37	
Sulphur	0.007	
Manganese	1.816	
Alumina	3.506	

The ore was carted to Pawling, and shipped thence to the owner's furnace, Millerton Iron Company, Irondale.

DEUEL HOLLOW MINE, Dover, Dutchess County. — This locality, two miles south-east of the South Dover station, ceased to be a productive mine many years ago.

DOVER MINE, Dover, Dutchess County. — This old mine was described by Prof. Mather, under the name of "Foss Ore Bed."* It has been worked at intervals — the last time in the spring of 1888. The ore was used at Dover Furnace, and subsequently at the furnace near the mine. A narrow gauge railway connects the mine and the Dover Furnace station on the New York and Harlem railroad. The furnace was burned in 1883. The ore occurs under a rather thick covering of glacial drift, and between strata of garnetiferous mica schist, which forms the mass of the rocky ridge on the east and the mountain on the west. The ore was won by underground workings. The place has been known as the "White Ore Bed," in later years.

SQUABBLE HOLE MINE, Amenia, Dutchess County. — This mine is one and a half miles south-west of Amenia and half a mile west of the Harlem railroad and near the Chestnut Ridge. It was opened in 1865, but has not been in operation for the last ten years. The locality is noteworthy for the occurrence of a carbonate of iron ore, associated with the brown hematite. The Manhattan Iron Works of New York city owns the property.

GRIDLEY MINE, Amenia, Dutchess County. — What is known as the Gridley pit adjoins on the south the old and celebrated Amenia mine, west of the village of Amenia. They are practically one, being separated by a property line only. No work has been done in the last five years, or since the death of N. Gridley & Son, its owners, to whose estate it now belongs. A notable fact is the amount of carbonate of iron, or, as it is known by the miners, "white horse." It has a grayish-white color on fresh and unweathered surfaces, and occurs in the limonite. A considerable quantity of this ore was mined near the south end of the mine and smelted in the Gridleys' furnace at Wassaic. It made an iron of unusual tensile strength — 39.669 to 47.500 pounds per square inch.†

AMENIA MINE, Amenia, Dutchess County. — The Amenia Mining Company owns and works the mine adjoining the Gridley pit

* *Geology of the First Geological District, by Wm. W. Mather,* Albany, 1843, p. 493.

† For analyses of the roasted ore and of pig-iron and tests of strength, see papers of Edward Gridley in *Trans. Am. Inst. Min. Eng.,* Vol. XII., pp. 91, 92 and 520.

on the north. It includes the Palmer pit and the Weed mine, but they and the Gridley mines are all on one continuous body of ore, lying upon the white, fine-crystalline limestone, near the adjacent black, micaceous schist. The limestone forms the west wall of the Palmer pit, and the bottom of the mine near this western rock wall. It is uncovered at the east side also, under the schist. Both the limestone and the "slate rock" (schist) dip toward the east-south-east at angles of 60° to 70°. The limestone was found nearly all the way across on the bottom, near the Weed pit. The ore is largely limonite. The carbonate, or "white horse" of the miners, occurs at the bottom and in the south wall of the Palmer pit in strata, which dip steeply eastward. The limonite appears to be deposited upon and between the beds of the carbonate ore. The association of these ores and rocks is geologically interesting and suggestive of the origin of the limonite through the oxidation and redeposition in part, of the carbonate. The further extension of the limits of the pits, vertically and laterally, will, no doubt discover the order of succession and their relations to one another. The limonite occurs in a variety of forms; in great pockets, mixed with clays of various colors; in compacted masses, which have to be broken down by blasting; and in "cups" and "bombs," spheroidal and cup-shaped masses in the clays. Notwithstanding the long and uninterrupted working, the breasts of ore are apparently as promising as at any time in the history of the mine. The working is in the open pits and the ore is taken in carts to the washer on the west side of the mine. The total length of the opening, from north to south, is 80 rods, and the Palmer pit is 115 feet deep. The extreme breadth of the ore has been as much as 300 feet, from foot to hanging-wall side. The ore is crushed by Blake crushers, washed in a Bradford washer, and carted to the railroad, three-quarters of a mile distant. The mine water is raised by a 10-inch Cornish pump and is used in washing the ore. The mine equipment includes two boilers and two engines in addition to pump and washer. The ore carries from 44 to 51 per cent. of metallic iron, is non-Bessemer, and is used mainly for car-wheel manufacture by Barnum, Richardson & Company, in their furnaces at East Canaan and at Sharon Valley, Connecticut. A smaller part is sold to the Burden Iron Works, at Troy. The mine has yielded 200,000 tons of ore in the last twenty years.

MANHATTAN MINE, town of Amenia, Dutchess County. — The Manhattan or Sharon mine is at Sharon Station, on the New

York and Harlem railroad. The first opening for ore was made about 1780. The ore body is in a grayish-blue limestone belt, and strata of this rock crop out in the north-west and in the south-east sides of the great pit, having a dip of 40° to 50° toward the south-east. The *stripping* consists of glacial drift and bluish-colored clays, and some calcareous marl and muck in places, and it varies from 10 to 14 feet in thickness. At the north-east, a blue clay separates the workable ore into two bodies, whose trend is to the north-east. The later workings were by underground drifts. The open pit is at least 500 feet in diameter and 160 feet deep. A large amount of ore has been taken out of it, and in 1880 its production exceeded that of any other brown hematite mine in this district. The ore was smelted at the Manhattan Iron Works, New York city. In August, 1888, work was stopped, and subsequently the machinery was removed and the mine abandoned. The ore, according to reported analyses, is low in phosphorus, and answers for Bessemer pig-iron. The mine is the property of the Sharon Bessemer Ore and Iron Co., of 69 Wall street, New York city.

MALTBY MINE, town of Northeast, Dutchess County. — The Maltby mine is at the south-west foot of Bird Hill, one and one-half miles north-east of Millerton, and within a quarter of a mile of the Connecticut line. It was opened in 1750, and has produced a large amount of ore; and much of it was smelted in a furnace on the property. The body of ore appears to lie between the slaty rocks on the north and the white, crystalline limestone at the south. No mining has been done here in the last four years. C. S. Maltby, of New Haven, Conn., is the owner.

DAKIN MINE, Northeast, Dutchess County. — The open pits known as the Dakin mine, are near the Riga station of the N. Y. and Harlem railroad. For several years it has been idle.

MT. RIGA MINE, Northeast, Dutchess County.—The Riga mine consists of a large open pit and some underground shafts and tunnels, about half a mile south-east of Mt. Riga station and near the foot of the Mt. Riga ridge. A branch railway connects the mine with the N. Y. and Harlem railroad. The plant is in fairly good order, although no ore has been raised since February, 1885. A pile of several thousands of tons is being shipped to furnaces in this region. The Mt. Riga Iron and Mining Co., of 15 Park Row, N. Y. city, owns the mine.

KELLY MINE, Northeast, Dutchess County.—One mile north of Mt. Riga station and at foot of mountain, was opened in 1880 and was closed in April, 1888.

MORGAN MINE, Ancram, Columbia County. — The Morgan mine is one of the oldest mines in this region, and is said to have been opened in 1776 by the Livingstons. It is near the western base of the Winchell mountain range, and one and a half miles south of Halstead station, on the New York and Massachusetts railroad. The ore appears to have been covered by a mantle of drift, 8 to 20 feet thick. At the north-east end of the old pit a stream has cut down through the earth and boulders and exposed a section 20 feet thick, of superior carbonate of iron. This ore on the weathered surfaces is reddish-brown in color, but under the thin, oxidized coating it presents the characteristic gray-white shade of carbonate ore. An analysis of this ore, made recently, shows it to contain 48.1 of metallic iron, 0.42 of sulphur and .038 of phosphorus. The carbonate or "white horse" has been found in some shallow, exploring pits on the adjoining Knight property, to the south. The property is owned by Albert Tower, of Poughkeepsie. This mine has been known also as the MacArthur place.

REYNOLDS MINE, Ancram, Columbia County.—The Reynolds mine is at least a quarter of a mile west of the mountain, in the limestone valley, and a half mile east of Halstead station on the New York and Massachusetts railroad. Prior to the building of that railroad there was a branch railway to Boston Corners. There are two large pits from which a large quantity of ore has been taken. The mine buildings and the dump are on the west of the pits ; the washer is on a stream between them. The rotten rock over the ore is stratified, and has its beds dipping easterly, at an angle of 20°. The mine has been idle since 1887. It was opened in 1857.

WEED MINE, Copake, Columbia County. — The Weed mine is on the west side of the N. Y. and Harlem railroad, and north of the line of the Hartford and Connecticut Western railroad, and one mile from Boston Corners. It was first opened in 1840. In June last it was re-opened by the present owners, the Millerton Iron Company, Irondale, Dutchess county. The ore body has been uncovered for a length of 1,600 feet, from north to south, and over an average width of 70 feet. A depth of 120 feet has been reached in the lowest part

of the excavation. The ore is bounded on the east and west sides by a black, slaty rock, whose beds dip eastward at an angle of 35°. On the hanging-wall side this rock is in a soft and crumbling condition. A double-compartment shaft has been sunk on the foot-wall side of the ore body, and preparations made for underground mining. Last season a new engine house, washer and office were erected on the west side of the pit. The plant now consists of an 80-horse-power engine, with hoisting machinery, having a capacity of 500 tons a day, one Bradford washer and two pumps for unwatering the bottom or underground workings. The great pit is drained to a depth of 80 feet by a natural outlet, to a stream in the valley on the south of the mine. A narrow gauge railway in the pit has served for removal of the ore. From the new washer a branch railway runs to the Hartford and Connecticut Western railroad line; and another branch to the Harlem railroad is projected. The ore appears to become harder and more compact in the deeper workings. According to an analysis communicated by the Millerton Iron Company it contains:

Metallic Iron	43.00	per cent.
Phosphorus	0.11	
Sulphur	none	
Alumina	6.06	
Silica	17.53	

It is used at Irondale near Millerton, Hudson, and the Lehigh valley region, Pennsylvania. The total output since it was first opened is reported to be 100,000 tons.

COPAKE MINE, Copake, Columbia County.—The Copake iron mine is at Copake station of the N. Y. and Harlem railroad. The old holes are west of the track and near the station. The pit last worked is a few rods north-east of the depot. It is about 500 feet long and half as wide. The ore was found covered by 6 to 20 feet of glacial drift. On the east and north-east sides of this pit the grayish white, sub-crystalline limestone was reached; its strata dipping 30° to the east-south-east. The plant consisted of a crusher, one washer, engine house and machinery for pumping and raising ore to side tracks from main line. The mine was opened many years ago and worked up to August, 1888, when the pumps were taken out and the pit began to fill with water. It is the property of Hon. Frederick Miles of Connecticut.

HILLSDALE OR SMITH MINE, Hillsdale, Columbia Co.— The Hillsdale and Smith mine is in the limestone valley, about three miles east of Hillsdale village and near the Massachusetts line. It was opened in 1834 and has been worked at intervals, the last time in the summer of 1887 by —— Northridge, of Brooklyn. Geo. W. Palmer of 132 Nassau st., New York, is the owner. The ore has to be carted to Hillsdale station on the N. Y. and Harlem railroad.

MITCHELL MINE, Hillsdale, Columbia County. — This mine is on the farm of A. & W. Mitchell, three miles north-east of Hillsdale village. It has been idle for twelve or more years. It was first opened in 1800.

HAIGHT OR FOSTER MINE, North Hillsdale, Columbia County. — The opening on the estate of Edward Haight, deceased, at North Hillsdale, bears this name. The location is in the valley, near the slate on the west, and a quarter of a mile west of the valley road. It was opened first in 1862, and was worked a little, five or six years ago by a New York city company. The nearest railway line is at Hillsdale.

VI.—THE LIMONITE, OR BROWN HEMATITE OF STATEN ISLAND (RICHMOND COUNTY).

NEW DORP MINE, TOWLE MINE, COOPER & HEWITT MINE, Middletown; **TYSON'S MINE,** Castleton.

The above-named mines are the larger openings in the brown hematite deposits of Staten Island. They are all in the north-eastern part of the island and on the range of serpentine rocks. The geological occurrence has been described briefly by Mather,* and recently by Dr. N. L. Britton, of Columbia College.† According to the latter authority the ore rests directly upon the serpentine or talcose rocks and is generally covered by the glacial drift. It ranges up to twelve feet in thickness. The lateral extent is limited to a few hundred feet in any direction. The ore varies in the percentage of metallic iron from 38 to 55 per cent. according to published analyses.‡ It contains a notable amount of chromium. Dr. Britton has

* *Natural History of New York: Geology of the first Geological District,* by Wm. W. Mather, pp. 489–490.

† *Annals of the New York Academy of Sciences, Vol. II, pp.* 175–177.

‡ *Tenth Census of the United States,* Vol. XV., pp. 122–127.

estimated the total production of these mines at 250,000 tons. They have been idle for nearly ten years. Although the nearest iron mines to New York city, they suffer the disadvantage arising from high freight rates to furnaces which would otherwise use them. The mines were worked early in the present century. (See Am. Jour. of Science, Vol. I, p. 145.)

We append to this section on the Limonites, of Dutchess and Columbia counties notes, of two mines which are, apparently, isolated deposits.

ACKERMAN MINE, Mount Pleasant, Westchester County.— An old opening, on a deposit of limonite, in the white, crystalline limestone, which was worked many years ago, bears the above name. It is on the left bank of the Saw Mill river, one mile south of Unionville.

TOWNSEND MINE, Cornwall, Orange County.— The so-called "Canterbury mine" is four miles west of Cornwall-on-Hudson and near the Newburgh Short Cut R. R. It is interesting on account of the geological position of the ore, in the Lower Helderberg limestones. The mine has been idle for a decade of years.

VII.—THE CARBONATE ORE OF THE HUDSON RIVER.

The iron mines of the Hudson river carbonate ore are in the towns of Greenport and Livingston, in Columbia county. The ore occurs in beds, and in a range of hills between one and two miles east of the river and east of Catskill and Linlithgo railroad stations. The outcrop is on the steep, western slope, and at an elevation of 300 to 400 feet above the river. The length of the outcrop, from Plass Hill, at the north, to Hart's Hill south of Burden, is four miles. Further south the strata are covered by the diluvial formations of the valley of the Roelef Jansen kill. The trend of the range is south-south-east. The ore is conformable in stratification with the underlying slates and the overlying sandstones and conglomerates, and belongs apparently in the Hudson River slate formation. The ore at the outcrop is everywhere more or less weathered, and is of a dark-red color. On Mt. Thomas, glacial markings were found on the ore surface, beneath the thin, earthy covering.

From north to south the several openings are here noted in the order of their succession, beginning with

PLASS HILL OPENINGS, in Greenport.—The ore has been uncovered and tested for a distance of 1,000 feet, approximately, and to a depth of 50 feet, in places, by a line of open cuts, which are from 10 to 100 feet below the top line of the ridge, and about 300 feet above the river. The dip of the beds is 25°–30° N. 80° E., and the thickness of the ore ranges between 10 and 16 feet, but in it there are some thin layers of shale. The foot-wall rock is a drab-colored shale; the hanging-wall strata are gray sandstone. The ore is of a gray shade where not weathered. It contains some quartz in small grains and scattered nodules of pyrite. According to the reported analyses it is rather lean, and is a non-Bessemer ore. These openings are a part of the Hudson River Ore and Iron Company's property. They are less than a mile from the river, at Catskill station.

South-east of Plass Hill and east of Plass Corner, the ore has been uncovered in two small openings near the road to Greenport church. It is lean and in thin and irregular seams.

Southward there is a gap in the range where it is concealed under the terrace formation of the Hudson River. It reappears at the foot of Cedar Hill.

CEDAR HILL OPENINGS. Cedar Hill and Mt. Thomas (or Miller Hill), make up the ridge sometimes known as Long Hill. On Cedar Hill the outcrop is on the crest, and is 400 to 450 feet above tide level. There are several open cuts on the lands of the Hudson River Ore and Iron Company, but none of them exceed 25 feet in depth. The dip of the beds is on an average 40° N. 80° to 85° E. The thickness of the ore varies from eight to 30 feet, including, in places, some interbedded sandstone and also some slaty rock in the ore. No work has been done since 1885, except in the new cut at the south end of the hill, which was opened in 1888.

LIVINGSTON'S MINE is east of the openings of the Hudson River Ore and Iron Company, and near the top of the ridge. The principal opening is a vertical shaft, 40 feet deep to the ore, then descending in the ore, eastward. The dip is 35° east-north-east. The thickness of the ore is 18 feet. The large amount of silica, in much of it, reduces the percentage of metallic iron, and it is non-Bessemer also. The mining plant comprises a hoisting engine, pumps, an air-

compressor, four roasting kilns (on the hill north of the mine), and a narrow gauge railway to the docks on the river. The railway is, however, badly out of repair. This mine has been idle five years. H. W. Livingston is the owner.

BURDEN MINES, Livingston, Columbia County.—The Burden mines may be described as being situated at Burden; and, as comprising the openings on Mt. Thomas, and mines No. 3 and No. 2 south-east of Mt. Thomas. On the west slope of Mt. Thomas there is a long open cut, 460 feet above the river and 50 feet below the top of the hill. In it there is a fine exposure of the stratified ore and the associated foot-wall and hanging-wall rocks. The ore at the south end is 41 feet wide, including a thin bed of sandstone near the hanging-wall. It has a laminated structure and contains more quartz than the ores of No. 2 and No. 3 mines; and is non-Bessemer. The ore bed has been opened at three levels and to a depth of 140 feet, by drifts running into the hillside on the course of the ore.

No. 3 mine is about 1,000 feet south-east of Mt. Thomas mine and in the low ground at the foot of the ridge. Its ore bed dips eastward at a moderately low angle. The workings are following the bed east and southward; and the average thickness of the ore is such that the mine is worked to excellent advantage.

Mine No. 2 lies south of No. 3, and the drifts of the two are only a few rods apart, at their extreme limits north and south, respectively. The ore bed was followed down, on the eastward-dipping, and then up, on the west-dipping sides of a synclinal fold or trough. The slights offsets also are noteworthy features of the structure revealed in the mining. A large area has been worked out; and the surface over a part of the mine has fallen in the thickness of the bed.

The ores of mines Nos. 2 and 3 are gray, subcrystalline and compact. They are stratified; and exhibit the slight variations in texture and composition, which are marks of bedded deposits. Calcite quartz and pyrite are the more common foreign minerals. The percentage of carbonate of iron varies according to the greater or less admixture of these constituents. Roasting removes the larger part of the sulphur, and raises the percentage of iron to about 50 per cent. Analyses of selected ores show 50 to 52 per cent of iron and .03 per cent of phosphorus. The phosphorus is low enough to make it suitable for Bessemer iron.

The Burden mines are connected by a narrow-gauge railroad three

and a half miles long, with the roasting kilns and shipping dock on the river.

The total output of these mines is estimated by the president of the company, Howard H. Burden, at 450,000 tons (roasted ore).

The date of the discovery of this carbonate ore is not known. The name "Red Hill"—given to the northern end of the range—shows that the ore outcrop attracted attention years ago. The first leases for mining ore are said to have been taken in 1873 and 4. In 1875 the Hudson River Spathic Iron Company was organized, and a large amount of ore was mined, principally in what is known as No. 2 mine, at Burden. The earlier shipments were to Peekskill and to the furnaces of Atkins Bros., Pottsville, Penn.*

In 1882 the Hudson River Ore and Iron Company was organized. This company has a large capital, and practically controls all of the Hudson River carbonate ore deposits. Howard H. Burden, of Troy, is president, and J. N. Stower, at Burden, is general manager.

The following localities of carbonate of iron, in workable quantities, are described here, although their geological horizon is higher than that of the Hudson River carbonate group.

NAPANOCK MINE, Wawarsing, Ulster County.—A few rods west of Napanock the Marcellus shale formation carries iron in quantity to make it workable as an ore. The ore bed was opened for 1,000 feet on the line of outcrop; and the ore was used in the Napanock furnace. It is an impure carbonate of iron and lean. The last work was done in 1873.

WAWARSING MINE, Wawarsing, Ulster County.—This locality was first opened about 1800, and the ore carted to a furnace in Amenia, Dutchess county. The ore was found between walls of black, shaly rock. (Marcellus?)

These Ulster county mines are notable for the occurrence of the ore, and not on account of their economic importance at present.

* See description of mines as worked in 1875, with analyses of these ores, in a paper by Dr. R. W. Raymond. *Trans. Am. Inst. Min. Eng.*, Vol. IV., pp. 339–343.

STATISTICS

— OF THE —

PRODUCTION OF IRON ORE,

— IN THE —

Several Iron-Ore Districts of New York.

	U. S. Census Year, 1879–1880.	1888.
I. Highlands of the Hudson—Magnetic Iron Ore,	184,859*	114,000
II. Adirondack Region, including the Lake Champlain Mines — Magnetic Iron Ore,	742,865	812,000
III. Jefferson and St. Lawrence Counties—Hematite,	94,765	110,000
IV. Ontario, Wayne and Cayuga Counties—Clinton Fossil Ore—Hematite,	85,442	75,000
V. Dutchess and Columbia Counties—Limonite,	144,878	43,000
VI. Staten Island—Limonite,	9,318	
VII. Hudson River—Carbonate Ore,	.....	112,000
	1,262,127	1,266,000

The production of the State in 1888 by kinds was as follows:

Magnetite	926,000 tons.
Hematite	185,000 "
Limonite	43,000 "
Spathic Ore or Carbonate	112,000 "
	1,266,000 tons.

*The U. S. Census statistics use *tons* of 2,000 pounds; the estimates for 1888 use the *gross ton*—2,240 pounds.

Comparative production of the United States and New York:

	GROSS TONS.		Per Centage.
	United States.	New York.	
U. S. Census Year, 1869–70,	3,210,918	470,491	14.00
" " " 1879–80,	7,974,806	1,262,127	15.4
1886	10,000,000	900,000	9.0
1887	11,300,000	1,100,000	9.7
1888	12,062,530	1,266,000	10.5

The rank of the State was third in 1880, falling behind Michigan and Pennsylvania. In 1888 it was fourth—Wisconsin having taken the third place.

NOTE.—The statistics for the United States for the years 1886, '87 and '88 are taken from Jas. M. Swank's *Ann. Stat. Rep.*, Philadelphia, 1889.

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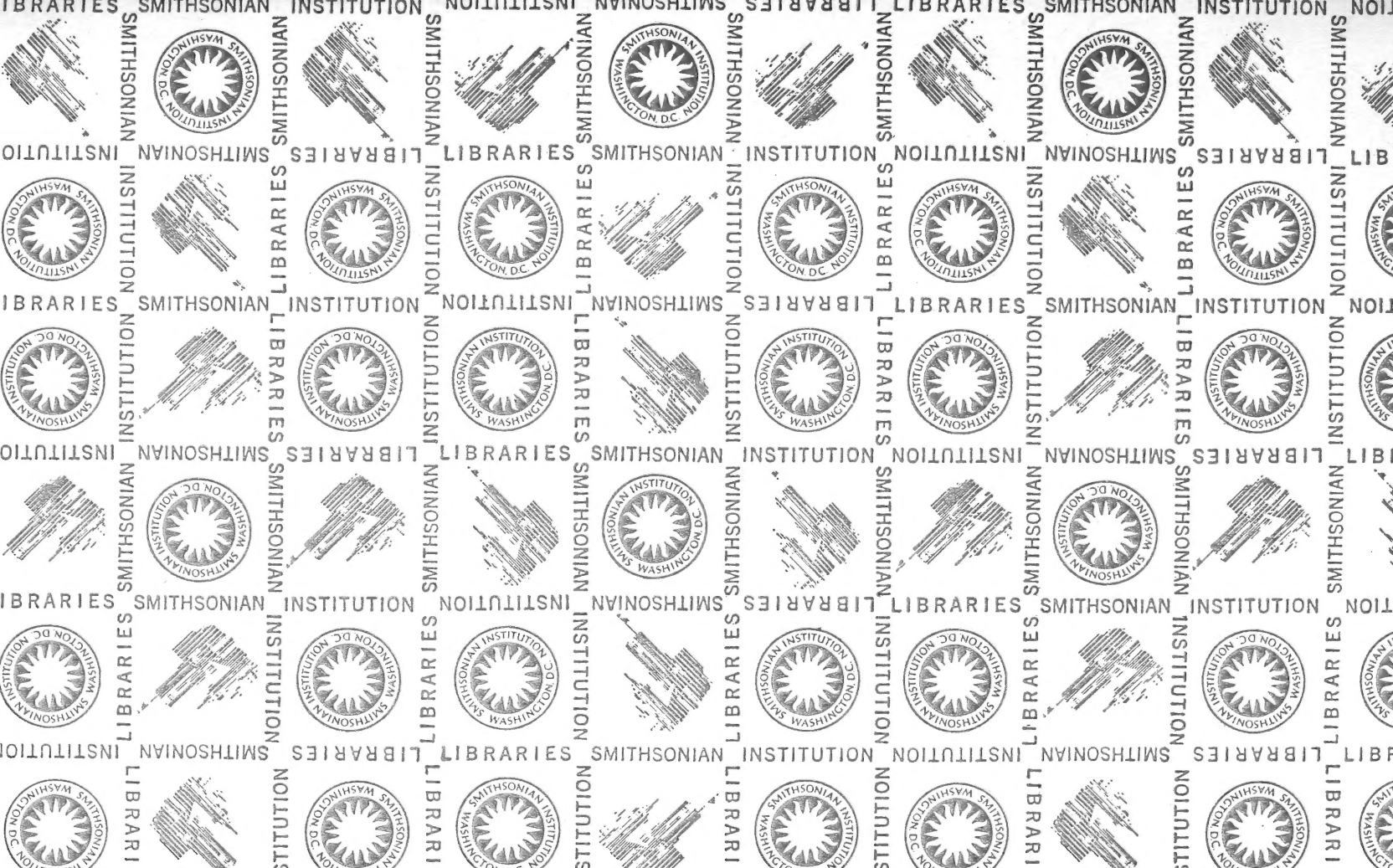
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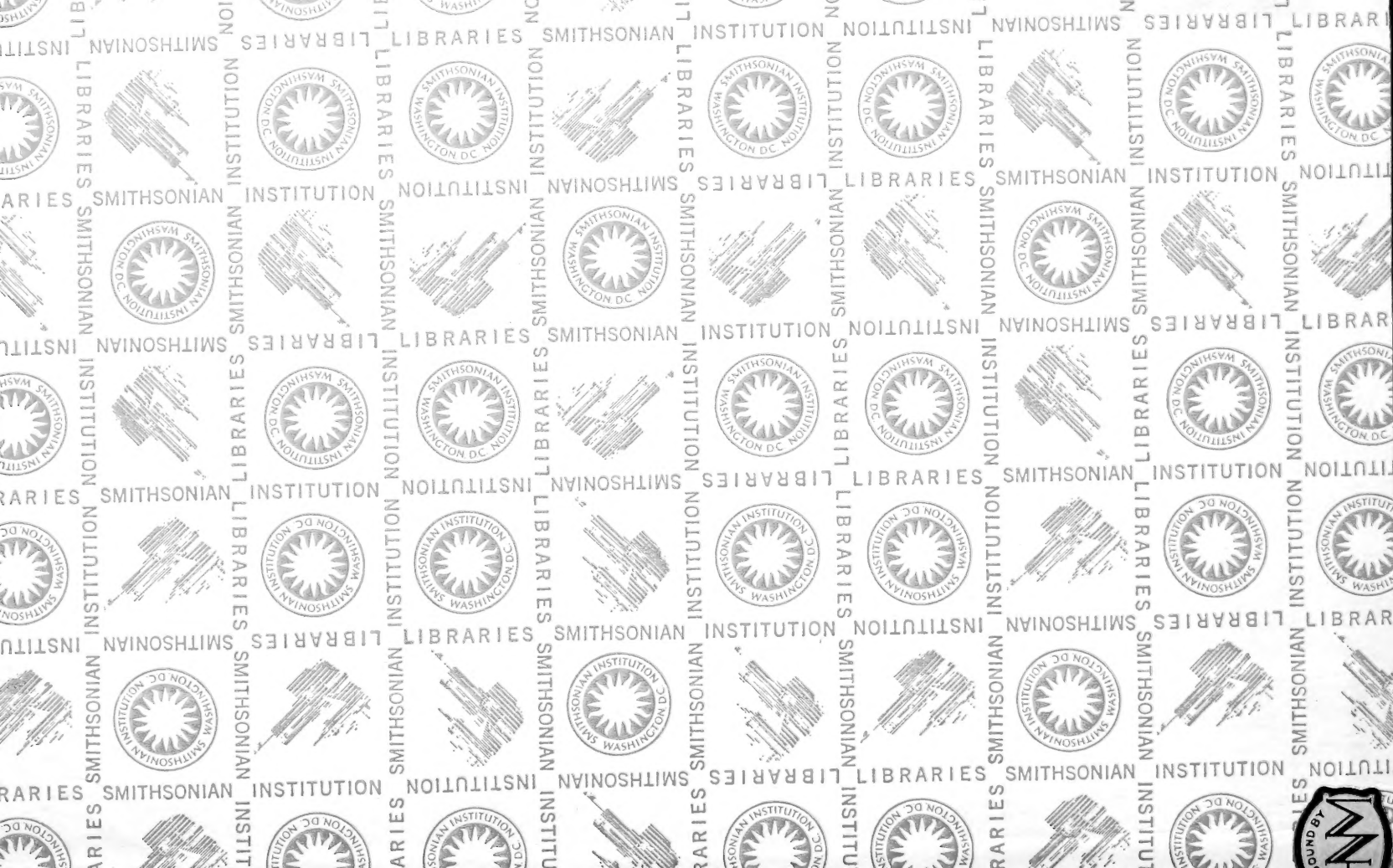
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