but generally these immense quantities of iron oxide combined with the rock-masses are not concentrated into seams of larger size, as the miner wants them, but are either uniformly dispersed through a siliceous ground-mass, not in a quantity to overbalance the siliceous matter enough, to make it harmless in the smelting process, or the really pure seams of ore are narrow, constantly alternating with low graded quartzose seams which make them unavailable for practical use. There is no particular horizon in this large succession of iron-bearing rock-beds, in which an ore-seam could be expected in preference to another; throughout the whole era in which these sediments were forming, never a lack of iron oxide existed which would have prevented the formation of an ore-belt, but the formation of such a belt depended only from a proper sifting of the heavier from the lighter molecules, induced by temporary and local conditions favoring this sifting process, which did occur at various times and in various places within restricted limits. A rich seam of ore, found in a certain position in one place, is therefore not at all a reliable proof of the occurrence of a similar seam in a correspondent position in a continuation of this group of ledges a quarter mile off from that spot; this may be so sometimes, but just as often it will happen that we meet with a low-graded, worthless siliceous ore in the place of the rich. Geology teaches the miner where to hunt for a thing and where not, but there is another factor in such calculations, which the wisest scientist cannot foretell. Nature is no stereotype impression after a certain mould; we have to study it in every place for itself, and where our wisdom will not reach, the pick and shovel, handled by a crafty arm, often will.

Exposures of the before-mentioned limestones inclosing tremolite crystals, are found at the base of the bluffs, formed of the upper siliceous division of the ore-formation in the S.W. quarter of the N.E. quarter of Sect. 31. A belt about 60 feet wide projects there, with vertically erected ledges. Next north and south of them are argillitic mica schists of red color, and a few steps farther on the north side the banded siliceous lean ores begin to emerge. A similar limestone exposure is found a quarter mile east from this place, also on the south side of the banded lean ores. The other red-colored dolomitic limestone, intermingled with micaceous seams, occurs in the bottom of test-pits opened in the

N.E. corner of the S.E. quarter of Sect. 36, Town. 42, R. 30. Going westward on the road across Sect. 36, we see on the north side a number of other test-pits opened in the banded siliceous lean-ore belt; to the left, in the south half of the S.W. quarter of Sect. 36, we see on the top of the hills large exposures of quartzite, which dips in different directions, and on its north side is a thick belt of micaceous quartz schists splitting in very even slabs, covered with large silvery mica scales on the cleavage plains. This schistose belt amounts to several hundred feet, and its beds stand vertical. North of it I notice a limestone belt indicated on Major Brooks' map, but I did not go to the spot to see it. I found, however, a large exposure of the white tremolitic limestone, near the centre of the west half of Sect. 34 and the micaceous quartz schists in contact with it. Leaving the S.W. corner of Sect. 36, and passing with the road across Sects. 2 and 3 of Town. 41, R. 30, we see on both sides large granite exposures; farther on, toward Badwater village, all the surface is covered with boulder-drift, but in a trip which I made across the centre of Sects. 17, 16, 15, 14, and 13, of that town, I found everywhere the granite to underlie the drift-masses. In the S.E. quarter of Sect. 17 are large bluffs of quartzite near a little lake, but I have not followed them to examine their extent.

Below Badwater village are exposures of schistose and massive diorites in the bed of the river, and high bluffs of them are near the mouth of the creek entering Menominee River at the N.W. corner of Sect. 32, Town. 41, R. 30. Before we follow these exposures and others below, I will lead the reader some distance up stream, to see an interesting series of sedimentary rock-beds, whose relative position to the other strata we have become acquainted with, I have so far not been able to ascertain positively. According to Major Brooks' views, these represent the upper horizon of the Huronian group, equivalent with the staurolitic mica schists of the islands in Lake Michigamee and the next lower strata. The lithological character of the mica schists, which occur at the falls of the Michigamee River, and also near the mouth of Brule River at its union with Paint River, is indeed very similar to the mica schists in Michigamee Lake; but I leave this question open until I have had a chance to examine this group of rocks, and their connection with other rocks in the Menominee region

more carefully, than by mere reconnoitring, as, for lack of time, I had to do this first time I saw them.

Rowing up the river from Badwater, we find the first rock-exposures near its intersection by the west line of Sect. 30, a short distance north of the quarter-post ; in the bed of the river and in the embankment of both sides the strike of the strata is north-north-west, their dip under a high angle west and correspondingly south. Lowest are greenish-gray colored schists composed of a gritty ground-mass of feldspar and quartz granules in intermixture with sericite, which gives it a silky lustre. Next above follows a large belt of a compact rock, cleaving in very even-faced rhomboidal blocks, partly of reddish, partly of greenish-gray color, with a gritty granular fracture. It consists of a quartzoso-feldspathic sub-crystalline mass, intimately mingled with glistening, very minute scales of sericite, or also perhaps chlorite in the greenish-colored ledges. Above this belt follow again sericite schists of dark gray color, some soft, very fissile, and much corrugated into larger plications, and also into very minute parallel wrinkles, visible on the glistening cleavage plains of the schists ; others of the strata are harder and less fissile by the larger proportion of quartzose and feldspathic substance in their composition ; some of the beds are also richly impregnated with hematitic pigment. These last-described beds are exposed on the Wisconsin side of the river. Farther up are for a while few exposures on the river, but the compact quartzoso-feldspathic rock-ledges are in several places seen to crop out farther back on the hill-sides of the Michigan shore. In the S.E. quarter of the S.E. quarter of Sect. 23, near the east line of the section, a large dioritic, or may be diabasic belt projects in cliffs at the water's edge ; it is a dark black rock, consisting of black hornblende crystals and of white semi-translucid feldspar crystals plainly discernible with the naked eyes. On the opposite Wisconsin shore are other outcrops of black, compact rocks of granular structure, composed of white quartz granules in intermixture with a very large proportion of black magnetite crystals, which compose at least half the bulk of the material. The compass needle is strongly attracted by it.

A short distance above, on the Michigan side, and on the group of islands in the north half of the S.E. quarter of Sect. 23, are again large exposures of the compact quartzoso-feldspathic rocks

and sericitic schistose layers identical with those first encountered near the west line of Sect. 30 ; they strike north-west, and dip southward. Farther on, in the S.W. quarter of the N.E. quarter of this same section, are large bluffs of an equivalent but coarser-grained rock, which shows more plainly than the others its origin from a sedimentary sand-rock ; it has a glistening glassy fracture, on which large quartz-grains of an opaline milky hue are discernible among others perfectly translucid. Other high cliffs of the same kind of rock, associated with seams of schistose structure from intermingled sericite, occur on the Michigan side in the N.E. quarter of the N.E. quarter of Sect. 22 ; they strike east and west, dip south. After passing from here a bend of the river, we find a short distance off other large exposures on the Wisconsin side, which differ considerably in aspect from the former, but essentially consist of the same feldspathic quartzose granular ground-mass in intermixture with much sericite, which gives to all the beds a schistose structure, but the principal difference consists in a large proportion of sparry carbonate of lime combined with the rock substance, and also in separate seams of saccharoidal grain. These schists exhibit a much distorted, corrugated, or a shattered condition ; they are hard, not fissile, and resemble certain schists found in connection with the dioritic rock-group near the upper Quinnesec falls.

Higher up, on the Wisconsin side, in the N.E. quarter of the N.W. quarter of Sect. 22 (according to the Michigan town subdivision), are very compact massive rocks of a greenish-gray color, and a minutely crystalline grain, which I consider to be diorite, as small hornblende crystals are plainly discernible constituents of the rock-mass, which, like the other beds of the mica schist series, contains sericitic or micaceous scales intermingled.

Onward comes another group of islands, and from there up to the falls of the Michigamee River are, on both sides of the river, continued exposures of the mica schist formation, with inclosed large belts of the harder quartzoso-feldspathic and micaceous compact rocks. The strike of the formation north of the islands is east-north-east, dip south ; the same strike and dip of the strata is observed at the falls of the Michigamee. It would be a useless repetition to give a special description of the rocks at the falls of the Michigamee, or of those above the islands near the quarter-post, between Sects. 15 and 16. They agree perfectly with the

before-described equivalent beds first seen on the west line of Sect. 30, Town. 41, R. 30, but are much more extensively exposed, and the micaceous schists are more even-bedded, richer in mica, and consequently have a much brighter silvery lustre than in the more southern exposures. Entirely similar rocks as those at the Michigamee Falls are found near the mouth of Brule River, at which locality the immense thickness of the formation can be observed by climbing from the river-bed across the strata up to the top of the hills. The strata dip under a high angle to the south, toward the hills on the other side of the Brule, which on their south side consist of diorite ; the north slope of them I have not examined.

From the falls of Michigamee River I followed the Menominee River farther on upward, which bends from here south-west. About 200 steps west of the fork of the two rivers commences, on the Michigan side, a long series of exposures of schistose beds, differing from the mica schists at the falls, and evidently representing another horizon of the same group of sediments, as a considerable similarity exists in the nature of the rock-material ; but as in this locality the strike and dip of the strata changes so very often, and frequent interruptions in the exposures occur, it is hard to determine the order in the succession of the beds, without making more detailed examinations of the surrounding country, than I had the time to do. The strata at the falls strike west-south-west and dip south ; the strata in the exposures a few hundred steps west of the forking of the rivers strike west-north-west, and dip north ; and soon after we find the strata to dip south, retaining the same direction in strike with the others ; subsequently we find, at the first rapids we meet, the strike of the strata to be north, and the dip in some places west, in others east. The schists are associated with massive dioritic rocks, which come to the surface in various places, evidently from beneath the schists. The schists themselves vary considerably ; a part of them is fine-grained, quite fissile, even-bedded, or corrugated, silky-shining, of lighter or darker gray or greenish-gray color, and consists of a homogeneous finely granular feldspathic and quartzose ground-mass, intimately mingled with the impalpably fine sericitic or micaceous scales. Other schistose beds connected with the sericitic are harder, less fissile, and less homogeneous, usually darker greenish colored and

of little lustre ; the sericite is in them replaced by a coarser scaly dark green mica, and in part sometimes by chloritic scales ; also the feldspathic and quartzose ground-mass is coarser grained, or forms separate lenticular seams, interlaminated with the micaceous. Some of them are disseminated with crystals of carbonate of lime, or calcareous seams are interlaminated, and other portions of the schistose layers are found impregnated with hematitic iron oxide. The diorites in these exposures are dark blackish-colored, sufficiently coarse-grained to distinguish the component minerals, of which the dark fibrous hornblende prevails considerably over the feldspar. All contain also a small proportion of carbonate of lime, besides micaceous scales, and an intermixture of granular quartz is often observable. I went as far as to the centre line of Sect. 17, where both sides of the river are bordered with dioritic rocks, and then returned, seeing that I had to make good many further researches before I would attempt to express a positive opinion regarding the relative age of this group of rocks. Major Brooks asserts the identity of these mica schists and quartzoso-feldspathic gneissoid rocks with the staurolitic mica schists of Michigamee Lake. As the next lower strata, younger yet than the Lake Hanbury slates and the Quinnesec iron-formation, which, as we learn from his report, are placed above the Norway limestone belt, he considers the dioritic rocks exposed at the Twin falls, at the Quinnesec falls, and lower down the Menominee River, giving as his reason the parallelism of the dioritic rock-belt with the ore-formation, which dips to the south in conformity with the diorite on its south side. For the same conformity in dip, Major Brooks declares the granites and gneisses north of the Felch Mountain ore-range as younger than the ore-formation, which like them dips northward ; but their superposition on the ore-formation is nowhere observable ; on the contrary, the south side of the ore-range exhibits in several places the direct superposition of the ore-formation on the granite. This fact is known to Major Brooks, but he solves the dilemma by identifying the granites on the south side of the Felch Mountain ore-formation with the Laurentian ; those on the north side, he claims, represent the youngest Huronian rocks. How he could do so I cannot conceive, as the concerned granitic and gneissoid rocks north and south of the ore-formation are so absolutely identical, that no

one who ever sees them can doubt for a moment the equality in the age of these rocks. Moreover, this identification of the northern granite with the upper Huronian, and of the southern with the Laurentian, implies another abnormity; groups of rocks, usually separated from each other by thousands of feet of intervening strata, are in this case thought to be in immediate superposition, which does sometimes occur, but not in coincidence with another improbability like the one stated in this instance.

Examining the relative position of the dioritic rock-series to the iron-formation in the southern part of the district, we find these two groups rarely in contact, and then usually so incompletely exposed as not to allow the positive observation of their stratigraphical relations. The diorite belt exposed at the Twin falls, which has as far as ascertainable a southern dip, extends without interruption for six miles eastward from the river, and on the south side of this belt we can observe all along the iron-formation, likewise with a southern dip. The contact of the formations is not seen, on account of the deposition of Silurian sandstone ledges and of heavy drift-masses over the surface.

Following the western extension of this diorite belt into Wisconsin, we find it there, in the centre of Sect. 8, Town. 39, R. 19, in direct contiguity with the ore-formation of the Commonwealth mines, which, as above stated, has its position above the Quinnesec ore-formation; but in this instance also of well-exposed contact nothing definite can be made out, as the strata adjoin in a vertical position. South of the Ludington mines I mentioned on a previous occasion the occurrence of sericite schists, belonging to the lower horizon of the ore-bearing formation which dip to the south, and near by, south of them, in the N.W. corner of the N.E. quarter of Sect. 36, Town. 40, R. 31, we find low hillocks of diorite, but there also nothing can be proved; the dioritic rocks generally play the part of an intrusive rock with regard to the strictly sedimentary rock-beds of the Huronian series. A superposition of the diorite formation on the Lake Hanbury rock-series, which adjoins it the whole length of the Menominee valley from the upper Quinnesec falls to the Sturgeon falls, asserted by Major Brooks, is not observable; the nearly vertical strata of both formations are even never seen in contact. There is always quite a large covered interval between them. The nearest exposures of the two groups are observable in Sect. 26, Town. 39, R. 29, where, in the centre of the section, a hill is formed of the vertical ledges of ferrugino-siliceous flagstones and slaty beds representing the Lake Hanbury series, and about two or three hundred steps from these exposures we find, on the south side of the road to Menominee, small hillocks of diorite. Major Brooks has identified these slates with the iron-formation of the Commonwealth mine, but I see no justifiable reason to do so. The Commonwealth ore-formation, wherever it occurs, is invariably connected with graphitic schists, of which in the Lake Hanbury series none are found. Giving a description of a cross-section from the Norway mines northward, I have previously stated the occurrence of graphitic schists, in association with iron-ore seams beneath the limestone formation, but according to my theory actually above it, which position I assign also to the Commonwealth ore-formation, on the strength of its lithological similarity with the rock-series north of the Norway mines; the limestones are rarely seen in that district. Still there are on Brule River, south-west of Chicagon Lake, large bluffs of limestone to be seen in close connection with exposures of this ore-formation, and evidently beneath it.

My reasons for holding the dioritic rocks south of the iron-formation as older than the latter, are based on the lithological similarity of this formation with the dioritic group of the Marquette district, and on the degree of metamorphism exhibited by the two groups, the dioritic and the iron-bearing. In the great succession of strata commencing with the Hanbury slate group and upward, we rarely find a bed so much altered that its sedimentary structure is altogether obsolesced, and the majority of the strata shows it very plain, while in the dioritic rocks, considered to be the younger, a stratified structure is also recognizable, but not one of these thousands of feet of ledges exhibits its original sedimentary lamination with any degree of distinctness like the others; they have evidently been transformed under co-operation of heat, and partially brought into a plastic condition, which is shown by the extreme corrugation and mode of intermixture of these rock-masses, of which effects the other rock-groups do not exhibit near as high a degree. It would be very strange, then, if the lowest beds, nearest to the focus of the central heat,

should have been so much less affected by these altering influences, than those pretended to be the higher upper strata of the rock crust. One might object: If the diorites are the older beds, why don't we find them just as well developed on the north side of the upheaved beds, between the quartzite and the granite? The sandy and conglomeratic nature of many of the strata of the quartzite and iron formation proves them to be shore deposits, while the dioritic group consists only of the finer material of deep-sea deposits, which explains the point in question. Moreover, the dioritic rocks are not altogether missing on the north side of the ore-formation, as we can see by the occurrence of the six-mile-long chain of diorite extending eastward from the Twin falls. A similar discrepancy between the rocks underlying the ore-formation on the two opposite sides of its exposure, is seen in the Negaunee district. On the south margin, at the Cascade and Palmer mines, it rests directly on the granite, while on the northern exposures the diorite underlies it in great thickness.

The equal dip of the strata to the south in these adjoining formations is not necessarily a proof of the younger age of the most southern beds. The whole succession is so near to a vertical position that in many instances it has to be left uncertain which way they dip, but suppose their dip is conformably to the south; the upheaval of the diorites by the eruption of the still more southern granite masses pushing the whole incumbent rock-series north, until all tipped over, is the hypothesis by which I explain the order in the succession of beds as an inverted one, the seemingly lowest beds being actually the youngest. But let us go and see these rocks from place to place, instead of making general speculations. The large body of dioritic rocks exposed in the Menominee River and its embankments below Badwater village, and continued to the upper and lower Twin falls and to the four-foot falls near the railroad bridge across the Menominee, have all one common character; they are dark greenish-gray or blackish-colored, partly schistose, and even slaty, partly massive, coarser or finer grained crystalline rocks, consisting all of a feldspathic ground-mass in intermixture with a dark green mineral, recognizable in the coarser grained rocks of crystalline structure, as hornblende, and in addition to it, with a minutely scaly mineral considered to be chlorite, but often nearer to mica or hydro-mica.

By differences in the proportions and in the molecular condition of these three components, a great variety in the aspect of these rocks is caused.

The micaceo-chloritic constituents are more abundant in the schistose strata, than in the crystalline massive form of the rock, which is generally middling fine-grained, not much differing from the diorites of the Marquette district. The hornblende crystals are somewhat fibrous, of bright lustre; they overbalance in quantity the white feldspathic ground-mass most generally, wherefore the rock has so dark a color; still pale green beds of finer grain also occur in which the feldspar considerably prevails over the hornblendes. Iron pyrites granules are constantly found dispersed through the mass; less common is the intermixture of magnetite granules.

Among the rock ledges exposed at the lower Twin falls I observe a thick belt of an aphanitic compact rock with flinty fracture, which consists of a pale green amorphous feldspathic ground-mass, semi-transparent in thin splinters, impregnated with an abundance of very minute chloritic or hydro-micaceous scales, so distributed in layers as to give the rock on cross fractures a most minutely lineated structure, parallel with the bedding; by cleavage cracks the rock divides into rhomboidal blocks with very even surfaces. The dip of the strata at the lower Twin falls is to the south, but in places the position of the beds is vertical; at the upper Twin falls the dip is northward, also nearly vertical. At the upper Quinnesec falls the dip of the strata is southward, in correspondence with the west-north-west trend of the formation, and approaching a vertical position. In the most northern exposures on the Michigan side, below the falls, are dark green-colored, partly schistose, partly massive crystalline rocks, not differing from the dioritic rocks of the Twin falls or the four-foot falls; north of them are drift-covered terraces which extend for over a mile northward to the foot of the Quinnesec ore-range. On their south side follows a large series of much lighter-colored, grayish-green, in certain seams porphyritic schists, inclosing well-formed orthoclas crystals within their mass; they are composed of a granular feldspathic body-substance in intermixture with an abundance of hydro-micaceous (paragonitic) scaly seams, and with a considerable proportion of carbonate of lime; also dimly defined pale green horn-

blende crystals are intermingled. A part of these ledges occurs in more even-bedded flaggy layers, which are the ones exhibiting the porphyritic character most distinctly.

Other beds, generally much corrugated, consist of an irregular wedge-like intermixture and alternation of micaceo-feldspathic seams and sparry laminæ ; still others are obscurely schistose, hard bulky rock-masses of the same micaceo-feldspathic and calcareous composition, in which large milk-white, ill-defined sub-globular concretions of feldspar are dispersed, which make them resemble a conglomeratic rock, and certain beds are crowded with poorly defined light green hornblende crystals. Next to them follows, on the south side, a belt about 100 feet wide, of very well stratified thinly laminated rocks of silky lustre ; some are gray, much corrugated, and consist of greenish-white semi-translucid laminæ of feldspar composition of one or two millimetres' thickness, in alternation with equally thin seams of hydro-mica. Here and there are quartz-grains as big as a lentil or pea wedged in between the laminæ ; they have no crystal facets, are rounded on the surface, and coated over with hydro-mica. Another series of beds intimately connected with them has a pale red color, consists of the same alternation of laminæ of feldspar and hydro-mica, but the feldspar is orthoclas ; the intermixture of quartz-grains is in them more abundant than in the former, and in the micaceous part of the laminæ are numerous clusters of fine needles of black turmaline ; also larger red feldspar crystals are sometimes observable. Another modification of the same schistose rock-belt is harder, less fissile, still consisting of a succession of thin laminæ with large quartz-grains wedged in between them ; their color is dark gray, variegated with red ill-defined blotches, which mainly are formed of granular red orthoclas. We are now right under the falls. A large massive belt of diorite, on the south side of the before-described schists, crosses here the river-bed ; it is not a single thick belt, but a succession of belts with interlaminated schistose seams, similar to the sparry calcareous schists below the falls. The massive diorite has, as I stated before, the same composition as the schists ; the larger portion of the rock is a magma of ill-defined granular crystals of white feldspar, with pale green hornblende crystals, and always with some proportion of the micaceous scales and of calcspar intermingled. Its color is light greenish-gray, of a

dull non-reflecting granular aspect ; other portions of the rock are formed of well-defined crystals, with brightly glistening facets. If the feldspar prevails the diorite is white, dotted with green ; if the hornblende prevails the ground color is green, speckled with white. These *diorites* are, in the Wisconsin Reports, described under the name of *diabase*, as by microscopical examination of some hand-specimens the discovery was made that augite besides hornblende was one of their constituents, in combination with anorthic feldspar. A number of Diorites from the Marquette region are also on the same ground pronounced to be Diabases. This is true with the specimen described by M. A. Wichmann from the Washington mine, but it is an essentially different rock from the other diabases he describes. We meet in the Marquette district with many dykes of augitic rock, some with large crystals of augite readily discernible with the naked eyes ; they are, however, of a much later origin than the dioritic rocks of that region. I have not made a microscopical examination of the dioritic rocks of the Menominee region, but I was able to find in almost every exposure of this kind of rocks, specimens of a crystalline grain coarse enough to see with the naked eyes, or with an ordinary magnifying-glass, the component minerals, and in every instance I could fully convince myself of the presence of hornblende in these so-called diabases as one of the main constituents, by the bright cleavages of the crystals intersecting each other under an angle of 124° ; and only in a few instances, in rock-masses which were in a state of beginning decomposition, I could observe a secondary transformation of former bright hornblende crystals, into opaque crystalline masses, which cleft by crushing them into nearly cubical little fragments supposed to be augite.

The beds of diorite and interstratified dioritic and calcareous schists exposed at the upper Quinnesec falls in uninterrupted continuity of succession, amount, with exclusion of the beds below the falls, to about 700 feet. After a short interruption of the outcrops, we find, higher up in the river-bed, the succession of strata continued by other schistose beds, scarcely differing from the former, and inclosing from time to time belts of compact crystalline diorite. One of these belts of diorite, cropping out at the base of the rapids a half mile above the falls, is the most beautiful variety of this rock I have seen ; it consists of brightly pale green, quite

large hornblende crystals, imbedded within a granular milky-white interstitial ground-mass of feldspar. The rapids in this place are occasioned by a succession of about 400 feet of thinly laminated schists, quite variant in molecular structure, but not so much in general composition. Some of the beds are smooth-bedded, very fissile mica schists, of dark greenish-gray color, with great lustre; other micaceous strata are not fissile, unhomogeneous, curly masses, formed of an aggregation of nodular rounded crystals of white feldspar of orthoclase and of quartz, imbedded within a schistose ground-mass composed of bright blackish mica scales and of sparry carbonate of lime. Another variety of the schists, formed of micaceo-feldspathic thin laminæ, resembles a conglomeratic rock from lenticular masses of quartz abundantly wedged in between the laminæ; other similar micaceous seams regularly alternate with narrow bands of granular quartz. Also dark green chlorito-micaceous belts occur in this succession, which by gradations merge into a crystalline chloritic hornblende rock

Beyond the rapids I did not examine the rocks of the exposures found some distance above. This whole large series of rock-beds, exposed at the upper Quinnesec falls, evidently represents one inseparable group of altered sedimentary deposits formed from bottom to top of the same material, in different molecular form and different proportion in the intermixture of the component mineral substances. This composition and structure also agrees with the dioritic rock-series of the Marquette district, as near as it can be expected in places remote from each other, which similarity is for me a strong inducement to consider them as analogous and contemporaneous formations. In the hills south of the falls, a quarter mile from the river-bed, the dioritic group is exposed in a row of vertical walls and in single cliffs; one of these localities exhibits the intersection of the massive crystalline diorite by a granitic dyke. This granite consists of a minutely granular, almost flinty ground-mass of feldspar composition, in which dimly defined large red crystals of feldspar and of quartz have segregated, besides scantily disseminated linear interrupted seams of dark micaceous scales. The larger outcrops of granite indicated on the map of Major Brooks I failed to find, in the hurried way I went over the drift-covered surface of this broken country. The rock-series at the lower Quinnesec falls is a direct continuation of the rocks at

the upper falls. North and above the falls are dark green diorites and dioritic schists, as on the north side of the Menominee below the upper falls, and the same as at the Twin falls. The lighter white and greenish speckled diorites, interstratified with schists of micaceo-feldspathic composition in intermixture with a large proportion of sparry carbonate of lime, are exposed at the falls, several belts of the crystalline rock above, and another large one at the foot of them. The schists occur in a good many variations, as at the other exposures. From the lower Quinnesec falls down to the sandy portage rapids in the N.E. quarter of Sect. 24, Town. 39, R. 30, an uninterrupted row of high rock-walls forms the brow of the hills on the Michigan side, which are composed of the same, partly schistose, partly crystalline massive dioritic beds; large exposures are also half a mile north of the river in the knobs projecting over the drift-covered terrace-lands in the central part of Sect. 14. At the upper end of *sandy portage rapids* commence exposures of hard, thinly laminated micaceo-feldspathic schists like those at the foot of the upper Quinnesec falls, but of a darker greenish color; dispersed through the substance are nodular masses and streaky seams of red orthoclas. Farther on, the schists change somewhat in structure, but not materially in quality; they are in a vertical position; several belts of massive rather dark green colored and comparatively fine-grained diorite are interstratified between them. The schists amount to 400 or 500 feet in thickness. By following the river downward we find, south of the former, much lighter whitish or reddish gray-colored delicately laminated micaceo-feldspathic schists of a sub-porous absorbent nature, and of gritty instead of lubricous feel; portions of this schistose series of beds are in a state of decomposition, and disintegrate into loose argillitic sand-masses, or into small splintery fragments. These light-colored schists extend across the river to the Wisconsin side, which side I have not farther examined. The same kind of schist is observable lower down the river, at Devil's Gut. From there are, for some time, no more outcrops to be seen on the Michigan side of the river, until we have passed the mouth of the Sturgeon River. A few hundred steps below it a belt of serpentine about 50 feet wide, associated with asbestine and sparry seams, crosses the river obliquely; lower down, after short interruption of the exposures, another belt of serpentine, about 100 feet wide, is vis-

ible in the bed of the river, but only at low water these beds are accessible. They consist of a dark greenish black serpentine, translucid in thin splinters, with a green color; it contains magnetite granules in considerable quantity, and gives with the blowpipe reaction of chrome. Nothing definite can be seen in these two exposures, in which relation the serpentine is to the dioritic rock-group, which forms the hills on the Wisconsin side at that place; but farther down, above Sturgeon falls, if we follow a small creek which enters the river not far from the quarter-post on the west line of Sect. 26, we come to the base of bald rock-knobs, consisting of a fine-grained diorite, speckled with large and small white dots of nodular segregations of feldspar within the grayish-green dioritic ground-mass, which massive rock-belt is intersected by a dyke of serpentine about 40 feet in diameter, sharply defined from the diorite, and plainly exhibiting its intrusive nature; it strikes from north-west to south-east, about parallel with the large diorite belt of the falls, which is about 300 steps south of the serpentine dyke. The serpentine is dark blackish green, full of cleavage cracks, causing it to break into very irregular sharp-edged fragments; the surface of these fractured faces is generally covered with a thin cuticle of silky-shining asbestine fibres; other portions of the serpentine are intersected by a great many sub-parallel and sometimes anastomosing seams of chrysotil of bright satin lustre. The Sturgeon falls are occasioned by the same rock barrier, which is broken through by the Menominee River at the upper and lower Quinnesec falls. The rocks of all the three falls are perfectly similar. We find here again the light-colored white and greenish-gray speckled diorite of a more or less perfect crystalline structure, massive or schistose, and then pervaded in all directions with narrow seams of calcspar; sometimes also veins of white dolomite-spar, a foot or more in width, occur. Near the base of the falls a broad belt of thinly laminated, silky-shining hydro-micaceo-feldspathic schists, like those at the two other falls, is exposed, succeeded on the south side by another diorite belt; all the beds dip south-west under a high angle. East and south-east of the falls, the country bordering the river is extremely broken, full of large exposures which represent this dioritic rock-formation, showing its very great thickness and a great variation in the structure of the rocks, although nearly all are composed of the same constituents

in different proportions and different molecular form. The order in which the various beds succeed is not clearly observable, but it appears the dark green, fine-grained diorite, speckled with comparatively large white crystals of feldspar, distantly dispersed, and quite obvious from a distance, which incloses the serpentine dyke, is one of the lowest of the exposed strata. To about the same horizon belongs the dark blackish diorite exposed in low hillocks on the west side of the road to Menominee, in the N.E. quarter of the S.W. quarter of Sect. 26. A part of the rock is almost aphanitic; another is composed of quite large crystals of dark brownish green hornblende, with scarcely any feldspar in the combination. The lighter white and gray-speckled diorite, which forms the barrier rock at the falls, occupies the central part of the formation. A very fine variety of this rock, of a most perfect crystalline structure, occurs in the S.E. quarter of the N.E. quarter, and in the N.E. quarter of the N.W. quarter of Sect. 35. The upper horizon of the group is formed of light greenish-gray colored schistose or massive very hard felsites, the schistose form of which contains a good proportion of hydro-mica in intimate intermixture with the feldspathic ground-mass; frequently also these felsites are porphyritic by segregation of red feldspar crystals within the body mass, which porphyritic masses resemble a granite, and probably are identical with the granite mentioned as occurring in this vicinity by Major Brooks. Iron pyrites is the never-missing accessory mineral in the composition of all these rocks.

Below Sturgeon falls we find large exposures of the porphyritic felsites, partly of non-stratified massive, partly of schistose structure, as we follow the river across Sect. 1, Town. 38, R. 29, and Sect. 6, Town. 38, R. 28; lower down the exposures are for a while interrupted, and the embankment is formed of loose drift-masses, but some distance off from the river-bed, on the road leading to Menominee, the drift-polished rounded heads of the underlying dark green crystalline diorite can often be observed in the cuts of the road. A half mile below Holmes Creek, in the S.E. quarter of the N.E. quarter of Sect. 20, Town. 38, R. 28, we find on the Michigan side, in the river bluffs, a large succession of well-stratified and banded silico-ferruginous rock-beds exposed, dipping under a high angle east-north-east; they are considerably

corrugated, or shattered and recemented into a breccia, consisting of alternating narrow seams of chalcedonic, or also porous cherty quartz, once little colored, whitish or grayish, and then again brightly red or brownish red-colored, by impregnation with hematitic iron oxide; some larger belts of glassy quartz occur interstratified. Above and below this rock-belt, which amounts to several hundred feet, are felsitic rocks in contiguity with it, which on the line of contact are likewise impregnated with hematitic oxide by secondary infiltration from the ferruginous beds, as it appears, as the more distant parts of these are not charged with iron. The incumbent beds are dark greenish-gray, schistose, porphyritic felsites; the imperfectly schistose structure is produced by interrupted linear fibroso-scaly seams of hydro-micaceous and augitic composition, permeating the felsitic ground-mass; the underlying beds are of non-stratified massive structure, light gray colored. Those next the siliceous iron-colored strata are in a state of commencing decomposition; they are absorbent, porous by partial transformation of the felsitic ground-mass into kaoline. The originally white-colored rock is mottled with large dark red blotches by infiltration of these parts with hematitic pigment. Below these porous weathered beds are hard compact felsites of a uniformly light gray color; they contain always some proportion of carbonate of lime, which makes them effervesce with acids, and inclose, sparingly dispersed, small black octahedrons of magnetite, or perhaps titanic iron, as they resist the action of acids. Lower down the river these massive felsites, of great thickness, are in contact with pale green, fine-grained homogeneous greenstones, which seem to be a modification of the felsite only, but are by insensible transition also connected with the dark green crystalline diorite, which forms, close by, large islands in the river, and is seen in a much greater display at the Quiver falls, also called Pemenee Bon Won falls. At the lower end of the largest of the islands, the pale green aphanitic greenstones are well exposed in association with a fine-grained crystalline diorite of green and white speckled color; there also masses of the aphanitic greenstone, porphyritic by red orthoclas crystals, abundantly disseminate through the mass. At the Quiver falls large hillocks of rock rise with vertical walls from the middle of the river-bed, dividing the stream in three arms, which wind themselves through

narrow chasms in the mural rocks, and finally rush down over stair-like offsets in the cliffs to a 60 or 70 feet lower level.

The rock composing the cliffs at the Quiver falls is a dark greenish-gray colored fine-grained diorite. Portions of the rock have a peculiar concretionary structure by segregation of globular nodules in the mass, densely crowded together as in an oolite, only of much larger size, from a small hazelnut to a hickorynut; they consist of a granular red orthoclas in intermixture with quartz. By decomposition of the rock these balls readily separate from the surrounding diorite mass. Below the Quiver falls the exposures of diorite continue for about a half mile downward in this grand style; then for several miles only here and there the rock comes to the surface in little islands in the river, or locally projecting above the drift-covered valley. In the north part of Town. 37 we find again rapids, and with them also large exposures of very coarsely crystalline, dark blackish-colored hornblende rocks, much differing in aspect from the diorites of the Quiver falls. One variety is a black glistening rock composed of a magma of granular crystals of white feldspar and black hornblende, in which mass large crystals of the hornblende are segregated, but inseparably amalgamated with the inclosing ground-mass, as being formed by the parallel arrangement of the smaller crystals into compound larger ones. Another very beautiful variety is composed of large blackish-green hornblende crystals of great lustre, in intermixture with a small proportion of red orthoclas crystals. A third variety consists of similar large crystals of hornblende in peculiar intermixture with the feldspathic constituent of the rock. Both minerals permeate each other in the crystals in a mode as if a process of paramorphosis from one into the other were going on. Interstitial between this magma of crystals is a purplish red, dull, earthy-looking but hard mineral matter, principally composed of hematitic iron oxide, which imparts to the rock a showy, variegated aspect; black mica-leaves are sparingly intermingled. In contiguity with these coarsely crystalline diorites we find in this locality quartzite beds and cherty argillitic stratified rocks richly impregnated with hematitic iron oxide, which in all probability are analogous with those occurring up the river near Holmes Creek.

About three quarters of a mile below these outcrops are the Pemenee falls, where an immense body of dark-colored feldspar

porphyries comes to the surface in bold cliffs, in the river, and on the borders of the river-bed. The exposures begin a half mile above the falls ; the rock is here a genuine granite, composed of a magma of indistinctly defined crystals of red feldspar, with a granular quartzose and partly feldspathic ground-mass, which is pervaded with streaky interrupted linear seams of a dark-green chlorite-like mineral, so often found substituted for mica in the granites of the Marquette district. From this granitic form of the rock, all transitions into an aphanitic homogeneous mass, with a flinty conchoidal fracture, are observable ; but this aphanitic dark blackish-colored ground-mass always incloses distantly disseminated, well-defined crystals of orthoclas, or sometimes amygdaloidal rounded nodules, formed of crystalline orthoclas, and, examined with the magnifying-glass, appears no more homogeneous ; the light-colored feldspathic susbtance, and the dark-colored chloritic or also augitic or hornblendic components of the mass are segregated to a certain extent into delicate linear seams, which sometimes impart to the rock a sub-schistose structure. This lineated structure of the rock becomes obvious to the naked eyes on weathered surfaces, and proves to full satisfaction the lava nature of this rock ; the serpentine torsions and convolutions of these lineations exhibit the flowing motion of the once liquid mass as clear as we see it exhibited in the banded slags of an iron furnace. At the base of the falls I found, in contiguity with the porphyritic rocks, lighter-colored sub-schistose felsite porphyries similar to those associated with the diorite at the Quinnesec or Sturgeon falls ; an exposure of the coarsely crystalline dark-colored hornblende rock, found a mile above the Pemenee falls, is observable below the falls in the river-bed. A short distance below the falls the rock disappears under the drift ; about a mile below, near the Pemenee farm, we can see in the river-bed an outcrop of a fine-grained dark greenish-colored diorite, which differs from the crystalline fine-grained variety of the porphyry at the falls only by the segregation of hornblende crystals in the mass. I returned to Quinnesec from the Pemenee farm, as I was not prepared to go farther down the river, but from notes made on a former trip ten years ago, I know the occurrence of porphyritic and granitic rocks similar to those at the Pemenee falls, at the Muscongo rapids ; they come there in close contact with well-laminated

schistose beds, and with coarsely crystalline and aphanitic dioritic rocks. Farther down, at the so-called chalk hills, we find the hematitic quartzites and argillitic strata once more associated with the diorite, as we saw it in two other localities above mentioned. It does not appear in any of these exposures as if valuable deposits of iron-ore were to be found in this group of rock-beds, but it is of great scientific interest to find out by future examinations in which relation these beds are with the dioritic rocks—whether they are a regular link belonging to this group, or whether they are deposits of a younger age incumbent on them, which during the upheaval became entangled between a fold of the dioritic and felsitic rocks. The lithological character of this ferruginous rock-belt is unlike the ore-formation of the Quinnesec mines.

Reviewing what we have seen of the formations along the Menominee River, said to be the youngest of the Huronian group, I again point out the great similarity in the composition and structure of this very large series of rocks with the dioritic formation of the Marquette district ; also its intersection by the serpentine group, which in the Marquette district is under similar circumstances associated with the diorite formation. Further in favor of this analogy is the intersection of the Menominee diorites by porphyritic granite in dyke form, as is the case with the diorite group of Marquette. These porphyritic granites are on their part in close relationship with the felsite porphyry of the Pemenee falls, merging by insensible gradations with the granite, which is only a more completely crystallized form of the same lava-mass. On the other hand, there exists not the slightest resemblance between the dioritic rock-belt of the Menominee River and those rock-beds of the Marquette district which represent subdivisions 15 to 20 of Major Brooks.

The exact order in which the different rock-masses composing the dioritic formation succeed each other—whether the dark green diorites of the Twin falls and in other places are the lowest, and the lighter colored diorites at the Quinnesec falls the higher ones —is at the present state of our knowledge uncertain, but it is most likely the case ; so the dark-colored coarsely crystalline hornblende rocks exposed a mile above the Pemenee falls may be older beds than those at the Quinnesec falls. The massive belts

of this series of altered sedimentary rocks, interlaminated with the schistose members, can, as I think, not all be considered as regular links in the stratified succession ; some of these, and particularly the larger masses, as they occur at the Quiver falls, I believe to be intrusive, in the same qualified sense in which I have considered some of the massive dioritic rock-belts of the Marquette district, and still in another sense they represent only a more altered portion of the stratified beds connected with them. Considering the granite on the south and west side of Menominee valley as an eruptive rock, like the porpyhry of the Pemenee falls, I can agree fully with Major Brooks in this part of his chronological system ; these rocks undoubtedly came to the surface after all the other Huronian strata of sedimentary origin were formed, as their eruption to the surface caused the upheaval of the others. I therefore have always represented the dyke granites of the Marquette district as actually the youngest rocks in the group, but I suppose this was not the original meaning of Major Brooks' system. In all his stratigraphical descriptions, he has not made a proper distinction between sedimentary succession and interstratification, counting up the beds just as they came in a cross-cut ; his Groups VII., IX., and XI. are a proof of this assertion.

It still remains for me to give a description of the country west and north-west of the Quinnesec mining district, which is equally important by its wealth in iron-ore, and even supersedes the other in the size of its ore-belts. One of the largest ore-deposits discovered is the Commonwealth mine ; it has a seam 162 feet wide, of a compact, solid, high-graded ore, in which only a few narrow bands of a more siliceous character occur, which are well defined and easily separable. The Commonwealth is on Wisconsin territory, south of the Brule River ; but also on the north side of the river, in Michigan, several equally large belts of the same kind of ore have been discovered, besides a great many smaller ones, and constantly new discoveries are made by hundreds of explorers roaming over this promising wilderness.

I have previously made the statement that the ore-formation of the Commonwealth mine represents a higher horizon than the Quinnesec ore-formation. Major Brooks places the Commonwealth ore-deposits into the upper part of the Lake Hanbury slate series, but while he considers that as one of the upper members of the Huronian series, I place it, on the contrary, below the Quinnesec ore-formation.

The abrupt termination of the Quinnesec ore-formation, on the east side of the Menominee River, near its junction with Pine River, is very singular. We see for the last time the limestones underlying the Quinnesec ore-formation uncovered in test-pits in the S.E. quarter of Sect. 23 ; and right across the river, in Sects. 21 and 20 of the Wisconsin town subdivision, Town. 39, R. 19, occur the characteristic sericitic and plumbaginous schists of the Commonwealth ore-formation ; the strata strike in the usual west-north-west direction, and dip north in an almost upright position. Some layers are slaty, very delicately laminated, soft argillitic-like, and fissile ; silky-shining, gray, or intensely red-colored ; others, mostly gray-colored strata, are harder, and consist of granular layers of feldspar in seamy intermixture with sericeous scales. With them occur black plumbago schists, containing irregular glassy quartz bands. No iron was found in the test-pits, which are not far off from the bed of Pine River. The higher part of the hill-side is deeply covered with drift. A mile north from here, in the centre of Sect. 8 of the same town, are, on the height of the drift-covered plateau, the previously mentioned knobs of diorite which form a continuation of the outcrops at the Twin falls. On their south side we find, in immediate contact with them, vertical strata of a greenish-drab colored, rather hard but absorbent schistose rock, weathering rusty brown, and breaking into uneven angular shelly fragments. It consists of a half-decomposed kaolinitic granular feldspar mass, abundantly intermingled with micaceous, or probably chloritic scales. These are succeeded by other somewhat softer micaceo-argillitic beds of an imperfect schistose structure, not cleavable into even slaty pieces ; their color is ash gray, or purplish gray, or deep red. With them occur more micaceous or sericitic beds, with a slaty cleavage ; the thickness of these strata is hard to be estimated, as they are only uncovered by test-pits. To these follows a large succession of red-colored quartzose beds, partly banded and compact, partly cherty cellulose ; interstratified with them occur argillites of a seamy or irregularly dotted variegated lighter and darker greenish and purplish color, produced by a streaky and corrugated intermixture of the variously tinted clay masses. In this association occur seams of iron-ore in

different degrees of purity. Some are more or less contaminated with siliceous or also argillitic matter. The pure ore forms a compact, amorphous, fine-grained mass, with a sub-conchoidal fracture without lustre ; its color is dark reddish or purplish brown ; scraped with the knife it gives a bright red streak. With these compact hematitic ores are cellulose concretionary ore-masses associated, which consist partly of a fine-grained compact martite with sub-metallic lustre, partly of hydrated oxide under the form of grape-ore ; and not rarely in the cell-cavities of this mixed mass fine large black crystals, like the crystallized iron oxide of the island of Elba, are found attached to the side-walls, or grow out from the surface of a stalactitic stem of the hydrated ore, which proves the formation of these crystals contemporaneously and after the formation of the stalactites.

The Commonwealth mine is about five miles north-west from the test-pits I have just described. One can see from here the spot where it is located. The ore-formation extends, in all probability, from here without interruption to the Commonwealth mine ; but the surface is so generally covered with drift that only by boring or digging is information obtainable about the underlying rocks of any part of this country. The Commonwealth mine is in Wisconsin, and fault may be found if I enter into a detailed description of it ; but if we want information about the geology of a district we cannot mind State boundary lines ; we must pick up information where we best can ; and here is certainly such an occasion. The Commonwealth mine is not far from the centre of Sect. 34, Town. 40, R. 18 (Wis. Surv.) ; it is on the plateau-like summit part of a ridge, declining on the north side toward the Menominee River, just about three miles south of the mouth of the Michigamee River. The south side of the ridge slopes down to the Pine River, distant about four miles. Under a cover of from 4 to 8 feet of drift, the ore-bearing rock-series can be found most everywhere on the summit part of this ridge ; the strata are near to a vertical position, and dip south. A belt of solid hard ore 162 feet wide is uncovered in the mine, which was incidentally mentioned before ; its stratification is very obscure. The extremely fine-grained brownish or blackish purple compact mass, with a dull clay-like fracture, exhibits to the observer the aspect of an extremely fine hardened mud-mass, with the same irregular cleavage into angular

small fragments as a piece of dried clay would ; by shrinkage of the indurating mud-mass, a great many fissures and little druse-cavities formed within the rock-mass, which are filled or coated over with crystals of dolomite-spar, or with brilliant crystals of iron oxide, or with bright purple scales of micaceous oxide, or with the hydrated grape-ore. The homogeneity of the substance is also frequently interrupted by a partial transformation of the amorphous oxide into a minutely granular crystalline form, with a dull metallic lustre. Portions of the ore-belt are locally found shattered and recemented into a breccia by feldspathic or argillitic seams of reddish or whitish green color, and interstratified with the ore-mass are a few narrow belts of banded ferruginous quartz-beds. South of this ore-belt is a large series of well-laminated schists, blackish-colored by graphita, with interlaminated quartz-seams ; some of the schists are so richly impregnated with graphita as to deserve attention regarding their economic value ; most of them, however, are very impure, siliceous, or clayey. The thickness of these plumbaginous schists with quartzose seams is very great, as can be observed in the ravines on the south side of the mines, but excepting these, all the other surface south of the mines is deeply covered with drift ; therefore, no estimation can be made how far these quartzoso-plumbaginous schists may extend southward, and what other kinds of strata succeed them. North of the ore-belt, consequently beneath it, are dark-colored hard siliceous and partially argillitic schists and flaggy layers, richly impregnated with iron oxide ; they inclose another seam of good iron-ore about four feet wide. Farther down the slope succeed other dark greenish or brown-colored schists of a siliceo-argillitic character, some with an even slaty cleavage, others cleaving very irregularly into uneven slivers ; certain layers are rich in sericitic scales, all contain much iron in the state of protoxide, but become rusty ochraceous by exposure. The larger portion of these schists contains an abundance of lenticular concretionary masses of iron pyrites, which by their decomposition cause the schists to open their laminæ in the above-mentioned slivered mode, and the surfaces of the cleft, still closely coherent slivers, become incrusted with a brightly shining glassy varnish of hydrated oxide of iron of a dark blackish brown color, often also lively iridescent ; the little cavities left after the decomposition of the pyrites are filled with

brownish yellow ochre. This kind of schists is very characteristic for the Commonwealth ore-formation, as much so as the plumbaginous schists ; they occur everywhere as far as this formation extends, and form the largest bulk of this rock-series ; they cover the surface of a great many square miles north of the Brule River and south of the Paint River, and by their occurrence the explorer generally knows that he is on ground where an ore-belt can be expected ; but he would be greatly mistaken, if he thinks to find the ore-deposits equally distributed in this formation in a certain fixed position. There were certainly periods during the time of the deposition of this group of sediments in which more molecules of iron oxide were carried by the turbid waters which made the sediments, than at others, and the prospects of success in such a horizon are for the explorer generally much better than in another ; but one must never imagine that at such a time a uniform sheet of irony deposits formed all over the then existing ocean bottom ; the materials were distributed by the currents according to their specific gravity, and according to the velocity and transporting power of the currents ; while here all circumstances favored the formation of an ore-deposit, in another place, not a great way off, a stronger current may have prevented the deposition of any sediments, or only allowed the coarser sandy grains to settle down. North of this great belt of schists, which incloses from time to time quartzose arenaceous seams or lenticular masses of quartz, or also a narrow seam of ore, we find another series of dark plumbaginous quartz-schists with interlaminated black and white banded quartzite ledges, which are well exposed in some shafts near the new-built dwelling of Captain Tobin, the superintendent of the Commonwealth mine, to whom I am greatly indebted for favors and assistance in the prosecution of my work. Some distance east and north of this locality, near the quarter-post on the east line of Sect. 34, are test-pits in which, under a cover of Silurian sand-rock, fine-grained, silky-shining, grayish or intensely red-colored sericitic slaty argillites are uncovered ; they dip under a high angle southward, and consequently must be considered as the lower members in the described succession. We find similar beds exposed a short distance farther east, in a brick-yard near the road-side. Farther north are no more exposures. Other test-pits on the south side of this road, in Sect. 35, struck in part soft black

plumbago schists, and in part the same sericitic argillites as those near the quarter-post ; these two kinds of schist alternate with each other several times, and amount to great thickness, as they are met with everywhere over a space a quarter of a mile wide.

This whole formation, above and below the ore-belt, amounting to not less than 2000 feet of strata, consists throughout of the finest mud-sediments, which have retained their delicate sedimentary lamination most perfectly, even in the slaty rock-beds, whose cleavage is generally parallel with the bedding, and not transverse to it, as in other slate-rocks. West of the Commonwealth mine, in the centre of the S.E. quarter of Sect. 33, on the south slope of the hill-range, is a large belt of the same ore, as we see it in the mine, naturally exposed ; the higher part of the ridge north of this ore-mass is formed of nearly vertical ledges of ferruginous and of graphitic quartz-schists. The extension of this large body of ore in east and west direction has not been fully examined yet. In the S.W. quarter of Sect. 32, near the west line, in a number of exploring pits, a large succession of quartzite beds of various character, interstratified with seams of a rich coarsely granular, somewhat magnetic ore of metallic lustre, has been exposed ; some of the quartzite beds inclose a large proportion of the crystalline coarse ore-granules ; others are purely quartzose, also banded beds of alternating ore and quartz-seams occur, and with them fine-grained dark greenish or blackish siliceo-feldspathic, very compact hard rock seams, which contain a large proportion of iron. In the western pits are well-laminated hard hydro-micaceous feldspathic schists exposed, some of which are beautifully mottled with copper-colored irregular blotches on the dark purplish gray ground-mass ; others are light greenish yellow, and resemble the novaculitic schists of the Marquette district. The strata are nearly vertical, seem to dip southward ; on their south side, in test-pits and by natural exposures, the plumbago schists interlaminated with quartz seams are to be observed, and on the north side of the exploring pits red and grayish purple sericitic slaty argillites occur, similar to those on the north side of the Commonwealth mine. About a quarter mile farther west, in the S.W. quarter of Sect. 31, south of the road, are high bluffs of a compact light reddish-colored quartzite.

The Florence mine, situated in the S.W. quarter of Sect. 21,

Town. 40, R. 18, corresponds with the Commonwealth mine in the character of the ore-belt and the rocks associated with it, as well as it can be expected in localities two or three miles apart; the strike of the formation is about the same as that of the Commonwealth, but its dip is opposite, northward. The ore-belt is considerably shattered on the surface, but is also very large, over a hundred feet wide. A part of the ore is very compact, finely granular, of dark steel-gray color, with a dull metallic lustre. The largest quantity of the ore presently mined is a compact amorphous dark shattered mass, full of fissures and little cavities filled with soft ochraceous oxide of yellow color, or incrusted with grape-ore. Larger stalactitic masses of hydrated grape-ore are quite abundant, and these grape-ore stalactites are often covered with black solid crystals of oxide, and with micaceous iron oxide, transparent with deep purple color. Interstratified between these ore-deposits are some quartzose seams and a belt of green and red mottled rather hard and compact argillite. South of the ore-belt, therefore beneath it, follows a series of siliceous ores, too low-graded to be used, and then succeed the hard dark blackish-colored and rusty yellow or brown weathering siliceo-argillaceous, pyritous schists, varnished over with a glassy coating of hydrated oxide of iron, which I have described as occurring north of the Commonwealth mine, and which, to avoid the lengthiness of description, I will in future only call *pyritous schists*. Above the ore-belt, on the north side of the hill, are graphitic schists with quartz seams, and abundantly disseminated with iron pyrites. Farther north the strata are hidden by drift-deposits, but west of the mine is a large number of test-pits partly opened by the Florence Mining Company, partly by Mr. Harvey in Sect. 20 and Sect. 17. The graphitic schists are there not immediately on the ore-belt, but red iron-colored micaceo-argillitic or harder feldspathic schistose, or slaty beds intervene. The ore-belt of the Florence mine does not seem to extend in this direction in equally large dimensions, but narrower seams of rich ore, interstratified with leaner siliceous ores and with quartzite seams, are found in its place. North of the graphitic schists succeeds a large series of sericitic schists, some dark red-colored with hematite, others lighter grayish, or almost white; their ground-mass is partly a hard granular feldspathic mass, partly kaolinite. These strata resemble the sericite schists north of the Commonwealth mine, which appear to be below the ore-formation, while those are clearly above it. Two different belts, a lower and a higher, of deposits of this kind seem to exist, but possibly they may represent the same horizon, and have come into such positions by plication or an overturn of the strata. I have so far not been able to decide this question, but as the miner is often guided in his explorations by these schists, it is of great practical importance to ascertain positively whether there are two distinct horizons of schists so similar to each other, or only one.

A very interesting field for observation of a different, most likely lower, horizon of the Commonwealth ore-formation is found on the north and west sides of Keyes Lake, in Sects. 25, 24, 23, 27, and 28, in Town. 40, R. 17. Besides a good many natural exposures, the great number of test-pits recently opened there have brought to light a great variety of rock-beds, but the order in the succession of these strata is not clearly recognizable, as the denudations by the test-pits are too much disconnected, and the frequent change observed in the dip of the strata indicates the existence of many plications of the rock-beds, causing their repetition in the different localities. We observe, in the S.E. quarter of Sect. 25, a large belt of vertical quartzite ledges over 200 feet in width, which can be traced to extend in a north-west direction across Sects. 24, 13, and 12, to the Brule River. A part of this rock is compact, light-colored, and resembles the quartzite exposed at the falls of the Sturgeon River, but the much greater portion of the rock occurs in thinly laminated schistose, very compact thick ledges, which schistose structure is due to the copious intermixture of linear hydro-micaceous laminæ with the granular quartz-mass. On the south side this quartzite belt is adjoined by an equally large succession of alternating quartzose and actinolitic seams of a dark color, in rough, irregular, somewhat shattered and recemented layers; the quartzose seams are partly compact in banded, streaky, or reticulated seamy intermixture with granular magnetite, or uniformly disseminated with larger or smaller proportions of it, partly porous saccharoidal, particularly the narrow bands of quartz wedged in between the actinolitic rock-masses. The actinolite forms very tough uneven layers, composed of a dense agglomeration of globular clusters of radiated, delicately fibrous

crystals, generally blackish-colored by intermingled granules of magnetite, but not rarely it is not tinged, whitish, of silky lustre. Single radiated globular masses of actinolite are often seen dispersed within the substance of the sandy quartz-seams, in contact with an actinolite seam. South of this actinolitic rock-belt, which occasionally incloses narrow seams of granular magnetic ore, succeed hard dark blackish-colored, fine-grained slaty rocks in various modifications ; their black color is due to graphitic matter, partly to granular magnetite, which usually is found dispersed through the siliceo-feldspathic hydro-micaceous ground-mass which composes all of them. Farther west and north, but south of the quartzite belt, in Mr. Burt's test-pits, in the S.E. quarter of the S.W. quarter of Sect. 24, we find a large succession of quartzose and argillitic, rather hard rock-beds, all of which are more or less richly impregnated with hematitic oxide ; associated with these are black plumbaginous schists of soft or harder siliceous nature. The strata in this location dip north, and in some test-pits they are almost horizontal ; in others they are steeply inclined.

Interlaminated with these beds are various smaller seams of valuable iron-ore, in compact aphanitic masses of blackish purple color, or in the form of grape-ore, in partly hydrated, partly not-hydrated condition ; also actinolitic seams richly impregnated with iron, and usually in a porous, earthy, decomposing condition, are found in these test-pits. In the S.W. quarter of the S.W. quarter of the same section white and reddish speckled porous kaolinitic beds of considerable thickness are found in the bottom of the pits, which might represent a decomposed dioritic rock. The most promising iron-ore seams are found in the test-pits of Mr. Tobin, in the N.W. quarter of the S.W. quarter of Sect. 24, where, in association with the quartzitic and argillitic ferruginous beds, rich layers of an earthy compact hematitic ore occur, in which a great quantity of large octahedric crystals is disseminated. As in the same mass also dim fibrous crystal groups of actinolite, transformed into a soft yellow ochraceous substance, are found imbedded, it becomes evident that the amorphous red hematite, inclosing the crystals, is a product of alteration of the rock by higher oxidation of the ground-mass, which has not yet affected the crystals. In the S.W. quarter of the S.E. quarter of Sect. 24 occur compact sub-magnetic ore-seams of dull metallic lustre, imbedded within

actinolitic quartz schists, which evidently represent the fresh unaltered condition of these hematitic earthy ores, with inclosed magnetite crystals; the steel-gray minutely granular mass exhibits the large octahedric crystals plainly. A short distance north of these test-pits the mural walls of the large quartzite belt ascend to form the summit of the range ; north of the quartzite are no more rock exposures. In test-pits opened in the S.E. quarter of the N.W. quarter of Sect. 25, the schists of this ore-bearing group are intersected or interlaminated by a doleritic rock-seam in a softened, decomposing condition, which totally differs from the dioritic rocks of this region, and completely resembles the doleritic dyke-rocks of the Marquette district ; the augite crystals are dark brown, not fibrous, but like basaltic augite ; the feldspar crystals have lost their glassy lustre, and have become pale brownish by imbibition of hydrated iron oxide. The denudations are not sufficient to see whether this dolerite belt is parallel with the strata, or whether it intersects them transversally. In the S.E. quarter of the N.E. quarter of Sect. 23 are other test-pits, opened by the Union Iron and Steel Company, in which generally light whitish or greenish-gray and red-colored sericitic and argillitic schists, associated with graphitic belts, have been found, but no promising seams of iron-ore.

Following the road from Keyes Lake to Wakefield's explorations, we see near the south corners of Sects. 25 and 26 exposures of highly ferruginous actinolitic schists, inclosing granular quartz-seams. Farther on, near the quarter-post, on the south line of Sect. 26, these schists are in close contact with a fine-grained dark greenish-black colored rock, consisting of a minutely granular feldspathic ground-mass of a pale whitish color, in intermixture with a scaly mineral, which is probably chlorite, and with a great abundance of small needles of black turmaline. Farther on, near the N.E. corner of Sect. 34, the graphitic schists are well exposed, and south of them follows a large succession of the actinolite schists with quartzose sandy seams, and with others of a compact magnetic ore, of partially actinolitic structure ; all these beds are so near to a vertical position, that nothing definite can be said about their dip. Going here off from the road in a north-west direction, we come over swampy grounds, with numerous exposures of dioritic rocks projecting above the surface in low hillocks ; they consist of quite

large, well-discernible crystals of green hornblende, with an interstitial white feldspathic mass. In the S.W. quarter of the N.W. quarter of Sect. 27, test-pits are opened in actinolitic schists in a vertical position, which are interlaminated with quartzite seams and cellulose cherty belts, besides narrow seams of a compact crystalline, somewhat magnetic, iron-ore, which thin flaggy ore-layers inclose quite a number of brownish red garnet crystals. The actinolite schists in this place have been cross-cut by trenches about 150 feet, which at each end struck a belt of diorite in close contact with the vertical rock-ledges ; the portions of the diorite next to the actinolite schists are in a weathered, friable condition ; farther off the fracture of the diorite is bright, fresh, perfectly similar to the diorite outcrops in the swamp. In the adjoining part of Sect. 28 are other test-pits, in which the actinolitic schists come likewise in contiguity with the dioritic rocks, believed by Major Brooks to be incumbent on the schists, but evidently intrusive masses, which is clearly evinced by the occurrence of a belt of ferruginous actinolite schists 150 feet wide, intermediate between two large bodies of diorite, on the other side of which again the actinolite schists come to the surface. From all observations I had occasion to make, I infer the age of the actinolitic rock-series to be older than that of the productive ore-belt of the Commonwealth mine, but both belong to one and the same group of deposits.

Going north of Florence we find, on the north-west shore of Fisher Lake, outcrops of a fine-grained massive, and partly schistose diorite ; all the surrounding country is covered with drift. On the road leading to the Brule River similar diorites are seen extensively exposed on the height of the hill-range in Sect. 16. The very steep descent to the river is all drift-covered in the place where the road goes, but farther east the slope toward the river is full of rock-cliffs, as I could see from the opposite side.

I have mentioned the occurrence of large exposures of mica schists, and of harder, compact, fine-grained gneissoid rocks in Sect. 12, on the north side of Brule River, near its junction with Paint River ; we leave these on our east side and follow the road westward, parallel with the course of the Brule. For six miles nothing but sand or boulder-drift is to be seen, while we pass over the undulating highlands bordering the river ; finally, in Sect. 31, Town. 42, R. 32, after crossing a small creek and ascending a very steep hill-side, we find it composed of the schists, which for brevity's sake I proposed to name *pyritous schists* on a previous page. They are almost vertical, and dip on different parts of the hill in different directions. Onward to Brown's trading-post, in the N.E. quarter of Sect. 36, Town. 42, R. 33, we see on every hill-slope of the very broken country these schists exposed, until we have descended into the valley of the Brule. Taking from here a northern course, we find the schists again exposed, or merely covered by a thin coating of soil, on the brow and summit of the hills in Sects. 25, 24, and farther north ; in fact, ignoring the loose drift-masses, these schists form the exclusive surface-rock of the town we are in, and of the adjoining towns, with very few exceptions, where in circumscribed narrow spots lower rock-beds reach the surface. The extension of these steeply upheaved beds over so large an area naturally implies their often repeated plication, which folds are not only often obliterated by compression of the curved sides into a parallel, conformable position with each other ; but even where this is not the case, the loose superficial masses of drift and soil hide the beds so much that in any of the exposures we find or make by artificial denudation of the beds, we can rarely make conclusions on the succession of the beds from their dip in a certain direction, as we have rarely occasion to observe the complicated flexions of the strata, which reverse the order of things at once ; and therefore we have in most instances to decide by the character of the rock-beds whether we ascend or descend in the series by going in a certain direction.

Passing on the road northward across Sects. 25 and 24, small outcrops of the schists and interlaminated jaspery quartzose seams frequently occur ; particularly well they are exposed in a ravine in the N.E. quarter of Sect. 24, where the beds are quite ferruginous and gave inducement to the opening of some test-pits in this place, but no ore-seam of any value could be found. Subsequently test-pits were opened by Mr. Porter 400 or 500 steps south-west of that locality, in which graphitic schists interlaminated with banded quartzose ledges of ferruginous character occurred ; the strike of the strata is north-west, their dip under a high angle north-east. From these pits a row of other pits and trenches was dug south-eastward, crossways to the formation, in which a variety of

siliceous, argillitic, and graphitic beds, amounting to a very great thickness, were intersected, all of which contained a larger or smaller proportion of hematitic oxide, and some narrower seams of a fair quality of hard ore, similar to the Commonwealth ore, had been found inclosed at the time I visited the place ; and later, after my return to Ann Arbor, the proprietors informed me of their final success in discovering, by extending the test-pits still farther south, a large belt of a compact dark purplish brown aphanitic ore of an excellent quality, as the specimens sent to me prove it. North of Porter's pit, near the line between Sects. 24 and 13, we have to descend into a swampy valley, in which several low hillocks project, which are composed of a fine-grained massive diorite. Leaving the swamp and ascending the hills farther north, we meet, in the north half of Sect. 13, again with the ferrugino-siliceous schists and banded jaspery beds we found near Porter's camp. East and west of us are crests formed of the nearly upright ledges of this rock-series ; arrived at the top, in a saddle-shaped, swampy depression between these crests, we discover a hillock, about 12 feet high, rising from the middle of the low ground, covered with quite thick deposits of bog iron-ore, and coming up to it we find it composed of solid iron-ore, the same as the Commonwealth ore, in intermixture with some jaspery seams confined to a certain limited part of the ore-belt, which strikes approximately north and south. The width of this ore-mass is about 70 feet ; the length of the exposure 300 or 400 feet ; south, in the direction of its strike, we find only the ferruginous quartz schists ; north is a swamp ; and east and west the same kind of ferruginous quartz schists occurs, which generally forms the surface of the country. This ore outcrop, claimed to be first discovered by Mr. Jac. Armstrong, one of the prominent explorers of this region, is named by him, on account of its large size, the Mastodon mine.

West of the Mastodon mine, near the S.E. corner of Sect. 11, Mr. Bond has opened test-pits in this siliceo-ferruginous schist-series ; the strata are in places vertical, in others they dip south, and locally I found them almost horizontal. The southern strata near the corner of the section are principally banded, fine-grained, or flinty siliceous rocks, some of which bands are richly impregnated with iron oxide of dark brown color on the outside ; the inner, not-weathered parts are blackish, as they contain the iron

oxide in a not-hydrated magnetic condition. These beds inclose irregular seams of a good quality of ore, like that of the Mastodon ; but none of those I saw were large enough to be of great practical value. In the north part of the section the structure of the rocks is more slaty, in a degree argillitic, yet rich in iron ; but no ore-seams are found in it. From Sect. 11 I went north-east into Sect. 1. Near the S.W. corner of Sect. 1 are quite extensive exposures of these slaty ferruginous strata to be seen in the bed of a creek ; they dip south, or are vertical. All the surface of Sect. 1 is composed of the same siliceo-ferruginous slates and schists, in alternation with large belts of graphitic schists, and occasionally a narrow seam of hematitic ore is encountered, but none of any larger bulk has been found, although a great amount of work has been done here by explorers. North of Sect. 1, in the N.W. quarter of Sect. 31, Town. 43, R. 32, Mr. Sheldon and Mr. Schaefer have had more success in their explorations ; a very large body of ore-beds, amounting to over 150 feet in diameter, has been uncovered there, which resembles the ore of the Commonwealth mine, but is less free of siliceous seams interlaminated with the ore-mass ; some slaty strata, almost rich enough in iron to be used as an ore, are exposed on the north side of the ore-belt, but no other rock-beds are denuded there in connection with the ore-belt, which stands vertical. In the bed of the creek crossing the south part of Sect. 31, and of Sect. 36 of the next township, are outcrops of a middling coarse-grained crystalline diorite ; the hill-sides round it are all drift-covered.

From these northern exploring pits I returned to Porter's camp, in the N.E. quarter of Sect. 24, and went from there across to the N.W. quarter of Sect. 23, where likewise some explorations for iron-ore have been made, but the drift-deposits are there most too thick for the explorer ; some of the pits had to be dug through 60 feet of this loose material before the rock-ledges were struck ; the work has for this reason been abandoned. The extension of the schists of the iron-formation over this part of the country is fully evinced by the rocks thrown out of these test-pits, and by several natural exposures found there. Farther west, by following the road to Lake Chicagon, from time to time rock-ledges of the same kind are found locally denuded from the drift, which generally forms the surface of the surrounding lands. Such ex-

posures are met with in Sect. 28, on the brow of an extremely steep hill-side sloping down to Armstrong's Creek. The schists in upright position form the higher part of the slope, and the basal portion is formed of bulky dioritic rock-masses. From there to Chicagon Lake, and thence to Iron River, in Sect. 36, Town. 43, R. 35, along the road no rock-ledges can be seen at the surface, formed of a coarse boulder-drift in which granitic and dioritic blocks largely prevail over other kinds of rock. In the valley of Iron River we find the iron-formation again well exposed in the hill-sides bordering it. In several places larger masses of ore were naturally exposed, which discovery attracted a number of exploring parties, who are at present earnestly at work in digging test-pits. The explorations of Mr. Sheldon are going on in the west half of the north-west quarter of Sect. 36; the strata are there considerably shattered at the surface, and it is difficult to ascertain their exact strike and dip, but in the bottom of the pits they are more regular, and dip under a high angle north-eastward. A large mass of iron-ore, entirely similar to the ore of the Commonwealth mine, is naturally exposed in the S.E. quarter of the N.E. quarter of Sect. 35, but following the line of strike of this mass, which is approximately north and south, parallel with the course of the river in this place, we soon lose sight of it, and test-pits opened in the same direction did not meet with a similar ore-mass. Above and below this seam of ore are siliceo-ferruginous and partly argillitic strata of great thickness; below it are, conspicuous, in particular, banded layers formed of alternating seams of white, or gray or brownish flinty quartz, and of others consisting of a fine-grained, compact, more or less siliceous ore. These flinty ledges are often brecciated, but do not represent an accumulation of different kinds of rock-fragments cemented together, but merely the shattered flinty quartzite strata, which often are not much dislocated, and have often the corresponding broken ends of the fragments right opposite to each other; their interstitial cement is a granular quartzose mud-mass, impregnated with hematitic oxide, or almost totally consisting of the oxide.

In the test-pits farther up on the river side, in the N.W. quarter of the N.W. quarter of Sect. 36, which are opened in a somewhat higher horizon of the series, argillitic strata prevail over the siliceous; some are well-stratified banded ledges, variegated by the

alternation of non-tinged whitish or greenish seams, with others intensely red-colored by hematite; others are of uniform color, red, or gray from impregnation of martite granules, or black from graphita in their composition; also mottled argillites are found in this association of brecciated structure, or else consisting of an imperfect intermixture of argillitic masses of different color, when in a plastic condition. Interstratified with these occur hematitic ore-masses, in pockets rather than in regular seams, and also unhomogeneous in their mass, as if crushed and baked together again; a part of the hematite-ores is soft, paint-like; another part is a hard, compact, amorphous mass, with intermingled crystalline ore-granules, and coated over with oxide crystals on the walls of little cavities in the ore. The massive ore-belt naturally exposed in Sect. 35 has its numerous irregular druse-cavities lined with brush-formed clusters of needle-shaped crystals of goethite, which are translucid, with a brownish purple color, similar to the color of iron mica in thin leaves; other cavities are incrusted with ordinary hydrated grape-ore. By going direct east from this natural ore-exposure unto the plateau-like top of the hill-range, we find a large belt of vertical ledges of a fine-grained, compact siliceous rock of a sub-schistose structure, which incloses a large proportion of disseminated minute granules of magnetite; its color is almost black, which may in part be due to an intermixture of fine molecules of graphita. Noteworthy is yet the occurrence of large rounded chunks of a high-graded schistose specular ore in the drift-masses, which are foreign to this ore-formation, and must have been transported from some northern locality representing another group of ore-bearing rocks, similar to those of the Marquette district.

On the west side of the river, opposite the described test-pits in Sect. 35, are high bluffs, some distance backward from the river channel, formed of the dark blackish-brown siliceo-ferruginous schists, with slivered, uneven cleavage, interlaminated with more compact ledges of the same siliceo-ferruginous composition, which series of rocks is all over the country characteristic of this formation, and composes the largest bulk of it. The strata are almost vertical. A half mile north of these bluffs the river bends at a right angle to the west across the centre of Sects. 26 and 27. In some parts of the generally drift-covered hill-slope, on the south

side of the river, we find the flinty siliceous rock-beds, banded with seams of siliceous iron-ore and brecciated, corresponding with those first described, as occurring below the large naturally exposed ore-belt on the other side of the river; the interstices between the siliceous fragments are usually filled with seams of grape-ore; the strata dip under a high angle south, and on their south side a thick series of light yellowish-colored fine-grained calcareous quartzite strata succeeds them conformably.

South of Mr. Sheldon's location Mr. Wood has opened test-pits, in the S.W. quarter of the S.W. quarter of Sect. 36; the strata are, as in the other location at the foot of the hill-slope, a banded, partially brecciated flinty quartz rock, recemented by ferruginous matter of greater or lesser purity. Above are rich deposits of ore, in irregular pocket-like, dilating and contracting seams, the ground-mass of which ore is amorphous, compact, hard, like the ore of the Commonwealth, but full of druse-cavities lined with a thick incrustation of ordinary hydrated grape-ore, or of the darker-colored goethite, or with thick rhomboid crystals like the Elba island ore, or with all the three forms of the oxide at the same time. Large bulky masses of this ore are exclusively formed of long stalactitic stems of goethite, or the ordinary grape-ore; some with the lustre of a mirror, others with velvet lustre. Above the ore, on the higher part of the hill, are argillitic and graphitic schists, associated with the quartzose seams; farther on, near the edge of the summit plateau, are the dark rusty-colored ferruginous quartz schists, typical of this iron-formation. The recognition of the order in the succession of the beds, which in different localities so little corresponds, is almost impossible, on account of their imperfect denudation and the great dislocation of the strata by plication. Examining the west side of the river, down stream, along the section line between Sects. 1 and 2, Town. 42, R. 35, I found the ferruginous schists, seen in the river bluffs in Sect. 35, again exposed in the N.W. quarter of the N.W. quarter of Sect 1; but farther south all the surface is covered with drift. On the line between Sects. 11 and 12 no outcrops can be discovered. Going from the S.E. corner of Sect. 11 to the centre of the N.W. quarter of Sect. 13, a low undulating elevation striking north-west is found to be composed of a gray and white speckled diorite, very similar to the diorites of the Quinnesec falls. Taking from the

diorite ridge a north-north-east course through the swampy valley of the river, and crossing it, we find bluffs of the ferruginous schists interlaminated with quartz-seams, inclosing narrow bands of siliceous iron-ore. These slate exposures can be followed all along the west line of the N.W. quarter of Sect. 12 into the S.E. quarter of Sect. 1, where the strata strike west-north-west, and dip toward the south. From here I went across the north part of Sect. 7, where the ferruginous quartzose schists are again exposed, but the surface of the greatest part of the hill-lands over which I passed, striking northward for the wagon-road to Mr. Sheldon's camp, is covered with drift. I mentioned on a former occasion the occurrence of large limestone bluffs on Brule River, in Sect. 19, Town. 41, R. 16, of the Wisconsin Town Maps. The limestones, of a siliceous character, in thick massive beds, amounting to a belt of 400 or 500 feet, have a vertical position; south of them are no exposures. The rock-ledges disappear under drift-masses, but at a distance of about a quarter mile south of the limestone another parallel undulating ridge is composed of a peculiar dark-colored rock, consisting of an aphanitic feldspathic ground-mass, intimately mingled with a minutely scaly, hydro-micaceous or chloritic mineral, in which mass glassy grains of quartz are abundantly dispersed, besides amygdaloidal masses of ferruginous calcspar and of single feldspar crystals. North of the limestone bluffs are also no other rock-strata seen in contiguity with them, but across the river on the Michigan side the schists of the iron-formation, in a vertical position, are well exposed. The limestone bluffs extend on the Wisconsin side about three quarters of a mile down the river, and then, after a short interruption of the outcrops, we find the ferruginous and graphitic schists with flinty quartz-seams extensively exposed in the river-bed, and in the embankments on the Wisconsin and Michigan sides. Some distance lower down the river massive and schistose dioritic rocks come to the surface; they form high bluffs on the Michigan side, in the N.E. quarter of Sect. 23, and are traceable for quite a distance northward off from the river. The massive dioritic beds are fine-grained, pale greenish or dark green, by chloritic intermixture; they inclose an abundance of small calcspar crystals within their mass, and weathered surfaces of the rock are therefore full of little cavities, once occupied by the spar.

I have come now to an end with the record of my explorations in the Menominee River district during the summer season of 1880. Within the given time I was unable to see the whole of this interesting country; and even the part I did see, I could not always examine with the accuracy, necessary for a complete understanding of the order in the succession of the greatly dislocated rock-beds of certain localities; and with the best will to make an exhaustive examination of such places, it could not have been successfully done, without having first acquired the knowledge of the general structure of the whole district, which to obtain was my present object. Having quietly looked over and described the results of my examinations, I see now clearly the deficiency of my information in certain points, some of the wants in knowledge could have been supplied at the time I made the observations; but an observer seeing new things of interest often becomes so absorbed by the thing itself, that he forgets to inquire into the relations it has to others surrounding it, because he is not aware at that moment of their importance.

Having described the rocks of the Marquette district and of the Menominee iron region in two independent chapters, it remains for me to answer the very important question, What relation exists between the rocks of these two districts? In accordance with the generally adopted opinion of geologists, I consider the upheaved stratified rock-series of the Marquette district, which reposes on granitic rocks, and is overlaid by horizontal Silurian sandstones, as analogous with the Huronian group of the Canadian geologists. I leave it undecided whether an analogy exists between the granites of the Marquette region and the Laurentian rocks of Canada; but I claim the granite-belts interstratified with the Huronian formation as decidedly younger, than most of the strata of this series.

The analogy between the rocks of the Marquette region and those of the Monominee iron region is likewise generally admitted; the two regions are in direct continuity, and only 60 miles apart; still very few of the rock-beds of the two are identical, and even the different groups of strata do not exactly correspond.

The dioritic rock-group of Marquette, as has been previously stated, is considered by me as the analogon of the dioritic rock-series exposed in the different falls of the Menominee River, for reasons

already stated. The felsite porphyry of the Pemenee falls I compare, in its relation to the dioritic group, to the intrusive granite-belts of the Marquette district. An analogon of the iron-formation of Marquette is found in the Quinnesec iron range. The quartzite formation of the Teal Lake range, and the quartzites connected with the ore-bearing rock-series, might be compared with the great quartzite formation of the Sturgeon River falls. The occurrence of a large limestone formation above the Quinnesec ore-formation, which has great similarity with the limestone formation exposed in connection with the quartzite ranges south of Marquette, seems to be contemporaneous with these, but the limestones of the Menominee district are always separated from the quartzite by a wide interval, while the limestones of Marquette are inseparably connected with the quartzite formation merging with it. The ore-deposits of the Taylor mine, S. C. Smith mine, and of the lately opened Northampton and D'Alaby mines in the Marquette district, which occupy the higher part of the fifth group in my adopted system of subdivision of the Huronian group, are evidently analogous with the Commonwealth ore-formation, and the actinolitic part of that series of strata finds its counterpart in the actinolite schists underlying the Northampton ore-deposits and overlying the quartzites of the Michigamee and Spurr mines. The Lake Hanbury series occupying the place of the lower actinolite schists below the ore-belt of the Washington and Republic mines has no lithological resemblance with these beds.

Whether the Felch Mountain ore-formation is analogous with the Quinnesec ore-formation, and the crystalline limestones, charged with tremolite crystals, correspond with the limestone formation connected with the Quinnesec ore-belt, I am not ready to decide; the similarity of the rocks of these two ore-formations is much greater, than it is between either of them and the Commonwealth ore-formation. I desist for the present from an attempt to make more special identifications, as by future examinations much is yet to be learned, before the suggested analogies can be proved. A forcible systematizing, as has been attempted in a tabular exhibition of the equivalency of Huronian rock-beds, in my opinion, does more to confuse a person than it helps to enlighten him.

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