centre of same section, seven years ago, by Messrs. Heater, Elison and Conrad; the latter having made the selections.

Between the Saginaw and New England mines, on Sec. 20, the Lake Superior Iron Co. have a very promising opening, from which a considerable shipment of specular slate ore was made in 1872.

The New England Mine, on same range, is situated on the east ½, northeast ¼, Sec. 20, T. 47, Range 27. The shipments from this mine commenced in 1866, and up to the present time about 60,000 tons of ore have been mined and shipped via Marquette. The property is mainly owned by Captain E. B. Ward, of Detroit, and the mining operations are conducted by H. G. Williams under a contract. The principal part of the product is a hematite ore. A very narrow bed of excellent specular slate ore was worked several years, but not proving sufficiently profitable, work was discontinued. The ore is chiefly consumed at the extensive works controlled by Capt. Ward at Chicago, Milwaukee, and Wyandotte.

Adjoining the New England is the **Winthrop Mine**, situated in the southwest ¼, Sec. 21, T. 47, R. 47, owned by A. B. Meeker and A. G. Clark, of Chicago, and H. J. Colwell, of Marquette, and opened in 1870 by Messrs. Richardson and Wood, who work the mine on contract. Up to the close of 1872 about 25,000 tons of ore have been shipped, and the indications are favorable for increased shipments during the coming year. The product is a hematite ore, one of the richest of the class in the district. A. B. Meeker, of Chicago, is *Prest.*, A. G. Clark, *Sec.* and *Treas.*, and H. G. Colwell, Clarksburgh, *Gen'l Agt.*

The Shenango Iron Co. was organized in September, 1872, with a capital stock of $500,000, in 20,000 shares of $25 each. The land worked by the company comprises the north-west ¼ of south-east ¼ of Sec. 21, T. 47, R. 27, and adjoins the Winthrop, the deposit being a continuation of that mine.

The officers are C. Donkersley, of Appleton, Wis., *Prest.*, and H. D. Smith, *Sec.* and *Treas.;* in addition to these, E. Decker, Charles Reis and George L. Hutchinson, constitute the Board of Directors. A small amount of ore was shipped during the fall of 1872, and the company are erecting machinery, including the sinking of a shaft 60 feet in depth, with the view of doing considerable mining the coming season. The land is leased of the Williams Iron Co., who in turn lease of the Pittsburgh and Lake Angeline Co., who are the owners of land. The ore is mined by Messrs. Hurd and Orthey, part owners, on contract.

The Boston Mine, situated on the southwest ¼ of the northeast ¼ of Sec. 28, was organized in 1872, and a lease of the property above described secured by Messrs. Day, Anderson and others, with a view of mining operations. The lease of these parties is the same as that of the Shenango.

The Parsons, or **"Old Parsons,"** mine is located between the New England and the Lake Superior Companies' opening on Section 16, northeast of the Winthrop. Several thousand tons of specular slate ore were shipped from each of these mines, but work has been discontinued.

The Kloman Iron Co. was organized in December, 1872, with a capital stock of $500,000, in 20,000 shares. The corporators were Andrew Kloman, William Coleman, Thomas M. Carnegie, Jacob Houghton and T. B. Brooks. The company own 437 acres of land adjoining and northwest of the Republican mountain, being in part in Sec. 6, T. 46, R. 29, on the west side of the Michigamme river. The company have commenced mining on the continuation of the Republic mountain deposit and are building a short railroad to connect the mine with the Republic branch.

The Howell Hoppock Iron Mining Co. filed articles of association January 13th, 1873. *Corporators:* Lewis J. Day, Wm. R. Bourne, Wm. Rice, James S. Ward and Frank Austin. Office in Ishpeming, Mich. Organized to mine on the northwest ¼ of northeast ¼ of Sec. 28, T. 47, R. 27. Capital stock, $500,000, in 20,000 shares.

The Watson Iron Co. filed articles of association January 16th, 1873, with capital stock fixed at $500,000, in 20,000 shares of $25 each. *Corporators:* C. J. Hussey, E. T. Daro, Thomas M. Howe, M. K. Moorhead, George F. McLeane, W. J. Moorhead, Charles F. Spang, John W. Chalfant, Campbell B. Herron and James W.

Brown, all of Pittsburgh, Pa., and James W. Watson, of Marquette county, Mich. The property of this company comprises the northwest ¼ of Sec. 32, T. 47, R. 26 and which constitutes $325,000 of the capital stock. This ¼ section is a part of the estate of the Pittsburgh and Lake Superior Iron Co. and is on the Cascade range. Operations were commenced in September last by this latter company, of which mention has already been made under the Hussey mine.

In the **Menominee Iron Region** two companies, called respectively the Breen and Ingalls Iron Mining Companies, have been organized and are engaged in explorations, and in addition to the operations inaugurated by these companies, explorations are being made by private parties. The completion of the Peninsula railroad from Escanaba to Menominee, affording better promises for transportation, will stimulate operations of this character, which have heretofore been deferred from want of railroad communications.

The Breen Mining Co. owns 120 acres of land in Sec. 22, T. 39, R. 28, distant from Escanaba by proposed road 35 miles, from Menominee 55 miles and from Deer river 28 miles. The ore is chiefly flag, with some hematite. The property is being explored by Capt. E. B. Ward, J. J. Hagerman and J. W. Vandyke, who have an option of leasing or purchasing the mine. The officers are E. S. Ingalls, *Pres.*, T. B. Breen, *Sec.*, S. P. Saxton, *Treas.*, Thomas Breen, Bently Breen, and S. P. Saxton, *Directors*—all of Menominee, Mich.

The Ingalls Mining Co.'s property constituted 240 acres of land situated in Sections 8 and 9, T. 39, R. 29. The distance from Escanaba by proposed road is 44 miles and from Menominee 64 miles. The officers are E. S. Ingalls, *Pres.*, C. L. Ingalls, *Sec.*, and F. S. Mullburg, *Treas.*

An effort has been made to manufacture pig-iron by using *peat as a fuel*, but has not as yet proved in the requisite degree successful. **A peat furnace** was constructed at Ishpeming and went into operation early in the year 1872, but very soon went out of blast; subsequently it started again and made about 200 tons of iron and

again stopped, it being the intention to alter and enlarge the stack, the better, it is thought, to adapt it to the peculiarities of the fuel. The peat is prepared from a bed of the material which exists in proximity to the furnace.

The Ericson Manufacturing Co. was organized in April, 1872, to conduct general manufacturing operations, with a nominal capital of $150,000. *Corporators:* Peter E. Ericson, John Carlson, A. J. Burt and Wm. Burt.

The company are operating a foundry and machine-shop, which they have built on Whetstone brook, within the city of Marquette. The machinery is driven by water-power.

Mr. Jno. Burt commenced, in September, 1872, the construction of a charcoal furnace, on the lake shore, at the mouth of the Carp river, south of Marquette. The stack is being built of stone, with a nine-foot bosh, and the whole is to be completed and put in operation in the spring of 1873. It is intended to supply the fuel from points along the lake shore, transporting it to the furnace in boats in the same manner that the wood for the Burt furnaces in Detroit is obtained, of which latter furnaces the one being built at the Carp will be a duplicate, and will be the first built on the Upper Peninsula based on this plan of obtaining fuel.

Very recently **The Carp River Iron Co.** has been organized, and own the furnace and about 500 acres of land at that point, including the water-power on the Carp, etc. The business office will be in Marquette.

SANDSTONES.

The Lake Superior sandstones are very carefully described by Dr. Rominger in his accompanying report, commencing with page 80, and the results of his observations, as therein described, are of great practical and scientific interest. There are two organized companies now engaged in quarrying and marketing sandstone within the limits of the city of Marquette, the locations being contiguous.

The Marquette Brown Stone Co. was organized in August, 1872, with a capital stock of $500,000, in 20,000 shares. The corporators were Peter White, Wm. Burt, F. P. Wetmore, S. P. Ely, Sidney Adams, J. H. Jacobs, H. R. Mather and Alfred Green. In addition to quarrying stone, the company's franchises include the mining and smelting of ore, etc. Office in Marquette, Mich.

This company's property was previously known as the Wolf Quarry, located on the farm formerly owned by J. P. Pendill, and has been worked for some time past, the stone being principally used in Chicago. It is of a uniform dark-brown color, free from pebbles and clay holes. It apparently exists in great quantity, and is readily quarried and transferred to vessels. Mr. Peter White is constructing in Marquette a fine business block with a variety of stone from this quarry, which is variegated and striped with different colors, giving to the building a unique and pleasing appearance.

The articles of association of **The Burt Free Stone Co.** were filed Oct. 3d, 1872. Capital stock $500,000, in 20,000 shares of $25 each. The corporators were John Burt, William Burt, Hiram A. Burt, A. Judson Burt and Wm. A. Burt. Office in Marquette.

This company have opened a quarry of sandstone adjoining the one described above and the deposit is similar, the stone being lighter colored.

Both companies are prepared to furnish stone in large quantities. For full description of the sandstone found in these quarries, see Dr. Rominger's report, pages 90 and 91.

In addition to the above, **The Lake Superior Stone Co.** has been more recently formed with the amount of capital stock and number of shares as the preceding. The company own and hold in lease about 296 acres of land, situated on the west side of Keweenaw bay and on the north side of Portage Entry. The stone outcrops horizontally in a bluff, which rises from the water of the bay and is thus readily accessible for removal from the bed to vessels.

It is intended to begin operations in the spring. The corporators are H. H. Stafford, V. B. Cochran, W. S. Dalliba, E. J. Mapes and A. Kidder. Office, Marquette, Mich. See Dr. Rominger's report, page 95.

The fine new Court-House at Milwaukee is built with sandstone obtained from Bass island, near Bayfield, on Lake Superior, at which point stones have been quarried for several years.

The quarry described by Dr. Rominger, page 89 of his report, is

now owned by Messrs. Winty and Mossinger, of Chicago, and Thomas Craig, of Marquette.

ROOFING SLATE.

There are three companies which were organized for the purpose of quarrying and selling roofing slate; but one of them, however, has actually commenced operations and is now at work on explorations.

The Huron Bay Iron and Slate Co. filed articles of association January 19th, 1872. Capital stock, $500,000, in 20,000 shares. The corporators were Peter White, W. L. Wetmore, F. P. Wetmore, J. C. Morse, James Pickands, A. R. Harlow, M. H. Maynard, D. H. Ball, Wm. Burt, D. H. Merritt, Sidney Adams and H. R. Mather. Office, Marquette, Michigan. The company own 2,000 acres of land in T. 51, R. 31.

The Huron Bay Slate and Iron Co. was organized subsequently, with same capital stock and number of shares. The corporators are W. L. Wetmore, Peter White, M. H. Maynard, Wm. Burt, Thomas Brown, J. J. Williams, S. L. Smith, Alex. McDonald, John H. Knight, W. C. Wheeler, H. R. Mather, Jas. D. Reid, F. P. Wetmore and R. C. Wetmore. Office in Marquette. The company own 1,100 acres of land in T. 51, R. 31, and have commenced work near Slate river, about four miles south of Huron bay, on the northeast quarter of section 33 in the above town. The slate apparently exists in very large quantities.

The Stafford Slate Co., an association comprising H. H. Stafford, V. B. Cochran, E. J. Mapes, A. Kidder, J. M. Wilkinson, Wm. Burt A. J. Burt and W. S. Dalliba, own 1,900 acres in T. 51, R. 31. The operations of this company thus far consist in having cut out a road from L'Anse to their property on Section 27, in the above town, a distance of 15 miles.

The color of the slate found in T. 51, R. 31, is somewhat varied, the green, purple and gray are found on Sections 14, 15, and 16. South of this are found large deposits of black slate, extending several miles east and west, with an apparent thickness of several hundred feet, the cleavage planes dipping to the south.

SAW-MILLS.

The following saw-mills are now in operation, all of which, with the exception of the ones at Whitefish Point, at Onota and Fayette (the two former of which are in Schoolcraft county and the latter in Delta), are in Marquette county:

Name of Firm.	Location.
Decker and Steele	Eagle Mills.
Edward Fraser	Cherry Creek.
George Wagner	Laughing Whitefish Pt.
A. R. Harlow	Little Presque Isle.
H. A. Stone	Bancroft.
Jackson Iron Co	Negaunee.
Iron Cliffs Co	"
Mr. Jackson	Palmer Falls (Cascade).
Hartman and Connelly	Little Lake.
Cleveland Iron Co	Ishpeming.
Lake Superior Iron Co	"
Deer Lake Iron Co	Deer Lake.
Michigan Iron Co	Clarksburg.
Michigamme Iron Co	Michigamme.
Edward Breitung	Republic Mt.
C. T. Harvey	Chocolate.
Bay Iron Co	Onota.

These mills produced in the aggregate, during the year 1872 (besides shingles, laths and a small amount of hard wood), thirteen and a half million feet of pine lumber, all of which, excepting the product of the three mills above designated, was, or will be, consumed in Marquette county. The total product during the coming year, if the winter is favorable, will be much greater, as most of these companies are preparing to get in a larger amount of logs. The Michigamme mill, which has a nominal capacity of 4,000,000 feet, has but recently started, and thus did not contribute to the total product of 1872.

COMPLETION OF THE RAILWAY SYSTEM.

Marquette, Houghton and Ontonagon R. R.

Among the most important events affecting the interests of this portion of our State, which transpired during the year 1872, was the extension of the C. and N. W. R. R. from Menominee to Escanaba, the consolidation of Marquette and Ontonagon Railroad with the Houghton and Ontonagon, and the completion of the line to L'Anse, thus making complete railroad communication from the head of Keweenaw bay to Chicago, a distance of 462 miles.

The development of the mineral resources of a country are so intimately blended with the improvement of its facilities for transportation, as to render it essential in considering the progress of the former, to give due credit to the latter. Iron ores having a low value per ton must be reached by rail or water before their value can be realized; differing in this particular from the ores of the precious metals, which will bear wagon or even pack-mule transportation. Especially is this true with reference to an isolated region like the Upper Peninsula, which is as yet a comparative wilderness, possessing but a small population, a rigorous climate, few thoroughfares and with a surface so rough and rocky in portions of its territory, as to render their construction a matter of much difficulty. It naturally follows, that the addition of two so important avenues of communication to the railroad facilities of the Peninsula becomes in a pre-eminent degree a matter of congratulation and importance. The history of the enterprise, which has thus resulted in the connection of the bays of Marquette and Keweenaw, is in brief as follows:

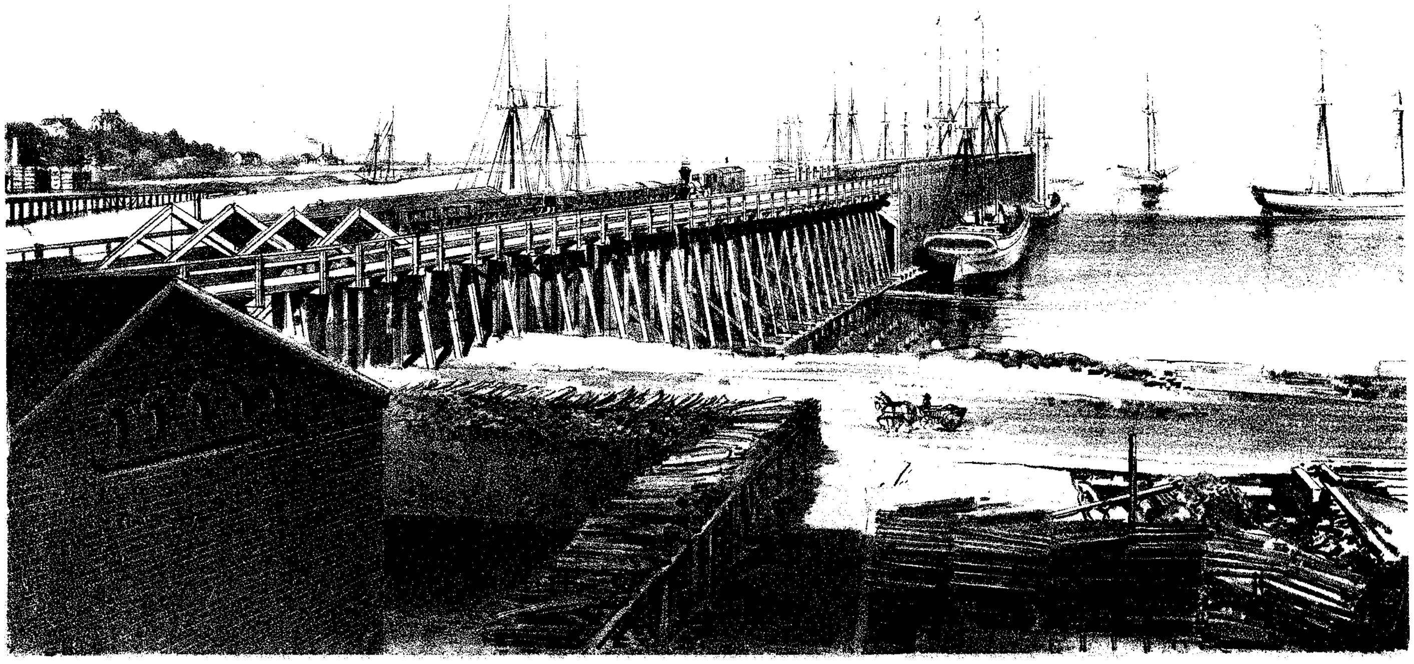
As has been previously related in speaking of the Peninsula road, the United States granted to the State of Michigan, by an act passed on the 3d of June, 1856, every alternate section of land for six sections in width, designated in odd numbers, to aid in constructing a railroad from Little Bay de Noquette to Marquette and thence to Ontonagon, and from the two last places to the Wisconsin State line. The State, by an act passed Feb. 14th, 1857, conferred this grant upon the Little Bay de Noquette and Ontonagon Railway

Co., and two other railroad corporations, all of which lines were required to be completed within ten years, a condition with which neither of the companies complied.

In 1863 the State conferred the forfeited franchises and grant previously given to the Marquette and Ontonagon *Railway* Co., upon the Marquette and Ontonagon *Railroad* Co., under certain conditions. Congress in 1864 extended the grant five years, in the subsequent year added four sections per mile thereto, and in 1868 fixed the time for a full compliance with the conditions of the grant until Dec. 31st, 1872. During the period of its existence, the company built twenty miles of main line of railroad, commencing near the Lake Superior mine at the terminus of what was formerly the Bay de Noquette road, and extending to a point on the south side of Lake Michigamme.

In 1870 the State decided that the company, by reason of its failure to complete any extension of their lines, had forfeited the greater portion of the grant. On the 24th of Jan., 1871, the Legislature confirmed the action taken by the State Board of Control during the month of April previous, which conferred the forfeited or unearned lands upon the Houghton and Ontonagon Railroad Company, a new organization, incorporated Jan. 15th, 1870, and of which the following Michigan men were among the principal stockholders: H. N. Walker, *President*, S. L. Smith, Chas. H. Palmer, Geo. Jerome and S. F. Seager. The conditions of the act of Congress required the completion of thirty miles of road before the close of the year 1872, which fortunately this company have succeeded in accomplishing. Jacob Houghton was chosen Chief Engineer; and having located the line from Champion to L'Anse during the winter, the construction was begun in the spring of 1871 at the L'Anse terminus, and on the 16th of Dec., 1872, the first train passed over the entire line to Marquette, sixty-four miles; the whole having been placed under one management by the consolidation of the two companies effected during the previous summer. The completion of the road to L'Anse, exclusive of innumerable other advantages, opens to market the products of several iron mines, among the most promising of the region.

In anticipation of future shipments of ore from L'Anse, the company have constructed at this terminus of the road an extensive dock, a full representation of which from careful drawings



J. Bien, lith. | Photo. by Childs.

ORE DOCK, MARQUETTE

M.H & O.Rd. (Looking East) Vessels loading - Break water.

is herewith presented.* They have also built, at this point, in a very substantial manner, a round-house, turn-table, machine-shop, etc.

The charter of the company and the grant of lands provide for the extension of the road to Ontonagon, and it is but reasonable to assume that the energy, which has characterized the prosecution of the enterprise thus far under its present efficient management, will result in the accomplishment of the work before the expiration of the time fixed by law. The length of the main line is 62 miles, of branches 20 miles and of sidings 18 miles, making 100 miles of road now constructed and in operation.

The dimensions and capacity of the company's railroad dock at Marquette, a representation of which is given in the accompanying view, are as follows:—Total length, 1,222½ feet; working length, 720 feet; height above water, 38 feet, and width of top, 53 feet, on which are four tracks for cars. Whole number of pockets, situated on both sides, 136, of which 120 have a capacity of 55 tons each, and 16 (steamboat-pockets) of 100 tons each. From both sides 8 vessels can be loading at the same time, and 6,000 tons have been loaded in a single day. Three vessels arrived on Saturday, after 8 o'clock in the evening, and were loaded and gone early Sunday morning. Vessels with a capacity of 476 tons may be loaded in one hour and fifteen minutes; vessels of 683 tons, in one hour and thirty-five minutes; the average time is three hours. The average capacity of vessels is about 650 tons, ranging from 400 for the smallest to 1,100 for the largest. Total amount of ore shipped over the dock from May 12th, 1872, to the following Nov. 25th, 301,210 tons, of which 75,000 tons were taken by steam, and 225,000 by sail-vessels; the estimated capacity of the dock, with a sufficient number of vessels to receive the ore, is 500,000 tons.

The working capacity is indicated by the amount of rolling stock, which at the opening of navigation, 1873, will consist of 1,600 ore-cars, 50 box and platform-cars, 7 passenger and baggage-cars and 28 locomotives. The present officers are: H. N. Walker, of Detroit, *President*, S. P. Ely, Marquette, *Vice-President*, Moses Taylor, New York, *Treasurer*, Freeman Norvell, Detroit, *Secretary*, Jacob Houghton, Michigamme, *Chief Engineer*.

Directors: H. N. Walker, Detroit, C. H. Palmer, Pontiac, S.

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* Appendix F., Vol. II.

P. Ely, Marquette, John Steward, New York, Alexander Agassiz, Boston, S. L. Smith, Lansing, George Jerome, Detroit, Moses Taylor, New York, C. Francis Adams, Jr., Boston.

By the Peninsula division of the **Chicago and Northwestern Railway** the distance from Escanaba to Lake Angeline is $67\frac{30}{100}$ miles, and the branches completed and in course of construction, $37\frac{90}{100}$ miles; sidings, $15\frac{90}{100}$ miles; making a total length of track between these points of $121\frac{10}{100}$ miles.

The total amount of track between Escanaba and Menominee is $65\frac{70}{100}$ miles, of which $2\frac{30}{100}$ are side-track, making a total amount of track between Menominee and Lake Angeline, inclusive of sidings and lurches, $186\frac{80}{100}$ miles.

Estimated amount of rolling stock, which will be necessary and available for the business of 1873, between Escanaba and Negaunee:

Number of locomotives	33
" ore-cars (750 of them 6-wheeled)	3,000
" other cars	100

For the estimated business between Escanaba and Menominee:

Number of locomotives	6
" cars (exclusive of ore-cars)	100

S. C. Baldwin, *Div. Supt.*
Marvin Hughitt, *Gen. Supt.* } C. & N. W. R. R.

Statistics showing past production, with present condition and capacity of the mines and furnaces of the Upper Peninsula, might properly follow this historical sketch, thus bringing it to date and supplying facts, which could not well have been incorporated into the text. It was thought better, however, to arrange such information in tabular form, which has been done on Plates XII. and XIII. of Atlas, to which attention is here again called.

The Marquette Mining Journal, of Marquette, Mich., publishes an interesting yearly exhibit of the product and condition of the mines and furnaces.

In Appendix G, Vol. II., will be found statistics of population for the whole Upper Peninsula, from the United States Census for 1870.

CHAPTER II.

GEOLOGICAL SKETCH OF THE UPPER PENINSULA.

(*Where to Explore.*)

1. GEOGRAPHICAL DISTRIBUTION OF THE ROCK SYSTEMS.

IN prospecting for valuable minerals the intelligent explorer should constantly observe several kinds of phenomena. If his search degenerates into a simple blind hunt for ore, he would deserve the success of a hunter who went into a gameless region, or who hunted for game whose habits he did not understand. The following general geological facts and laws will possess value to the explorer in enabling him to wisely select his field of labor and in prosecuting his work.

As all the *sandstone* suitable for building, which has yet been found in the Lake Superior region, belongs to a system of rocks named by geologists Lower Silurian, and all the workable deposits of *iron ore* have been found in another system called the Huronian, while all the *copper* and workable *silver*, in a third system appears known as the Copper-Bearing Rocks; and as no workable deposits of useful minerals have yet been found in the fourth and oldest system, the Laurentian or granitic rocks, it follows, that it is of the utmost importance to the explorer that he be acquainted with the boundaries of these several fields and not waste his energies on unproductive ground. I do not mean to assert that iron ore will not be found in the Silurian sandstones, for in St. Lawrence County, N. Y., and in the Maramec district, Missouri, valuable deposits of ore exist in rocks of this age. Large deposits of iron ore also occur in the Laurentian (granite) rocks of Canada and Northern New York, and again, the iron ores of Thunder bay are contained in rocks which the Canadian geologists declare to be the equivalents of our Copper series; but at this date it is a fact, that no workable deposits of iron ore have been found in the Upper Peninsula in rocks of these systems, and an explorer or miner would not be considered wise, who should search for iron outside the Huronian limits. It is not only important that he be acquainted with the boundaries of the four great rock systems, but also with their leading characteristics. We will therefore first sketch in some detail the geographical distribution of these systems, as developed on the south shore of Lake Superior, beginning with the youngest and uppermost. The reader should have before him the map of the Upper Peninsula Pl. I. of the Atlas. The boundaries marked are not always exact, but embody the best information available and are not far wrong.

I. *Lower Silurian.*—The Lower Silurian system, the youngest or lowest division of the Palæozoic rocks represented on the Upper Peninsula, is made up of various sandstones and limestones which are fully described in Dr. Rominger's Report, Part III. The entire Peninsula, east of the meridian of Marquette, is underlaid by Silurian rocks and the "Copper range" is flanked by a Silurian flat on the south side, which separates it from the iron series, until the two, together with the South copper range, come together west of Lake Gogebic.

About two-thirds of the whole area of the Upper Peninsula, or 9,982 square miles, is underlaid by this system.

II. *The Copper-bearing Rocks*, corresponding with the upper copper-bearing rocks of the Canadian geologists, occupy a narrow belt on the northwestern edge of the Upper Peninsula. These rocks have less superficial extent than either of the other formations, underlying only about 1,186 square miles, or, say 7 per cent. of the whole surface. For descriptions of them see Prof. Pumpelly's Report, Part II.

III. *The Iron-bearing Rocks*, corresponding, it is assumed, with the Huronian system of Canada, consist of a series of extensively folded beds of diorite, quartzite, chloritic schists, clay and mica slates, and graphitic shales, among which are intercalated extensive beds of several varieties of iron ore. The same rocks occur on the east and north shores of Lake Superior, where they also contain iron. The Huronian area represented on the map equals about 1,992 square miles, or nearly one-eighth of the whole area of the Upper Peninsula.

IV. *The Granitic Rocks*, which so far have produced no useful minerals, and which are believed to be the equivalents of the Laurentian of Canada, are represented as underlaying about 1,839 square miles, equal to 12 per cent. of the total area.

As our examinations in the southwestern part adjoining the Wisconsin line have not been thorough, there is considerable uncertainty regarding some of the lines dividing the Huronian and Laurentian rocks, and a portion of this region, equal to about 668 square miles, or 4 per cent. of the whole area, is left blank on the map.

While, as has been stated, it is not proven that iron ore may not exist in the other great systems in workable quantities, there is every reason to believe, that by far the greater part, if not all the workable deposits, are contained in the Huronian area above described. It must not, however, by any means be understood, that all of this area is iron-bearing. The several iron districts, which have been more or less explored, will be described in another place; they will be found to cover not more than about one-fifth part of the Huronian area, or, say one-fortieth of the whole area of the Upper Peninsula, and on less than one-half of this area have the ores been proven to have commercial value.

Recapitulation.

I.	Lower Silurian area, about	9,982	square miles.
II.	Copper-bearing area, about	1,186	"
III.	Huronian or Iron-bearing area, about	1,992	"
IV.	Laurentian area, about	1,839	"
	Unknown area, about	668	"
	Total area of Upper Peninsula, exclusive of islands, about	15,667	"

In a complete and systematically arranged geological sketch the lithology of the four systems would properly belong here, but what is written on this subject necessarily pertains almost entirely to the Huronian, the whole matter will therefore be considered in Chapter III., following, and in Appendices A, B and C, Vol. II.

II.—TOPOGRAPHY.

It is of importance to the prospecter to carefully observe the topography or form of the surface, for it is well known that useful minerals generally occur in corresponding topographical positions over considerable areas; again, the topography is the very best key to the nature of the underlying rocks, if these be concealed by earth, as is often the case. As the human physiognomy indicates the fundamental characteristics of the man, so the earth's physiognomy suggests the forces and materials lying beneath. It is safe to assert that within certain limits an experienced topographical geologist can, from a correct topographical map, judge of the nature of the rock underlying the surface represented; and conversely, from a geological map, he can predict the general form of the surface. In the same way, an experienced explorer does not hesitate to express an opinion as to whether he is on the "mineral range," from the form of the ground. We will now sketch in some detail the characteristic topography of the four great systems.

I. *Silurian.*—The prevailing surface characteristic of the Silurian region is a nearly level plain, underlaid by horizontal sandstones and limestones, often swampy and sometimes, where fire has destroyed the timber, a desert. The tame, flat, sandy and swampy country along the line of the Chicago and Northwestern Railroad, between Escanaba and Negaunee, is underlaid by Silurian rocks, but is far below the average in the value of its timber. Where rivers or water-courses have cut into these rocks, or waves wasted them, perpendicular bluffs are presented, which afford an excellent opportunity to explore and study the formation. The famous "Pictured Rocks" are bluffs of this character, from 50 to 200 feet high. From the top of these bluffs the country is flat, proving that they are the results of the action of water cutting its way into a horizontal plane, and are not, so to speak, built up and completed hills like those of the older rocks.

There is one apparent exception to this general flatness of the Silurian topography. Many of the highest hills and mountains in the Menominee iron region are capped with horizontal sandstone and limestone, which is never found in the valleys; the base, however, embracing the great mass of these elevations is always an old rock, and in the iron fields always Huronian. There is no doubt but that the sandstone once filled the valleys, extending in an unbroken bed of irregular thickness across the whole of the Menominee region, covering the older rocks, just as it now covers them further east. Since its formation it has here been mostly

eroded, but still caps the elevations as described. If it were all gone, the hills, made as they are, largely of highly inclined beds of quartzite, marble and ferruginous rocks, would remain, but with somewhat diminished heights.

Should the eastern part of the Upper Peninsula be elevated at any future time, so as to bring the underlying azoic rocks above the lake level, the Silurian rocks may there also become so eroded as to only cap the Huronian hills, as they now do in the region described. That the older rocks extend eastward under the Silurian, is, I suppose, a geological necessity, and is, I think, directly proven by the existence of local magnetic attractions in this Silurian area, which are undoubtedly due to the existence of beds of iron ore in the underlying Huronian. The explorer in the Menominee region finds these beds of sandstone much in his way, covering, as they do, in some instances, the ores.

Small lakes of clear water, with sandy bottoms but no outlets, are a characteristic feature of the Silurian area. The U. S. Survey maps represent about one-half of the whole surface of these rocks, which underlie the central and eastern portion of the Upper Peninsula, as swamp; the solid rock has often been found within a few feet of the surface in the swamp region. The western Silurian area being the prolongation of the Keweenaw Bay valley west, and embracing in part the Sturgeon, Ontonagon, Presquisle and Black rivers, has fewer lakes, much less swamp, and is more broken, than the eastern part already described.

Soft woods, including pine, are more prevalent on the Silurian rocks than on the older series; but on the other hand, some of the finest bodies of sugar-maple and beech found on the Upper Peninsula, are on these rocks. Beech has not, so far as I know, been found growing on the older rocks; whether this be due to climatic or soil influence has not been determined.*

The water divide, or height of land, of the central and east part of the Peninsula, is much nearer Lake Superior than Lake Michigan. It is an irregular line, approximately parallel with the shore of the lake, having an elevation where it crosses the Peninsula railroad of about 650 feet. See Map, Pl. I.

II. *Copper-bearing Rocks.*—There is probably no more striking

* A timber map has been prepared, but could not be published for want of means.

topographical feature in Michigan, than the "Mineral" or Copper range, including Keweenaw Peninsula, of which it is the backbone. Ranges would better express the fact, for west of the Ontonagon river there are three; the Main or central Range which extends from Keweenaw Point far into Wisconsin, being flanked on the north by the Porcupine mountain range and on the south by the South copper range, each separated from the other by broad Silurian flats. The general trend of the three ranges is north, 60° east, and south 60° west, but they are not quite straight, as may be seen on the map. The ridge is broad, generally more than three miles, and the crest quite even, but is cut down to lake level at Portage lake, and further west is deeply eroded by the Fire steel, Flint steel, Ontonagon and other rivers. The surface of the ridge or plateau is from 500 to 600 feet high in the vicinity of Portage lake, and rises to a height of 884 feet at Mount Houghton, near Keweenaw Point. Between the Ontonagon river and Lake Gogebic the Central range attains, in isolated peaks, an elevation of 1,100 feet, and the Porcupine mountain range is over 900 feet high; the range is more broken towards the west, and in the vicinity of Rockland presents a series of oval mammillary hills with steep escarpments on the south side. This is also the character of the South copper range, between Lake Gogebic and Montreal river.

The iron range immediately south of the South copper range, and west of Gogebic, is lower, the hills having more gentle slopes; the range being in places obscured by low ground. As this is the only part of the Upper Peninsula, so far as I know, where the iron explorer may come in contact with copper rocks, it is important to observe the topographical differences above noted, especially as the copper traps in some places resemble the diorites or greenstones of the iron region. Lakes and swamps, so numerous in the iron and granite regions, are infrequent on the copper belt, as must follow from the form of the surface. The reason for the striking regularity in the leading topographical features of the copper range is to be found in the great uniformity in the strike and dip of the rocks, as is explained under Stratigraphy. The timber of the copper range is generally sugar-maple, is abundant and of excellent quality; very little pine or other soft wood occurs here.

III. *Iron-bearing Rocks.*—The topography of the Huronian rocks differs essentially from that of either the Silurian, or the copper series. It is almost everywhere hilly and often mountainous, forming peaks higher than any in the copper range; but instead of a continuous range, or series of parallel ranges, it is rather a broad belt or irregular area of mountains, hills, swamps and lakes. It may be said, that the ruling topographical features, especially the mountains, have a general east and west trend, but there are numerous exceptions to this law; for example, the Michigamme river, from the lake to Republic mountain, runs northwest to southeast; and Michigamme lake itself has a north-south arm, nearly as long as the main lake, which runs east-west. The ridges west of Paint river, in T. 42, R. 33, run north-south, conforming with the bedding of the rocks.

Probably one of the most persistent ridges in the Marquette region is formed by the "lower quartzite," which outcrops on the shore of Lake Superior just south of Marquette, and rising rapidly from the lake it forms Mt. Mesnard on Sec. 34, T. 48, R. 25; from this peak it extends westerly, crossing the railroad at the Morgan furnace, then by way of the old Jackson Forge and along north side of Teal lake to south side of Deer lake, it holds its westerly course for a total aggregate distance of over 15 miles. The Chocolate and Morgan flux quarries and the Teal lake whetstone quarry are in this range. More persistent and conspicuous, and nearly as long, is the Greenstone ridge, which skirts the north side of the Michigamme and the Three lakes extending from the Bijiki river to the west end of the First lake, a distance of eleven miles:—points on this range are three hundred feet above Michigamme lake, which is 950 feet above Lake Superior. Summit mountain, one mile easterly from the Foster Mine, is one of the prominent landmarks of the region, looking as it does from an elevation of about 1,300 feet over the flat granite and Silurian region to the south. It forms one of a chain of hills which extend from the south end of Lake Fairbanks westerly for about 10 miles, but which form in no sense a ridge.

The mountains, or hill ranges, above described are exceptional in their regularity and continuity. Broken chains of irregular hills and short ridges of various sizes, separated by lakes and swamps, is the prevailing character; the highest hills are seldom over 300 feet above the low grounds at their base and about 1,300 feet above Lake Superior. Outcrops of rock, forming often perpendicular ledges of moderate height, are more numerous in the iron-bearing rocks, than in either of the systems described, except in the westerly part of the copper range. Although the relief of the surface is considerably modified by drift, it is generally plain that the strike, dip, and texture of the underlying rock has determined the general outline or contour; we should therefore expect that the great variation in these rocks, hereafter to be described, would produce this varied topography.

The topography of the Marquette region is very like the iron region of southern New York and northern New Jersey, except in its smaller elevations; a profile running north and south through the Jackson Mine, Marquette, would closely resemble a profile running northwest and southeast through the Sterling Mine, New York, platted say to half the scale.

Passing to the Menominee iron region, we find greater simplicity in the geological structure and a correspondingly less varied surface.

Obeying the influences of the great rock beds beneath, the elevations there have a tolerably uniform east-west trend and consequent parallelism. The south iron range, of which the Breen Mine is the east end so far as known, can be traced through a greater part of its course by a ridge, often bold, which crosses Town. 39, R. 29, and T. 40, R. 30, for a distance of over 15 miles, the bearing being west-northwest. The north iron range, about 12 miles from the other in the south part of Town. 42, Ranges 28, 29 and 30, is in places a prominent topographical feature. The capping of horizontal sandstones, which has already been mentioned as characterizing the Menominee hills, gives a somewhat more even character to the crest lines, and in places produces a strikingly different profile.

The Gogebic and Montreal river range, above referred to, is better marked by its running parallel with and lying south of the South copper range, than by any essential character of its own.

IV. *Laurentian*.—The surface of the granite country south of the Marquette region, at the same time the most extensive and best known, is not unlike that of the iron-bearing rocks on a much smaller scale. There are no mountains, the hills are lower, being usually mere knobs, seldom exceeding 50 feet in height; the ridges shorter and swamps more numerous. A coarse pitting of the surface, or promiscuous sprinkling of little hills, and low, short ridges may convey the idea. Sometimes the knobs range themselves in lines constituting low ridges, with jagged crest line; these ridges, when near the Huronian rocks, are usually parallel with them; if they have any prevailing direction, it is east and west.

Perpendicular walls of granitic gneiss 15 to 40 feet in height sometimes face the ridges for several hundred feet in length, constituting the most regular topographical feature within the Laurentian area.

Small beaver meadows are common here as in the other rocks, and sometimes a succession of dams, one above the other, forms a long narrow meadow, which produces considerable quantities of wild hay.

This region was once heavily timbered, largely with pine, which has been prostrated by a hurricane, and since burned over several times. The soil, naturally light, has burned up and so washed away, as to expose the white-gray, pink and dark-green rocks in every direction, affording an unsurpassed opportunity to study this series; the boulders are very numerous and often of great size. The light colors of the rock, scarcity of vegetation and an abundance of standing trunks of dead trees give the landscape a peculiar aspect; but a second growth of poplar and wild cherry is rapidly changing this dismal character.

The fallen timber, swamps, steep bluffs and ledges, and numerous boulders, make travelling through the Laurentian area difficult and laborious in the highest degree. Florida swamps have denser vegetation and are much larger; sea-coast marshes often have more mud; the highlands of the Hudson present more formidable elevations, but, all in all, the writer believes it requires more physical exertion to travel 5 miles per day (all a man can accomplish with a pack) through Lake Superior granite windfall, than in any other region east of the Mississippi. The trees were prostrated by northwesterly winds, judging by the direction in which they lie; persons have travelled in a southeasterly direction on the trunks of fallen trees (mostly pine) for over a mile without once touching the ground.

III.—STRATIGRAPHY.

Scarcely second to the two classes of phenomena already mentioned is the observance of the rock masses, or strata, as to their direction or strike, and inclination or dip ; the order of their superposition and thickness ; but more important than either is to ascertain between what rocks the mineral sought for occurs. Useful minerals which occur in beds, like the iron ores of Lake Superior, will usually be overlaid and underlayed by rocks, having different characters and which maintain those characters for considerable distances. Next to finding the ore itself, it is desirable to find the hanging or footwall rock. Whoever identifies the upper quartzite in the Marquette region, or the upper marble in the Menominee region, has a sure key to the discovery of any ore that may exist in the vicinity.

With few exceptions, all the rocks in the region we are describing are stratified—that is, arranged in more or less regular beds or layers, which are sometimes horizontal, but usually highly inclined. This stratification or *bedding* is generally indicated by a difference in color of the several layers, oftentimes by a difference in the material itself, but occasionally the only difference is in the texture or size and arrangement of the minerals, making up the rock. Thus, rocks made of quartz, sand and pebbles, may vary from a fine sandstone to a coarse conglomerate. In general, a *striped rock*, whether the stripes be broad or narrow, plain or obscure, on fresh fracture or weathered surface, is a stratified rock. Usually rocks split easier on the bedding planes, than in any other direction ; but the converse is true in the case of most clay slates and in some other rocks, which split more easily on their *joints* and *cleavage* planes, the direction of which seldom coincides with the bedding and is often at right angles with it. If a rock splits most easily along its striping, it is always safe to assume, the true bedding planes have been found. Such planes are supposed to have had their origin in the original deposition of the mud and sand, of which most rocks are made. Similar marks can be seen in excavations in sand and clay, which may be regarded as unconsolidated rocks. The cleavage and joint planes above indicated, which are always more regular in strike and dip, than the others, are supposed to have originated from pressure, subsequent to the formation of the rock.

The term plane, as used in describing bedding, must not be understood to signify a straight-line surface ; on the contrary, they are usually curved planes, sometimes folding and doubling on each

other, so as to produce a very intricate structure. Not only do these plicatures take place on the small scale, as shown in hand specimens, but precisely similar folds exist in masses of rock, which may be hundreds of feet thick. The resulting curved strata take the name of troughs or basins, if the convexity is downward, the general term *synclinal* structure being applied to this form. Connecting the synclinal troughs and basins are *anticlinal* domes and saddles. The whole may be described as rolling or wave-like forms. Sometimes the power which produced the *folds* seemed greater than the rocks could bear, and cracks or breaks, and *faults* or throws, are the result, though these are not numerous in the Lake Superior region. Cracks so produced and filled with material, other than that constituting the adjacent rocks, are called *dykes ;* or if the material be crystalline and metalliferous, *veins*. As iron ore in workable quantities does not occur in this form in this region, vein phenomena will not be considered here.

An examination of the four great rock systems will illustrate and prove the above remarks on stratification.

I. Beginning, as before, with the uppermost or youngest, which is at the same time the softest and lightest rock, the *Silurian* brown and gray sandstones and limestones, so well exposed on the south shore of Lake Superior, we have a perfect illustration of the regular and horizontal bedding, without folds, faults, or dykes. An inspection of the Marquette quarry, or any of the numerous natural exposures, will convince any one that these rocks are but consolidated sandbanks.

II. *The Copper-bearing Rocks.*—Some beds of this series are sandstones nearly or quite identical with the Silurian in appearance, but the great mass is made up of different varieties of copper trap, which are often amygdaloidal ; interstratified are beds of a peculiar conglomerate. The stratification of these rocks, considered in large masses, is nearly as regular as the sandstones, and differs only in the fact that the layers are inclined, dipping northwest and north toward Lake Superior at a varying angle, which seems to be greatest on the south side of the range, and is there often vertical. It is least at Keweenaw Point, where it is as low as 23°.

III. *The Iron-bearing* or *Huronian Rocks* are immediately beneath, and are exposed to the south of the copper rocks. This series are, on the average, heavier and harder, than either of the others and folded to a far greater degree. The prevailing rock is a greenstone or diorite, in which, like the copper traps, the bedding is usually obscure; but the intercalated schists and slates which usually bear strong marks of stratification, make it usually not difficult to determine the dip of the beds at any point. This dip varies both in amount and direction, but is generally at a high angle, and is more apt to be to the north or south than in any other direction.

IV. Descending to the oldest or bottom rocks of the Lake Superior country, the granites and associated beds (*Laurentian*), we find the bedding indications still more obscure and often entirely wanting. Here there is, if possible, more irregularity in strike and dip, than in the Huronian.

IV.—BOULDERS (FLOAT ORE).

Fragments of iron ore which have been detached from the parent ledge and are found loose on the surface, or in the drift beneath, possess great interest to the explorer, and are among his most important helps and guides. The same remarks are applicable, but to a less extent, to boulders of other rocks. As a rule, in the iron region of Lake Superior, it is safe to assume, that when boulders of a particular variety of rock are abundant on the surface, a ledge of the same will be found in place very near—if not immediately under the boulders, then up hill from them, or perhaps a little to the north or east; the more angular or sharp-cornered the boulders, the nearer we would expect to find the ledge.

In the Menominee region it may almost be said, that this rule is invariable, as there seems to have been less movement of the drift material here than farther to the north.

In the Michigamme district a large amount of float ore is found some distance south of the iron range, part of the fragments being very large and containing at least 100 tons of ore. Sections 19, 29, and 30 of T. 48, R. 30, and Sections 25, 36, and 35 of T. 48, R. 31, contain many such boulders, which were probably derived from the Michigamme range. Considerable digging has been done at several of the larger boulders, which has failed to find the ore in place, and the magnetic attractions are of a character which

indicate detached boulders and not a continuous ledge. For mode of distinguishing boulders of magnetic ore, see chapter on use of the magnetic needle.

These Michigamme ore boulders are all found south of the iron range which produced them, and but few at a greater distance than two and one-half miles, most of them being much nearer. This southerly and westerly direction of the drift is, so far as I know, universal in the iron region of the Upper Peninsula, and it is fully confirmed by the direction of the drift scratches in the solid rock, which vary from north to east, averaging about northeast and southwest.

Therefore, if iron boulders be found in considerable abundance, the explorer may assume, especially if they are angular, that he has iron underneath the surface; if rounded or abraded, the ledge may be to the north or east. If the boulders be magnetic, the place of the ledge should be found, with comparative ease, by means of the needle; but if specular, it may be an expensive and difficult work. Soft hematite, from its nature, can never occur in the form of boulders, as it would weather into a reddish soil. Iron boulders are often met with in digging test-pits and shafts; in such instances, if near the ledge, I have generally found the ore in place very near; if considerably above it in the drift, the same rules would apply as to surface boulders.

Attention should be given to the character of boulders other than iron, which may be associated with it, or found where there is no iron. Occasional granite boulders occur everywhere in the Lake Superior iron region and have no economic significance. I have never seen an abundance of granite boulders, however, except over granitic rocks, and so far, these rocks have not produced workable deposits of iron.

Boulders of quartzite, diorite and slate usually accompany those of iron in the Marquette region, and marble boulders, as well as quartzite, are most significant in the Menominee region.

The above laws, regarding the occurrence of *iron boulders*, give the facts regarding their geographical distribution great importance in iron explorations. If, where there are iron boulders, we may confidently look for iron, then conversely, where there are none, we should not expect to find iron. I do not assert that every deposit of hard ore is marked by float or boulders, but, so far as the facts have come to my knowledge, this is the case in the region under consideration.

Except in one or two instances, which have not been verified, I have heard of no iron boulders in the so-called silver-lead region, which extends north from the Marquette iron region to Lake Superior, which would lead one to believe, that merchantable hard ores will be found there. And except the L'Anse range in north part of T. 49, R. 33, this is true of the belt of country, west from the so-called silver-lead region. The region, without iron boulders, may be briefly described by saying, that it is bounded west and south by the line of the Peninsula division of the Chicago and Northwestern, and by the Marquette, Houghton, and Ontonagon railways. In other words, a person travelling by rail from Escanaba through Negaunee to L'Anse would have the region of iron boulders on the left, and the boulderless region on the right hand, or towards the lake.

Limiting their distribution still further, we may say, that iron boulders have only been found in quantity and quality, which would point toward economic importance in (1.) T. 45, R. 25, in the vicinity of the S. C. Smith mine, which is the most easterly locality in which they have been observed on the Upper Peninsula of Michigan; (2.) the Negaunee and Michigamme iron districts, extending in belts of irregular width from Negaunee west to the First lake in S. 17, T. 48, R. 31; (3.) the L'Anse iron range, in north part of T. 49, R. 33; (4.) south and southwest from Michigamme lake, embracing wholly or in part Towns. 44 to 47 north, and Ranges 39 to 32 west; (5.) the Menominee iron region, embracing wholly or in part Towns. 39 to 42 north, and from Range 28 west to the Menominee and Brulé rivers, but not west of Range 33; (6.) the Lake Gogebic and Montreal river iron belt, south of the South copper range.

Hunting for boulders is something like hunting game; when on the ground the best woodsman, the most active and observant will be the most successful, assuming, of course, that he knows at sight what he is looking for. (See chapter on Explorations.) I have found Indians good help in this kind of work, and believe that the incentive of a bonus in money for boulders or outcrops is often good policy. The best places in which to observe boulder phenomena is in the beds of rapid streams and under the roots of trees, the latter, probably, having been the most fruitful field. A

windfall is as good as five thousand dollars' worth of test-pits to the section.

With boulder phenomena may be classed the reddish or *brownish earth*, which comes from the disintegration of iron ore rocks of a hematitic character, and *magnetic sand*, which is very generally distributed, and which comes from the disintegration of magnetic ore. Such material may, for our purposes, be regarded as made up of minute boulders and the same remarks will apply, except that I should not expect to find red earth far removed from the ferruginous rock which produced it. Minute quantities of magnetic sand can be found almost everywhere in this region.

CHAPTER III.

LITHOLOGY.* (*Mineral Composition and Classification of Rocks.*)

In the preceding sketch the terms sandstone, limestone, conglomerate, trap, diorite, granite, etc., occur. It is evident that no satisfactory and useful progress can be made in geological field-work, which includes prospecting, until one has learned to recognize and name the more common varieties of rock. For this purpose we have to give attention to their mineral composition, that is, we must ascertain of what simple mineral or minerals the rock in question is chiefly made up and to observe, whether such minerals are angular, presenting bright facets (crystalline), or whether they are rounded like sand and gravel (fragmental). Not only must the prospector be able to recognize at sight the mineral he is seeking, but in case it is not exposed, which often happens, then those rocks, which are known to indicate its presence or absence. Experienced prospectors will not spend much time in looking for iron among granite rocks, nor in the copper traps, nor yet in the region of horizontal sandstones and limestones.

The mineral composition of rocks, by which they are identified, described and named, constitutes the science of Lithology, one of the most abstruse departments of Geology. A high authority on this subject has remarked :—" In all attempts to define and classify rocks, it should be borne in mind that they are not definite lithological species, but admixtures of two or more mineralogical species, and can only be arbitrarily defined and limited." When rocks present recognizable crystalline minerals, the task of describing and naming is comparatively easy ; but when the constituent minerals are obscure, as is often the case in the rocks we are considering, the attempt to employ specific names, which shall define such vaguely compounded aggregates, will be exceedingly difficult.

* The stratigraphical order of the rocks here considered will be found in the succeeding chapter.

The difficulty may be illustrated by supposing, were an attempt made, to give such name to a common brick, as will designate its composition and structure. Bricks are made in general of sand and clay, but several varieties of sand, and as many of clay, are employed in different localities, which, being mixed in various proportions and differently burned, give rise to a wide variation in composition and appearance and could not be expressed by a single word or term. In the case of rocks we have, of course, no previous knowledge of the numerous ingredients employed in their composition, by which the difficulty is greatly increased. It may seem at first sight, as if chemical analysis should form a reliable basis for rock nomenclature, but this is not the case. Van Cotta asserts, that a rock containing 72 silica, 11 alumina, 2.8 oxide of iron, 1 lime, 1.2 magnesia, 1.2 potash, 2 soda and 0.4 water, may be either a granite or a gneiss, protogine, granulite, quartz-porphyry, felsite, petrosilex, pitch-stone, trachyte-porphyry, obsidian, or pearlstone ; and by giving a little range in the percentages of some of the constituents, half a dozen other rock names could be added. Here we have eleven different rocks, having precisely the same chemical composition, but widely different in physical character.

It must be borne in mind, in studying this subject, that the solid crust of the globe is almost entirely made up of ten or eleven simple *chemical elements*, which variously combined, according to the laws of chemistry, produce the few *minerals* which in turn, mechanically mixed, constitute ordinary *rocks;* hence we should expect, that the average chemical composition of a series of rocks, wherever found and of whatever character, would nearly agree.

The materials of the first formed rocks, whatever their origin, have been worked over and over by rains and waves and chemical forces, distributed over sea-bottoms, consolidated and elevated, to pass again through the same process by just such means, as are now at work in producing similar results.

The reader who may not be familiar with the physical characters and composition of the minerals—quartz, feldspar, hornblende, chlorite, talc, argillite, mica and the oxides of iron and manganese, which make up the great bulk of the rocks herein described, is advised to refer to some elementary work on geology or mineralogy.

Extensive rock formations are now generally named after the locality, where they were first thoroughly studied, or are best exposed, and their minor beds and layers are often named according to their peculiar mineral composition, or with reference to their relative age, that is, order of superposition. The names Laurentian, Huronian and Silurian are geographical names of the first class. No attempt will here be made to describe the lithological character of either the Copper bearing traps, conglomerates and sandstones, nor the Silurian sandstones and limestones; these will be fully treated by Prof. Pumpelly and Dr. Rominger, respectively. What has been and will hereafter be said of the geographical distribution and topographical and stratigraphical character of these rocks was considered necessary, to acquaint the prospector and explorer with those general principles of geology, which lie at the foundation of intelligent and successful work. Whoever would become thoroughly acquainted with these systems is referred to Parts II. and III. of this volume. A number of specimens from the Laurentian are described in Appendix A, Vol. II. (see descriptions 252 to 299); but they do not cover all the lithological families represented in that system.

In subdividing the Huronian or iron-bearing series, which we have particularly to study, the rocks have been grouped (1) *lithologically*, *i.e.*, according to their mineral composition, and (2) *stratigraphically*, *i.e.*, according to relative age. As this system was first described and named by the Canadian geologists, their names have been employed as far as possible in the body of this report; the identity in composition of many of our rocks with theirs, having been established by an examination of a large number of Marquette specimens by Dr. T. Sterry Hunt.

Alexis A. Julien, A.M., of the School of Mines, New York, has made careful studies, both in the field and laboratory, of a large number of specimens from the Lake Superior region, his results being in part given in Appendix A, Vol. II. As his paper was not obtained in time to modify this chapter and the geological descriptions which follow, in accordance with Mr. Julien's nomenclature and orthography, what follows may be regarded as an independent and popular presentation of this subject, which is scientifically and more fully treated in the Appendix, the practical needs of the explorer and miner being here chiefly considered.

The specimens examined by Mr. Julien are in part from the Marquette region; the L'Anse, Menominee, and Gogebic districts

are also well represented, thus embracing an area over 125 miles long and having an extreme width of 60 miles. The specimens described belong to a catalogued collection, numbering over 2,500 specimens, being probably the most complete suite of rocks from the Azoic of the Upper Peninsula yet collected. Those from the Montreal river and Gogebic district were collected by Prof. R. Pumpelly and myself, and are believed to be the first described from that region. Prof. Pumpelly took very full lithological notes in the field, but has not yet, so far as I know, made them public. Dr. H. Credner's publications are very full on the lithology of the Menominee region, he having spent two seasons in that field.

Appendix B, Vol. II., contains a list (named by Mr. Julien) of the specimens constituting the State collection, over thirty duplicate suites of which were collected and have been distributed among the incorporated colleges of Michigan and other leading institutions and cabinets, of this country and Europe.

Appendix C, Vol. II., contains a list of 76 specimens, number 1,001 to 1,076, determined by the microscope by Chas. E. Wright, under the direction of the Faculty of the School of Mines, Freiberg, Saxony. A suite of these rocks is at Freiberg and others in Michigan.

The several beds or layers of the Huronian system, as developed in the Marquette region, are numbered upwards from I. to XIX., always written in Roman numerals. These strata being particularly described as to thickness, geographical extent, etc., in following chapters, it need here only be said in general that I., II., III., IV. are composed of beds of silicious ferruginous schist, alternating with chloritic schists and diorites, the relations of which have not been fully made out; V. is a quartzite, sometimes containing marble and beds of argillite and novaculite; VI., VIII. and X. are silicious ferruginous schists; VII., IX. and XI. are dioritic rocks, varying much in character; XIII. is the bed which contains all the rich specular and magnetic ore, associated with mixed ore and magnesian schist; XIV. is a quartzite, often conglomeritic; XV. is argillite or clay slate; XVI. is uncertain, it contains some soft hematite; XVII. is anthophyllitic schist, containing iron and manganese; XVIII. is doubtful; XIX. is mica schist, containing staurolite, andalusite and garnets. This classification, it will be borne in mind, applies only to the Marquette region, the equivalency of the rocks of the Menominee and other regions not having been fully made out.

These beds appear to be metamorphosed sedimentary strata, having many folds or corrugations, thereby forming in the Marquette region an irregular trough or basin, which, commencing on the shore of Lake Superior, extends west more than forty miles. The upturned edges of these rocks are quite irregular in their trend and present numerous outcrops. While some of the beds present lithological characters so constant, that they can be identified wherever seen, others undergo great changes. Marble passes into quartzite, which in turn graduates into novaculite; diorites, almost porphyritic, are the equivalents of soft magnesian schists. In this fact is found the objection to designating beds by their lithological character, while to numbers or geographical names no such objection exists. The total thickness of the whole series in the Marquette region is least at Lake Superior, where only the lower beds exist, and greatest at Lake Michigamme, where the whole nineteen are apparently present, and may have an aggregate thickness of 5,000 feet.

Near the junction of the Huronian and Laurentian systems, in the Marquette region, are several varieties of gneissic rocks, composed in the main of crystalline feldspar, with glassy quartz and much chlorite. Intersecting these are beds of hornblendic schist, argillite and sometimes chloritic schist. These rocks are entirely beneath all of the iron beds, seem to contain no useful minerals or ores and are of uncertain age. No attempt is here made to describe or classify them.

The following description and classification has resulted from an examination of a large number of specimens of "ore and rock," collected with the view of embracing all varieties found in the iron-bearing series of the Marquette region, together with a study of the parent masses in the field, which latter is of great importance on account of the variations in composition of the same bed, to which attention has been directed.

The *specific gravity* of over five hundred specimens, weighing from 3,000 to 10,000 grains, was determined by a balance, which turned when loaded, by the addition of two grains. The magnetic properties were carefully examined and are given in part in the chapter on the magnetism of rocks. Most of the specimens examined were arranged into ten *lithological groups* (having no reference to age), which are designated in what follows by the first ten letters of the alphabet. When a specimen represented a very

small and unimportant layer, it was thrown out as exceptional and not important to the object of this report.

It must be constantly borne in mind, that the divisions between these ten lithological groups or families are not sharply marked; one passes into the other by insensible gradations, thus producing many intermediate varieties, which it was difficult, if not impossible, to classify or describe. The first family, A, will include all valuable iron ores, the remaining nine (B to J) will include "rocks." But as iron ore, in large masses, has all the geological characters of the associated rocks, the popular general classification of minerals into "ores" and "rocks" will be disregarded except as above mentioned. Except in a few instances, where Mr. Julien's collection was incomplete, all minute lithological descriptions have been omitted, for such, frequent reference will be made to his paper; and for the reason that he had not access to maps and sections, which gave the stratigraphical distribution of the various rocks, this part has been made quite full in that respect.

In a few instances reference is made to the full suite of Marquette rocks, numbered 6,000 to 6,222, deposited by me in the cabinet of the University of Michigan, at Ann Arbor.

A. Iron Ores.

(Occurring in formations X., XII., XIII. and below V.)

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

The commercial statistics, modes of mining, and composition will be considered under their proper heads,* attention being directed here chiefly to the mineralogical and physical character of each

* See Chapters IX. and X., Plate XIII. of Atlas, and Appendix J, Vol. II.

ore. Under Woodcraft and Surface Explorations, Chapter VII., are given some brief practical rules for distinguishing iron ores, for the benefit of those, who know little or nothing of rocks.

All the specular, magnetic, and mixed ores, and a part of the soft hematites, are found in one formation; bed XIII. of my arrangement, which has its most easterly exposure near the Jackson mine and extends irregularly and indefinitely westward, embracing all the mines now producing rich hard ore.

It may be said of these ores in general, that they are essentially oxides of iron, with a few per cent. of silica added, and generally contain minute quantities of sulphur and phosphorus, but no titanium. Alumina in quantity not exceeding two and one-half per cent., with one-fourth as much manganese, is sometimes found, together with alkalies, which seldom aggregate over one and one-half per cent. The soft hematites are in part hydrated sesquioxides, hence contain water and usually more silica, than the hard ores; traces of organic matter are sometimes found, and manganese is almost exclusively confined, to the soft ores. Many specimens of specular and magnetic ore have been analyzed, which gave ninety-eight per cent. of oxide of iron, the balance being nearly pure silica. For numerous analyses of all the ores, see Chapter X., Appendix J, Vol. II., and Plate XIII. of Atlas. Weathering has no appreciable effect on the hard ores, except to crumble and cover with soil the more granular varieties. The exposed surfaces of the compact ores (by far the most prevalent variety) are of almost as high lustre as fresh fractures, and are often highly polished, showing no weathered coating like almost all other rocks. In the "mixed ores" the jasper bands are sometimes slightly elevated on the weathered surface, due to their greater hardness.

a. Red Specular Ores.—Miners divide these into *slate* and *granular*. The former resembles closely in its structure the soft greenish chloritic schists, commonly associated with it. The slabs, into which the slate ore easily splits, are not uniform in thickness like roofing-slate, but taper always in one and often in three ways, producing elongated pieces often resembling in form a short, stout, two-edged sword-blade, with surfaces as bright as polished steel, but striated and uneven. See Specimens 46, 47, 48, State Collection, Appendix B, Vol. II., and 1,050 Appendix C, Vol. II. Thin edges of such slates can be pulverized into a bright scaly powder by the finger-nail, and

occasionally the whole mass is too friable for economic handling. The magnet will generally lift one or two per cent. of the powdered ore, and occasionally one-fourth of the whole, in which case the streak is purple. These last, constituting magnetic slates, are more friable than the pure red specular slates, due in some way to the larger admixture of magnetite. See Specimen 49, State Collection, Appendix B, Vol. II.

The *granular* or massive specular ore shows no tendency to split in slabs, and is made up usually of minute crystalline grains, which are sometimes, however, so large that their octahedral form can be easily recognized without the aid of a lens; fine specimens of this variety occur at the Cleveland and New York Mines. Mineralogists apply the name *martite* to the red oxide of iron, when it has the crystalline form of the octahedron, which belongs to magnetic ore. See Specimens 2, 43, 44 and 45, State Collection, Appendix B, Vol. II. It is not improbable, that all of the granular specular ores under consideration may have once been magnetic and in some way have gained the two per cent. of oxygen necessary to change them from black to red oxides. See Dana's System of Mineralogy, 5th ed., p. 142.

The granular ore is generally firm in texture and never friable, like the granular magnetic. Some highly compacted varieties, which contain a little silica, are very hard, constituting the hardest rock to drill which the miner encounters. This variety is called the "fine-grained steely ore;" some specimens of it possess almost the highest specific gravity observed, 5.23, while the rich softer ores of the same class averaged about 4.85. See Spec. 45, State Collection, Appendix B, Vol. II.

From the examination of a considerable number of specimens of red ore, it was found that the magnet would usually lift an appreciable portion of the powder. In the case of one coarse-grained specimen of pure ore from the New York mine, one-third of the pulverized ore was removed by the magnet. Spec. 1060, App. C, Vol. II. The percentage of powder lifted by a magnet in twenty-one specimens, together with color of powder, is given in Table, App. H, Vol. II. Numerous specific-gravity determinations of this variety of ore will be found in App. B, Vol. II.

b. Magnetic Ore.—The description given above of the granular specular ore applies with equal force to this class, except that the latter is more of granular and often friable, has the magnetic property and gives a black or purple powder instead of red. Sometimes the rich magnetites crumble easily into grains, like some Lake Champlain ores, to which the term "shot ore" is applied; again, it is very hard, as in Pit No. 8 of the Washington mine. See Specs. 39, 40, 41 and 42, State Coll., App. B, Vol. II. The compact tabular form so frequent in the magnetic ores of New Jersey and Southern New York is not common in the best ores of the Marquette region, nor are the latter ores as highly magnetic as the former, or at least good loadstones are not so common; the ore from the Magnetic mine (see Spec. 17, State Coll.) has most of this tabular character.

Typical *slate* ores occur with the magnetites, but they are of the character already described, that is, mixtures of the two oxides, the magnet not removing over one-fourth of the powder, while it takes all in the case of the granular variety. The specific gravity of the granular magnetic ores, as will be seen in Appendix B, Vol. II., varied from 4.59 to 5.01, the average of many specimens being 4.81. Specs. 1,054 and 1,059 of Appendix C, Vol. II., are also varieties of this ore.

The following minerals and rocks are most commonly associated with hard ores: a soft grayish-green *chloritic schist*, which sometimes, owing to bad sorting, goes to market in sufficient quantity to perceptibly reduce the furnace yield. The magnesia it contains might tend to stiffen the slag, otherwise it can have no effect in the furnace further, than what is mentioned above. This rock is described under Group D. See Specs. 53, 54, and 55, State Coll., App. B, Vol. II.

Micaceous red oxide of iron often occurs in scales and bunches, particularly in proximity to jasper. It has been improperly called plumbago, but is in reality in no way related to it, being chemically pure oxide of iron, having the crystalline structure of mica. A soft whitish mineral, often called *magnesia*, and appearing not unlike flour, occurs occasionally in specular ore and frequently in "soft hematite." This substance is usually most abundant in the more jaspery varieties of specular ore; an examination by Prof. Brush determined it to be *kaolinite*, a hydrated silicate of alumina (clay) in minute crystalline scales. The presence of this clay in small quantity could not but help the working of the furnace, by

forming a more fusible slag, but it would of course diminish the yield of iron, if in quantity.

The needle and velvety forms of the mineral *Göethite* (a hydrated oxide of iron) are not uncommon at the Jackson mine, and "*Grape ore*" (botryoidal limonite), sometimes finely colored with yellow ochre, is found at several of the mines, but always in soft hematite. Fine specimens of crystallized quartz are rare, and no form of lime has been observed, although analyses show minute quantities. Bunches of *iron pyrites* are occasionally found, especially in the magnetic mines. At the Champion mine a thin layer containing this mineral occurs next the hanging wall, but it is easily separated from the ore, and is not sent to market. Hornblende, so generally present in the magnetic mines of New York, New Jersey and Sweden, is rare in the Marquette mines, of XII. and XIII.

c. Second-class Ore.—By far the most abundant, and commercially objectionable ingredient in the Marquette ores of all kinds, is the so-called jasper, a reddish ferruginous quartz, which is invariably found associated with the best ores, usually in thin seams or lamina conforming to the bedding, but sometimes in a form approaching a breccia. In the hard ores this impurity can usually be readily distinguished, but in the soft hematites it is often only found by analyses. As this rock possesses considerable scientific as well as commercial interest (the better varieties constituting the second-class ores), I will attempt to describe and illustrate it somewhat minutely. It consists of jasper, varying from bright red to dull reddish-brown, with occasional seams of white quartz, and usually pure specular or magnetic ore of high lustre. These materials are arranged in alternating lamina, varying in thickness up to one inch. These lamina are often highly contorted, zigzagging, and turning sometimes in opposite directions within a few inches. The jasper bands are in places broken up into little rectangular fragments, which are slightly thrown out of place, as it were, by tiny faults; the ore fills the break, so that the whole mass has the appearance of a breccia. There can be little doubt, but that the true breccia at the east end of the Jackson mine has this origin, and it would be interesting to consider whether this idea might not be extended to other conglomerates in the Huronian series. The contorted laminated structure, with the striking contrast of colors, is beautiful, and affords fine miniature examples of the anticlinal and synclinal folding and faulting of large rock masses. Sometimes the lamina are very irregular and indistinct, and one or the other of the minerals greatly preponderates. When the jasper layers all thin out (as they usually do somewhere), the ore becomes first class. Some phases of this interesting rock, with descriptions, are given in Appendix K, Vol. II., Figures 19 to 29. See Specs. 36 and 37, State Coll., Appendix B, Vol. II.

The miners call this material "mixed ore;" and those varieties in which the jasper does not constitute over 20 per cent. of the whole, are sold as second-class ore, yielding about fifty per cent. in the furnace; for rail-heads and some other uses requiring a hard iron, the presence of silica in the ore is not objectionable. The quantity of "mixed ore" is greatly in excess of the pure ore, and it will some time undoubtedly have considerable commercial value. Its nature is such, as to admit of the ready mechanical separation of the pulverized ore from the jasper by jigging, a process now employed in separating ores in the Lake Champlain region. For fixing puddling furnaces, or for any branch of iron industry which may demand pulverized ore (as the Elerhausen process promised to), it is very probable that this method may advantageously be employed, and a cheap ore produced.

"Mixed ore" is seen in outcrops far oftener than the purer ores, the softer character of which has caused their erosion, whereby they had become covered with soil; but as the mixed ores are usually associated with the pure varieties, their outcrops possess great significance in prospecting. It is important in this connection not to confound the "flag ores," (e) to be described, which they sometimes closely resemble, with this variety. The quartz of the magnetic mixed ore is usually white, or lighter colored than the red mixed ore.

d. The *soft hematites* of the Marquette region differ entirely from the ores above described, and are closely related to the brown hematites of Eastern Pennsylvania and Connecticut. In color they are various shades of brown, red and yellow, earthy in form, and generally so slightly compacted, as to be easily mined with pick and shovel. They are invariably associated with, or rather occur in, a limonitic silicious schist, from which they seem to have been derived by decomposition and disintegration. These ores occur in two distinct formations, X. and XII., and probably in others, in irregular bunches or pockets, surrounded by the schist and passing by gradations, often abrupt, into it. Scattered through the ore, and conforming in their positions with the original bedding of the rock, are fragments of the schist. When the ore shows stratification, which it often does not, it also conforms with the bedding of the schist. The specific gravity of the soft hematite ore varied from 3.50 to 3.81, the average of five specimens being 3.59, and specimens of the schist varied from 2.80 to 3.38. Strictly this schist should be described under the next group of rocks, B, to which it belongs, but its assumed parentage of the hematite ore, here considered, has led to the digression. See Specs. of soft hematite 1,067, 1,077, 1,079, and of schist 1,040, 1,065, and 1,069, Appendix C, Vol. II.; also, Specs. 25 and 26, State Coll., App. B., Vol. II.

The following analyses of the schist and ore, from the Foster mine, by Dr. C. F. Chandler, will help to make their relations better understood:—

		Schist.	Ore.
Sesquioxide of iron		44.33	79.49
Alumina		2.14	1.19
Oxide of Manganese		.16	.25
Lime		.36	.27
Magnesia		.13	.33
Silica		47.10	9.28
Phosphoric Acid		0.13	0.19
Sulphuric Acid		0.17	0.17
Water		5.19	8.74
		99.71	99.91
Equivalent to	Iron	31.03	55.64
	Sulphur	.068	.068
	Phosphorus	.057	.083

It will be observed that the essential difference is in the amount of silica, of which the schist has over 47 per cent., while the ore has less than 10 per cent., and again the ore has 25 per cent. more metallic iron than the rock. The one would evidently be converted into the other, both as to its chemical and physical characters, by the abstraction of the greater part of its silica. It is not at all improbable, that this change may have been brought about by the alkaline waters of former thermal springs, such as are now producing similar results in other parts of the world. There seems to be very little sand or clay in this ore, and washing has not appeared to improve its quality, as is the case with the eastern ores which it resembles. If the fragments of silicious rock, which are scattered through it, are carefully picked out by the miner, an ore uniform in character is obtained. Except the ever-present silica, there are only two minerals, which it is necessary to mention as being generally associated with this variety of ore. 1st. The *white clay* (kaolinite), above described, which is far more abundant in this ore than the hard ores; bunches as large as a hen's egg being sometimes seen. There can be no doubt but that the kindly working of the furnace usually obtained by using the best quality of this ore, is due in part to this clay as well as to the porous character of the ore. (Calcining the ore would expel the water, of which it contains from 2 to 9 per cent., and should also cause it to reduce more easily in the furnace.) The second and most important mineral to be mentioned is the *oxide of manganese*, usually if not always in the form of Pyrolusite; minute quantities of this metal, always less than one per cent., are sometimes found in the hard ores, but from 1 to 4 per cent. is constantly present in several of the hematite deposits, which is so important an element in their value, as to almost warrant the subdivision of the soft hematites into two classes, the *manganiferous* and *non-manganiferous*.

The recently developed hematite mines near Negaunee, belonging to formation X., contain most manganese; others contain little or none. Scarcely enough of the ore has been worked to determine its place in the market; but there can be no doubt, that when equally rich in metallic iron, the manganese would give this ore the advantage, as a mixture for the furnace, over the non-manganiferous varieties. See Spec. 25, State Coll., App. B, Vol. II.

The hematite ores now in the market, as a class, vary greatly in richness, from an average of not exceeding 40 per cent. of metallic iron for some deposits, to at least 55 per cent. in the case of others. This difference is in part brought out in Chapter X.

Passing from the Marquette region to the undeveloped districts, we find on the L'Anse range, at the Taylor mine, a large deposit of hematite of excellent quality. At the Breen mine, on the south belt of the Menominee region, is also a good "show" of hematite. Promising indications of this ore were also found between Lake Gogebic and Montreal river; all of these localities and their ores will be described hereafter.

e. The last variety of merchantable ore, to be described in this report and designated *Flag*, has been in use so short a time, that but little can be said of its metallurgical character. It corresponds more nearly with the second-class ores (*c*), than with either variety described, differing from it more in structure than in composition. The ores embraced under this head are abundant and have received various local names, which will be found significant and convenient, as lean ores, iron slates, magnetic slates and silicious ores. They have also been called "lower ores," in reference to their subordinate geological position, being older than the rich ores of formation XIII., already described. Flag ores are in reality only varieties of the ferruginous schists, constituting Group B, next to be described, which are sufficiently rich in iron, to possess market value. The percentage of metallic iron in these ores and the associated schists varies from say 5 to nearly 60, those above 50 now constituting a merchantable ore. The remaining material is generally silica, always silicious, but sometimes contains more or less chlorite, manganese, argillite, mica, garnet, or hornblende added. This ore is always flaggy in structure, the layers being occasionally thin enough, to warrant the application of the term slate. All forms of the oxide of iron can be observed, a mixture of the black and red prevailing. The hydrated oxide, producing limonitic silicious schist, has been described above, as the rock from which the soft hematite ore seems to have been derived, and an analysis is there given, to which nothing need be added here.

Stratigraphically these rocks are older than the ores described under *a* and *b*, and constitute at least four beds, X., VIII., VI., and below V., separated by diorites, chloritic schists, quartzites and argillites. Like the mixed ores (*c*) they are banded, but the marking is seldom bright and often obscure, produced by the interlamination of a dull reddish or whitish quartz, with dull *silicious* instead of *pure* ore. There are exceptions to this rule, but they are not numerous in this region. As this is a point of much importance to iron prospectors, it may be asserted, that when white or red quartz (jasper) is found banded with an ore which can be scratched with the knife, it is in all probability the "mixed ore," which accompanies the pure ores of bed XIII.; but if the quartz be dull and not sharply defined in its layers, and particularly if the knife marks the ore layers like a pencil, instead of cutting them, then we probably have one of the flag-ore formations. It is difficult to say, whether the red or black oxides prevail in many flag ores; hence whether particular varieties should be described as hematitic or magnetic.

All ores and ferruginous rocks become more magnetic as they are followed west in the Marquette region, the maximum amount of magnetite occurring in the Michigamme district. The ferruginous schists of the Republic Mountain series are among the most highly magnetic rocks in the whole region. At the Ogden mine, Section 13, T. 47, R. 27, the abrupt transition of the hematitic into the magnetic variety can be plainly observed, by following the *strike* of the beds less than 200 feet. This transition probably often occurs in the same bed, and, of course, might occur still oftener in crossing the formations, that is, in passing from one bed to another.

Several varieties of *flag ore* will now be described, showing a wide range in lithological character, which we should not be warranted in grouping together in a strictly scientific classification; but our arrangement of rocks, as has been stated, is rather economic and for the use of practical men.

(1) A showy, granular, chloritic, specular ore was found in a small pocket-like mass at the north ¼ post of Sec. 26, T. 47, R. 26, at locality known as the Gillmore mine. A specimen having a specific gravity of 4.28 gave Dr. C. F. Chandler metallic iron 60.46, alumina 3.49, lime 0.60, magnesia 1.33, silica 7.05, sulphur 0.30, phosphoric acid 0.08, water and alkalies not determined 0.77.

A similar ore, but containing some magnetite and peculiar white glistening spots, which appear to be mica scales, is found at the Chippewa location, Sec. 22, T. 47, R. 30. A specimen of this gave Prof. A. B. Prescott metallic iron 53.17, and insoluble silicious matter 20.20. Neither of these varieties are flaggy. See Specs. 6,156 and 6,206, University of Michigan cabinet.

(2) A specular slate ore, holding reddish specks on freshly fractured surfaces, is found at the Cascade location, bedded with layers of jasper, having the local significant name of "Bird's-eye Slate." A specimen of this gave J. B. Britton metallic iron 59.65, insoluble silicious matter 12.24, alumina 0.88, lime 0.14, magnesia 0.08, oxide of manganese 0.02, water 1.08, with traces of sulphur and phosphorus. See Spec. 6,190, University of Michigan cabinet, and Spec. 6, State Coll., App. B, Vol. II.

(3) South of the Cascade range is a flag ore, beautifully banded with red jasper and silicious iron ore, closely resembling some of the mixed ores of Bed XIII. above described, and interesting on this account.

(4) Northeast of the Cascade location, and near the centre of Sec. 29, T. 47, R. 26, is a granular slate ore showing on fresh fracture a peculiar fine reticulated appearance and indistinct octahedral forms. A specimen of this gave Mr. Britton 59.42 per cent. of metallic iron. See Spec. 6,191, University of Mich. cabinet. Since the foregoing was written, shipments of flag ore have been made from the Cascade mines (see Plate XII. of Atlas), and with it a considerable amount of a good quality of specular ore.

(5) At the Tilden mine, while the prevailing ore is a 40 per cent. ordinary red flag ore, there are seams or layers of bright steely ore, very hard and heavy, which yield, according to analyses made by Dr. Draper, 62 per cent. metallic iron. This ore possesses particular interest from its close resemblance to the Pilot Knob ore, Mo.

(6) While the most abundant ore at the Iron Mountain mine, Sec. 14, T. 47, R. 27, is much like the Tilden and Ogden ores already mentioned, there is a peculiar variety, containing manganese, which is also found on the hills south of Negaunee and on the lands of the Deer Lake Company, north of the New York mine. This ore is a very dark-colored silicious hematitic schist, containing on the average several per cent. of manganese, single specimens of which have proved to be nearly pure oxide of manganese. Some of this ore from Iron Mountain was tested in the furnace as a mixture, but was found to be silicious. The need of ferro-manganese in steel-making would make ores of this character a legitimate object of exploration. An experienced iron-master recently expressed the opinion that a 30 per cent. iron ore, with 12 to 20 per cent. of manganese, would soon have commercial value. It is possible that such a variety may exist in some of the beds under consideration. The soft or hematitic variety of this ore has already been mentioned.

(7) Passing from the Negaunee to the Michigamme district, we find two flag ores worth noticing. On the Magnetic Company's property, Sec. 20, T. 47, R. 30, is a large amount of a very compact, hard, heavy, highly magnetic ore, laminated with a greenish horn-blendic mineral, producing an unusual banded structure. A piece of one of the layers of ore gave Mr. Britton 56.78 metallic

iron, 19.44 insoluble silicious matter, less than one per cent. of alumina, lime and magnesia, and a trace of phosphorus. See Spec. 18, State Coll., App. B, Vol. II.; also Chapter X. Recent explorations have developed a workable deposit of this ore.

(8) Adjoining this property, to the southeast is Sec. 28, owned by the Cannon Iron Co., on the north side of which is a thin layer of micaceous specular ore, closely resembling that described above under A, but containing more silica. A specimen of this afforded Professor Prescott 55.12 metallic iron, 19.80 insoluble silicious matter, with traces of sulphur and phosphorus. This and the banded ore associated with it, has a closer resemblance to the slate and "mixed ore" of some of the old mines, than any place I have seen in the flag-ore series, to which it seems to me geologically to belong; its relation to the associated mica schist is interesting. See Group H below. The Chippewa ore, near the Cannon, has already been mentioned above in connection with the Gillmore.

The foregoing brief descriptions of several varieties of flag ore embrace all those, which have come under my notice in the Marquette region and give promise of having early commercial value.

As will be elsewhere (Chapter V.) more fully described, the hard ores found in the Menominee region up to October, 1872, are more nearly allied to flag ores than to either of the first-class ores of the Marquette region. Flag ores of a low grade have also been found in the L'Anse and Gogebic districts, as will be mentioned hereafter.

A very limited experience in working these ores, together with the little I have been able to learn from others, leads me to believe, that they require more limestone and coal and produce a harder metal, having comparatively little strength, but which is probably well adapted to making nail-heads. I think a large mixture of manganiferous hematite might help the working of a furnace consuming flag ore. Precisely the same remarks may be made of the second-class ores (*c*); indeed, these two classes are to all intents and purposes identical in their metallurgical character, and are only separated here because of their different geological occurrence. The second-class ores are, it will be remembered, simply inferior grades of the rich hard ores of XIII.

The flag ores have here received relatively far more attention, than their present commercial importance warrants, for the following reasons:—1st, Their quantity, so far as can now be judged, is greater by tenfold than the first-class hard ores, and for this reason they must, at some future time, constitute a large part of the total production of the region. 2d. Very serious disappointments and losses have occurred in the past, and are likely to be repeated in the future, from mistaking flag ore for first-class ore. This arises from the fact, that the better varieties of flag ore closely resemble the poorer varieties of the rich ore. So close is this resemblance, that the best judges of ore in the Marquette region have erred. It is doubtful, if the matter can be settled definitely, except by thorough explorations, aided by the well-known laws of the geological occurrence of the two ores, which will be more fully brought out in succeeding chapters.

It is not asserted that first-class hard ores may not be found associated with the flag ores, hence below and older than formation XIII.; but it is a fact, that over one million dollars have been sunk in such search, and excepting the West End mine of the Cascade range (if that is an exception), no workable deposit of strictly high grade hard ore has been found in the flag-ore series.

B. Ferruginous, Silicious, and Jaspery Schists.

(Occurring in formations XII., X., VIII., VI., and below V.)

The best general idea of the character of the rocks embraced here can be conveyed by saying, that they are identical with the flag ores last described, except in containing less iron and usually more silicious matter. On geological grounds, as has been remarked, the flag ores should be embraced under this head and described as a subclass, rich in iron. It remains therefore for me to mention briefly, a few of the remaining varieties of this series, which are so poor in iron as to render it highly improbable that they will ever possess value as ores: I design to embrace in this group Mr. Julien's quartz schist, silicious schist, and jasper schist, Appendix A, Vol. II. For minute lithological descriptions of numerous varieties see Specs. 154 to 173, App. A, Vol. II.

At Republic Mountain are three highly magnetic beds of silicious, chloritic and hornblendic schists, numbers VI., VIII., and X. See Map No. VI. of Atlas. The peculiar striping—whitish, greenish, brownish, and yellowish—exhibited in the large outcrops suggested the name "rag-carpet schist." A specimen made up of numerous chippings of this rock gave 31 per cent. of metallic iron; this is believed to be above the average. Both the red and black oxides are present, and some of the layers hold an ore, which, if it could be separated, might yield 50 per cent.

South of the Washington mine these rocks contain the minimum amount of iron, a specimen of which gave Charles E. Wright less than 5 per cent. Garnets and anthophyllite, or mica, seem to replace the iron, producing a grayish and brownish schist, the mineralogical character of which is obscure. See Group I. The old Michigan mine ore, Section 18, T. 47, R. 28, seems to be a variety of this peculiar schist, but much more highly charged with metal, specimens of which, I should judge, would afford 30 to 40 per cent. of metallic iron.

Passing to the Negaunee district we find in the railroad cut at the northwest end of Lake Fairbanks a chloritic, magnetic, silicious schist of a brownish gray color, faintly banded and very hard; it is aphanitic in character, and shows no disposition to split on the planes of bedding. In the railroad cut near the centre of Section 8, one mile and a half southeast of Negaunee, is a soft variety of ferruginous rock, affording some good red chalk. The rock seems to be chloritic, layers of which are impregnated with red oxide of iron. A similar material was found in numerous test pits in the east part of Section 18, T. 47, R. 26. Recent explorations in this vicinity prove this rock to be associated with the Negaunee hematites, which are fully described in Chapter IV.*

One of the best characterized and abundant varieties of this group is the banded ferruginous jaspery schist, which constitutes in the Michigamme district the whole of formation XII., and is also abundant in parts of ore formation XIII. Such varieties of "mixed ore," as contain too little iron to give them commercial value (unfortunately the greater part), would be classed here. The full descriptions and illustrations already given of "mixed ore" under A, will make any further description unnecessary, for this is a similar rock with little or no iron. See Spec. 32, State Coll., App. B, Vol. II., and for several other varieties of this group see Specs. 1,026, 1,034, 1,061, and 1,064, Appendix C, Vol. II. The Felch mountain series contain a large amount of a similar rock.

* It is questionable whether this rock should be classed under D or G.

C. Diorites, Dioritic Schists and Related Rocks (*Greenstones*,)*

(constituting formations XI., IX., VII., and one or more beds below them.)

These obscurely bedded rocks, locally designated greenstones and sometimes traps, are co-extensive with the ferruginous rocks A and B, very abundant, outcropping throughout the Huronian region, and present much variety in appearance. They range in structure from very fine-grained or compact (almost aphanite) to coarsely granular and crystalline, being sometimes porphyritic in character. The color of the fresh fracture is from dull-light to dark or blackish green, the weathered surface being usually lighter and of a grayish green or brownish color, not unfrequently spotted or mottled, showing a dark-green, or black, lamellar mineral (hornblende), set in a whitish, and sometimes reddish, softer mineral (feldspar). The rock is exceedingly tough, powdering under blows of the hammer rather than break. It can be scratched by the knife, giving a light grayish-green powder, and is fused without difficulty before the blow-pipe. On the one hand, it graduates into a heavier, tougher, blacker variety, which is unquestionably hornblende rock, with some feldspar, well shown at the Greenwood Furnace quarry, on Sec. 15, T. 47, R. 28. See Specs. 1,018 and 1,020, App. C, Vol. II. On the other hand, it passes into a softer, lighter colored rock of lower specific gravity, which, while it has the same streak, weathers similar to the true diorite, is eminently schistose in character, splitting easily, and appearing more like chloritic schist than any other rock. The Pioneer Furnace quarry at Negaunee contains this schist and several transition varieties, some of which approach the granular massive rock. See Specs. 1,001, 1,005, 1,006, and 1,015, App. C, Vol. II. On the north side of Lake Michigamme, and west, varieties occur having a true slaty structure in appearance, although not splitting easily. See Spec. 1,028, App. C, Vol. II.

At several points dioritic schists, semi-amygdaloidal in character, were observed, and in one instance the rock had a strong resemblance to a conglomerate. See Spec. 1,024, App. C, Vol. II.; and

* See Dr. Houghton's Notes on Diorites, Appendix E, Vol. II.

Spec. 71, State Coll., App. B, Vol. II. It is of much practical importance to distinguish between the schist of this group and the true chloritic schist to be described under the next head, D, which is usually found associated with the pure ores of Bed XIII.*

At Republic mountain a dioritic schist graduates into black mica schist, and large garnets are there found in typical diorite. Iron pyrites are usually seen sprinkled through the rock, and epidote is sometimes observed. Dr. Hunt found chromium in two specimens. South of the Old Washington mine, in Bed XI., occurs a variety, which in places may almost be described as hornblendic schist; that in other parts of the same bed, near at hand, graduates into the above-described dioritic schist.

In the railroad cut at the foot of Moss Mt., west of Negaunee, is an exposure of soft dioritic schist, in which are imbedded rounded lumps of diorite, which, when broken, show a crystalline reddish feldspar. See Specs. 1,001 and 1,002, App. C, Vol. II. Spec. 77, App. B, Vol. II., is another beautiful and rare variety, in which the feldspar is red. On the south side of Sec. 9, T. 49, R. 33, is a heavy bed of coarse-grained friable diorite, which has in places disintegrated into sand. Mr. Julien regards this and the associated dioritic rocks of the L'Anse range as possessing such distinctive characteristic as to warrant him in describing them as a distinct variety. See Specs. 342 to 353, App. A, Vol. II. He also classes the well-known peculiar serpentine rock of Presque isle with the diorites. See Spec. 321, App. A, Vol. II, also App. E.

The magnet usually lifts less than one per cent. of a powdered diorite, but in one case it took nearly all, and the specimen attracted the needle. This piece was from the ridge south of the New England mine; it had the essential character of a compact, perhaps hornblendic diorite, but its magnetic property and very high specific gravity, 3.29, prove that it is exceptionally rich in iron. It will be shown below, that in addition to the magnetite, seventeen per cent. of metallic iron exists in some diorites in the form of combined protoxide, which does not attract the needle. The specific gravity of the typical rock varied from 2.84 to 2.96, the average of six specimens being 2.91. The hornblendic varieties ranged as high as 3.01, while the schistose variety fell as low as 2.70,

* See Julien's remarks under Chloritic schist, App. A, Vol. II.

averaging 2.82. A garnetiferous specimen, from Smith Mountain, gave 3.02, while a peculiar variety from north of Greenwood Furnace, which appeared to be feldspathic in character, gave but 2.71. Numerous additional specific gravity determinations are given in App. B, Vol. II. The precise character of the constituent minerals of this rock is obscure. Mr. Julien has minutely described numerous varieties in App. A, Vol. II., Specs. 302 to 353.

The following analysis of a specimen from bed XI. is from Foster & Whitney's Report, Part 2d, p. 92. The specimen was from Sect. 10, T. 47, R. 27, on south side of the Cleveland and Lake Superior ore deposits:—

		OXYGEN.
Silica	46.31	24.06
Alumina	11.14	5.21
Protoxide of iron	21.69	4.82
Lime	9.68	2.76
Soda	6.91	1.78
Water	4.44	
Magnesia	trace.	
	100.17	

From this it is deduced that the rock is a mixture of labradorite feldspar with hornblende or pyroxene. Regarding the presence of water, numerous analysis of similar rocks in Canada show the same result. See Geology of Canada, pages 469, 604, 605, and 612. Dr. Hunt expresses the opinion, that in the case of the Marquette diorites, the hornblendic mineral often becomes softened and hydrated, passing into a degenerate form more nearly allied to chlorite or delessite (in which water is an essential constituent), than to a true hornblende. This chloritic mineral is sometimes seen scattered through the body of the rock, and very often near the weathered surface.

The absence of *magnesia*, which is regarded as an essential ingredient of chlorite and delessite, and as very rarely absent from hornblende, as shown by the above analysis, deserves notice. Dr. Hunt remarks that the hornblendic element may very likely be the iron hornblende described by Dana, System of Mineralogy, 5th ed. p. 234, under the name grünerite. The unusually large amount of iron shown by Whitney's analysis and the high specific gravity observed would favor this view. The conversion of this non-magnesian diorite into a magnesian schist (chloritic or delessitic) would require the introduction of the magnesian element under some law of pseudomorphism, the possibility of which is proven by chemical geology.

Magnesia is not, however, absent from all varieties of the diorite. A chromiferous specimen from near the centre of Sec. 36, T. 48, R. 28, was found by Dr. Hunt to be rich in magnesia, containing more of this element than of lime; the specimen was not a typical one, but showed a tendency to pass into a steatitic rock, which might be expected to contain magnesia. Until, however, the presence of magnesia in the schists and its absence from the diorites is proven by more analyses, it is not worth while to conjecture in the matter, and I here digress only to record a few facts, bearing on an interesting and unsettled question in chemical geology. In the absence of any additional light, we adopt the hypothesis that the Marquette "greenstones" are diorites, composed essentially of a non-magnesian iron hornblende and some feldspar other than orthoclase.

It is of great importance that the prospector should have a good practical acquaintance with this rock, for it is everywhere associated with iron ores in the Upper Peninsula. He should be able to recognize it at sight, to distinguish its varieties, and especially he must not confound the Huronian diorite with a similar rock, found in the Laurentian, nor with Copper trap. More than one piece of land has been bought for iron on the Laurentian area, because "greenstone" was found on it.

The bedding of these rocks is generally obscure, and in the granular varieties entirely wanting. It is usually only after a full study of the rock in mass, and after its relations with the under and overlaying beds are fully made out, that one becomes convinced, whatever its origin, it presents in mass precisely the same phenomenon as regards stratification, as do the accompanying schists and quartzites.

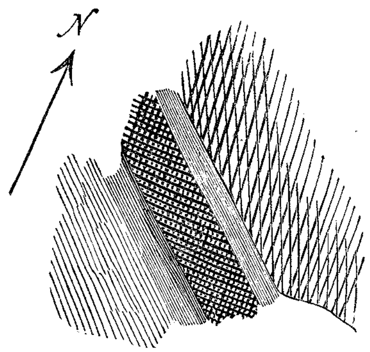
I have nowhere seen the granular diorites show more unmistakable evidence of bedding than on the small knob southwest of Bear Lake, Republic Mountain, shown in Fig. 1, scale $\frac{1}{50}$th. The cross shading represents massive diorite, and the parallel shading a slaty silicious iron ore.

No reference is here made to the false stratification or joints, which are numerous and interesting, but which, unfortunately, for want of space, can receive no other attention here, than to warn the observer against mistaking *joint* planes for *bedding* planes, which is sometimes done, even by experienced observers.

This description, as has been stated, is intended to apply to the diorites of the iron-bearing or Huronian series, and more especially

Fig. 1.

Stratification of Diorite.



to the Marquette region; but a similar rock, as has been observed, occurs abundantly in dykes or veins, and probably in beds in the Laurentian rocks. A fine example of such a dyke can be seen penetrating a granitic gneiss, near the northeast corner of Sec. 7, T. 46, R. 29. At other points in the Laurentian area immense masses of a dioritic rock were observed, the stratigraphical relations of which to the gneiss and granites was not made out. The average specific gravity of the dyke diorite was 3.03. Mr. Julien describes some specimens of diorite from the Laurentian in App. A, Vol. II.

The following designated specimens, in addition to those already referred to, constitute a tolerably full collection of the more important varieties:—Granular diorites, 1,007, 1,008, 1,009, 1,010, 1,011, 1,012, 1,014, and 1,016; Dioritic schists, 1,001, 1,019, and 1,023 of App. C, Vol. II. The State Collection, App. B, Vol. II., also contains a large number of specimens of diorite of several varieties.

The distribution of this rock in the Huronian of the Upper Peninsula is interesting. It is far more abundant in the Marquette region and contiguous to the ore deposits, than elsewhere. The related rocks in the L'Anse region are abundant; but in the West iron district, and on its prolongation into Wisconsin, where it forms the Penokie range, diorites are rare. In the Menominee region they seem to be replaced to a great extent by chloritic schists and hornblendic schists, as described in Chapter V. Whether future explorations will prove that the best ores are always associated with the typical diorite, remains to be seen.

D. Magnesian Schists (*mostly chloritic*).

(See Mr. Julien's description, Specs. 179 to 188, App. A, Vol. II.)

Intercalated with the pure hard and mixed ores, at all the mines worked in formation XIII., are layers of a soft schistose rock, of some shade of grayish green, and often talcy in feeling. The Cleveland, Lake Superior and Champion mines are good localities for an examination of this rock. It is unquestionably a magnesian schist, varying from chloritic to talcose in character, and sometimes apparently containing a large percentage of argillite. In places, as at the Old Washington, its character is unmistakably talcose. Specimens obtained there held 4.2 per cent. of water, and had a specific gravity of 2.81, with light grayish-green color, and other characteristics of talcose schist. See Specs. 1,046, App. C, Vol. II. The corresponding schist at the Champion mine is also decidedly talcy. On the same magnetic range, but further west, at the Spurr Mountain, the equivalent schist is unmistakably chloritic. See Specs. 179 to 181, App. A, Vol. II. A rare variety of talc schist is represented by Spec. 74, App. B, Vol. II., obtained at the Grace furnace, Marquette.

In the Lake Superior and Barnum mines this rock is, in places, of a light green color, less soapy in feel, has a higher specific gravity and is of uncertain composition. See Spec. 55, State Coll., App. B, Vol. II. At this locality it has a marked cleavage structure, the planes of which trend east and west, and are nearly vertical, being distinct from its bedding, which latter is very obscure. Its structure bears a striking resemblance to that of the specular slate ores, noticed under A, even to the presence in both of minute octahedral crystals. Prof. Pumpelly has suggested, that one may be a pseudomorph after the other. In this connection it may be remarked, that no gradual transition of one into the other was observed, the division planes being in each instance sharply defined.

Specimen No, 1,043, App. C, Vol. II., from the Washington mine, is grayish, less schistose in structure than the last described variety, and gave up, when pulverized, one-third its bulk to the magnet. A similar massive variety from the same mine, which contained three per cent. of water, held black hard scales, which Prof. Brush decided had the character of ottrelite.

A reddish gray variety of this rock (see Spec. 6,164, University of Mich. Cabinet), holding grains of vitreous quartz, is from a heavy bed on the northeast side of the S. C. Smith soft hematite ore deposit, on Sections 17, 18, and 20, T. 45, R. 25.

South of the Edwards mine, at the Republic Mountain, and at other places in the ferruginous schists, occur bunches and thin irregular beds of a pure chlorite, often micaceous, which always contain garnets. See Spec. 6,097, University of Mich. Cabinet. This specimen shows, under the lens, minute elongated crystalline faces, closely resembling those seen in the diorite. Spec. 184, App. A, Vol. II., is garnetiferous. The "keal" or red chalk, found at several mines, is a variety of this schist impregnated with oxide of iron. See Spec. 6,183, University of Mich. Cabinet.

A very peculiar occurrence of this rock are the so-called "slate-dykes," which can be seen at the New England, Lake Superior and Jackson mines, but still better in the quartzite ridge, just north of the outlet of Teal lake. These dykes are often several feet in width, cut across the stratification, and are filled with a magnesian schist. If space permits, this subject will be more fully considered elsewhere. See Specs. 1,053, 1,068, App. C, Vol. II.

The Lower Quartzite bed V. often contains talc in bunches, small beds and disseminated, producing in places a talcy rock. The *novaculite* of that formation is due to the presence of talc and argillite. These rocks will, on account of their association, be more fully described in the Quartzite group.

It would be difficult for a skilled lithologist, and impossible for me, to draw the line between the chloritic schists here considered and the dioritic schists mentioned under Group C. So far I have chiefly noted occurrences of the magnesian schists, in formations XIII. and V., where they are not associated with true diorites. But at the Marquette quarries we find what may be called typical chloritic schists, bedded with granular diorites. See Specs. 182 and 183, App. A, Vol. II. At this locality the planes separating the two kinds of rock are well defined; at others, which have been designated, the transition is gradual.

Along the north border of the Laurentian area, which lies south of Lake Gogebic (see Map I.), are numerous exposures of a chloritic schist (see Specs. 187 and 188, App. A, Vol. II.), which in places becomes massive and granular, a form designated "greenstone" by the United States Linear Surveyors, and so marked on their maps. See Specs. of Diorite, 309 and 212, App. A, Vol. II.

The specimens of Laurentian Gneiss, 275 and 299, App. A, Vol. II., contain chlorite as an essential ingredient, proving this mineral to be as widely disseminated in the Laurentian as Huronian. An examination of Prof. Pumpelly's very exhaustive chapters on the lithology of the copper-bearing rocks, will show chlorite to be of frequent occurrence in that system; demonstrating it to be next to feldspar and quartz, one of the most universally diffused minerals in the Azoic of the Upper Peninsula.

E. QUARTZITE—*Conglomerates, Breccias, and Sandstones.*

(Principal development in Formations V. and XIV. See Mr. Julien's descriptions, 126 to 140, and also 358 and 359, App. A, Vol. II.)

After diorite and the ferruginous schists, no rock is more abundant in the Marquette region, and none more frequently found in outcrops, than the different varieties of this group. Two extensive beds exist—XIV. lies immediately over the ore formation, and V. near the base of the series. The last appears to be the most persistent and wide-spread member of the Huronian system. It can be traced from the shore of Lake Superior, near Chocolate river, westward for 40 miles, and possesses unusually economic interest from its affording the marble, used to a limited extent as furnace flux, and the whetstone rock (novaculite), which was at one time quarried for market. This quartzite has also recently been successfully employed as lining for Bessemer converters.

The Upper Quartzite (XIV.) is co-extensive with the ore formation XIII.; it is seen as the hanging wall of the most easterly point, at which rich hard ore is mined, and overlays the most westerly deposit yet explored. Between these is a third bed, seen in the railroad cut

near the west end of Lake Fairbanks, the extent of which has not been made out. See Spec. 21, App. B, Vol. II.

At the west end of Lake Michigamme, near the centre of Sec. 25, T. 48, R. 31, is a large mass of quartzite, which appears to be a ledge, but if so, the bed is concealed to a greater extent than usual, for it has not been observed elsewhere. No. XVIII. is assigned for this quartzite, or for whatever rock may be found in the gap between Beds XVII. and XIX. The Cascade iron range is divided by a thin bed of quartzose rock, which varies from a quartzite to the coarsest conglomerate I have observed in the region, but which, like the two last-mentioned beds, seems to be local. At the Greenwood furnace is a heavy and persistent bed of quartzite, in which are intercalated layers of clay slate; its age has not been determined; it resembles the lower quartzite.

The extreme hardness of quartzite (the knife makes no impression on it, and it will readily scratch glass), and its general dissimilarity to the other members of the series, renders its recognition easy and much description unnecessary.

Vein quartz, occurring in bunches, seams and veins, in nearly all rocks, is not embraced in this description; nor are those slightly ferruginous quartz schists, already described in Group B, which a strictly scientific classification would place under this head. Quartzite is seldom white, often light-gray, or dark-gray and sometimes reddish or greenish. The effect of weathering does not penetrate the rock beyond a mere film, dulling the lustre and color of a fresh fracture rather, than changing it; but the latter effect is sometimes produced in the impure varieties. Broken pieces often show grains of glassy quartz; and the arenaceous character is sometimes so plain, as to leave no doubt in the mind, that the rock is a metamorphosed sandstone or conglomerate (see Fig. 2). Again, the whole mass is compact, having much the appearance of vein-quartz. In structure it is usually massive, and the bedding obscure; but in places, as at the northeast corner of Teal lake, it is banded, presenting a flaggy structure, like the ferruginous schists. The mean specific gravity of a large number of specimens was 2.69. See App. B, Vol. II.

The foregoing description applies in general to all the beds; but as it is often of importance to the explorer to distinguish the Upper bed on account of its relation to the ore formation, a few points of difference will be noted. As has been remarked, the Lower bed is often calcareous, turning in places into a true marble, as at the Morgan Furnace; and the same formation is often talcy in character, containing in certain localities bunches and beds of a talcy material and in other places beds of argillite. An intimate mixture of these minerals with the quartzose material produces novaculite, which was formerly quarried just east of Teal Lake outlet. See Spec. 13, State Coll., App. B., Vol. II. Red oxide of iron in grains and small bunches, is not infrequent in the Lower bed, as can be seen in northeast quarter of Sec. 22, T. 47, R. 26.

So far I have seen neither marble, talc, nor novaculite in the Upper Quartzite, and only once, at the Lake Superior Mine, have I seen argillite associated with it. As this exception has much interest, it will be fully considered in another place. The Lower Quartzite is seldom conglomeritic, the upper one often so, and in places on the Spurr Mountain range it is a true conglomerate, containing pebbles of white and glassy quartz and jasper. See Specs. 115 to 118, App. A, Vol. II. At Republic Mountain large fragments of ferruginous schist are seen in the base of the Upper bed. Southwest of the Old Washington mine it is a coarse conglomeritic rock, which is in places schistose or slaty. See Spec. 122, App. A, Vol. II.

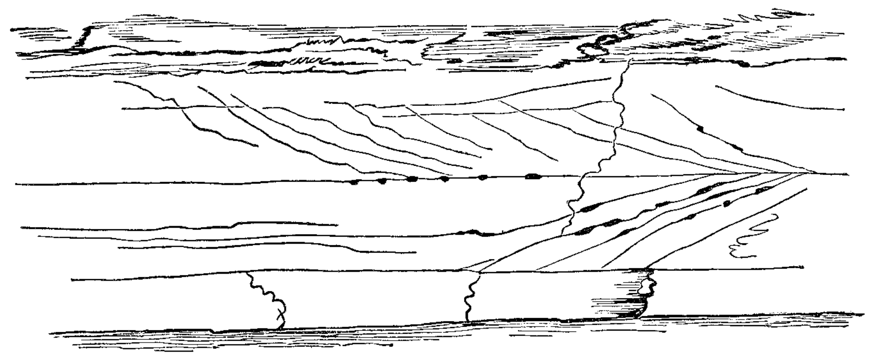
The matrix of this variety (See also Spec. 6,085, University of Mich. Cabinet) is a soft, micaceous, slaty material, containing fine grains of specular ore and holding pebbles of white quartz. The Upper bed overlying the east end of the Jackson, and that over the New York mine, also hold pebbles. Mica scales and epidote were found in the same bed at the Republic Mountain, and in places it had almost the appearance of fine-grained granite.

As if to leave in our minds no shadow of doubt, as to the sedimentary origin of this rock, nature has, in addition to the conglomerate on the Spurr Mountain range, given us a variety of the Upper Quartzite, which can only be described as a fine-grained, friable, banded *sandstone*. See Specs. 358 and 359, App. A, Vol. II. The alternations of magnetic sand with quartz sand, producing the stripes, is very interesting in connection with the origin of these ores. It is doubtful if any true breccias (conglomerates with angular pebbles) occur associated with the rocks here described, if at all in the region. The brecciated rocks, a variety of "mixed

ore" found in formation XIII., is believed to have had the origin ascribed under Group A.

Specimens of University of Mich. Cabinet, Nos. 6,193, 6,084, 6,180, 6,211, 6,219, and 6,122 are from these quartzite beds. Specs. 8 to 14, State Coll., App. B, Vol. II., are from the Lower bed, and Specs. 50, 51, and 52, same Coll., are from the Upper. The extensive beds of quartzite, which occur in the Menominee region, will be fully considered in Chapter V. This rock is also of frequent occurrence in the L'Anse range and toward the Montreal river, as will appear in following Chapters. A beautiful example of false stratification, or discordant parallelism, was observed in this last-named region, as is shown by Fig. 2, sketched near the south quarter post of Sec. 10, T. 47, R. 45. It was a true granular quartzite, but showed deposition marks almost as plainly as a fresh-cut sandbank.

Fig. 2.
False bedding (discordant parallelism) of Quartzite—Gogebic Region.



F. Marble (*Limestone and Dolomite*).

(See Mr. Julien's descriptions, 101 to 113, App. A, Vol. II.)

The association of this rock with the Lower Quartzite, or rather the transition of the latter into marble, has been mentioned. This transition is seldom complete, the marble being always more or less silicious. As is usual in such cases, the change is gradual, producing all varieties, from calcareous quartzite to silicious marble. The prevailing colors are light gray, salmon and reddish. The purest varieties often present a sparry structure, with large lamellar facets like orthoclase feldspar, with which it is often confounded, but from which it can readily be distinguished by its softness. Beds of argillite are invariably associated with the marble. See Fig. 19, App. E, Vol. II. Outcrops often present minute ribs or ridges of the more silicious layers, left by the weathering away of the purer marble.

The mean specific gravity of a large number of specimens averaged 2.82. See App. B, Vol. II. Pure marble has the same composition as pure limestone, of which it is simply a crystalline or highly altered form, that is, it is a carbonate of lime;—if carbonate of magnesia is present in considerable quantity, as is often the case on the Upper Peninsula, the rock becomes a *dolomite*. Marble is readily distinguished from its effervescing with acids, when pulverized.

Marquette marble has been considerably used as a blast furnace flux, for which purpose it only answers passably well, on account of the silica so generally present; silica, in the form of quartz, and jasper being always present in the *ores*, it is very desirable to have none in the *flux*, for it is to get rid of silica in the form of slag, that lime is used in the furnace. Large amounts of Kelly island limestone, which is quite pure, is now being imported. For building purposes, its hardness, variability in texture and the difficulty of securing large blocks, have so far prevented its use; beautifully variegated small blocks can, however, be easily procured. Specs. 6,198, 6,199, 6,200, University of Michigan Cabinet, are from the Morgan Furnace quarry, and Specs. 106 to 113, State Col., App. B, Vol. II., from the Chocolate quarry, just south of Marquette, all belonging to formation V., represent the chief varieties of this rock.

No marble has been observed in the L'Anse district, nor between Lake Gogebic and Montreal river, but it is one of the most abundant rocks in the Menominee region, where it occurs in a much purer form than in Marquette, usually more dolomitic. See Chapter V. and Specs. 102 and 103, App. A, Vol. II. Marble of similar quality is also abundant in the vicinity of Fence and Michigamme rivers, in Towns 44 and 45, R. 31. See Spec. 105, App. A, Vol. II.

G. Argillite or Clay Slates and Related Rocks.*

(Constitutes bed XV., and occurs in bed V. and elsewhere.)

It was previously mentioned under Groups E and F, that beds of clay-slate were sometimes interstratified with layers of quartzite and marble. Fine examples of this, in the case of both rocks, can be seen respectively at the Greenwood and Morgan furnaces. In addition to these, at least two distinct beds of argillite have been made out; one immediately beneath the ferruginous schist of formation X., to be seen in outcrop on the south shore of Teal lake, near west end, and in the railroad cut about one mile east of Negaunee. See Spec. 20, App. B, Vol. II. Another and far more extensive bed is XV., which forms the stratum next above the Upper Quartzite; boulders of this bed, which had the appearance of being near the parent ledge, were found in the railroad cutting, near the pockets at the Washington mine. At the Champion this formation is exposed in the branch railroad, and it is found at numerous points on the north shore of Lake Michigamme.

The prevailing color of this rock is usually dark brown or blackish, but where associated with the marble it is sometimes reddish. It has a true slaty cleavage, distinct from the bedding, but seldom splits in sufficiently large or regular slates to warrant us in supposing it may in places produce roofing slates, although experienced persons express the belief, that good slates will yet be found in the Marquette region. Black carbonaceous matter is often present in this slate, a preponderance of which produces the rock which will be described hereafter under J. A variety at the Greenwood furnace contains a large amount of iron-pyrites; and the first stack built of it had to be taken down, from the decomposition of this mineral. The slate in the branch railroad cut, at Champion, shows a slight tendency to be micaceous and holds garnets. See Spec. 56, App. B, Vol. II. Silicious bands often exist

* Mr. Julien has in App. A, Vol. II., given the results of much study of these rocks, and has divided them into the true argillites and several other varieties possessing a different composition. See descriptions 189 to 225. As this difference cannot readily be made out by the unscientific, and as it is not important to the practical man, it will not here be attempted to separate these varieties.

in this rock, faintly marking its bedding at an angle with the cleavage, as can be seen in Spec. 20, App. B, Vol. II.

Overlaying the Lake Superior and Barnum ore deposits, hence occupying the place of the Upper Quartzite, is a greenish-gray schist, obscure in its composition, and somewhat like the magnesian schists D, but apparently of the same general character as this group. See Spec. 55, App. B, Vol. II. This rock may very properly be regarded as the connecting link between Groups D and G, which evidently graduate into each other, as did C and D. It is frequently stained reddish-brown along the seams and cracks, proving the presence of protoxide of iron, and shows in places beautiful dendritic delineations of manganese. This formation does not show the cleavage structure, so conspicuous in the schists of Group D, which are bedded with the pure ore at these mines. At the most westerly opening of the Lake Superior, thin beds of quartzite appear, indicating that the presence of argillite in this bed is probably only local. See Map No. IX.

An example of a magnesian schist (D) graduating into an argillaceous variety can be seen in the slate which overlies the specular ore of No. 1 pit, New England mine, which, by its high specific gravity (3.03), evidently contains considerable iron. Another ferruginous and probably chloritic variety occurs on N. W. ¼ Sec. 31, T. 47, R. 25, where explorations for iron have been made by the Morgan Iron Co.

The average specific gravity of a number of typical specimens of argillite was 2.75. See App. B, Vol. II. The rocks above described are illustrated by Specimens 1,039, 1,072, and 1,036, App. C, Vol. II.

Beyond the limits of the Marquette region, we find in the recently explored Huron Bay district, particularly in the south part of T. 51, R. 31, the finest clay slates so far discovered in Michigan. Several competent experts have examined this district, and pronounced the slates of the best quality for roofing and other purposes, and in immense quantity. See Spec. 81, App. B, Vol. II. Companies are now at work in this district, the organization of which is given at the end of Chap. I. For an account of the clay-slates in the Menominee region, see Dr. H. Credner's papers (Leipsic).

This rock also occurs west of Lake Gogebic, as will be mentioned hereafter.

H. Mica-schist.

(Formation XIX. contains the principal development of this rock. See Mr. Julien's description, No. 301, App. A, Vol. II.)

There appears to be but one extensive stratum of this rock, the character of which is unmistakable, which is at the same time the youngest and one of the thickest beds of the whole Huronian series. This formation, which I have numbered XIX., forms the surface rock along the south shore of Michigamme lake, among its islands, along the outlet for several miles, and westward from the lake through the southern parts of T. 48, Ranges 31 and 32, as shown on Map III. The rock is sometimes so silicious as to be rather a micaceous quartzite, but usually its true character is very plain. It frequently contains seams and bunches of white quartz, occasionally seams of black hornblende, and often holds numerous imperfect crystals of a delicately pink-colored, coarsely fibrous mineral, which Prof. Brush decided was andalusite, and brownish, smaller, and more perfect crystals of staurolite.

Andalusite and staurolite have not been observed elsewhere in the Marquette region in rocks of any age. Imperfect small reddish garnets are sometimes abundant, but they were not observed at the same places as the first-named minerals, and seemed to be nearer the base of the formation. The mica, which usually holds but little quartz, is of a brownish color on fresh fracture, weathering more grayish; its scales show a constant tendency to bend themselves around the imbedded crystals, like the fibres of wood around a knot. The projecting rounded crystals give the weathered rock a warty look, having somewhat the appearance of a conglomerate, as can be seen on the most southerly islands in Lake Michigamme. The specific gravity of this porphyritic mica-schist varied from 2.81 to 2.89, the mean being 2.84. See Specs. 1,031, App. C, and 61, App. B, Vol. II.

Descending in the series, the next mica-schist to be noticed is entirely different from the above, in being black, and decidedly dioritic in its affinities. It occurs in the upper part of diorite bed XI. at Republic Mountain. The deposit is not extensive, and its relations with the diorite indicate that it is a local variety, apparently graduating into dioritic schist.*

* The local micaceous character of bed XV. has been noticed.

One other mica-schist, that associated with the Cannon ore on Sec. 28, T. 47, R. 30, deserves notice. This rock resembles XIX. only in the brownish color of its mica; it contains no crystals of other minerals, and is always quartzose, sometimes to the point of becoming a micaceous quartz-schist. The age of this rock has not been satisfactorily determined, but it is near the base of the series. The striking peculiarity of this variety is the fact, that in places the mica is replaced by micaceous specular iron ore, thereby becoming a specular schist, a rock very nearly related to the itaberite of some writers. The Cannon Iron Company's explorations, in which a fair specular slate ore has been found, are located in a highly ferruginous part of this bed. See Spec. 16, App. B, Vol. II. The relations of this rock with the lower quartzite of the North belt, Menominee Iron region, is fully discussed in another place.

I. ANTHOPHYLLITIC SCHIST.—(in bed XVII. and others.)

(See Mr. Julien's descriptions 174 to 178, App. A, Vol. II.)

Immediately below the great mica-schist bed, XIX., and probably separated from it by a stratum of quartzite, XVIII., is a well-defined stratum of a slightly magnetic rock, varying in color from brownish-black to dull slate on fresh fracture, and grayish to blackish in outcrop. It often shows manganese,* and always a fibrous, light-brown mineral, which Prof. Brush, from the examination of some imperfect specimens, decided to be anthophyllite,† a variety of hornblende, and suggested the name here employed for this group.

Numerous outcrops of the rock occur along the north shore of Michigamme lake, and a fine development at the mouth of the Bi-ji-ki river, as well as at the Champion furnace, where layers rich in manganese occur. A specimen afforded Dr. C. F. Chandler 25.2 per cent. of metallic iron, and 4.37 per cent. of metallic manganese. See Specs. 58 and 59, App. B, Vol. II., and 178 App. A, Vol. II.

Below the ore formation XIII., at the Spurr Mountain, are layers of schist of a similar character, a specimen of which afforded Mr. Britton 45.21 metallic iron, 1.78 metallic manganese, 26.36 silica.

* This variety resembles plumbago, and may contain carbon.

† Prof. Dana now regards anthopholite as a distinct mineral.

A moderate increase in the percentage of iron and manganese therein found (which may very likely take place in some part of the bed) might render this rock a workable ore, particularly as the associated mineral is an easily fusible hornblende instead of the silica so common in the other ores. Ores containing 12 to 20 per cent. of manganese need not be rich in iron, to give them merchantable value.

Underlying this formation (XVII.), or perhaps forming its base, is a rock, numbered XVI., which at Champion and on Sec. 26, T. 48, R. 31, shows a tendency to pass into a *limonitic schist*, and may very likely afford workable soft hematite ore in some part of its course. The propriety of giving this rock, about which so little is known, a distinct stratigraphical designation, may be questioned; but its ferruginous character, pointing toward the possibility of commercial value, led to this course.

South of the Washington mine, and therefore stratigraphically below the ore formation,—for the whole dips north,—there is an obscure schistose rock of a gray color, weathering brown, and containing very little iron, often garnets, but made up chiefly of a light brownish fibrous mineral, which is probably anthophyllite, but which in places resembles mica. These rocks are extensive, stretching from the Champion mine eastward to the old Michigan mine. They are generally slightly magnetic, and unquestionably occupy the place of the silicious ferruginous schists of Group B. The diorites associated with them are also peculiar, the two sometimes resembling each other. This obscure series is well illustrated by Specimens 6,086 to 6,099, University of Mich. Collection. See also Specs. 174 and 175, App. A, Vol. II., and 27, App. B, Vol. II. Their affinities are apparently with this group.

J. CARBONACEOUS SHALE.

(See Mr. Julien's descriptions, 246 to 251, App. A, Vol. II.)

The presence of plumbago or graphite (a form of carbon) was noticed in the anthophyllitic schists, last described. Carbonaceous matter has also been observed in various clay-slates, as was noticed in describing the Argillite Group, and we could have placed this rock there as a variety of clay-slate, very rich in carbonaceous matter. It is of a bluish-black color, but burns white before the blow-pipe, marks paper like a piece of charcoal, is soft and brittle, slaty in structure, and is the lightest rock yet found, having a specific gravity of but 2.06.

This rock has been found in the Marquette region only at two localities: 1. The S. C. Smith mine, T. 45, R. 25, where it seems to bound the iron-ore formation on the northeast. See Spec. 6,163, University of Mich. Collection.

(2.) On the south side of Sec. 9, T. 49, R. 33, along Plumbago brook, as will be fully described in the account of the L'Anse Iron range, is a large deposit of carbonaceous shale, a specimen of which gave Prof. Brush—carbon, 20.86; earthy matter, 77.78; moisture, 1.37. Another sample from same locality gave Mr. Britton—moisture and carbonaceous matter, 22.51; oxide of iron, 4.37; earthy matter, 73.12. See Spec. 64, App. B. Vol. II. These analyses prove the material to have no commercial value, but possess scientific interest as proving the existence of a large amount of carbon in the Huronian rocks. The equivalency of these shales with the members of the Marquette series has not been established; they are undoubtedly Huronian, and are, I suppose, younger than the ore formation XIII.

CHAPTER IV.

GEOLOGY OF THE MARQUETTE IRON REGION.

1. Michigamme District.

In describing the geological structure of the Marquette Iron series, I shall begin with the Michigamme district, because its structure is simplest, the iron ranges easily followed on account of their magnetism, and because my explorations and surveys have there been more thorough than in either of the other districts.

The **Champion mine**, 33 miles west of Marquette, is at one of the most extensive, regular and typical deposits of ore in the whole region (see Map No. VII.). The strike is a few degrees south of west, and dip north at an angle of 68°. The extent and nature of the workings at the date of the survey may be seen by reference to the map. Up to this time the mine has produced an aggregate of 225,000 tons of magnetic and slate ore of first quality. The general form of the ore mass is that of a huge irregular lens, or flattened cylinder-shaped mass, which thins out to the east and west to so narrow a width, as not to be workable. The easterly portion of the deposit is black, fine and coarse-grained magnetic ore; the westerly portion is specular slate ore, with a small admixture of magnetite. The local magnetic attractions are very strong and are fully considered in Chapter VIII. The position of the plane dividing the two varieties is approximately shown in the sketch of workings on Map No. VII. The whole mass here described is not, however, pure ore, as may be seen by inspecting plans of the first and second levels on the map. Minor irregular lens and pod-shaped masses of pure ore, "mixed ore" (banded ore and quartz), together with whitish and greenish magnesian schists, alternate like the muscles of an animal, forming, as a whole, a comparatively regular deposit. Overlying the ore on the north side is a hanging wall of gray quartzite, the thickness of which is considerable, but could not be accurately determined on account of the drift. Immediately south of the ore, if it may not be regarded as a part of the ore formation, is a banded jaspery or quartzose rock, containing some iron. Next south, and underlying the whole ore formation, as may be seen by an outcrop near the east end of the mine, is a bed of diorite ("greenstone"); this rock in places becomes schistose and chloritic in character. South of the diorite is a silicious schist and then a swamp. The arrangement of these beds may be seen in geological section A—A," on the map, where they are numbered in Roman numerals X. to XIV., the latter designating the quartzite.

Following the Champion range east one mile, we arrive at the **Keystone Company's mine,*** where but little work has been done, and the arrangement of the rocks in consequence not so easily made out. A small bed of magnetic ore was opened at this locality two years ago, and what is said to be a large deposit of specular ore has but just been discovered on the same place. Five hundred feet north are a number of outcrops, indicating the presence of a heavy bed of conglomeritic schist, which holds masses of quartzite, varying in size from pebbles to others two feet by one thick, and even larger. It also contains flattish fragments of various schists and slates. Further north it passes into a brownish schist, containing pebbles of quartzite. This rock is believed to correspond with the overlying quartzite of the Champion, and is marked XIV. on the map and sections. North of this, and exposed in the railroad cut, is a micaceous slate, containing garnets, marked XV., and represented by Specimen 56, State Collection, App. B, Vol. II.

North and west of this locality, about one-fifth of a mile, are a number of test-pits, in many of which is exposed a soft, brownish, ferruginous rock, which affords hand specimens of soft hematite ore. This rock is marked XVI., and is represented in the State Collection by Specimen 57, App. B, Vol. II. Immediately south of the Keystone workings is a specular schist or conglomerate, in which flattened pebbles, or very uneven lamina of quartz, are contained between thin layers of micaceous specular ore. This formation is believed to be the equivalent of XII. of the Champion mine section, and is so numbered on the map.

West and south are numerous extensive outcrops of a brownish banded magnetic schist, marked X. on Section C—C", Map VII.

* Late "Parsons Mine."

The arrangement and character of the rocks along the intermediate section, B—B,' will be sufficiently understood from the above descriptions and an inspection of the map. The other formations represented will be considered in another place.

At the **Spurr and Michigamme mines** we find rocks identical in their general character and sequence, although the order is reversed, this series being on the opposite side of the basin from the Champion. Projecting all the facts observed along the north shore of Michigamme Lake on one plane, which we will assume to pass north and south through the Spurr Mountain mine, the following Geological Section is easily made out:

Commencing at the most southerly and uppermost bed (the whole series dips to the south), we have, first, a comparatively soft, grayish and blackish flaggy rock, containing considerable iron, a little manganese and often made up largely of a hornblendic mineral, which occurs in needle-shaped crystals. Professor Brush calls this rock anthophyllitic schist. See Specimens 58 and 59, State Collection, App. B, Vol. II., and Chap. III.

This rock is numbered XVII. on geological section No. 9, map of the Marquette Iron region, which see. It is also well exposed at the mouth of the Bi-ji-ki river, in the railroad cut just east, at the Champion furnace, and at numerous projecting points along the north shore of the lake.

The next rock to the north, in descending order, (numbered XVI. on the map and section,) on account of its tendency to decomposition, has never been seen in outcrop; it is exposed by the explorations for ore, made on the north side of Sec. 26, T. 48, R. 31, and at the Champion; its character was indicated in describing the Champion series, and need not be repeated here. As will be seen, this rock has the same number in each section, and the two exposures are believed to belong to the same bed. It is not improbable that future investigations may prove it to be a variety of the ferruginous anthophyllitic schist XVII., already described, a point which was considered in Chapter III., Group I.

Next below is a dark-colored clay-slate, which also, on account of its softness, is seldom seen in outcrop. It is, however, exposed on the point in northeast part of Section 29, and at other places along the north shore of the lake. On the Spurr mountain, geological section No. 9, this formation is numbered XV., and is believed to underlay the swamp and creek immediately south of the mountain which finds easterly prolongation in Black bay. As will be seen by reference to the Champion sections, this rock is regarded as the equivalent of the micaceous clay-slate XV., there described.

North of this clay-slate, and immediately overlying the ore at both the Spurr and Michigamme mines, is a quartzose rock numbered XIV., which is in places a hard conglomerate, and again, especially when in contact with the ore, a fine whitish sandstone. See Specimen 52, State Collection, App. B, Vol. II., and Julien's descriptions, Specs. 358 and 359, App. A, Vol. II. This rock is unquestionably the equivalent of the upper quartzite XIV. of the Champion section, which, on the whole, it closely resembles in its lithological character. See also Group E, Chapter III.

The prevailing variety of ore of the mines on this range is a fine-grained, somewhat friable, rich, blackish magnetite. See Specimens 40 and 41, State Collection, App. B, Vol. II., and also Iron Ores, Chap. III. There is also at the Michigamme mine a hard, fine-grained, steely magnetic ore, in considerable quantity. Analyses of these ores will be found in Chapter X. The surface indications, magnetic attractions, explorations and mining operations but just commenced, point unmistakably to large deposits of high grade magnetic ore at both localities.

The **Spurr Mountain** is an east and west ridge, the summit of which is 118 feet above Lake Michigamme and 75 feet above the creek, which passes south of it. This ridge terminates abruptly to the west near the centre of the northwest ¼ of the southwest ¼ of Sec. 24, T. 48, R. 31, where there is a natural exposure of merchantable ore 40 feet thick horizontally, being the largest outcrop of pure magnetic ore I ever saw. Mining operations, just begun, have demonstrated the thickness to be still greater, and the deposit to extend at least several hundred feet east and west, with a probability, based on magnetic attractions, of its extending much farther. The bold face, small amount of earth covering, softness of the ore, its apparent freedom from rock, convenience of the railroad and accessibility, present facilities for mining and shipping, which could not well be surpassed. The magnetic observations made at this locality, where the attractions were remarkably strong, are given with illustrative diagrams in the special chapter devoted

to that subject. It is easy by means of the dip compass, to follow this iron range two-thirds of the distance along the north side of Michigamme lake, and west-northwest from the Spurr to the First lake, an aggregate distance of over nine miles, as may be seen by the map of the Marquette Iron region, No. III. It must not by any means, however, be supposed, that here is a workable deposit of ore nine miles long; this has not been proven, but on the contrary, it has been proven that for a considerable portion of this distance the ore is not workable, having altogether too large an admixture of rock. Therefore, while it may be confidently asserted, that all of the rich hard ore which will be found in this vicinity, will be in or near the belt of magnetic attraction already described, it may be asserted with equal truth, that at least three-fourths of the whole length of this belt is barren ground, according to the present standard of merchantable ore. The law of the distribution of the rich "chimneys," "shoots," or "courses of ore," as they are designated in different mining regions, along a given iron range, has not been made out. The subject is more fully considered in Chapters VII. and IX.

Besides the deposits already described on this range, one other has to be mentioned, that on the east side of railroad Sec. 23, adjoining the Spurr on the west. The magnetic attractions here are remarkably strong, and explorations have revealed the existence of a small workable deposit of first-class magnetic ore. Whether this deposit connects with the Spurr or not, was not fully determined.

As has been remarked, both the granular and compact varieties of magnetic ore occur at the **Michigamme mine.** The explorations on this location, which were conducted by the writer, developed in a distance of 1,200 feet, east and west, seven places, where pure ore existed of a thickness of from seven to thirty-five feet, rendering it probable, that the ore deposit is continuous and workable for the whole of this distance. Mining operations, which have commenced at this location, confirm these results. Pure ore was found in place at two points on same range west, on Sec. 19 of the Michigamme Company's property, but not enough work was done to prove their extent. Eastward the ore can be traced by the magnetic needle into Michigamme lake, on the south side of Sec. 20.

There can be no doubt these deposits and the Champion belong to the same horizon, being the opposite croppings of the synclinal basin, which passes under Michigamme lake; although the Champion deposit has not been traced westward, nor the Michigamme range eastward, to points where they come directly opposite each other. Whether the specular slate ore found so abundantly at the Champion will be found on the north side of the lake, remains to be seen. I see no reason why it should not; the explorations, so far, have been based entirely on magnetic attractions, and would therefore not be likely to result in finding specular ore.

Underlying the pure ore here, as at the Champion, is a ferruginous quartzose rock, which has an immense development on the Spurr-Michigamme range, where it is a well-characterized reddish quartz schist (jasper), containing thin layers of pure specular ore; these layers being occasionally thick enough to afford hand specimens. See Specimen 33, State Collection, App. B, Vol. II. A similar rock found, as will be seen hereafter, at the Republic mountain, where it has the same relative position and number, XII.

Underlying this iron series we find, as at the Champion, a diorite (greenstone), but which here has a much greater development, forming a conspicuous ridge which borders the Michigamme and Three Lakes valley on the north, and which has already been described under Topography in Chapter II.

This greenstone ridge is separated from the granite region to the north by a valley about half a mile wide, which is underlaid by various schists and quartzites, about which little is known. Two are marked X. and V. on the Spurr-mountain section No. 9.

The most easterly developed mines in the Michigamme district are the **Washington** and **Edwards,** represented by map No. VIII. The general structure, which we are now considering, can be easiest made out at the Edwards and "old mine," which are adjacent, and about three-fourths of a mile west of the Washington mine proper. The general character and order of the ore and accompanying rocks at this locality is so similar to that of the mines already described, that a careful inspection of the map and accompanying sections leaves but little to be said. The Upper Quartzite XIV. is fully exposed in outcrop, as well as in the railroad cut, just west of the mines, where it is a coarse conglomerate, often schistose, as is shown by Specimen No. 51, State Collection, App. B, Vol. II.

The same formation is a compact gray quartzite at the Edwards mine, and at other points in the vicinity.

The ore formation XIII. affords at this group of mines all the varieties, already designated as being found at the Champion, Spurr, and Michigamme mines. Like the Champion, here are intercalated beds of magnesian schist, the arrangement of which are shown on the sections of workings given on the map already referred to, as well as in the plan of the Edwards mine, by A. Kidder, Plate XIX., Chap. IX., where the subject of detailed structure is more fully considered. One of these schists, of a decided talcy character, is represented by Specimen 54 of State Collection, App. B, Vol. II.

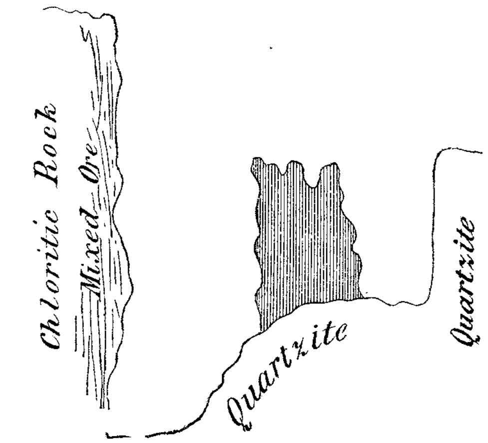
The underlying ferruginous quartzose rock, XII, has a large development south of the Edwards mine, and to it probably belongs the "red ore" of the old Washington. Southwest of the latter mine are large exposures of the peculiar conglomeritic specular schist, mentioned as occurring on the Keystone property, east of the Champion.

The dioritic formation, XI., is represented by a large outcrop of a greenish schistose rock, apparently chloritic, which can be seen immediately south of the old mine. Below this formation are alternating schists and diorites of different varieties, which are sufficiently well shown on the map and sections. One of the most interesting varieties is represented by Specimen No. 27, State Collection, App. B, Vol. II., procured 500 feet south of Pit No. 9, Washington mine.

The Washington mine proper presents some of the most complicated structural problems, to be found in the Marquette region, and I will not here either attempt their solution, or even advance the hypothesis which I have formed. Suffice it to say that, in general, the mine is a monoclinal deposit, dipping away from the St. Clair mountain (which term I apply to the high ground to the south) to the north and under the great swamp. The minor rolls, the peculiar faulting at the East Hill, and the trap dykes, would, if fully considered, occupy a chapter.

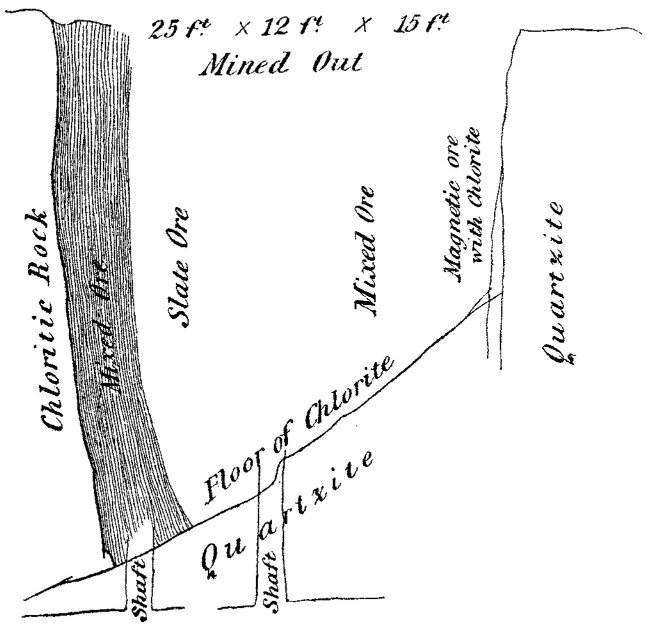
I cannot, however, pass to another mine, without noticing the singular manner in which the mass of ore, known as Anderson's cut, or Pit No. 1, is terminated in its downward course, as shown by Figs. 3 and 4. It will have been observed, that the usual form of ore masses is *lenticular, i.e.*, they generally terminate by *wedging* *out* more or less gradually each way. This exceptional mass, as will be seen, is obliquely and abruptly cut off, the bottom rock be-

Fig. 3.—Looking East.



ing a quartzite of the same kind, that bounds the deposit on the north, and there is no evidence of faulting on the plane of this floor,

Fig. 4.—Looking East.



or along the quartzite wall. An hypothesis to account for this phenomena, based on a sedimentary origin for these rocks, will readily suggest itself and need not be stated.

The **Republic mountain** and its prolongation on the Kloman lot, is the only remaining ore deposit of the class under consideration, which remains to be described in the Michigamme district. See map No. VI. The **Magnetic mine** group, embracing the Cannon and Chippewa locations, belong to a different geological horizon, produce different ores, and will be considered hereafter.

The immense mass of pure specular ore, which was naturally exposed near the centre of the north ½ of the southeast ¼ of Sec. 7, T. 46, R. 29, could leave no reasonable doubt in the mind of the experienced observer, that this deposit of ore was one of the largest, if not *the* largest, in the Marquette region. This outcrop, the extent of which is shown on the map of the Republic mountain, being there marked "pure specular ore," is, so far as I know, the largest outcrop of any equally rich ore, ever found in the United States.

The elevation of the ore, 120 to 150 feet above Michigamme river, gives an unsurpassed opportunity for mining operations, which began in the spring of 1872, and confirm, as far as they extend, the "surface show." Several other small outcrops of pure ore occur in the iron belt, one of the largest of which is near the centre of the Kloman mine lot, in southwest fractional ¼ of Sec. 6, same Township.

The numerous outcrops of rock and ore at this mountain, the strong magnetism possessed by three of the beds, the remarkable uniformity in thickness of the several formations, and the bold topographical features presented, all of which were carefully surveyed and are faithfully represented and explained on the accompanying topographical, geological, and magnetic maps and charts (Plates VI. and XII. Atlas), leave but little more to be said in this place, regarding the general structure of the Republic mountain.

The lithological character of the rocks and ores will also be fully understood from the 14 specimens from this locality, which are embraced in the State Collection, App. B, Vol. II. The ten formations represented by colors on the map, as composing the Huronian series, will now be enumerated, commencing with the lowest, which reposes non-conformably on the Laurentian granites and gneisses.*

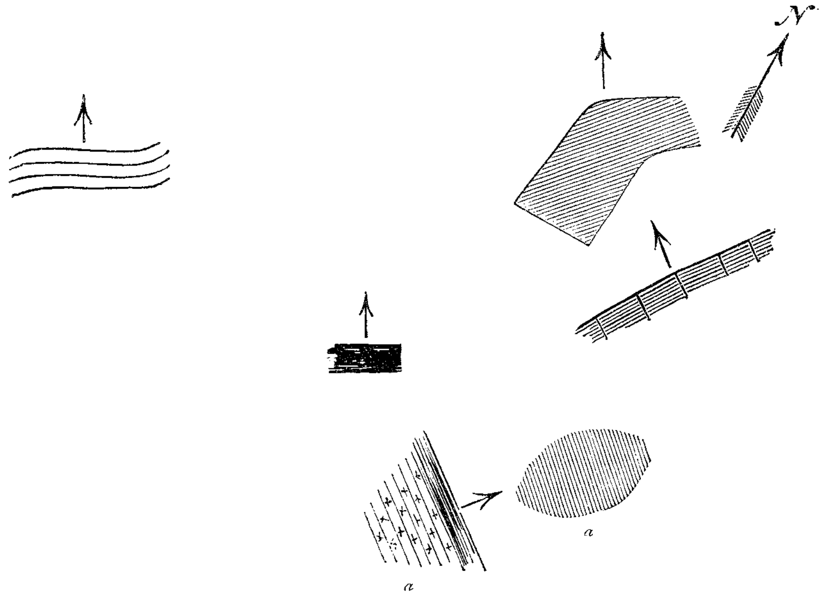
The lowest bed of the se s will be numbered V., for reasons which will hereafter appear.

V. A quartzose rock, which is exposed at but a few points, and is best seen near 4,600 southwest and 6,200 southeast (see rectangular ordinates on map), from which locality Specimen 8, State Collection, App. B, Vol. II., was obtained.

VI. Is a magnetic, bright, banded, silicious and chloritic schist, containing considerable iron. See Specimen 15, State Collection, App. B, Vol. II., from near locality of Specimen 8. Very large exposures of this schist occur on the northeast side of the mountain, and southeast of Bear lake. The regular, various-colored stripes,

* This sketch (6,100 southeast and 4,700 southwest, Map VI.) represents outcrops of Huronian quartzites and schists dipping north-northwest, and the Laurentian gneisses, *a a*, dipping northeast, the latter being within 50 feet of the former. The actual contact is not seen, but the stratigraphical relations indicated, in connection with the wide difference in

Fig. 5.



their lithological character, leaves no doubt in my mind of the non-conformability of the two systems, the Huronian being the youngest. This non-conformability can also be observed on the L'Anse Range. See page 156.

which this formation, as well as VIII. and X. displays, strongly suggests a rag carpet. The greenish layers are apparently chloritic, the whitish and grayish are quartz, and the brown and dark gray are silicious layers of the red and black oxides of iron. Some of these lamina are quite pure iron ore, and the whole mass may contain from 15 to 30 per cent. of metallic iron. The magnetic power displayed by these schists is remarkable, as will be seen by inspecting the charts and explanatory text already referred to.

VII. Is a diorite of the general character of those, so fully described by Mr. Julien in App. A, Vol. II., as will be seen by reference to Specimen No. 18, State Collection, App. B, Vol. II.

VIII. This magnetic silicious schist in its lithological character differs in no essential particular from No. VI., already described. See Specimen No. 19, State Collection, App. B, Vol. II. This formation is noticeably thin, not exceeding 40 or 50 feet, the other beds being from three to five times this thickness, as can be seen on the map.

IX. Is a Diorite similar to VII. See Specimen No. 22, State Collection, App. B, Vol. II.

X. A magnetic silicious schist similar to VIII. and VI., but containing in places more iron, as at 5,600 southeast and 2,500 southwest, from which locality Specimen 23, State Collection, was obtained. This, it will be observed, is a fair specimen of magnetic flag ore, containing probably 45 per cent. of metallic iron.

XI. This formation is made up of a coarse-grained diorite, in which a light grayish and reddish feldspar is a conspicuous ingredient, as may be seen on the Kloman lot, as well as at the knob southwest of Bear lake, from which Specimen No. 29, State Collection, App. B, Vol. II., was obtained.

A schistose variety, containing considerable black mica, occurs in the same formation, at 3,400 southwest and 5,300 southeast, where Specimen No. 30, State Collection, was obtained, although it does not truly represent the prevailing variety at this locality.

XII. This is a reddish quartz or jasper schist, containing thin lamina of specular ore, and very similar to the corresponding formation of the Spurr mountain series already described, as will be seen by an examination of Specimen 32, State Collection, App. B, Vol. II.

XIII. We have now reached the iron-ore formation, the principal