THE GEOLOGICAL

—AND—

NATURAL HISTORY

SURVEY OF MINNESOTA,

THE TENTH ANNUAL REPORT,

FOR THE YEAR 1881.

N. H. WINCHELL,

STATE GEOLOGIST.

1

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ADDRESS.

To W. W. FOLWELL, President of the University.

DEAR SIR:—The accompanying report gives a summary of the work of the Geological and Natural History Survey of the State during the year 1881, being the tenth annual report. In thus rounding a complete decade of consecutive annual reports on the Geology and Natural History of the State, I think, sir, that the University and the State may be congratulated on the success which has attended the enterprise, a large share of which is due directly to the wise provisions of the law by which the survey is carried on, as conceived by yourself in 1871.

Respectfully submitted,

N. H. WINCHELL,

State Geologist and Curator of the General Museum.

The University of Minnesota, Minneapolis, December 31, 1881.

REPORT.

I.

SUMMARY STATEMENT.

The field work has been continued by Mr. Upham, aided in July and August by Mr. H. V. Winchell. The field of examination has been the north-central and northwestern portions of the State. These counties are almost entirely covered with a heavy sheet of drift, and necessarily, most of the recorded observations and investigations have related to the surface geology, and a large fund of valuable information has been added by Mr. Upham to the historical geology of the Quaternary Age. That ancient body of inland water which in former reports has been styled *Lake Agassiz*, has been found to have extended its highest shore line far toward the east, in the northern part of the State, probably including within its limits the present Red and Rainy lakes, and the Lake of the Woods, giving the well known topographic features of the Red River Valley, to a much larger extent of territory in Minnesota than had formerly been supposed, even quadrupling the known area pertaining to the valley as heretofore limited. Not only is this a valuable accession to the known agricultural capabilities of Minnesota, but the results attained in other directions, are equally valuable to science. The beach lines of Lake Agassiz have been subjected to a careful inspection over a distance north and south of about one hundred and seventy-five miles, resulting in the discovery of some peculiarities which have a direct bearing on their formation and history, and aid in filling out an obscure chapter in the geology of the Ice Age. Some of these peculiarities may be mentioned briefly.

The lake had three stationary periods, forming three beaches. They all ascend above a given datum level toward the north, the rate increasing in going toward the north. The highest beach line ascends one hundred and twenty-five feet in about one hundred and fifty miles, the beach being one continuous shore line. The northern portion of the lake fell at intervals from this high beach-line, forming lower beaches successively at about eight, fifteen, thirty, and forty feet, while the water level in the extreme southern part stood nearly stationary, the northern fractional beaches converging into one toward the southern extremity of the lake. The next distinct beach found in the southern part of the region ascends toward the north seventy feet in one hundred and fifty miles. The surface of-the lake had now fallen thirty feet in Traverse and Grant counties, fifty feet in northern Clay county, and ninety feet northwest of Maple lake. The fall of the lake had therefore been sixty feet more at the northern than at the southern end. Double and multiple ridges occur along the northern half of this distance. The third beach-line, formed when the outlet had been excavated to the level of Lake Traverse, is known along a distance of one hundred and thirty-five miles, and its northward ascent was at first fifty feet and and afterward only about twenty-five feet. Toward the northern extent of this beach are also additional lower beaches, indicating a halting descent of the water level. The fall of Lake Agassiz from the highest beach level to the third, at Lake Traverse, was about eighty feet, and in the vicinity of Maple Lake one hundred and sixty-five feet. But the rate of ascent of this third beach-line is less in the northern portion than toward the south. These phenomena seem inconsistent with that hypothesis which supposes an elevation of northern land as a barrier to contain this vast inland lake, inasmuch as these beaches would have to present a slope in the opposite direction in order to change the outlet from Lake Traverse to Hudson's Bay. The same kinds of beaches appear about the southern shores of Lake Erie and Michigan, and have often been referred to in geological reports. They have been ascribed to the operation of the glacial period in the epoch of its decline, when the ice still existed toward the north as a barrier to prevent northern drainage. The same obstruction must have existed in the Red River Valley, and in the opinion of Mr. Upham, its attraction was sufficient to move the mass of the water toward itself and to cause an ascending shore line in that direction. Any such barrier, operating inversely as the squares of its distance from different parts of the lake, would thus cause a more rapid ascent in those portions of the shore line near it than in those more remote.

Lake Agassiz, probably covered Red Lake under fifty or one hundred feet of water above its present level, Lake of the Woods under about two hundred feet, the Red River Valley at St. Vincent, four hundred and fifty feet, and Lake Winnipeg, about six hundred feet. It is supposed to have extended east as far as the east end of Rainy Lake, but no definite statements can be made yet concerning the northern slope of the State between Red Lake and Vermilion Lake.

The distribution and characters of the crystalline rocks in the central portion of the State, including the counties of Stearns, Sherburne, Benton, Morrison, Mille Lacs, Kanabec, Aitkin and Todd, and portions of Carlton and Pine, have also been ascertained by Mr. Upham.

The failing health of Mr. C. M. Terry, rendered it necessary for him to suspend active work about the middle of May. A trip to Florida afforded him no relief, still he was preparing to resume work on the survey in the latter part of summer, when he was taken worse and he died.

His contribution to the last report of progress, pertaining to the Hydrology of the State, shows the carefulness and the scope of his work. His perseverance and industry were remarkable, and the amount he accomplished, with his feeble health, was a surprise to those who knew the obstacles under which he labored. He has left some maps, notes, and incomplete manuscript, which will be made to contribute in his name, to the completion of the subject to which they pertain. I cannot forbear at this place, giving testimony to his uniformly, cheerful disposition and urbane personal bearing, his high integrity, his zeal and industry, and his truly scientific methods of work and thought. Having spent some years in the christian ministry, one of the most instructive facts of his brief labors for the survey, is the ease and quickness with which he turned himself to purely scientific pursuits. He began with careful laboratory work, requiring patient mechanical manipulation, and he succeeded from the outset. Whatever he undertook, he knew how to accomplish at once. Having a trained mind, it was no task for him to apply it vigorously and persistently, in a new field of labor. A general suggestion, or an intimation as to the direction to be given to his labor, was all that was necessary. Had he been able to finish the work that he had in hand, one of the most useful, thorough and instructive chapters of the final report of the survey would have been written by him.

Mr. C. L. Herrick continued to work in the laboratory of the survey and in the Museum, till the first of July. He sailed for Europe in September, and is studying in Leipzig. A contribution of his to the survey reports has been under way ever since the publication of his paper on *Microscopic Entomostraca* in the seventh annual report.

My personal labor has been given to the preparation of chapters for the final report, which, with the prosecution of the building-stone investigation, the office and executive duties, and the conduct of the last annual report through the press, have occupied my whole time. It has been necessary to visit most of the quarrying localities in order to obtain samples of suitable size for use in the examination of the building-stones of the State. At the same time the quarrying statistics of the State were furnished the U. S. census for 1880, and additional samples were forwarded to Washington to be subjected to a careful analytical examination by the government, calculated to further elucidate the nature of the rocks of Minnesota.

In the Museum report will be seen the recorded additions to the collections, and their sources. No important purchases or changes have been made either in the material of the collections or arrangements of the Museum rooms. There will be no occasion to make important changes before the erection of the new building for the use of the Museum, which has been ordered by the State legislature. Indeed, it would be poor policy to lay out much more expense on the old rooms. In the new building it is expected better accommodations will be afforded not only for the exhibition of the specimens, but also for the handling and examination of the various classes of rocks. The thanks of the University are due to Col. J. B. Clough, for fossil specimens of extinct vertebrates from Montana, and for Indian implements, for the General Museum, and for other specimens, and to O. E. Garrison, for procuring samples of water from Mille Lacs; and to Dr. —— Miller, of the Little Missouri Cantonment, for a collection of fossil leaves from that locality.

The survey is also under obligations to Prof. A. H. Chester, of Hamilton College, N. Y., for a report on the geology of the iron region east of Vermilion Lake, based on observations made by him during two seasons spent in that part of the State exploring for iron in the interests of non-resident capitalists. The report of the survey for the year 1878 called attention to the existence of iron ore in the northern part of the State in large quantities, and to the fact that parties interested in iron from eastern States have made costly surveys and examinations, attesting the value of these deposits by field exploration, and by laboratory assay. Since then others have become interested in the same way, and it is not premature to predict that the iron ore of Minnesota will, not many years hence, be largely wrought, and yield to the State a revenue which will be commensurate with the extent of the deposits and the importance of such industry. It would be well if the capatalists of Minnesota would look after this matter, and by concerted action, retain within the State as much as possible of the profits of such development of these ores. The blast furnace which is now in operation at Duluth, using ores from Marquette, should be supplied from Minnesota, and Minnesota railroad companies should see to it that these ores are made accessible. Our iron ores are the farthest west of all the Lake Superior deposits, and being in the midst of timbered lands are situated favorably for reduction by charcoal; while the great region west and northwest, destitute of the rocks producing these ores, will always have to depend on us for iron and its products in the same manner as for lumber. Eastern iron deposits and eastern furnaces should not be allowed to find it profitable to send their products past our doors when we have every requisite and every facility for producing the same. It would be a thing highly creditable to the Regents and to the University, to be directly instrumental in developing this great industry, and I hope that general attention may be called to its feasibility.

I wish to call your attention again to the destruction of the forests by fire in the northern portions of the State, and to refer you to representations made in the report for 1878, (p. 24) and again in the report for 1879, (p. 134). The Legislature should be asked to enact the necessary laws, with penalties, to preserve the forests, and especially the pine forests, from destruction. These fires are not occasional, but seem to be habitual. No country in the world, claiming to be a civilized and enlightened commonwealth, should permit such wanton destruction of the public domain for one moment when once informed of it, and it would not be possible were it not for the sparseness of the inhabitants, and the indifference to the public interests too often exhibited by republican Legislatures. It would be well if co-operation could be had with the Canadian government in any effort to suppress these fires, since they originate on both sides of the international boundary. The The University pine lands, on the St. Louis river, are annually in danger of being devastated.

II.

PRELIMINARY LIST OF ROCKS

COLLECTED BY N. H. WINCHELL IN 1879—CONTINUED FROM THE LAST REPORT.

FROM FOND DU LAC TO KNIFE FALLS.

443. The red sand rock at Fond du Lac. This dips E. S. E., or S. E., about ten degrees.

443A. Quartz pebbles from No. 443.

444. About the center of S. W. ¼, sec. 6, 48, 15. Here a bed of dark-red shale strikes across the bluff. This is about eighteen feet thick, and has thin beds of sandstone occasionally, much as the limestone is embraced in the shales of the Hudson river formation. This shale has spots that are greenish. Pieces of the same color (and also red) are sometimes seen in the midst of the massive sand rock (443) which, on weathering out, (where quarried,) give the rock a loosely porous and (apparently) conglomeritic structure. There are belts and thin strips, parallel with the bedding, that are conglomeritic with white, or glassy (not milky,) water-worn quartz pebbles, that are sometimes larger than hen's eggs, but the great mass of the whole is a homogeneous sandrock. They are sometimes more shaly, and also on separating some of the thin layers, they even show micaceous interlamminations. The general color is a dark red-brown, like the brown sand rock of the "brown fronts," but it has layers that are of the ordinary light-colored sand rock. This light color is sometimes disseminated through the red in round spots or specks, or is clouded and mottled in it over considerable areas. Sometimes a solitary quartz pebble, as large as a walnut, is seen in the otherwise homogeneous brown sand rock; and occasionally one is as large as a man's fist.

Below the above-mentioned bed of dark-brown or red shale, the rock is altogether less firm and siliceous than it is above, or to the east. After a thickness of about twelve feet of rock, somewhat like the rock overlying, another bed of shale, or shaly rock, is met with, whose extent cannot be defined, as it seems to alternate with thin bands of shaly sand rock confusedly, the latter having cross-stratification, until finally the whole formation, so far as seen in the bluff, almost deserves to be styled a shale. It resembles the red shaly sand rock of Good Harbor Bay, near Grand Marais. It sometimes weathers out in slates, (less than one-fourth inch thick) which are flexible, and red like the rest, but rather fragile. It has belts of green shale running parallel with the bedding. There is a thickness of about thirty feet of this shale visible along the river by the railroad, before it is hid again by trees and talus. It becomes all shale. The apparent horizontality is due to a change of direction in the bluff. Some of it is quite siliceous, but in very thin sheets. The brick-red color is sprinkled with light spots; and there are belts, three or four inches thick, of a light bluish-green color. The green color, indeed, seems to be the original color, and prevails largely on tearing down a lot of the layers. Although following the layering in belts, or elongated with the bedding, yet these light-green spots are also globular, or oblate spheres passing through several sheets of the thin shale, which shows no change but that of color.

At the high bridge, "No. 1," which is over a little creek at center of sec. 1, 48, 16, the formation shows about the same dip, but is more nearly a sandrock again, but still with alternating layers of slaty sandrock, (often with cross-bedding,) and red aluminous shale in thin layers; but where the creek joins the river there is a bed of about three and one half feet of red, crumbling, conglomerate. This lies below the shale last mentioned, and has below it an exposure of about six inches of cross-bedded sandrock. Thus, in ascending the creek, the layering is as follows, No. 1 being the lowest:

1.	Cross-bedded sandrock, next the water	6 in.
2.	Crumbling conglomerate, rather fine	3½ ft.
3.	Shale, with layers of six and eight inches of shaly sandrock with cross-bedding	4 ft.
4.	Shale	18 in.
5.	Sandrock	8 ft.
6.	Like No. 3	12 ft.
	Total	29 ft. 6 in.

The above section is all on the lower side of a *fault*, i. e., on the river side, and on the left bank of the creek. Above the fault, which is hid on the opposite side of the creek, the visible section consists of the following:

1.	Crumbling conglomerate, rather fine	3½ ft.
2.	Shaly sandrock, with belts of greenish, shaly sandrock and of shale	10 ft.
	Total	13½ ft.

It seems as if the conglomerate had passed up to the upper level, a distance of about fourteen feet, but there are fractured and curved beds at the fault, indicating a subsequent settling again of about six inches, after the fault had closed up.

446. Black roofing slate, near the section line, between 30 and 31, in town 49, 15, in the bottom of a branch of Mission creek, very inconspicuous exposure, covered in high water. The slaty cleavage strikes across the creek east and west.

447. Nearly on the town line, next south, below the two forks from the northwest, in the bottom of Mission creek. This is a lighter colored slate than the last, but related to it closely. It strikes in the same direction and rises about four feet in the right bank of the creek.

448. Crumbling, red conglomerate, from the tilted beds of the St. Louis, at a point near the bridge ("No. 1,") over the creek mentioned, but lower in the formation than the three and a half foot bed. This bed is fifteen feet thick, shows a strong dip, and is underlain, in ascending the creek, by two feet of shaly sandstone, and then by fifteen feet of shale not well exposed. Under that, still higher up the creek, may be seen six feet of red conglomerate descending below the turf, and extending along the bank so as to make, with the dip constant, about fifty feet.

449. Below the last appears this number, which is a hard pyritiferous, pebbly conglomerate, consisting largely of quartz pebbles. This is seen on S. W. ¼ of N. E. ¼ Sec. 1, T. 48, 16. It dips with the red beds, about 10° E. of S., by compass. Some of the pebbles are two or three inches across. The pebbles are mainly of milky quartz. Some are translucent. Some are black or gray. In some places nearly one-half of the gravel is of the underlying slate formation. Just above the junction of the two creeks there is a blind vein of calcite about two inches thick, running north and south in this conglomerate. The conglomerate extends a few rods along the creek, both branches, and before it disappears, which it does by rising in an incline along the left bank in accordance with the dip, it shows about eight feet of bedding; and within the distance of about two rods the Thomson slate formation appears in the bed of the creek, and soon form a considerable exposure along the bank. The slates stand nearly perpendicular as the weathering separates the cleavage planes, and they strike east and west, as at Thomson. But it seems as if the conglomerate lies lower where it is last seen in the bed of the creek, than the slate when it first appears, and so low that even with the dip, which would of course tend to throw it higher in ascending the creek, it could not get over

the slate. Hence it is probable that the conglomerate lies in depressions in the slate surface, and is thicker in some places than in others. At this place the contact is not visible, but there cannot be much between the points seen on each side. So that, as already stated, there is too much conglomerate to fill the unseen interval. This conglomerate appears conspicuously on the St. Louis, S. E. ¼ Sec. 2, T. 48, 16. (For a complete section of the red sandrock beds, see after No. 510).

450. Samples of the Thomson slate, from the river bank, S. E. ¼ Sec. 2, T. 48, 16, underlying the conglomerate, No. 449.

451. Samples of the same showing, the slaty cleavage transverse to the bedding. The dip of the slate beds is to the S. W., amounting to about four degrees, the conglomerate being unconformable.

452. Slate pencils, formed naturally by the intersection of diffierent divisional planes, having a rhomboidal section. The overlying coarse, gray conglomerate, seems to have a thickneess of about 100 feet. Above that is a considerable red, finer conglomerate, perhaps fifty feet.

453. Slate from the lower falls of the St. Louis river, S. E. ¼ Sec. 10, T. 48, 16.

454. Near the foot of the falls, on the left bank, are several "veins," or folia of white quartz, parallel with the slates, some of which are four to six inches in thickness. They are all in an interval of about three feet, with folia of slate between.

455. Slate embraced between and contiguous to the white quartz.

456. Harsh, arenaceous, gray, firm beds, two to three feet thick, embraced in the slate at the lower falls, having no slatiness.

457. Slate; average sample for the rock of the lower falls.

The cause of the lower falls is the occurrence of a dyke of igneous rock which crosses the falls near their brink, hardening the layers of the formation. The falls cross the river stragglingly about east and west in conformity with the strike of the formation, and descend about twenty-two feet in the distance of about six rods, but the water is rapidly descending in other short cascades for a quarter of a mile above the falls. Also below the falls it continues as a rapid to the foot of the islands, descending about fifteen feet more. The dip, which is taken to be the general incline of the heavy beds toward the S. E., is 63°, but there is a multiplicity of folia, joints and seams, and sedimentary planes, that all confuse the question of the dip. This measurement was made near the dyke, and on the east side of the river.

458. Hardened slate formation, contiguous to the dyke at the lower falls. The slate here has a coarsely basaltic structure along the east

side of the dyke. The columns run E., S. E. and dip about thirty degrees from the horizon.

459. The doleryte dyke at the lower falls, by compass, runs N. N. E. and is at least twenty feet wide. It may be twenty-five feet, but the high stage of water prevented a full view of its western extent. This has so hardened the slates that they are more durable under the action of the river than the dyke itself.

460. Above the falls, nearly opposite Island No. 6, (the islands being numbered up stream,) two other dykes are seen on the east shore, the rock being of the same kind as the large dyke (459), but finer grained. One seems to be about eight feet and the other about ten feet wide.

461. Sample from the eight-foot dyke.

Above the lower falls, along the east side of the next island, the rock stands up in the channel as very rough islands, the water descending about twelve feet near the lower end, and about nine feet near the upper end of the island. The fall near the upper end of the Island No. 5, is due to the occurrence of a rather soft and fissile layer of the slate immediately below (i. e., down stream,) a harder part, the softer part having been torn out faster than the rest. At the large rock island, east of the upper end of Island No. 5, the dip of the formation is 27° S. E.

There may be other dykes, not visible on account of their crossing the river under water entirely and entering the banks where they are hid by drift-wood or by standing trees and bushes. The dyke rock wears away faster than the formation that they cut.

The rapids below all the islands (on Sec. 15,) are over boulders. These rapids continue on between the islands to the foot of the fall which is on Sec 10, at the head of Island No. 3, the island itself cutting the fall into two parts, the greater part running to the east of the island. Six or eight rods below the foot of the fall begins the second island. Island No. 1 begins still further down stream and is cut by the section line between 10 and 15. This last is a very small island, having but three large pine trees, (though several small ones,) and seems to consist of boulders, and rises but two or three feet above the water. Island No. 2 rises twenty feet above the river, and is wholly covered with pine, with a few birches and cedars. A high drift-bluff, (227 feet,) causes the current here to turn rapidly toward the southwest, uniting with that which passes down the west side of the west island. Just above Island No. 6* is the wildest and most tumultuous portion

*The islands number 6 instead of 5. They are wrongly represented on the township plats. There are also a number of rock islands.

of the river, where it comes nearly along the strike of the slate. The descent here, in about a quarter of a mile, must be about forty feet. There is no regular fall, but a rushing and foaming torrent, dashing from side to side of the channel, cut and parted by the jagged protrusions of the highly dipping slate, which by its variations of hardness forms troughs that alternate with sharp and angular ridges. The dip of the slate, which sometimes rises in the middle of the river twelve or eighteen feet, and is very conspicuously disposed, varies from thirty to forty-eight degrees to the S. and the S. S. E. The former dip is to the S. and the latter to the S. S. E., the slaty cleavage being nearly perpendicular all the time. The grand bedding of the slate is in thicknesses of fifteen to twenty-four inches, but there is also a thinner bedding which is in layers of a few inches. Perhaps the heavier beds would show a finer bedding if favorably weathered.

The roar of this river here is greater than that of St. Anthony Falls, and it seems equal to that of Niagara. It is continued over so long a distance that the multitudinous dashing seems to make as much atmospheric commotion as the single plunge of a large stream at Niagara, and to be comparable to the roar of an extended beach-line. It can be heard for sveral miles, and is like the rumble of a heavy freight train on the railroad, for which it is apt to be mistaken at first, as it comes with the changing currents of wind or is echoed on the bluffs.

462. Fine-grained dyke-rock, from a dyke crossing the river at the mouth of the creek coming from the north on S. W. ¼ Sec. 10. It is above the foregoing rough and jagged portion of the river channel, visible only on the shore. It is less durable than the hardened slate. It is about thirty feet wide.

463. Rock similar to the last, from a dyke eight feet wide running N., about 15° E.. on N. E. ¼ of the S. E. ¼ Sec. 9, T. 48, 16, crossing the river.

464. From a dyke crossing the river a short distance above the last in the same direction, but thirty feet wide.

About thirty feet above the last appears to be another narrow dyke about six feet wide, but no certain pieces *in place* can be seen on the north bank. It shows as a gorge in the slate on the south bank. It is situated about ten rods below the small island in the river seen on the S. E. ¼ of Sec. 9, and about five rods above is another of the same uncertain character.

At the island on the S. E. ¼ of Sec. 9, T. 48, 16, the river is very rough as it separates and plunges among the rocks. The strike of the slate is nearly in the direction of the river. The island itself is made of a knob of hardened slate, with a few trees, and the beds that have a strike on each side of it stand up in the channel like inverted plows, and cause the water to twirl along on one side for a few rods or feet when it leaps over, or rises and falls over like the turf on the coulter, and runs into another trough from which it escapes in the same way. This takes place on each side of the island, but is particularly interesting and beautiful near the head of the island on the north side. Below the island, in the main channel, it then repeats this operation as it makes its way through other troughs. Generally the whole river is divided into several such troughs, but in a few places it is all embraced in one rapid chute about twenty-five feet in width; along the sides of which there is a boiling return current up stream, as the central current plunges and foams downward. I think there is nothing in the State that surpasses several of the scenes along this river. Norwood says the upper falls are indescribably beautiful, but I do not see how they can exceed these. Above this for half or three-quarters of a mile the river is more tame, but still constantly rapid, and impassable even for canoes, with frequent ridges of slate along shore and in the channel.

Just at the head of the island, and on the south shore, is an interesting irregularity in the layers of the slate. They first appear horrizontal, or rise gently from the water to horizontality. Then they bend downward, and even dip slightly northward, toward the river; then are suddenly deflected upward, but return to horizontality, when they again begin to dip into the river. This apparent change of dip is to a large extent only apparent. The beds still really dip south, the appearance being due to undulations of the strata, as viewed against the strike, combined with a jointage which breaks off so as to leave smooth planes sloping northward.

465. The slate formation from the railroad cut, N. W. ¼ S. W. ¼ Sec. 9, T. 48, 16. Tough gray, firm rock, hardly showing any tendency to slaty cleavage, finely arenaceous.

466. Siliceous slate, quartzyte, from the falls, center of Sec. 8, 48, 16.

Near the center of Sec. 8, is another fall of twenty-two feet, the river coming directly across the slate range from the N. W., the slate striking E. and W. The beds here dip 33½° toward the S. S. W., swinging round to the S S.E., and being then in a dip of 39 to 43°. This highest dip is seen at the narrows, where the water crosses the strike of the heavy beds. At these falls the rock appears less slaty than usual, though occasional similar layers of more siliceous rock occur mingled with the slates at points lower down the dalles. Here are heavy siliceous layers that require for the formation rather the designation of a quartzyte than a slate. Yet it is slaty, and breaks with the cleavage easier than against it. The rock here is also accompanied with deposits of white quartz, which is like that seen at Little Falls, and cracks up like that. The quartz deposits are seen to be rather veins than foliations, though they follow nearly the direction of the slaty cleavage.

The strike of the slate hills in sections 9 to 4, (48, 16,) is east, 10° north, and the dip is from 46½ to 60° toward the south, and the slaty cleavage runs almost east and west.

467. Rock of the dyke at Thomson bridge.

468. Rock adjoining the dyke at Thomson bridge.

The river at the railroad bridge over the St. Louis is running in the course of a dyke of igneous rock, about twenty-five feet wide. This being more jointed, and at the same time more easily rotted and disintegrated, has caused the gorge through which the river passes under the bridge. The walls on either side being of hardened quartzitic slate, are much more durable. This dyke is visible in the bluff facing the bridge down stream, and the rock is coarse and gray, but it is nearly hid by its own tumbling debris, while the slates stand up firm from sixty to seventy feet above the river. The dyke has a direction N. N. E., but is some crooked.

There is an island, also of hardened slate and quartzyte, in the river, visible from the bridge. This is due to the existence of another fracture in the formation which runs southwardly nearly to the bridge when it unites with the larger dyke; but just as it meets the larger dyke, the intervening slates were so finely, and so entirely metamorphosed, that the hardened mass has formed still another island (in very high water,) on which a pier of the foot-bridge rests. There is no evidence of this second smaller dyke except the gorge and the hardened slate walls. This gorge that forms, with the larger gorge, the two islands, continues northward a short distance in the north bank of the stream, but there is so much fallen drift and quartzyte in it that no igneous rock can be seen. The dip of the formation is 46½°. Half a mile northeast is a large dyke, sixty feet wide, which comes to the river between Thomson and the railroad bridge. It runs at an angle of forty-six degrees with the strike of the slate and quartzyte hills, but it is much more easily destroyed than they.

469. From near Miller's Mill, north of Thomson, a quarter of a mile. This is from a bed of harder, non-slaty, gray quartzyte, belonging to the formation. It weathers nearly white from feldspathic

ingredients, and from the abundant quartz, so as to look much like the trachytes of the western territories, but within is much darker. This bed is eleven feet thick, and in some places is conglomeritic. It has slaty layers on each side of it. It is massive, but parted by seams of white quartz, some of which are four inches thick. These seams wedge out lenticularly, and diagonally across the beds. The same sort of quartz veins are in other parts of the formation. Indeed, white quartz deposits are quite frequent in all kinds of seams or joints, or cleavage openings. The feldspar of this rock is triclinic and the ridge is *faulted*, the east side being moved south about twelve feet. (V. Nos. 310, and 418, and 505).

470. Slate, quarried for roofing, near Miller's Mill. This is black and of even, fine grain.

471. Slate like the last, from another old quarry.

472. White quartz, from a heavy deposit, forty rods above the railroad bridge, where the county road crosses the river, in the right bank. It is embraced in the slate, and its manner of occurrence is exposed on the side toward the river. It coincides in direction with the slaty cleavage. Near the top, the deposit is nearly ten feet thick, N. and S. but standing vertical it runs but little distance downward. It can be seen to run out, almost entirely, about twelve feet below the top, something like the roots of a tooth running into the jaw below the crown. It is not coincident with the bedding, nor with any system of joints, but stands perpendicular. It extends E. and W. conspicuously about ten rods. It is crossed by a narrow dyke, and it is faintly exhibited on the wall of a slate-ridge further west, and at a level twenty-five feet higher. Along the river channel where the water sweeps it, one large root runs below the water with a width of nearly two feet, and also another of six inches, but the greater part of it pinches out within ten feet of the top. At the place of deposit of this quartz there seems to have been an anticlinal locally formed in the slate formation, and the opening produced by the upheaved fracturing was afterward filled by quartz, some of it also collecting in other openings, the whole standing in nearly a vertical position. All about here is evidence of much displacement and crumpling, but rarely is there seen so evident a dip toward the north. The quartz is milky white, and mainly massive, but sometimes shows a splintery cleavage in the direction of the slates. It is jointed, and disintegrates by falling out in blocks which are distributed down the river, and once probably furnished stones for the quartz conglomerate (No. 449.) As to minerals, this quartz contains galenite, pyrite and siderite.

473. Pyritiferous gray quartzyte (?); from the ridge along which the large quartz vein (472) is visible. The pyrite is scattered in perfect cubes, sometimes three-fourth inches across, and occasionally an inch, through the rock. The most of the cubes are about the size of peas. The rock is like No. 469, but finer, and has siderite as well as pyrite disseminated finely through the whole, the former becoming oxidized at the surface.

In some of the quartz veins which cross the strike diagonally, particularly in rock 469, and 473, which veins die out and are replaced by others a little further to the right or left, lenticularly, the white quartz has been intercrystalized with siderite, which on weathering changes to hæmatite, and then washes out if wholly free to the air, leaving a gashed appearance among the quartz crystals when exposed. On deep fracture, when not thus exposed, the siderite is preserved—and in other places can be seen passing into hæmatite.

474. Dyke rock, near the Northern Pacific Junction. This dyke is thirty feet wide. The average dip of the slate formation in S. W. ¼ Sec. 6, T. 48, 16, is 57 deg. to the S. 5 deg. E. West of dyke rock, No. 474, which is a little east of Paine's saw mill, are other dykes, parallel to 474, one being still nearer the mill, on the east side, and one west of the mill. They all run about N. 5 deg. E. (compass), with a slight variation a little east or west of that, and they all consist essentially of the same kind of rock—a greenish gray doleryte. In both respects they are like those seen crossing the river below Thomson.

475. Doleryte from the most westerly of the above mentioned dykes—one of the triclinic feldspars appears porphyritically in this, which is not common in the rock of these dykes.

Up Otter Creek, two or three miles west of the Junction, there is said to be a large exposure of rock, like that at the Junction. It seems then to continue on to Moose lake, where it is again seen thirty miles south of the Junction, and causes a rough and more elevated tract of country. On the road to Twin lakes, about a mile south of the Junction, there are three or four ridges of slate.

Northward from the Junction, along the Knife Falls railroad, a number of cuts in the rock display its character and position. Cut No. 1 is about three-fourths mile from the Junction and is in slate that dips south at about the usual angle. There is a little ridge further north, and on the west side, that has a much higher dip to the south—about seventy-five degrees. Cut No. 2, which is nearly a mile further north is in a hard, gray, massive quartzyte, which has joints running in various directions, and shows no dip, but in a small slate outcrop along its northern side there is sign of sedimentation dipping about 45 deg. S. (as usual.) The same dip can be seen in a parallel slate range on the west of the road nearly opposite this cut. This quartzyte range is high, long and conspicuous toward the east, but to the west it soon ceases. The slate range on the west also is short, and the surface settles down to a valley in which there is a stream, with a high timbered plateau on the north side.

Cut No. 3, about two miles north of the Junction, is near this high land, but the road bends east at the cut so as not to go directly toward it. (See No. 505.) North and west of the Junction are numerous slate ridges which are not struck by the railroad.

The river below Thomson is filled with rapids and falls all the way to "Bridge No. 5." There are four spots, in particular, where there is valuable water power:—first, near bridge No. 5, where the river in a short space is divided into various channels, by six islands that occur between its banks. Three of these islands are above the fall and three are below, but there is also a considerable fall above island No. 3, (numbering from below) extending to near the head of island No. 6. This whole fall is fifty-five feet. The existence of the islands and the widening of the river, as well as the extent through which the fall is carried before it reaches rather quiet water again, are favorable for the improvement of this power, and its utilization. But a short distance above the head of island No. 6, is the second fall, where the river is narrow, but has the rock formation of the country in conspicuous strike along each bank confining the water like artificial dykes, within troughs which run somewhat obliquely across the course of the river, and rising in knobs and rough islands (with constant dip toward the S. E.) in the midst of the river itself, sometimes eighteen or twenty feet. This condition of the river extends from near the head of island No. 6 to the dyke (No. 462 above), which is near the mouth of the creek that crosses the railroad on the N. W. ¼ of Sec. 10, and the fall here, which may be called cascade No. 2, amounts to sixty-five feet. There is then a gradual ascent of twenty-five feet among the rocks to the foot of the fall at island No. 7, and of twenty-five feet more in getting round the island itself, where the river is divided and beautified by the disposition of the slate ranges as already described under No. 464. This is cascade No. 3. Above this the river is more steady in descent for one-half mile, when there is a widening of the channel near the mouth of a little creek from the north, and a fall of about six feet over one of the harder beds that protrudes above the rest. This goes diagonally across the stream. There is then a similarity in the stream to and beyond the "retaining wall" of the railroad, a distance of nearly a mile, through which there is actually a steady ascent, amounting in the aggregate, from the head of cascade No. 3 to the foot of the Thomson Fall, to seventy feet The Thomson Fall is regarded as beginning near the 133d mile-post of the railroad, (near the center of Sec. 8) and extending to the large island on Secs. 5 and 6. That part of it below the mouth of Otter creek which joins the river near the railroad bridge south of the railroad, extending a distance of nearly a mile, is thirty feet, and is caused by the strike of the rock going directly across the river, causing it in several places to be suddenly contracted in width to twenty or twenty-five feet, through which narrow passages the river rushes with some fall and a swift current. The most of the fall is near the foot of the distance stated, but there is an irregular rapid and rocky river all the way up to the railroad bridge that cannot consistently be subdivided, though it is more rocky at and near the mouth of Otter creek. That part above the mouth of Otter creek, extending to the foot of the large island, is thirty-five feet. The greater part of this is near the foot of the island, but the river is a rushing torrent, in a rough narrow gorge, sometimes split by islands, all the way from the first fall to the creek. The total fall from the brink of Knife Falls to the water at the foot of the lowest falls, N. E. ¼ Sec. 15, T. 48, 16, by ameroid, is five hundred feet, with an estimated descent of fifty feet more to the level of Lake Superior.

476. Rock from near the river, south bank, about a mile above Knife Falls. The same formation, with the same dip and outward aspect occurs along here. It extends at least to the village of Cloquet, the direction of the slates being E. 10 deg. S. inclined to the south at an angle of 75 deg. or 80 deg. Along the river are occasional low slate exposures. The islands are caused by low slate elevations.

477. From the same place as the last; coarser, similar to that near Miller's Mill. (No. 469)

These rocks are in some places cut by slaty cleavage. They are rather firm, but have a *grain* running in the line of the slaty cleavage (476), but in other places (477), it is not affected by cleavage, but is cut by joints running in all directions across it, so that there is a semblance to dip toward both the south and north. The slaty cleavage goes diagonally across the jointage systems. After a careful study the dip is made out satisfactorily to be toward the south. Between this place and the Indian Reservation, which is a mile above "Pose's," the country is covered with drift, and timbered heavily. At Pose's the bank is about one hundred feet high, and apparently consists wholly of drift. Usually there is a belt of swampy, clayey alluvium between the drift banks and the river, about six feet above the present stage of the water. The river is very quiet above Pose's to the little island known as *Pine Island*, three miles above, where there is a fall of about eight feet in a tumbling rapid, the most of the descent being below the island. No rock in place is visible at the island—only boulders, of many varieties, chiefly like the Rice Point rock at Duluth. The island has a covering of tall pine trees. The country is not hilly, only moderately undulating, with considerable good pine. The long, narrow island at Pose's is low and not rocky, or stony, even, but sandy and clayey. The lower islands are rocky.

478 Represents the last rock on the right bank of the St. Louis above Knife Falls. This is found on the south bank nearly opposite the foot of the island known as Homestead Island, very near the same place as No. 477 and 476, but further west This is firm, gray, crystalline, with translucent grains as if of quartz, also having rusty specks when weathered, as if from oxidized siderite or pyrite. This, under the microscope shows in thin sections that it is one of the arenaceous members of the formation. This is an important rock-horizon. It seems to run further east, and also to extend under the river, forming the islands—at least such layers occur in the strike of the islands, and also form the brink of Knife Falls. It varies a little, becoming more like the rock at Miller's Mill, (469), than 478 is.

This is supposed to be Norwood's "last rock," which he styled an igneous rock, or doleryte, (his No. 454), having a direction nearly north and south, crossing the river nearly at right angles. This rock has translucent grains (which may be his supposed nepheline) but it is certainly a part of the formation and strikes east and west.

479. Rock from the brink of Knife Falls, similar to No. 477, a gray quartzyte.

480 From the brink of Knife Falls, finely crystalline, with minute grains of quartz visible in thin section. There are places in the formation where there is a change in the crystalline character, a greater frequency of joints, a finer grain, a loss of cleavage, and other features that accompany the metamorphosing proximity of a dyke, but where no dyke-rock can be seen. This sample seems to be from such a place.

At Knife Falls the descent is fifteen feet altogether, and about six feet perpendicular.

On the island first above Knife Falls the dip is N. 25 deg., forming an angle with the slaty cleavage which dips S. about 85 deg., and frequent joints cut the strata. The rock at this point is slaty in the direction stated, but the real slatiness does not appear as soon as a coarser slaty lamination which, on the surfaces of opened jointage planes, is in layers about one and one-fourth inch thick and looks like a bedding of sedimentation dipping almost or quite parallel with the slaty cleavage.

481. Slate, from the point above described. The piece has the lines of supposed sedimentation crossing the slaty cleavage as noted.

Just below the point of the last observation, which is where a small channel crosses the island in time of high water, is a nice little fall of about five feet, in the channel on the north side of the island, the channel itself being about twenty feet across. This rock is firmer than the rest of the formation here, and consists of alternations of argillaceous slate with a slaty cleavage, and a gray quartzyte. This quartzyte has translucent grains like the rock of 479. Here the dip is plainly 48 deg. S. 3 deg. E., the alternating quartzyte and slaty layers being a sure indication of *what* the dip is. This observation negatives the last note in regard to dip, the structure there supposed to be dip. (illustrated by No. 481), being due to a former slaty cleavage, or to a foliation, or to a striation produced by friction, or to what? The water crosses the strike at an angle of about 45 deg., where it passes over these beds. There are ten beds of argillaceous slate that do not (with one exception of a bed of about three feet) exceed eighteen inches in thickness, some being but about six inches, alternating with hard and gray quartzyte layers which have a little greater average thickness. These layers strike to the north of the main falls in the south channel, and appear on the east end of the island below the falls. The slate beds have a perpendicular slaty cleavage, but the quartzyte beds have no cleavage of that kind, but are variously jointed. The slaty cleavage gradually fades out in the quartzyte beds, firmly cementing them with the slaty beds. Many of the joints of the quartzyte pass through the slate beds, particularly those that run at right angles to the strike.

482. From the above slaty layers.

483. From the above quartzyte layers.

484. Samples showing intermediate characters.

At the real Knife Falls, which are on the N. W. ¼ of the S. W. ¼ Sec. 13, T. 49, 17, and face toward the north, the brink running exactly east and west, the dip is 48 deg. toward the south, and the rock consists of alternations of slaty layers with gray quartzyte, exactly as ast described fôr mumbers 482-3-4. But there are here two very prominent and persistent beds of the gray quartzyte, one of which forms the brink of the falls, while the other is forty feet below the falls, and lies immediately over the section of beds represented by Nos. 482-3-4, or is separated from them by an interval of twenty or twenty-five feet occupied by the same sorts of rocks as those. This lower quartzyte bed forms a spit of jointed rock that projects eastward just below the falls. Along the banks, both on the island at the west end of the falls, and on the main at the east end, immediately below the falls, there are heavy beds of gray quartzyte which seem to be as durable as the rock in the brink of the fall, but they have not resisted the water so well as those further down, just mentioned. They rise, however, higher in the banks, especially at the east end. The rock over which the water plunges has a basaltiform jointed structure about at right angles to the dip, but no characters of undoubted igneous rock can be seen, nor evidence of igneous action in the form of dyke-rock. Yet, just at the west end, even west of the little island that is in the fall and cuts it into two parts (the little island and the west channel make about one-third of the whole)—there near the west end of the little channel the rock is closely jointed in a direction N. and S. (or nearly) and hardened, becoming fine-grained, these characters also striking the spit running east from the main channel. This dyke-like appearance has a width of about four feet, and although it is in a low spot across the spit where sometimes water flows in a high stage of the river, yet it forms a little island in the rocky channel just in the brink of the falls.

485. Is from this fine-grained rock which has the manner of a dyke, though it does not show the mineral characters of the dykes that cross the formation. This belt runs N. and S. as above described. In thin section this rock proves to be granular and finely arenaceous, and hence a part of the country formation.

486. From the quartzyte spit below the falls.

487. Slaty alternations in the spit below Knife Falls.

488. Gray quartzyte, similar to 478 and 469.

This is from the north channel, from near the lower end of the third island (not counting the little island in the brink of the falls) and is north of that called Homestead Island. The rapids are twenty rods above its first exposure, which is much greater than on the south shore where 478 was obtained. These heavy, gray quartzyte beds, although they differ widely from the most of the formation, having a massive and jointed outward aspect, and thus resemble the dykes of true igneous rock, have not the composition of the dolerytes. Further, they run E. and W. instead of N. and S., and are interbedded with slaty layers. They could not be mistaken for dykes wherever their stratigraphic relations are visible. In this place no other rock can be seen. It extends along the shore about thirty rods (E. and W.) and does not vary. The main jointage system runs N. 3 deg. E. The rock gradually disappears among boulders some of which are very large, and yet seem to be like the same rock. They show, however, a little *grain*, or schistose structure, approaching that seen in some of the slaty beds of the formation.

489. Samples from one of these large boulders that seem to show a gradation toward the slaty beds. In rock 488 are veins of white quartz some being five inches thick.

About fifty rods further up the north channel is a cross-channel, between two islands, the water running north; opposite which, and immediately below, in the middle channel, are seen other rapids and much rock in place. The surveyors' plat of the river about Knife Falls is quite faulty. The islands are all represented as one, and the river seems to have but two channels instead of three. This rock shows a slaty cleavage running E. and W., which has a dip to the north, or is nearly perpendicular. It belongs to the formation of the country. South of this rock exposure, which forms a rapid place crossing the middle channel diagonally, is Homestead Island, or island No. 5. The rock is very like that forming the falls, but probably lies below it, as it is a little further north. In these rapids is a little rocky island, rising about eight or ten feet above the river, having three or four growing pines and cedars. These rapids are higher up the river than Norwood's "last rock."

490. An arenaceous, somewhat slaty, hard, gray rock, from the rapids in the middle channel, north of island No. 5, near Knife Falls.

491. From near the same place as No. 490, and related to it in position, in the same manner as the spit of hard rock below the falls is to the rock in the brink of the falls, *i. e.* in a conspicuous strike parallel and thirty or forty feet further north; a firm gray quartzyte.

492. Doleryte, from large boulders at the rapids at the head of island No. 4, scattered about as if from a large dyke in place near, but cannot be seen in place.

493. Gray quartzyte from boulders apparently derived from the rock in place near. The rock of the formation is in place at this point.

494. Rock from one of the firmer beds of the formation about one-half mile below Knife Falls, at the river bank.

Below Knife Falls in the first quarter of a mile there is a descent by rapids, of about twenty feet. The river then turns SE. The water is still rapid, and has a broken cascade over boulders at one-half mile, with a fall of about three feet. The rock is exposed constantly from

Knife Falls, the precipitous walls rising, at the cascade just mentioned, to the hight of twenty-five feet.

At a quarter of a mile below this is a fall of about seventeen feet in three hundred feet, there being no perpendicular fall. There is a division of the stream into four channels by the strike of five different persistent beds in the formation, the water running in the strike of the intervening beds, the hard beds forming islands in the falls. The width of the river at the brink is about two hundred and thirty feet, and a dyke of about two hundred feet crosses the river just at the head of the fall. This dyke is destroyed by the river faster than the rock itself, owing to its frequent jointage; and the most rapid descent of the water is over the hardened beds of the formation on the east side of the dyke.

495. Rock from the two hundred feet dyke at the falls above men, tioned. This dyke runs N. 5 deg. E., and is of a firm and fine grain though principally feldspathic. The dyke is finely jointed and easily shattered by the frost. The dip of the formation is S. 60 deg.

About one-fourth mile below this fall the river turns about south, so as to go directly against the strike of the rocks. The banks increase in height, the dip increases in degree, and at three-fourths of a mile further, there is a high rocky island (Fortress Island) from the foot of which a portage trail sets out to Knife Falls, on the west side of the river. The larger part of the stream passes on the left of the island, the descent being eight feet over large boulders. At this place the rock of the country is wholly slaty; and although a short distance above the island there is a gradual change in dip from 60 to 70 deg., and then to 90 deg., as the river exposes the beds, yet in viewing the island from the N. W. down stream, there is, besides the slaty cleavage, a coarse bedding or jointage system visible on the east side of the island that seems to dip about 45 deg. S. E. At a distance the island itself, in its perpendicular walls, covered with a red lichen, cut by joints that cause the slates to fall away in masses, looks like a basaltic island of igneous rock. But there is no igneous rock in it. It rises fifty or fifty-five feet above the water, and is covered by small pines, among which are many Norways. The actual bedding either coincides with the slaty cleavage or dips S. E. at about 45 deg. This is an interesting spot. The appearance of the island reminds one of basaltic Staffa, but of course its structure does not illustrate that. The banks of the river are not so high as the island, but on the east side the rock rises fully as high a short distance back. Below the island the valley is deep and has high, slaty walls, the water being steady for at least half a mile.

The portage trail which sets out here, going west, is that traveled by Norwood, and by the explorers and geologists that preceded him. Duluth was probably the first white man that passed over it. It leads to the Mississippi and to Vermilion lake. Douglass Houghton traveled it with Schoolcraft, and with Lewis Cass. It was the outlet for the immense fur-traffic of the Upper Mississippi region. The name "Knife Portage," by which it is usually known, is well applied, because where it starts, and for some distance, the slates are thin, perpendicular and sharp like knives.

496. The rock of the conntry, from the beds *in situ* at the head of the uppermost of the chain islands above Knife Falls, (same as 493.) This was got by Mr. Terry on making a re-examination of the rapids. He reported no dyke in place there.

497. From near the middle of the central channel, a short distance above the head of the uppermost chain island, gray quartzyte, (Terry.)

Mr. Terry also found similar rock in place near the head of Homestead Island, but a little on the north side, in the central channel, which seems to be really the "last rock" to be found in the St. Louis, until reaching its higher tributaries.

498. The rock of the country from one hundred and fifty yards above the fall where 495 was obtained. (Weitbrecht.)

499. Rock immediately overlying 498. (Weitbrecht.)

500. Slate from just below the falls described under No 494. (Weitbrecht.)

501. Doleryte dyke-rock, center of Sec. 19, 49, 16, right bank of the river.

Below Fortress Island, where the first little rapid is seen, a dyke crosses the river about N. and S. It is forty or fifty feet wide, and is best exposed in the right bank some rods below the rapids. It is represented by No. 501 This dyke appears again thirty rods further down, and can be traced for half a mile along the right bank, to and beyond the floodwood. The direction of this dyke carries it across the railroad, near Paine's mile at N. P. Junction.

The river is then tolerably slow to and beyond the cluster of small islands just below the floodwood (hence named *Floodwood Islands.*) The floodwood now is a floating jam, in length about the same as the width of the river, six hundred feet, with a few alders on it, and is wholly above the islands, the lower end of it being about 1,200 feet above the islands. There is, however, a considerable other floodwood lodged about the islands and sunken between them.

The river is then slow and broad down to three other islands (not represented on the surveyors' charts) below which it again soon descends over rapids caused by boulders, about two feet. Here the river is broad and shallow. Then appear two islands represented in the S. W. ¼ Sec. 30. Between the larger of these and the right bank of the river is another rapid descent about three feet, over boulders. The rock of the country, however, closely underlies, as shown by an outcrop a few rods west of the right bank.

At about a mile above "Cut No. 3" (N) on the grade of the Knife Falls railroad, mentioned under No 475, a creek crosses the new grade. At this place there is a cut in the rock on each side of the bridge. That on the south side is short and about four feet high, while that on the north side is about nine feet high, and extends about one hundred and twenty feet. In the south cut the slaty cleavage dips to the south, but is nearly perpendicular. In the north cut it is also nearly perpendicular but dips to the north. The sedimentary bedding is not discerned. There are belts of lumpy, white vesicular quartz, coincident with the slaty cleavage, which lenticular lumps are surrounded by a greenish slippery coating that often appears slickensided. These belts are sometimes wholly of quartz, and are continuous for some feet, and reach five or six inches in thickness. They seem to be the result of foliation coincident with the direction of the original sedimentation.

At the next cut which is about one-fourth mile further north, the depth is five feet, and the slaty cleavage dips slightly to the north. The cut extends about four and one-half rods. The rock is wholly slaty, and no sedimentary structure is observable unless it coincides with the slaty cleavage.

The road runs over water-worn boulders, with much corduroy, with no soil, nearly to the creek mentioned Then there is a filling, then occasional fills and shallow cuts in a little stony loam, with large boulders, the country being clothed with swampy varieties of trees.

Just beyond the point where the road strikes the drift bluffs of the river, another cut in slate-rock appears, the cleavage dipping north, as before, and including conformable layers or folia of white quartz, in varying quantities This is a firm slate, suitable for roofing, like much of it throughout the country. A short distance further are two small cuts in slate. In the northern one the slaty cleavage is different in different parts contiguous. The most of it dips toward the north, at an angle of about 45 deg., but in the midst of it are two belts that run from the top to the bottom of the cut, in which the dip is about 80 deg. toward the north. This cut is thirty feet long and six feet high. Further N. W. the road runs on a dirt fill on the slate ranges about a quarter of a mile. The rock can be seen and shows heavy bedding dipping toward the south about 45 deg., the slaty cleavage crossing the bedding with a dip of about the same amount in the opposite direction, the cleavage showing a *twist* out of the normal direction as it passes the joints from bed to bed. The whole aspect of these ridges is light-green.

At half a mile further is a long cut in greenish slates, perpendicular, or at the north end slightly dipping to the north, and at one-eighth mile further another small cut having the same features. Two more small ones appear before reaching a dyke which exposes a width at least of thirty feet. It appears on the N. E. side of the road and runs apparently, E. N. E. It is cut by the grade to the depth of about three feet, with a slate cut immediately south east of it. At half a mile further another dyke ot similar character is seen near the Knife Falls. It is in place by the N. E. side of the grade, and was slightly cut in the grading. Its width and direction cannot easily be seen owing to the forest.

502. Gray doleryte, like No. 501, from the dyke last mentioned. One other cut in slate appears beyond the dyke about a quarter of a mile, but showing only on the north side, though frequent ranges of slate appear along the grade on both sides, rising six or ten feet.

503. Gray doleryte from the E. N. E. dyke before mentioned, apparently the same as No. 502.

504. Gray quartzyte holding slate-pebbles, as if conglomeritic, about two and one-half miles from the Junction on the grade of the railroad, situated between the "Cut No. 3" and the creek mentioned after No. 501. This quartzyte hardly has any cleavage, but shows a lamination in laminae about an inch thick, which indistinctly appear on shattering the rock by blasting. These have a high angle of dip toward the north, across the bedding, which dips south at about the same angle; and they are probably the product in this quartzyte of the same operation that caused the slaty cleavage in the slates. Although styled quartzyte, here as well as in other places, this rock also contains a large ingerdient of feldspar which in No. 504 is partly orthoclose. In others, the feldspar has been seen to be, at least in part, a striated feldspar. The slaty pebbles in this rock are rounded, and are often half an inch in diameter, and occasionally are two inches long.

They are fine-grained, and resemble the slippery coating that surrounds the quartz deposits mentioned under No. 501.

505. At the long "cut No. 3," mentioned under No. 475, there are several interesting features exhibited by the strata of the formation. This is nearly two miles north of the N. P. Junction.

1st. In the north end of the cut the slaty cleavage dips north about 80 deg., and in the south end it is nearly perpendicular.

2nd. In the southern portion of the cut is a change in the formation from slate to a gray arenaceous rock like Nos. 469, 478, 488, 491, 493, 497 and 504, though it is not conglomeritic like the last; and the slaty cleavage on both sides of this rock is conformable with its surfaces. This rock is represented by No. 505. It has somewhat the outward appearance of a dyke of igneous rock crossing the road in a zigzag course E 5 deg. N. It weathers nearly white and has a width of twenty-seven paces.

3rd. This rock, (505) has no slaty cleavage, but a coarse jointing. The slate beds on the north side dip N. and on the south side they are about perpendicular.

4th. On the east of the road, one-fourth mile distant, is a high hill of rock of this kind, and near the north end, on the west side, the ridges show a twisting in their strike, or a quaquaversal throw, so that the E. and W. slaty cleavage crosses them diagonally, the ridges bearing S. E. and N. W.

5th. Hence the slaty cleavage came after the tilting of the formation, and keeps its E. and W. course whatever the direction or amount of the dip.

6th. The hill of this rock, above mentioned, is east of the road less than one-fourth mile. It is an isolated knob rising about twenty-five feet above all the other ridges. It is about circular and five rods over, with a broad rounded top. It seems to be a sudden augmentation of No. 505 among the slates, and its connection with No. 505 in cut No. 3, can be traced connectedly. The course of 505 is about toward the rapid in the St. Louis, three quarters of a mile above the Big Island in the river near Thomson.

506. Large sample of slate, showing the slaty cleavage crossing the sedimentation, from one mile north of N. P. Junction, Knife Falls railroad.

Along the east side of the Big Island near Thomson, the ranges cross the river, causing rapids, and a descent of about ten feet in twenty rods, the most of it being in the lower ten rods. The river here runs against the strike, and the channel is narrowed as below

Thomson suddenly, to about thirty feet. The rock dips 45 deg. N. and stands up conspicuously along both sides of the channel, the slaty cleavage dipping 45 deg. to the south. There is then comparatively still water to about the middle of Sec. 31, (south of it a little), where the rock again causes rapids and a descent of six or eight feet.

507. Gray, slaty quartzyte, "just across the north channel at the head of the second rapids, on Homestead Island." (Terry.)

508. At the extreme upper end of Homestead Island, at the very point, higher up than any rock along there before mentioned; a gray quartzyte, with visible grains of quartz. (Terry.)

509. Some rods east of the head of Homestead Island, on the north side, about one hundred rods west of the head of the rapids that there run across to the other islands; a gray quartzyte. (Terry.)

510. Slate from the very foot of Homestead Island, below the rapids last mentioned. (Terry.)

The Chain islands, here so designated, are often known as Green Islands, from the man who preempted them. The "Grand Rapids," of the St. Louis begin one-half mile above Pine Island, and continue five or six miles. The water then is comparatively quiet to the mouth of the Cloquet. Just below its mouth is a large rapid. (Mallmann.)

*Downward section of the red sand rock and shales at Fond dn Lac.**

1. (443.) Red sand rock, quarried at Fond du Lac. This begins above the level of the railroad grade and extends downward through a thickness of (estimated) .... 50 ft.

2. Dark red shale .... 18 ft.

3. Shaly sand rock, less firm and siliceous than No. 1, (changes gradually to the next) .... 12 ft.

4. Red shale, with some sandy beds .... 30 ft.

Ascending the river, here it turns south, and as the dip is to the S. or S. E. the sand rock No. 1 is brought again into sight in the banks of the river at the extremity of the point, and in the opposite bank of the river. This is about one-half mile west of the state line. No. 4 again occupies the low river bank (north bank) above the point, after it turns west again, for ten or fifteen rods. It has some beds of light color, a few inches thick, such lighter colored beds being coarser. After a short distance of no visible rock, the underlying beds appear, viz.:

		Ft.	In.
5.	Fine conglomerate light		6
6.	Red fissile shale		8

*Also see Nos. 443 to 449.

		Ft.	In.
7.	Light colored coarse sandrock, or fine conglomerate..		8
8.	Red fissile shale	4	6
9.	Fine conglomerate (light)		5
10.	Fissile red shale	3	
11.	Fine conglomerate (light)	3	
12.	Fissile shale, with green spots, some beds ripple-marked	14	
13.	Fine conglomerate		8
14.	Fissile shale		3
15.	Fine conglomerate	2	
16.	Fissile shale		3
17.	Fine conglomerate		4
18.	Fissile shale		4
19.	Fine conglomerate	1	
20.	Fissile shale	3	6
21.	Fine conglomerate	1	6
22.	Shale and shaly sandrock, with layers of light green, seen	14	

The bluff here is about twenty-two feet, (of exposed rock) for about thirty-five rods, below the creek that comes under "Bridge No. 1," and for about ten rods above, the opposite bank having no exposure.

		Ft.	In.
23.	Light red sandstone	3	
24.	Fine red conglomerate	4	6
25.	Shaly sandrock, red	10	
26.	Fine red conglomerate	3	6
27.	Red shale and shaly sandstone; makes a dark band...	9	
28.	Lighter colored sandrock	8	
29.	Green shale		6
30.	Red shale and shaly sandrock	9	
31.	Fine conglomerate, with some thin layers of shale....	4	
32.	Sandrock, mottled and striped with cross-sedimentation	5	

The mouth of the creek coming under Bridge No. 1, is on this sandrock.

		Ft.	In.
33.	Fine conglomerate; the middle of this has pebbles an inch across, but is finer above and below	7	
34.	Shaly sandrock, with specular specks, as if micaceous or hæmatitic. This extends but few feet, and pinches out into fine conglomerate		8
35.	Fine conglomerate		10

36.	Fine shale		4
37.	Fine conglomerate	2	
38.	Shale		2
39.	Fine conglomerate, light-colored		6
40.	Sandstone, light-colored and red, with horizontal bedding; pinches out in fine conglomerate in twenty feet	1	2
41.	Fine red conglomerate with false bedding, passing below into a coarse, light-colored sandrock with false bedding	3	6
42.	Red, crumbling conglomerate, coarser below, with some pebbles of two inches	7	
43.	Shale, with green spots and some conglomerate	1	6
44.	Firmer, lighter colored conglomerate, inclosing beds of shaly sandrock which have cross-sedimentation.	3	
45.	Fine green and red shale		7
46.	Coarse shale	1	
47.	Fine red shale. Of this, but one foot can be seen at first; but as No. 44 strikes across the river forming a little rapid, and shows its place of beginning on the right bank, the section is easily continued on that bank. The stream here runs nearly at right angles to the strike, and a bluff rises about eighteen feet on the right bank consisting of Nos. 41, 42 and 43, or beds like them. Large blocks of No. 44 lie along the river, in the talus on the left bank. In these blocks are mainly pebbles of white quartz; then jasperoid and colored quartzytes; then arenaceous quartzyte of a red or pink color; then pieces of a greenish slate, and rock like the Thomson slate rock. The pebbles are generally under an inch in size, and the surrounding material is also a fine conglomerate	15	
48.	Coarse, firm, light-colored pyritiferous conglomerate, sloping gradually into the water. This includes lenticular spots of shaly sandrock, and of red conglomerate. For some rods the upper surface of this conglomerate forms the low shore and is washed by high water, dipping into the river at an angle of 8 deg. It then stops abruptly by a fault, and the shore is occupied by a red and spot-		

ted green shale like 47, of which the dip is more to the south. Where the conglomerate is broken off it is highly pyritiferous, and cemented into a compact rock, and at the very fracture the whole is changed and vitrified, making a firm greenish quartzyte. In the bluffs on the opposite shore, (i. e. on the right bank,) may be seen four separate faults crossing the red shale andsand stone beds (apparently 41, 42 and 43,) from the top to the bottom. This is just opposite the point of faulting of the conglomerate on the left bank. After the abrupt disappearance of this conglomerate the left bank in ascending the stream is found to be occupied by a low exposure of layers of green and red shale belonging to some higher portion of the section, while the right bank opposite is a bluff with an average exposure of ten feet of rock, consisting of red shale and shaly rock, with varying dip. All at once the coarse conglomerate rises again, but not so suddenly as it disappeared, and forms the shore to the place where the slate formation is found underlying it unconformably. Where the conglomerate reappears it seems not to be faulted, but bent and somewhat broken upward, the shale-beds above also being somewhat bent and compressed, though maintaining a green color where in contact with the conglomerate. The change of level is about two feet, and it is expressed on the opposite shore in undulations in the strata. It is about forty rods above this point that the slates first appear under the conglomerate, estimated.................................. 50 ft.

49. Coarser conglomerate, containing about the same materials as the last, except the layers of sandrock. Dips S. E. or S. S. E. 7-10 deg. The white quartz pebbles are sometimes six or more inches in diameter. Some are of gray, or even a black jaspery quartzyte, and some are pieces of the underlying slate, showing the slate must have hardened as slate prior to the deposit of the conglomerate. On the oth-

er hand it is to be noticed that a roughly slaty manner of disintegration passes upward into the conglomerate from the slates where the weather has acted on the two at that horizon, the pebbles and cement falling off in slabs or lumps that are elongated in the direction of the slatiness of the slates and parallel with them, as if the cause that operated to produce the slatiness had taken effect since the deposition of the conglomerate, and had resulted in a similar structure in the overlying rock. In this conglomerate are pebbles of gray and black jaspery quartzyte which much resemble the great quartzyte of the boundary line, seen at Pigeon Point, and really can be referred to that formation. This seems to imply that that formation, which, with its jasper beds overlies the slates, should come in between the conglomerate and the slates, but for some reason is wanting here. The conglomerate at Grand Portage Bay may have that relation. (V. No. 254.) In some places a layer of green shale lies between the conglomerate and the slates. It is a foot thick. The coarse pebbly quartzose conglomerate has an estimated thickness of.. 100 ft.

The overlying finer conglomerate is often red.

Total observed thickness of the Potsdam at Fond du Lac is therefore............................ 412 ft. 4 in.

By making a general trigonometrical calculation, with an average dip of 6 deg., and a hypothenuse one and one-half miles long, from Chamber's quarry to about half way between bridge No. 1 and No. 2, where the conglomerate begins, the thickness of the red sandrock and shale is found to be 883 feet. To this must be added the coarse conglomerate.

From Duluth to Silver Islet and Return.

511. At a point in the bed of Miller's Creek, just above the highway bridge near the ¼ section line of 32 T. 50, 14, 424 feet above Lake Superior, this sample was obtained. The rock, which is gabbro associated with fine red syenite, extends indefinitely up stream. It is jointed conspicuously N. W. and S. E. like a dyke. It is in some

places speckled finely with red feldspar, and in others it is crossed by veins of red feldspar, some being an inch in width and others very thin, somewhat resembling the rock at the old quarry of Maj. Newson at Duluth. Below the bridge is a rapid descent over rock of the same sort, in which the formation shows a coarse bedded structure, and dips E. at an angle of about 25 degrees. The left bank of the creek rises perpendicular about 23 feet, and the right slopes up gradually with the dip of the rock. The summit of the gap through the hill range is 607 feet above lake Superior. This is about a mile beyond the crossing of Miller's creek.

512. N. E. ¼ Sec. 25, T. 50, 15. Along the Herman town road occasional exposures are seen, rising above the rolling surface of gravelly red clay, of which this is a sample. It is a heavy, gray trappean rock with so much magnetite as to disturb the needle. Land of Peter Benson.

513. Rice Point gabbro, from a cropping on the N. W. ¼ N. E. ¼ Sec 27, T. 50, 15.

514. S. W. ¼ Sec. 22, T. 50, 15, (near the center of the quarter), land of John Mallmann. Here is an unusually magnetited bed of the rock of the country. It can be traced along about 200 feet, having a width of about 20 feet, as exposed, in low ground, bearing E. 10° N. It lies 5 rods to the north of another series of croppings of rock like No. 513. On the opposite side of a little creek, north of this number, is also a line of outcrop of rock like 513. No. 514 controls the needle entirely. It is dark, but specked with porphyritic crystals of labradorite. The center of Sec. 30, T. 50, 14, is the highest point in the hill-range, on the Herman town road, and is 747 feet above lake Superior.

Reviewing the rocks between Minnesota Point and Kinichigaquag creek one is compelled to the conclusion that they are mainly sedimentary; *i. e.*, in the sense that they were deposited in water and in that way received their stratified arrangement. They dip S. E. They also exhibit some of the characters of igneous rocks, viz.: their amygdaloidal structure, their color, their hardness, and an occasional wrinkled surface, that was formed by the fluid condition of the rock when flowing down an incline. The last characteristic particularly seems to prove that some of the beds were molten. On the other hand they show nearly all the characters of sedementation—parallel lamination, dipping in a constant, or nearly constant, direction, cross-stratification, variation of texture and color as well as mineral composition in the direction across the bedding. Whether they lie, stratgiraphic ally, above or below the sandrock at Fond du Lac is solely a matter of speculation, so far as the evidence here has any bearing.

There is a red sectile rock (Nos. 18, 19 and 30) that shows conspicuously along here, between Duluth and Chester Creek, which may have been driven by semi-fusion, and by igneous injection into the openings, &c., of the lower part of the igneous rock that forms Rice Point, and the hills back of Duluth. This is on the supposition that the Rice Point rock lies over the Chester Creek bed, and is in keeping with the fact that a red feldspathic rock occurs in patches in Duluth, and is in seams in the Rice Point rock at Newson's quarry. In that case the point of outflow of igneous rock was further to the northwest, and the lava ran over the broken beds toward the S. E. Before the full force of the igneous overflow is met in passing N. E. along the coast, the sedimentary beds occupy the coast except where, by dykes, or by interbedding, or by local outflows, the trap rock is found in its place. This indicates that during the period of deposition the igneous disturbances were going on, and that the semi-igneous nature of the beds may be due partly to the proximity of the igneous vents which would not only give an occasional flow of truly igneous rock, but would furnish a sediment quite different from an ordinary oceanic deposit. Ordinarily the sedimentary beds have a reddish color, but in the neighborhood of Chester Creek, and in Duluth some of them are greenish. The trap-rock seems to take a bluish green color along the shore. Occasionally a hardening of the sedimentary beds is produced so as to form a rounded point or promontory, or a sharp rocky point. Without such hardening the sedimentary beds usually are less durable than the trap-rock. In some cases, still, there is so close a mingling of igneous and sedimentary characters it is wholly impossible to decide, on the spot, whether a rock be igneous or not.

515. At Sucker river (V. No. 89). A fine-grained igneous rock, which crosses the mouth of the river. But it runs N. E. instead of N. 5° E.

516. Forms the bed of the stream, and appears like a bed of lava, being not jointed regularly, but smooth and massive, with pot-holes. This disintegrates into globules and rots to a great depth before falling away. It is heavy, dark green, and almost black when wet. In the stream are many pieces of prehnite-amygdaloid with a little native copper. These must have come down the stream from a belt which runs from French river southwesterly, back of Crystal Bay, and N. E. to Sucker river.

East of Stony Point, which is the east point of Sucker bay, the rock forming the immediate shore is an overflow of heavy dark trap which extends to Knife river; but within the bay east of Knife river are amygdaloids and purgatories for a mile and a half. Thin clay hides the rock, except occasionally, to the west point of Agate bay where begins about the same series of amygdaloids and non-amygdaloids as seen near Knife river, extending round the point and along the west side of Agate bay. Thus the rock from Stony Point to Agate Bay is all igneous. There is a similar alternation on the west side of Burlington Bay. (V. Nos. 94–102.)

517. Fine-grained trap, bedded, from the foot of the high bluff at the north of Gooseberry river. (V. 108.)

518. Trap-rock, top of the low bluff at the south end of the beach at Gooseberry river, containing amygdules of chalcedony. Furnishes some of the pebbles, and all of the agates of the Gooseberry beach. This rock slopes into the water, and where it is constantly under the action of the waves, and partly decayed, it is reddish, like the pebbles, but the pebbles mostly come from another bluff.

519. Agates, taken from the rock at Gooseberry river. At Gooseberry river is a high beach (25 ft.) of red gravel, extending from rock to rock (from 517 to 518), facing east, thrown up by the counter action of the current of the river against the easterly storms on the lake, which not only sweep the pebbles along the beach toward the west, but prevail with great violence in the spring and fall months. It is 300 paces long. In the red gravel of the beach are numerous chalcedonic agates, derived from the rock of the place. The bluff at the north end of the beach is about 75 feet high, and at the south end it is about 10 feet. In each case the rock slopes E. S. E. down to the lake, and below the water. They were once probably connected, forming a continuous sloping surface of trap-rock. The lower part of the bluff at the north end is bedded, and more jointed, but is fine-grained and firm. It is probably igneous, and seems to contain considerable chrysolite. The upper part contains chalcedonic amygdules, and is trappean. It decomposes in globuliferous parts, and is spotted by them before decay, the general color being a dark or bluish green. The whole bluff is trap and 75 feet thick. The beach is red with a few blue pebbles. The red gravel is finely amygdaloidal, and cannot come from the trap. The globuliferous decay is not noticeable in rock at the east of the bluff, near the water, perhaps because the erosion wears it away too fast.

The lower part of the high bluff at Gooseberry river, a short distance east of the river, is amygdaloidal with laumontite, and crumbles out faster than the overlying trap, causing the fall of large blocks from the top of the bluff.

The beds 517 and 518 occupy the coast exclusively (except one or two amygdaloidal beds,) with short intervals of red pebbly beach, to about one mile from Splitrock river, when a bluff rises from the water in a bay (No 110) and continues eastwardly. This bluff is the source of the red pebbles at Gooseberry beach. It is finely porphyritic with red feldspar, and seems also to have fine grains of calcite and quartz, as well as a few green amygdules. These, weathering out, produce a pitted water-worn exterior. The rock does not crumble, but goes to pieces in a multitude of small fragments which strew the beach and make the gravel. It greatly resembles the rock at Crystal bay (No. 78) and also the Palisade rock (Nos. 138 and 139), but is less firm than the latter. Its disintegration in angular bits in the bluff, by frequent divisional planes (not properly a jointage) is exactly like the Crystal Bay rock, but here it contains no large geodes of calcite, as there. It has the appearance somewhat of underlying the trap of Gooseberry river, but it actually overlies it.

520. Sample of the above rock, one mile west of Splitrock river.

520. A.—Sample of calcite-laumontite, from a vein in No. 520.

The westerly end of this bluff seems to show that it rises from under the rocks 517 and 518 with a strong dip toward the W. S. W. perhaps 40 degrees, but this westerly dip is not due to sedimentation tilted in that direction, but to a transverse jointage. It is so intimately jointed and angular that the original bedding, by which a deviation of dip is to be ascertained, is nearly obliterated.

521. Is an irregular thrust-up rock, appearing in the beach near the west end of 520. Its bedding is distorted. It almost appears conglomeritic, but the lumps and nodules that appear in it are due rather to crystalline aggregations, imperfectly formed. Some of its firm parts appear like the metamorphosed greenish quartzyte seen under the conglomerate near bridge No. 5 above Fond du Lac (V. after No. 510, in the *Section of the Red Sandrock at Fond du Lac* (Sub.-No. 48). But in the midst of this green are thin red (vitreous?) laminations that resemble in form, but not in color, the translucent streamed(?) interlaminations seen in No. 140. It is essentially a part of No. 520, but modified by some closely contiguous igneous agent. (V. 816).

Toward the east the bluff (520) shows horizontal bedding one, two and three inches thick, and the red rock passes inland among cedars, balsams and pines. At nearly the same point a lower trap-rock appears in the beach, being the same as that forming the little island opposite the bluff, 520, since it can be traced connectedly from the little island—by the shallow water—directly to the the foot of the red bluff. This lower trap holds a gray amygdaloid about 8 feet thick, and its lower beds run in the gravel beach, nearly to the Splitrock river, the chief exposure being just at the point, and 15 feet high (V. Nos. 111 A & 111 B). The red pebbles at once disappear, except that a few, mixed with the gray, are seen even at the mouth of the Splitrock, brought down the river and distributed westwardly. Where this lower trap appears in the little island it is agatiferous, at least has concretionary masses of quartz a foot or more in diameter, as well as other dark masses, 384 ft. in diameter. The geodic quartz cavities have few amethystine crystals. In this respect this trap bed seems to resemble the trap at the top of the bluffs at Gooseberry, instead of being another layer. In some places this is finely amygdaloidal, on the island, but generally heavy, compact, angular, and dark colored. These parts are irregularly mixed, and sometimes surround each other, as if in concretions, or as if one had been mixed in the other as a matrix.

Splitrock Point exhibits a novel and interesting geology. While the large feldspar mass seems to be in place, and to have furnished the smaller pieces embraced in basaltic trap toward the S. E. and E. it is highly probable that it is itself a transported mass. The oblique basaltiform structure of the trap shows it was molten and the feldspar was not. The feldspar is not basaltic, only coarsely jointed. This feldspar rock has a close resemblance to the Rice Point granite. It seems also to be older than the sandstone and conglomerate beds along here, and not to pass into the trap layers that are so conspicuous along the shore. There is a constant dip toward the S. W. in passing along here, and finally the feldspar rock seems to come to view as if lower than all. There is trap near the water, at the base on the east side. This continues, and shows oblique basaltic structure which slopes N. E. and a bedding that dips S. W. (V. 112 and 113.)

Immediately across a little bay east of Splitrock Point, and on the north side of the bay, at the foot of a high bluff (175 ft.) of Feldspar rock which stands a little inland, is an exposure of a dark-red, frequently jointed, rock. It is somewhat amygdaloidal, and especially near the top of the bluff, and seems to be a slightly altered condition of No. 520. It shows only a short distance (6 rods) and dips N. N. E. about 30°. It is darker red than No. 520 on fresh fracture, but the joints that give color to the bluff are lined with lighter red. It is probably also one of the shale beds of the formation, if not the lowest.

It is cut square off, and is immediately replaced by the obliquely basaltic trap (No. 524) which embraces masses of feldspar rock. Here the trap rises 50–75 feet above the talus of fallen pieces as the bluff extends east.

522. From the foregoing reddish-brown rock near its point of contact with the basaltic trap, near the top of the bluff, in the bay first north of Splitrock point. It here becomes darker, denser and firmer, and also amygdaloidal, bringing it to the characters of the rock that forms Two Harbors, the next point east. This seems to be another condition of 520, or beds like No. 520. In thin-sections it seems to be identical with the Two Harbor rock.

523. From the base of the same bluff. Similar rock, but more red. The Two Harbor rock is No. 117.

Just beyond Two Harbor Bay, (east) the relative superposition of Nos. 522 and 523, and their relation to the Two Harbor rock as well as to the Feldspar rock, can be seen. A feldspar bluff rises perpendicularly from the water about 125 feet. On the west of this bluff and in immediate contact with it, rises a basaltic trap bluff which is composed of the rocks.

524. Is a basaltic dark trap, 75 feet thick—underlain by 522, 523 and the Two Harbor rock, in the order named—the Two Harbor rock rising but little above the water. (V. No. 112).

Numbers 522 and 523 here show a sedimentary structure very evident, but it is in patches, and alternates irregularly with patches of laumontitic amygdaloid.

525. Sometimes a sandy sedimentary rock is in immediate contact with and surrounds patches of the amygdaloid. In the sandrock, which is of a light color, blotched with red, are impressions of fucoids. (V. No. 817).

On the east of this high Feldspar point there is a huge pudding stone of trap and feldspar for a short distance, and then under it a short exposure of No. 520 just as the bay begins. This last rises and runs inland, and the Two Harbor rock makes the immediate shore through the bay to the third high point, which is composed of a sudden upheaval of both the 520 and the Two Harbor rocks, the latter being basaltic and making the high point. (V. 119).

526. The knob of rock at the west side of Beaver Bay is of a crystalline red rock, feldspathic and firm. The green trap embracing the feldspar masses abuts suddenly upon it, from the west, and so ceases. This probably is the same rock as 119, and 520.

527. Sample showing the union and welding of the feldspar ma s

at Beaver Bay with coarse trap inclosing it. It is not thus welded generally, so far as visible, but is loosened fron the trap.

528. Slaty, gray quartzyte, at the mouth of Beaver Bay creek. These samples are from the rock at the very mouth of the creek. It also runs back from the creek toward the west. Its abrupt and isolated outcrops will not permit any satisfactory identification of its horizon or its place in the shore series. (V. 127 and after 816).

529. (No. 1 to No. 6). Series of changes from trap rock to soil, Beaver Bay:

(1). Unchanged traprock, heavy and coarsely crystalline.
(2). Iron-shot and jointed trap-rock.
(3). Showing incipient decay.
(4). Crumbled trap-rock.
(5). Gravelly, earthy soil.
(6). Loam, soil and turf.

These are produced by the rotting of the trap-rock of the country, on the promontory where no other ingredient contributes to the soil.

530. Finer, dark trap, of the same general character as that which covers the country, but finer grained, magnetited, and perpendicularly basaltic, having a coarser grain in a dyke-like belt (2½ feet wide) running E. and W. This rock contains patches of red rock like No. 526 and within two rods, after a short interval not exposed, the rock No. 526 is seen in full force forming a bush-covered bank. The patches are as fragments or boulders, generally, but some patches do not appear like transported masses, but like dykes and veins. This is from the bay one-half mile west of the knob which is represented by 526.

531. Sample of the above narrow dyke-like belt, which is similar to No. 529, but seems to contain free quartz. The general dip of the rock 528 is to the east, as seen in passing inland, and along the road to town, so as to throw it, if continued, under the rock of the promontory.

532. Reddish, and sometimes greenish, trap-like rock, surrounding, or embracing pieces of the feldspar at Beaver Bay. This rock is similar to rock No. 526, at least in some of its parts. The feldspar masses have the appearance of having been carried in this rock, or to have been *in situ* when it was deposited as a sedimentary rock, and subsequently to have suffered the metamorphosing forces with it. (V. No. 816.)

533. Rock of the great palisades. (V. 139.)

At the point that encloses the beach of gravel at Little Marais, a red pebbly conglomerate is seen running under the basaltic trap (No.

160) that makes the point, but separated from it by about two feet of amygdaloid that bears white thomsonites. This conglomerate must be that seen a short distance below Baptism river (155). The Sawthuth Hills, a spur of which runs out at Baptism Pt., run here still further back from shore, so as to bring the lower beds of any rock involved in them, at the shore along Little Marais. This conglomerate is also probably the real rock underlying the long stony beach extending for a mile or more above the point that is on the west of Little Marais.

East of Little Marais, for a couple of miles, the coast is formed by the Little Marais trap, sloping rather steeply into the water. The underlying amygdaloid is exposed also. The conglomerate is sometimes converted into an amygdaloid, and its true original character is hardly discernable. There are, however, red blotches that indicate the original pebbly character of the whole.

These three parts:—

1. Basltic trap-rock.
2. Reddish amygdaloid.
3. Reddish conglomerate.

make a jagged coast, with sharp points and little bays, almost continuously rocky, to about a mile and a half or two miles east of Manitou river. They sometimes rise 40 feet perpendicularly from the water. There is a little harbor from S. W. winds about one mile east of Manitou river. There seems to have been one grand igneous overflow here, just after the conglomerate, which is about 70 feet thick. The conglomerate itself is amygdaloidal, and the whole is red. The pebbles also are amygdaloidal, and generally less than an inch in diameter, but some are 8 or 9 inches across. The amygdules are calcite, laumontite, and white thomsonite. Sometimes beds of conglomerate and amygdaloid not conglomeratic alternate two or three times, and sometimes they blend or cross each other, showing no widespread variation in the nature of the conditions under which the whole was deposited, but rather indicating that at other points the whole would be found to be a conglomerate.

534. Samples of red amygdaloidal conglomerate from 1 mile east of Manitou river. The same is seen at the mouth of Manitou river. At this point the strike of the trap passes some distance inland, forming a spur of hills that rise several hundred feet back of Pork Bay, with low tillable land along the shore.

535. (V. No. 193).

Thomsonite amygdaloid, from Terrace point, near Good Harbor Bay.

535. A.—Thomsonites, picked from the rock at Terrace Point.

535. B.—Thomsonites, &c., gathered from the beach at Terrace Pt. These pink thomsonites seem to have some of the characters of edingtonites, as in a weak H. Cl. solution they give a precipitate with sulphuric acid, which must be sulphate of baryta.

536. Samples of the basalt rock, at Grand Marais, many of the small pieces being sections of the smaller basaltic columns.

537. Bedded trap, from the west side of the point on S. W. ¼ Sec. 10, T. 61, 2, E. Similar to the trap at Grand Marais. (V. 211.)

538. Red rock, similar to the rock of the Great Palisades. This is the first rock east of Cow's Tongue Pt. in the bay. (V. 212.)

The rock of Fish Hook Point (No. 213) lies as an overflow, and is visible under the water toward the west for some distance, cut also by dykes, some of which appear on the shore.

539. Brown trap, with chlorite amygdules; similar to, if not the same as the Fish Hook Pt. rock, from a short distance west of the mouth of the Brulé river, near the river. (V. 220.) There is no rock at the mouth of the Brulé, but a remarkable high beach, which shuts in a lagoon on the landward side. The pebbles composing it are of mixed character, some are red, from the red rock of the country (538), and some are blue or green, from the fine basalt or dykes, with amygdaloid and porphyry pebbles.

540. Coarse doleritic trap; a mile and a half east of the Brulé river. This rock sets in immediately east of the Brulé (No. 221), and forms the coast nearly continuously. At the point where this sample is got there is a little eastward facing bay, and a gravelly beach, but the same kind of rock is found on the east of the bay. This rock is light gray under the friction of the beach-gravel, but is black with rough lichens when washed only by the water. This rock seems to lie under the red rock which disappeared under the lake on the west of the Brulé. It continues to Horseshoe bay, on the west side of which is a basaltic bluff like that on the west side of Sickle bay. In the interval between these two bays the rock is occasionally interrupted by short re-entrant bends in the coast, where stony beaches largely made of the trap of the country are found, but the most of the distance is rocky and generally less than ten feet in height. The bluff on the west side of Horseshoe bay is 60 or more feet high (V. No. 228).

There is a high range of hills that run across the head of Double bay, rising apparently from the coast in spurs, one from the west side of Sickle bay, and one from the west side of Horseshoe bay. This range is short, as it can be seen for only three or four miles. The top is of the rock No. 540, which probably lies under the red rock and over the Grand Portage slates and quartzyte. It seems to be the same as the basaltic rock that caps the hills of slate and quartzyte along the international boundary. The beach at Cannonball bay is of rounded stones of all sorts, but a little sandy patch is covered with iron sand, derived from No. 540 inland. The rock 540 is seen to run below the E. Palisades, or the "red rock," so-called, judging by the general topography and the prevailing trend of all the beds. As the trend of 540 passes inland, a range of hills rises several hundred feet, extending N. E., the "red rock" occupying the low land between them and the lake, cut by heavy dykes of basaltic green trap. The Eastern Palisades have a short exposure just west of the mouth of Red Rock creek, rising gradually up from the water to about 25 feet, and then breaking off square and suddenly on the land side. They extend perhaps 150 feet along the coast in this manner, but are wider in a low exposure half covered with beach pebbles toward the west, at least 50 feet. The dip here is toward the southeast, but at Red Point, about a mile and a half further east, it dips S. W., at an angle of 25° or 30°, showing the underlying trap again on the east side. Between the Palisade rock and rock 540 seems to be a firmer trap rock, or rock resembling the Two Harbor rock, which appears in the bay east of Red Point, where it is cut by dykes.

The high range of hills that culminate in Mt. Josephine are made up largely of the rock No. 540.

At Grand Portage Island is a section of the rocks just lower than the "red rock," which here seem to have been preserved and thickened, as well as hardened, by local inflows of trap. The island itself is elongated east and west, but not much. It is rudely elliptical in horizontal form. Its highest parts are at the eastern end, where the bluffs, that face north are about 100 feet high. There is a gravel spit that is formed by the joint and opposite action of waves from the east and west as they whip round the sides of the island, jutting northwest from near the middle of the north shore, and from it a shoal extends still further in the same direction. The beach shows foreign drift-boulders, as well as many varieties of rock from the island itself, among the former being various porphyries and granites. The only piece of "Winnepeg limestone" found on the "north shore" was found on the northwest side of this island, though a fossiliferous piece of chert was picked up at Good Harbor Bay. There are also pieces of dark, hornblendic rock, and of micaceous schist that do not occur in the rocks forming the island, as well as a good many fragments of the "red rock." These last are so angular, and also so frail, that they seem not to have been far transported. They are perhaps from below the water of the lake south of the island, and are thrown up and brought ashore by ice and waves. Some of the "red rock" is rather sandy, and spotted with light brown spots, like the shale and sandrock of the St. Louis river, the spots being pink in the dark red. Some of the fragments are confused in structure as if crumpled, and are amygdaloidal; and some are harder and porphyritic, resembling the typical Palisade rock. The main beds of the island dip to the S. S. E. at a varying angle, and have an exposed aggregate thickness of 134 feet, viz:

541. At the N. E. corner of the island a dyke 10 feet wide cuts the quartzyte and conglomerate, running E. 10° N. by needle, without displacement of the bedding. It is a very fine-grained black, or blue-black rock.

542. A layer of trap like No. 540, which on the east shore is basaltic, rising about 12 feet. This is stratigraphically the highest rock in the island.................................... 14 ft.

543. A chalcedonic amygdaloid, though the chalcedony and calcite amygdules appear specially at the south east end of the island, may be.................. 20 ft.

544. A curious, dark, heavy, globuliferous trap-rock, disintegrating readily, the hard globules, which are of stony structure (not minerals) and nearly black, rolling out like shot, or bullets, and covering the ground after the rest of the rock has rotted to a greenish soil. The rock itself is chloritic and dark green. This is in a belt crossing the island east and west, appearing some like a dyke, but is in reality probably an overflow like the next underlying. Indeed it seems to pass into the next, in some places, showing it is only a local phase of a larger bed. It is the last to run under the water at the west end of the island, and at the east end it is the topmost rock in the bluff. Its thickness may be.................................. 20 ft.

545. A bed of fibrous green trap, passing through the center of the island and forming its highest parts, and also producing a long sloping beach on the S. E. side running under the chalcedonic amygdaloid. In the center of the island it appears like

a burnt scoria or slag, due perhaps to the effect of Nos. 543 and 542, though these have been removed in the central part of the island appearing now only along the south and southwest shores . 35 ft.

546. Sandrock, even-grained, rather fine, light colored, but of a pinkish and purplish cast, firm and compact in regular beds of 10 to 18 inches thick..... 8 ft.

547. Another bed of trap, like the dyke No. 541. This is sometimes brecciated, or finely and irregularly jointed, with white nodules of saccharoidal calcite.. 36 ft.

547A.—Nodules of saccharoidal calcite from 547.

548. Quartzyte, sometimes with mica specks between the beds, of a dark color, generally striped with red and brown, some of the beds being brown-red, with thin laminations, and some show ripple-marks.. 5 ft.

549. A breccia, or conglomerate-breccia, the cementing rock being a quartzyte like No. 548, or arenaceous like a grit.. 16 ft.

550. Near the dyke (No. 541) is another which cuts the beds, running E. 10° N. This is a little south of No. 541, and is 34 feet wide sloping a little to the north.

551. Another dyke crosses the S. E. corner of the island in direction N. N. E. by E. and is of a coarse doleryte. It is probably due to these dykes that the island exists, as by their intersection their effect has been to harden the beds, and to present toward the east the apex of a triangle to ward off the waves of the severest storms.

There must be, besides the foregoing, also the following nearly associated with them—although they do not appear any where in the bluff soft he island—since they are seen in fragments on the beach.

(a). A true pebbly conglomerate, or coarse grit, nearly white or of a light color.

(b). A true conglomerate like (a), but containing pebbles, at least crystals, of red feldspar.

(c). A conglomerate with few pebbles, but a green aluminous, or chloritic cementing material.

The true place of these cannot be ascertained, but (a) is probably near the bottom of No. 546, as well as (b), and (c) resembles the shale and sandrock cut by dykes in the bay east of Red Point, (Nos. 232 and 235), which must be just under the "red rock," and so probably belongs near the top of, if not wholly over, the foregoing section. Indeed it must come, in that case, from the lake, below the water.

A generalized section of the alternating beds of the formation as they occur along here would be as follows in descending order:

1. The Palisade rock, or the "red rock."
2. Green shales, &c., in the bay east of Red Point, (Nos. 232, 235, 238 and 239).
3. Layer of trap like 540 (No. 542)........................ 14 ft.
4. Chalcedonic amygdaloid (No. 543).................... 20 ft.
5. Fibrous, green trap striking E. and W. through the island and forming its highest parts. In spots it is globuliferous with hard, dark, strong, shot-like pellets about $\frac{1}{4}$ in. in diameter, (Nos. 544 and 545),.. 35 ft.
6. Even grained sandrock (546)......................... 8 ft.
7. Trap bed, finely and irregularly jointed, with nodules of white saccharoidal calcite (No. 547).......... 36 ft.
8. Quartzyte (No. 548).................................. 5 ft.
9. Conglomerate (No. 549)............................... 16 ft.
10. The rock No. 540, forming the great trap covering of the quartzyte hills at Grand Portage, 50 ft....... 250 ft.
11. The slate and quartzyte terraces seen in the hills at Grand Portage, generally and along the international boundary as far west as the west end of Gunflint lake(estimated)........................ 400 ft.
12. The jasper and iron ore beds of the Misabi, and southeast of Vermilion lake.
13. The micaceous and chloritic schists and slates of Vermilion lake and the Dalles of the St. Louis river.
14. The mica schists, granites and syenites of the region north of Gunflint lake, (V. after No. 753).

This takes no account of the great labradorite range, which in some places forms the Mesabi, nor of the iron ore deposits of Mayhew Lake, because they are apparently included in the rock Nos. 258 and 540, or in an immense outflow of molten matter at a date somewhat earlier. (V. Nos. 695 and 816.) Nor does it mention the conglomerate of Ogishkie Muncie lake, because that is apparently an incident of the slaty and talcose beds included in Sub. No. 13, nor the red granites of the region of Brulé Mt. because they are probably a modified condition of the Palisade rock.

Nine dykes are seen crossing Hat Point on the west side of Wauswaugoning bay, cutting the slates and quartzytes near the water, running a little northeasterly varying from 3 feet to 70 feet wide. A heavy dyke of basalt runs along the head of the bay terminating the bay in that direction. It cuts the slates, hardening and solidifying them so that their walls, broken and oblique, sometimes stand alone, appearing like other dykes. It runs on into the "Cypress Swamp," of Norwood, and appears to be the same that forms little islands in the south arm of Pigeon Bay.

552. Plumbaginous quartzyte, Pigeon Pt., near the trail to Parkerville. Sec. 32, T. 64, 7. (V. No. 270.)

553. Quartzyte, near the portage trail, at the north shore.

The Grand Portage range of hills laps over another as it approaches Parkerville, and also gradually dies out, the Pigeon river coming through the low spot in the valley between them. The other range runs along the north side of Pigeon Bay, in Canada, turning a little northwest as it approaches Parkerville.

554. The "Two Harbor Rock," (?) from the east end of the island most easterly, separating Washington Harbor from Grace Harbor, on Isle Royale. This is more coarsely jointed than the Rock at Two Harbor, and has somewhat the appearance of an imperfectly basaltic dyke, but as it develops a few rods further north it appears as an overflow, t least it lies on other trap and amygdaloid. It forms a little boat-harbor where fishing shanties are erected. It is at least a fine-grained brown, trappean rock, and in this section seems to hold no free quartz.

The south side of Grace harbor is of pebbles and stones, the pebbles derived from a red conglomerate that occasionally is seen in the beach, but which in the S. W. corner of Isle Royale is finely exposed. This red conglomerate is coarse, some of the stones being over a foot across, and dips for a long distance gently toward the south and southeast. On approaching the point in the coast nearly south of Siskiwit bay, the dip increases, and still more toward the entrance to Siskiwit bay. Above the conglomerate appears a red sand-rock, nearly a red quartzyte, resembling rock No. 548 of Grand Portage Island. This has regular bedding, cut into cuboidal or rhomboidal blocks by divisional ripple-marked with some softer, shaly or hæmatitic laminæ, and with hæmatitic lumps of shale more or less inclosed in the mass of the beds themselves. Some of these beds are about 30 inches in thickness, and some are less than an inch. These beds are firm and durable, blackening under the waves like a trap, to which at a distance they have some resemblance. Its dip, color and bedding recall the red quartzyte in S. W. Minnesota, but it is rather less siliceous than that. In the same manner, however, it overlies a coarse pebbly conglomerate, which in the same way indicates its relations to the red quartzyte of Grand Portage Island and of Pigeon Pt. peninsula (No. 290), as well as to the red sandrock and shales of Fond du Lac.

At Grand Portage Island it appears that a trap inflow separates the red sandstone and shale formation into two parts, only a small portion being below the trap, the greater portion being out in the lake further south, while on Isle Royale no such trap overflow divides it.

555. Red quartzyte or sandrock from Siskiwit Point, Isle Royale (the point that encloses Siskiwit Bay). This has been quarried further west in the bay, on the south shore, and advertised in Detroit under the title "Isle Royale Brown stone," by Buchan & Co., 117 Griswold St. West from the point, on the south shore of the bay this rock stands out prominently, dipping from 10 to 20 degrees to the south, forming a jagged and rocky coast, having a perpendicular rise from the water the most of the distance to the first bay on that side. Altogether there must be three or four hundred feet in thickness of these beds, involved in the point that shuts in the bay, but they actually rise above the lake but about 60 feet. The former beds do not lie immediately on the coarse conglomerate, but are separated from it by a shale, which appears at the point forming the first little bay west from Siskiwit Point. This red shale, though appearing rocky, breaks with a sectile fracture, into a great many small pieces when struck with a hammer. It is bedded like the quartzyte, but is intersected by numerous *gashes*, or gash veins, which are of a very different color, being greenish, or greenish gray, and about one-fourth to one-half inch wide and but a foot or two in length, running nearly north and south as they appear on the weathered surface, though some are irregular in direction and follow other cracks. These gashes seem to have been caused by the change produced in the rock by the gases escaping through fissures produced by the disturbance of the formation, rising from heated regions below, rather than by the downward effect of heat from trap overflows. This shale is the most destructible of the whole formation, and probably is

mainly the cause of the low swampy land that intervenes between the head of Siskiwit Bay and the S. W. corner of Isle Royale. The conglomerate itself is under the shale, and is more durable.

556. Red, hardened shale, south shore of Siskiwit Bay, as above described.

The same red conglomerate that forms the S. W. end of the island also forms the north coast of Siskiwit bay, and is the rock containing the copper at the Island Mine, which is near the head of the bay.

557. Cupriferous conglomerate, from the Island Mine, Isle Royale near the head of Siskiwit bay; this is also argentiferous.

557 A.—Variety of pebbles from the conglomerate, 43 kinds.

557 B.—Stamped rock and copper. Island Mine.

558. Amygdaloidal dark trap, near the stamping mill of the Island Mine, Isle Royale. This is near the creek coming through the location.

558 A.—Wernerite, from 558. This mineral has the following chemical and blowpipe reaction:

Blowpipe Reaction of No. 558 *A.*

Fuses at 2 or 2.5, with intumescence.

After fusion gives a quick alkaline reaction when moistened on turmeric paper.

Gives no sulphur reaction on silver.

Salt of Phosphorous bead shows a skeleton of silica.

H Cl. solution does not gelatinize.

H Cl. solution gives no precipitate with Ba Cl.

H Cl. solution gives slight precipitate with NH_4 HO.

In closed tube, B. B. gives no water or the slightest trace only.

Fused and moistened with H Cl. gives a copper flame.

Some fragments effervesce slightly in H Cl.

H Cl. solution gives no precipitate with S. O.

Hardness 5 or 6.

Color, light, lilac-gray, or a pinkish white, or white.

Structure, massive, or fibrous and divergent, the rays becoming separated, acicular, tetragonal crystals.

H Cl. solution does not give titanium reaction with tin.

Borax bead is slightly yellow from iron.

H Cl. solution does not gelatinize even after boiling.

After fusion the H Cl. solution gives no jelly.

These characters bring the mineral between Wernerite and Cancrinite. The occasional effervesence allies it with Cancrinite, but its color and the tetragonal form of the fine crystals show it to be Wernerite. The effervescence is probably due to something attached to the fragment. This mineral is in amygdaloidal cavities or irregular openings in the trap, some of the masses being two inches or more across.

558 B.—In 558 are veins of a green rock which is heavy and amygdaloidal with what also appears like Wernerite.

559. Trap that immediately overlies the cupriferous bed of conglomerate, at the Island Mine.

560. Trap that forms a bed under the cupriferous conglomerate, known as the *Greenstone Range* where it rises to the surface further north.

561. Decayed rock, or volcanic ash, so-called by Norwood, from the cupriferous bed of the conglomerate.

At the location of the Island Mine, a beach, apparently formed by jamming of ice, is 95 feet above the water. The road from the dock to the mine runs on it some distance. There are other beaches or ridges, lower, some of them running somewhat transversely across the intervening space. These are short, and more evidently due to the jamming of ice. The 95 feet beach is the upper limit of a strictly pebbly surface; above that the surface being one of loam and gravelly clay, or a stony loam, so that there may be said to be a soil. Below the top of this ridge, as well as wholly over it, there is absolutely no soil,—only red gravel and stones derived from the conglomerate, with an occasional out-crop of the conglomerate itself.

The conglomerate slopes southward into the water of the bay all along the shore, but between the shore and the mine several trap and amygdaloid beds appear, having a bearing, or strike, apparently in the direction of the coast, the whole of them being near the mine. The location of the mine is from 250 to 300 feet above the lake, and about a mile north from the bay The shafting is in the conglomerate rock lying between trap beds, and slopes towards the south with the dip of the formation.

There is some coarse sandstone, or grit, disseminated among the conglomerate, some beds being a foot in thickness, but fading out to the right and left.

The mine is not now worked (1879) and has not been for a couple of years. There is not a man, woman or child here, but there are many houses, stores, shops, and offices, including a Court House, this being the county seat of Isle Royale county. Everything is deserted. The machinery is mostly still here. The cars, shovel, and various accoutrements lie simply abandoned. The mills are perfect, the enginery for stamping and washing the ore being still on the ground and in good condition.

Toward the east from the dock of the Island Mine the coast is wholly occupied by the conglomerate, or by the overlying slate and sandrock, as far as Wright's Island, but the beach much of the way is formed of drift-brought stones.

562. Trap, somewhat decayed, from a niche in the coast line, south of the east end of Siskiwit lake. This is under the sandstone, but over the conglomerate. It rises from the water with a dip to the south. It has involved with it irregular beds of a porphyritic, harder rock, and patches of epidotic green rock.

563. The porphyry is finer than the porphyry of the pebbles of the conglomerate, but it seems possible that these porphyritic belts may come from a metamorphism of patches of that conglomerate holding such pebbles. The trap is confusedly bedded. The porphyry is also amygdaloidal, mottled with green and red-brown, with white calcite. At Chippewa harbor beds of sandstone and shale are between beds of trap, visible on both sides of the entrance dipping about 35 or 40 degrees to the south. On the east side but one bed of sedimentary rock is visible. It has a thickness of perhaps 75 feet. The overlying trap rises perpendicular perhaps 45 feet. A little further west a trap rises from below the sandrock and shale, and west of that another lower bed of fine shale appears in the coast line, the last being about 10 feet thick. On the west side, near the entrance, are visible two beds of shale and sandrock, alternating with trap. The trap contains fragments of shale and of angular quartzyte along a thickness of about a foot just over the shale-bed. The trap separating these beds of shale seems to be about 120 feet thick. That on the top of them, which also forms the coast line either side of Chippewa harbor, is also about 100 feet thick, and over that is much more sandstone, forming islands off the coast five or six miles west of the harbor. Chippewa Harbor enters nearly at right angles to the strike of the rock-beds, but after passing the narrows it turns more southerly and passes along the strike behind the bluffs formed by the foreging layers.

564. A white mineral from the trap at Chippewa Harbor, on the east side near the entrance, appears to be the same as the Wernerite from the trap at the Island Mine, but it has somewhat the appearance of pectolite. In this lot are also some green amygdules which are closely associated with the Wernerite in the rock.

565. Calcite, from a mass on the beach, containing a green radiated mineral like prochlorite, also Wernerite, and a little quartz.

566. From an amygdaloidal bed of trap that disintegrates, near the narrows of Chippewa Harbor. These green amygdules appear some like chlorastrolites, but they are probably some form of chlorite.

They have a radiating, fibrous interior, sometimes several centers in one mass.

The trap-rock of Chippewa Harbor, without exposed sandstone, continues to the little bay next south of Conglomerate bay, known as Lucky bay, where the rock is of the same kinds and probably of the same horizon as Nos. 562 and 563.

567. From Lucky bay, showing a passage from porphyritic trap to non-porphyritic. This porphyry is from the trap of the place, but it is in patches, or lenticular beds that are generally less than a foot thick, the mass of the rock being porphyritic; but sometimes having a few amygdules of green chlorite. The face of the rock shows a spotted surface when water-worn and partly decayed like much of the trap of the north shore.

568. Trap-rock, taken from the Saginaw Mine, near Conglomerate bay.

569. Epidotic rock, from the Saginaw Mine, the same being the ore of the vein mined for copper.

570. Amygdaloid containing calcite, chlorastrolite and chlorite, from the rock at the light house at the entrance to Rock Harbor.

570A. Chlorastrolites picked from the beach at Rock Harbor.

570B. Green "thomsonites," chlorastrolites, &c., from Rock Harbor.

Conglomerate bay has no conglomerate at the entrance, but toward the head of the bay it is found. The trap is crumpled and faulted between Lucky and Conglomerate bays, and dip generally E. S. E.

At the Siskiwit mine the work was on a vein of epidote and calcite. In the islands opposite is a bed of conglomerate, embraced between trap beds.

571. Samples of trap and gangue rock, from Siskiwit mine, Rock Harbor.

572. Trap rock from Scoville's Pt., Isle Royale.

573. Radiated, white, fibrous, zeolitic mineral from the trap at Scoville's Point, picked up on the beach.

574. Trap rock from the extremity of Black's Pt., east end of Isle Royale.

575. Thomsonites (?) and other zeolitic minerals, from the beach of the mainland, north shore of Isle Royale, about two miles S. W. from Lock's Point.

576. Prehnite and copper (some attached to the amygdaloid from which they come, from the little bay at the east extremity of Fish Island).

577. Black oxide of copper, from the Minong mine, Isle Royale, attached to a large piece of the rock.

578. "Stamp ore," showing the nature of the rock in which the copper occurs.

579. Shows an occasional form of the rock in nodules, also included in the "Stamp ore."

580. Coarse green amygdaloid, the cavities being filled with chlorite or with geodic quartz with interior rosettes of chlorite, coated with green—the amygdules making up more than half of the bulk of the whole. It also shows some calcite and some laumontite. This adjoins the copper-bearing rock.

581. Native copper, from the Minong mine, Isle Royale.

582. Native alloy, and intimate mixture of copper and silver, Minong mine, Isle Royale.

583. Native copper, with attached crystals of—?

584. Battered copper, found about the large masses worked by the ancients.

585. Stone hammers used by the ancient miners at the Minong mine, Isle Royale. These are generally rounded or oval pebbles of fine basalt, evidently transported from the north shore of the lake, where they got their form by the action of the waves on the beach. They are not withed*. They are found in the debris about the old pits

586. Wood, found in the ancient dumping heaps.

At Silver Islet the shaft in 1879 was 720 feet below the level of the lake. The vein runs about N. and S. in the slates and quartzyte of the region, and varies from almost nothing towards the north to ten or twelve feet in its greatest width, which is where it intersects diorite dykes running N. E. and S. W. (said to be E. and W.) The dyke is set off where the vein crosses it, the east side being further to the south than the west. The richest deposits are near the intersection of the vein and dyke, and are accompanied with plumbago which has seggregated from the organic matter contained in the slates. The gangue-rock is a breccia of slate, filled with calc-spar and quartz, though mainly calc-spar. The silver is native and is disseminated through saccharoidal calcite. It is also found in the galena, but in general the galena is discarded. There are also blende and pyrite. This silver has been lately found combined in new forms with arsenic, antimony, &c., &c., creating new mineral species—Huntilite and

* See the *Popular Science Monthly* for September, 1881, for an account of these ancient miners, by the writer.

Animikite. The vein seems to have been enlarged in passing the dyke and charged with these minerals. The work is now being pushed north and south, in hope of striking other dykes. In the vein are large spar-lined cavities in which gas accumulates, (carburetted hydrogen) which has caused some trouble from its slightly explosive character. Water gathering in the mine is strongly charged with some gas, probably the same, but at the bottom of the mine in the "diorite" rock, no water accumulates, and it is necessary to carry down water to serve the drill which is driven by compressed air, the same operation ventilating the shaft. The great deposits of native silver have been in near connection with the dyke, and the large cavities with calcite and galenite are in the same way related to it. The plumbago is along the hanging wall, and is closely connected with the "diorite" of the dyke—indeed is permeated sometimes with igneous rock matter.

587. Calcite and galenite masses with crystalline points perfect. The galenite here is in octahedrons instead of cubes.

588. Mass of octahedra of galenite, Silver Islet.

589. Plumbago, Silver Islet.

590. "Diorite," from the bottom of the mine, Silver Islet, 720 feet below the level of Lake Superior.

591. Saccharoidal spar, which is the gangue-rock.

592. Cemented breccia, from the vein.

593. Igneous rock, from the vein.

594. Slate, that incloses the vein.

595. Cores of the diamond drill, Silver Islet,

596. Stamp ore, with saccharoidal, flesh-colored calcite. Silver Islet.

596 A. Huntilite, from the Silver Islet mine, an arsenate of silver, antimony, cobalt, &c. (Wurtz.)

The following general section was taken at Silver Islet Landing. Some of these beds are seen only at a mile or two north from the lake. It is given in descending order.

(1.) Mottled, red-and-bluff, fissile shale, checked and crumbling into small angular pieces; below conglomeritic and lighter colored, siliceous limestone and chert predominating, ashy and loose........ 40 ft.

(2.) Light-red dolomitic sandrock, some parts being red sandrock, weathering generally of a light color 35 ft.

(3.) Siliceous conglomerate, with rounded pebbles...... 5 ft.

(4.) Greenish, weathering dark, fissile sandrock, appearing at a distance like thin-bedded slate—really fine-grained and aluminous, apparently the top of the slate and quartzyte in which the silver occurs. The transition is gradual from a hard quartzyte and slate, near the bottom, to an arenaceous slate, through a greenish color which is first brownish and then reddish, thus getting the color of the beds higher still. Seem.............................. 55 ft.

Seem total..................................135 ft.

There is, presumably, slate to the thickness of about 50 or 60 feet more, hid by tubes. The above are all conformable, so far as can be seen here, and are cut by "diorite" dykes running to the top.

597. Fissile, mottled red-and-buff shale, from No. 1 of the foregoing section.

597 A. Siliceous and cherty, with calcareous nodules, from the lower, and conglomeritic, portion of 597.

598. Light-red dolomitic, sandrock, compact, mixed with red sandrock, from No. 2 above.

599. Siliceous conglomerate, from No. 3 above.

599 A. Pebbles from 599, water-worn.

600. Greenish fissile slate, from No. 4 above. Aluminous and fine-grained. The samples are rather too quartzose to fairly represent the bed. They are from the lower portion. The higher beds are softer.

601. Coarse porphyritic "dioryte," in a dyke running parallel with and contiguous to and passing into

602. A fine-grained dioryte, in the form of a dyke. The interval of transition is perhaps two feet wide and the crystals of feldspar are scatteringly disseminated through it on the south side, and wholly disappear on the north side. They run in the same direction as the dyke on Silver Islet. The whole is 45 feet wide, but is evenly divided between Nos. 601 and 602, from about a mile north of the "Landing" at Silver Islet.

Pigeon River Falls are formed by the range of hills of trap that set in near the head of Wauswaugoning Bay. The range is an immense dyke cutting the slate, and continues east so as to make the peninsula that separates the bay into North and South Arms, but undulates up and down. It is in one of the downward undulations that the falls occur. Probably more of these hills than has been supposed, are simply dykes piled up over the fissure when the rock was molten, sometimes flowing over. Hat Point and Mt. Josephine are thus dykes.

603. Porphyritic dioryte, such as cover the hills of quartzyte and slate at Pigeon Pt. From the extremity of Pigeon Pt. (V. No. 291.)

604. Black, fine-grained, hardened slate, from south of the dyke (No. 605) on the point next east of the little bay where the portage passes over Pigeon Pt., on the south shore of Pigeon Pt. The portage is 87 paces over, from the top of the beach on the south side to the same on the north side, and passes wholly over moss-covered, loosened fragments of rock.

605. Dyke-rock, cutting the slates and quartzyte, 35 feet wide, at the bay where the little portage crosses the point.

606. Rock of the surface next north of the dyke, in contact with it.

607. Modification of the quartzytes next north of the dyke, and under No. 606, fine-grained quartzose syenite, some of it not showing orthoclase.

608. Fine-grained, reddish quartzose syenite, a modification of the quartzytes, under No. 606.

609. Similar to the last, but further from the dyke No. 605.

610. Similar to the last, but more red, further from No. 605.

611. Red, fragile syenite, a further modification of the rock underlying the rock No. 606, and further within the bay.

612. A further modification of the same beds or underlying beds, from a few feet within the bay toward the portage trail, northwesterly from 604. This is evidently mingled with igneous matter, though having a slightly red color. There is a fine cross-jointage in 610 and 612 that resembles that of some igneous dykes, but this is not anywhere seen.

The relations of 607—612 to the dyke and to the quartzyte cannot be stated positively, for the whole situation is confused, yet the position of the beds from which they are derived is such that they would succeed each other in descending order. No. 604 seems to be the quartzyte hardened. It forms a surface sloping to the lake. It is cut by No. 605, but as 605 rises five or six feet above the lake it comes in contact on the north side with 606, which, while so situated as to be the apparent continuation of 604, has a very different lithology. It is much like the rock 603, at the extremity of the point; is coarser-grained than 604, but has free quartz and horn-blende. No. 606 overlies the numbers following to No. 612. These last cannot be said to come exactly in the order numbered, but probably do approximately. The layers are in strata and dip S. or S. E. weathering out thin-bedded.

The samples did not come from successive beds, but rather at increasing distances along the beach, somewhat descending in the strata. The fragile parts (Nos. 611 and 612) are at once followed by the pebbly beach where the portage trail passes over to the north side. These are piled in successive steps upon each other to the height of 15 feet, and continue across the bay. It was doubtless owing to the occurrence of these soft beds, which rot and chip up, under the water and ice of the lake, that the break-down in the peninsula exists here.

613. On the west side of this little bay the point consists of rock like some of the rock on the other point (607—612), but is hard and firm. It has a resemblance to the plumbaginous quartzyte (552), but with the naked eye no plumbago can be detected.

614. Near the point a dyke cuts this rock, blackening and hardening it. The dyke seems to dip N. E. so as to stand at right angles to the dip of the quartzyte, and the north wall is very distinct, the dyke having been torn away by the lake.

615. Rock of the above dyke.

This dyke, which is 12 feet wide, has not the direction of that on the other point, but runs out into the lake S. E. while that on the other point seems to run into the bay, lying to the north of this. These dykes each point toward a hill of quartzyte near the coast a short distance west.

616. Further within the bay, on the west point, the rock bluff facing east is reddish and mottled, like much of that on the other point. Sometimes the prevailing color is red, and sometimes green, but the colors do not apparently change in any observable regularity, or in accordance with the strata. By far the greater portion on the west point is red, while on the east point a green color is more common; bands and veins of red run through the green, or *vice versa*.

The two dykes mentioned at Little Portage bay converge toward a hill near the south coast—indeed the rock forming the point (613) seems to rise and culminate in this hill, though the hill is at last sudden in ascent on nearly all sides. It is about one-half mile west of the portage.

617. From near the base of the hill mentioned, a reddish gray quartzyte.

618. Gray quartzyte, from the top of the same hill. This hill is with the exception of that back of Clark's Bay, the highest on the peninsula, and consists of metamorphosed, highly inclined, basaltified, gray quartzyte. The softer beds that allow of the narrows in the

peninsula form a belt of low land running north of this hill, and striking the north coast N. W. from the hill.

There are four principal elevations on the peninsula. 1st. East of the narrows, forming a basaltic bluff perpendicular from the water on the north side of the point. 2nd. The quartzyte hill near and west of the Little Portage bay. 3rd. Hill at the head of Clark's Bay, north of it. 4th. The hill range cut by the Parker vein. Of these the third is the highest, being about three hundred and fifty feet above the lake.

619. From the same hill as No. 618, on the south side where the structure is basaltic.

This quartzyte assumes forms, structures, colors and positions that give it a very great resemblance to igneous rock. It is often finely or coarsely basaltic (at least cut by numerous N. and S. parallel points), and sometimes rises suddenly to the height of over one hundred and fifty feet. It is dark gray, greenish, red, black. It is globuliferous, or at least disintegrates in a rough or cavernous manner somewhat like trap rock. It is porphyritic, with feldspar. These characters do not combine, but occur separately, and it can hence generally be identified.

620. Rock of the E. Palisades (V. No. 230). This rock is red on weathering under friction, but, being coarsely fissile, or shaly, cut by innumerable seams, it rarely fractures freshly but parts into small augular pieces by a blow from the hammer, showing only greenish coatings in the seams. Its true fracture is ragged. This rock has fine translucent grains of quartz resembling those of the Great Palisades and a general outward resemblance to the rock of the Great Palisades.

621. Thomsonites (?) &c., from a short beach at Lover's Bay. The trap that encloses this bay is dark, but slightly greenish, and amygdaloidal with Thomsonites and Wernerite. They are few and dull in color. They are generally of a pink color, or massive and white. (See after No. 192.)

622. Stilbite, thomsonite, calcite &c.; mouth of False Poplar river.

623. Dark, greenish trap, forming the upper layer of the point that encloses Eclipse beach on the east. This is two and one-half feet thick, not amygdaloidal, but very chloritic from decay.

624. Laumontitic amygdaloid, lying below No. 623. This has some stilbite and some thomsonite. This bed by easy disintegration forms two small harbors, one protecting from the N. E. and one from the S. W. The beach of the west harbor is of gravel, and has many thomsonites, but the east harbor is entirely rock-bound. This bed is

about eight feet, but varies some, as the characters of No. 623 fluctuate up and down. The general color is a dull red.

625. Greenish trap, having much thomsonite, prochlorite and some stilbite. From this bed the thomsonites of Eclipse beach weather out. Some of the masses of thomsonites are three or four, or even ten inches across; but in the case of large masses the mineral lies rather in sheets, with radiating points on the upper and lower contact surfaces. Some large masses two inches across also have two or three points of radiation. When polished on the beach the pieces which result from the destruction of the large masses are prismatic, but there are also many round and oval which have not been broken on separation from the rock. These show the circular radiating results of different colors on the outer surfaces when polished on the beach. The colors are pink, red, white and green,—at least the same green mineral is found here, always smaller than the other thomsonites, as is found at Terrace Point. This green mineral often surrounds the pink and white radiating masses of thomsonite. It is itself not evidently radiated, and the radiations of the thomsonite penetrate it.

This rock is very nearly, if not exactly, on the same horizon as the trap at Terrace Point, judging from the run of the beds, as they extend along the coast from that place. The same horizon extends to Poplar river without much deviation. Some thomsonites are to be seen on the beach at Poplar river. The thickness of No. 625 cannot be made out, as it forms the coast-line eastward. (V. No. 187.)

625A. Thomsonites, picked from the rock at Eclipse Beach.

625B. Thomsonites, picked from the beach at Eclipse Beach.*

626. Red laumontitic amygdaloid, from about mid-way between Poplar and Temperance rivers (Nos. 177 and 178). This is in regular beds, of a few inches, or less than an inch, lying like a sedimentary rock. The general color is pinkish-red. These specimens may represent the red amygdaloid of several miles along here, even from Poplar river, though the sedimentation is not so plain in all cases. Over them here is a heavy bed of trap, massive or coarsely jointed. This trap bed forms arched purgatories, and tables extending over the lake, where it extends down to the water, the amygdaloid being eaten out by the lake. Occasional thomsonites occur here on the beach.

From two or three miles east of Temperance river to about half way to Poplar, is a very picturesque and interesting, but difficult coast.

*This is called Eclipse Beach, because in 1878, in the latter part of July, our boat was driven in here by high wind, and during our enforced stay in the afternoon, the sun was eclipsed about half an hour. Being compelled to spend the night here, our camp was pitched on the bluff and between the two harbors.

The trap and amygdaloid form a thousand fantastic shapes, as the line of the lake level cuts across the undulations of their bedding and change of dip. Sometimes the bridge of trap rock, produced by the eating away of the soft underlying amygdaloid, runs intact down to the lake, forming deep reverberating purgatories in which by the confinement and compression of pockets and chambers of air, the waves that close up the entrance are thrust back quickly again. Sometimes the bridge breaks down, leaving islands of rock just off the line of coast. Sometimes bridge, islands and all are taken away, letting the lake break on the base of the high bluff rising often perpendicular from the water, or skirted by a narrow pebbly beach, a few rods inside the line where the islands had existed. The effect of wave-and-frost-action on a line of stratigraphy of alternating hardness could not be more perfectly illustrated.

627. Dark trap, forming an arched rock at the shore three-fourths of a mile west of Cross river. The eroded bed is one of two feet thickness of stilbite-thalite-laumontite amygdaloid, which lies on a firm bed of trap having thomsonite and stilbite with less thalite.

628. Basalt; mouth of the Manitou river. At this place about thirty feet of trap that shows red surfaces in falling to pieces, lies on an amygdaloid conglomerate, the two together forming precipitous bluffs on either side of the river, with lower stretches where the trap, which is basaltic or semi-basaltic, runs unbroken down to the water. This kind of coast runs east at least to the point west of Pork bay and west to Little Marais. (V. No. 160.)

629. Conglomerate, from the mouth of Manitou river. The conglomerate is crumbling, soft, red, amygdaloidal, the form and original structure of the pebbles being obscured or lost in the metamorphism.

Over this conglomerate at Manitou river the trap (628) is basaltic. Along the coast it greatly resembles the Grand Marais trap. The basalt is bedded, or at least jointed in the direction of the dip, so that the columns break off in pieces a few feet long, leaving a smooth surface below, but one on which the outlines of the tops of another tier of columns can be seen, and which is itself broken away at a lower level, so as to disclose another tier still lower. Thus in successive benches, or tiers of columns the bluffs ascend somewhat irregularly from twenty to eighty feet. Sometimes one of the lower tiers is not broken, but like a dome rises gradually from the water and runs under one of the upper tiers. This regularity is not the invariable form of the breaking away. Instead, a very rough surface, caused by the separate and individual fracture of the columns all over, sometimes runs down to the lake level. This is the case in approaching Little Marais from the east, where at the point the whole range of trap strikes southwardly into the lake and disappears under the water, forming a ragged, rocky point, and letting the coast line on to the conglomerate, which is but little seen, the only exposure being just at the point on the west of the strike of the trap.

630. Green, chloritic trap, from two miles west of Little Marais Point, forms perpendicular bluffs.

631. Green chloritic amygdaloid, from the same place.

631A. Red, compact, rock-like veins in 631. This red rock, which seems to be foreign to the rock 631 in which it appears, is found embraced in veins with stilbite and calcite.

West from Little Marais beach, the first little point is formed by a trap exposure which probably lies below the conglomerate. This continues west under a stony beach for a mile or so, when, with a high dip, it begins to show more and more, and finally to make a continuous bluff twenty to forty feet high. This trap (630) has a very different aspect from the Little Marais trap, being green instead of red, the amygdaloidal portions also being green. It contains stilbite, calcite, chlorite, (thalite) and some thomsonite. This trap and amygdaloid are bedded, but not basaltic. Running through it are seams, one and two inches wide, (631A.) which are made up of layers of stilbite and a red rocky substance that resembles the rock Nos. 7 and 42. On the beach are amygdules of quartz and thomsonite. This rock, taken all together, much resembles the rock at Eclipse Beach, and perhaps, if the horizons could be compared, it would prove to be synchronous in origin.

A little further west, as Nos. 630 and 631 rise above the beach, a reddish amygdaloid is brought into view, which on close examination proves to be a conglomerate. This rises, as the anticlinal bend of the trap passes inland so as to show about thirty-five feet with purgatories in a perpendicular bluff. Under it soon appears another trap which also rises in anticlinal, is broken away by the action of the lake, and discloses in an eastward facing bluff a lower conglomerate bed of unknown thickness. This anticlinal covers about a mile and a half. The beds return to the lake again at the headland about one-half mile still further west. This is on Secs. 29, 30 and 31, T. 57, R. 6, about three miles west of Little Marais.

632. Trap, from a point of rock on Sec. 29, T. 57, 6, separated from the green trap 630 by a conglomerate thirty-five feet thick. This is red in many spots, on account of the red partings along all the

joints, styled heulanditic by Norwood. It is crossed by red siliceous seams about one-half inch thick, and has large lumps of quartz and geodes. These red veins resemble the red vein material of 631A. but not so abundantly accompanied by stilbite. Thickness 12 feet.

632A. Siliceous, jaspery seams from trap No. 632, from a point about one-half mile west of where 630 appears.

632B. In the same beds of 632, or which at least contain 632A. are siliceous geodes, lined sometimes with amethyst, and a great many agates. These are in a bed but little above a conglomerate, and seem to have been derived from the fusion and dissemination of the material of the conglomerate, the same cause doubtless as filled the siliceous veins of 632A. In some geodes the central mass is laumontite.

633. Thin, irregular beds of trap, immediately under 632, containing red amygdules.

634. Nearly the same as 633, but underlies it; this seems to be a heulandite amygdaloid. It is near the top of the conglomerate. It also contains agate, stilbite, laumontite and chlorite. The red coatings and the heulanditic characters prevail along the red seams that cross and re-cross the rock. In some cases the red mineral penetrates the whole and is disseminated generally through the mass in the manner of amygdules.

634A. Amygdules of "heulandite," and of agate, stilbite and chlorite, picked from No. 634.

634B. Stilbite crystals from 634.

635. Greenish, rather soft, fine, sub-crystalline, compact crumbling rock, containing siliceous nodules. At first this polishes under the friction of the waves, but after long exposure it crumbles from the abundance of chlorite. It lies under No. 634 and also has heulandite in the upper portion. Nos. 633-35 have a thickness of only three or four feet, and are variously affected by proximity to the conglomerate.

635A. Stilbite amygdaloid, containing also agatized nodules, jasper, &c., lying below 634. The heulandite material coats the amygdules and all seams and joints; contains some chloritic amygdules.

Beginning with the Little Marais trap bed the succession downward appears as follows in going west along the coast:

1.	Little Marais trap, Nos. 160 and 628	30 ft.
2.	Amygdaloidal conglomerate (No. 629)	50 ft.
3.	Green trap, (two miles west of Little Marais, Nos. 630 and 636,	50 ft.
4.	Crumbling conglomerate, amygdaloidal, seen	35 ft.
5.	Trap, with heulandite (No. 632)	12 ft.

6. Trap, amygdaloidal with heulandite (?) (Nos. 633-4-5,.. 5 ft.

7. Amygdaloidal conglomerate. Thickness unknown.

636. Samples of red granite; resembles the red granite at the west point of Beaver Bay, but is coarser than that. At a distance this is apt to be mistaken for the Palisade rock. Sec. 1, T. 56, 7. This makes a high point, with a perpendicular face toward the S., but there is only a small area of it in the formation. (V. No. 157). This rock passes by slow changes into the Palisade rock. It appears at a number of other places along this part of the shore. (V. No. 643.)

637. Feldspar rock, Beaver Bay, at the west point of the bay, (V. No. 120).

637A. A light flesh-colored mineral, with a radiated structure, in scales filling seams in No. 637. The scales are generally about one-fourth inch thick, but are sometimes one-half inch.

638. Rock at the base of Encampment Island, from the north side of the island, (same as 106).

639. Green, heavy doleritic trap, coarse-grained, from the high bluff about a mile east of Silver Creek. (V. Nos. 105, 819.)

640. Two Harbor Rock, separated from No. 639 by a red amygdaloid, eighteen to twenty feet, as at Two Harbors; at the water level, under the hill formed by 639, about a mile E. of Silver Creek.

641. Trap amygdaloid, Knife river, grayish green, containing thalite and chlorite. (V. No. 91.)

From Grand Marais to Ogishkee Muncie Lake, and Mouth of Poplar River.

The hills that lie near the mouth of Silver creek, and that extend in a chain N. E. from here, are the first of that form and outward aspect similar to the Mt. Josephine class, that can be seen from the tug-boat in going down the shore from Duluth.

The range next east of Carlton's Peak has the same outward form but Carlton's Peak itself is different. Between Carlton's Peak and Poplar river are four prominent hills, rising about as high as Carlton's Peak. West of Carlton's Peak for a long distance, is an unbroken line of continuous high land, but further west still is a very ragged range of hills.

East from Poplar river are two gentle swells of high land at once; then the high land is more even-topped, gradually descending to the coast at Cascade river. The range appears double at Poplar river, a high hill farther inland overlapping the gap at both ends. The same is true at Cascade river.

In passing toward Grand Marais some of the hills, which do not from the S. W. show any semblance to the saw-teeth structure, change their profile, and fall into line as parts of the regular range. The range thus runs to Grand Marais, where it seems to fall away, or to recede from the coast.

The appearance of the hills suggests that the Silver creek range, already mentioned, having the outward appearance of those at Grand Portage, is of the same geological structure, and that the range east of Carlton's Peak, extending to Grand Marais, may be of another geological age or formation.

On the road from Grand Marais to Rove lake there is first a gradual ascent, with some flat spots, to "the summit," which is reached at about 1¾ miles from Grand Marais, where the aneroid shows 785 feet above Lake Superior. There is then an undulating ascent, or flat surface, to near the valley of the stream crossing Sec. 9, T. 61, R. 1 E. when there is a descent of about 40 feet over drift, to the creek, which is by aneroid 838 feet above Lake Superior. The valley here is broad and shallow, without any rock-cut*. The country thence is undulating, with good soil and sub-soil, and rather light timber, to the E. and W. town line, where there is a short swamp, but on the other side of the town line good farming land again returns. The whole distance from Grand Marais, along this road, is a tract generally tillable, even the hillside up which the tract runs. The underlying rock, in the hill seems to be the Palisade rock, probably with igneous rocks in dykes and overflow, but north of the hill the red rock returns again, as may be presumed from the occurrence of loose pieces of the red rock, and its shingle, occasionally on the trail. The rock in actual outcrop is not to be seen on the trail between Grand Marais and the E. and W. town line mentioned.

From the town line north to the Devil's Track river is about a mile. This stream is a little larger than the other, but has a similar valley. There is no rock exposed at the crossing of Mayhew's road to Rove Lake. The valley is in the drift, but most of the stones are from the red formation—either real Palisade rock, or red granite like that seen east of Beaver Bay and at Beaver Bay (V. No. 665).

Along the same road toward Rove Lake, north from the crossing of the Devil's Track river, the red rock continues to form the basis of the country, as shown by the fragments of such rock along the trail, and where trees have been thrown down by wind, to about 1½ miles north of the town line where a belt of coarse dark trap appears, extending

*The surveyor's plats here erroneously extend the steep bluffs of rock along both sides of the river.

perhaps 20 rods, when the red returns for one-fourth mile. Then another belt of coarse trap-rock like that in the Grand Portage region follows for about 20 rods. The general surface is not rough, but undulating. It is covered loosely by a loam, or mold, which supports trees to a certain size. They are generally blown over and afterward consumed by fire which also burns up the soil. There is not much drift.

At the center of T. 62, 1 E. a little knoll of dry land occurs in the midst of a swamp. Here the rock is coarsely crystalline doleryte. At a short distance further an amygdaloid appears, and the "Two Harbor Rock," so-called in these descriptions. This last appears soon after passing a little creek; but the country is in general a swamp, with caribou trail in soft wet moss running among the spruces and tamaracks. The surface is closely underlain by the rock *in situ* or by fragments which are lightly covered by the moss or by a vegetable mold. Among fragments of the "Two Harbor Rock" (and occasionally the rock in place) are to be seen also masses of igneous, coarse-grained rock like that overlying the Two Harbor rock.

642. From about one mile north of the center of T. 62 N. 1 E. on Mayhew's trail. This red rock here which appears as a fine red syenite forms an escarpment about 15 feet high, mostly hid by the trees and moss, facing N. N. E. This is not wholly red within, though it weathers red, but is a reddish-brown, and has red crystalline specks scattered through it. It is in heavy, hard layers, and does not shatter into angular small pieces like the red rock. It contains free quartz. Toward the south the land is higher than this bluff, but the bluff overlooks immediately a swamp, and a creek, toward the north. Toward the west this escarpment rises into a hill 75 or 80 feet high. At the foot of the bluff is the rare feature of a foreign syenite boulder.

643. In the northern tier of sections in T. 62 N. 1 E., where the trail crosses them, is a hill range 100 to 150 feet high, with white pine, birch and white cedar, of larger dimensions than in the lower land. This range is composed of a red rock very much like the last number, approaching the character of the red granite seen east of Beaver Bay (No. 636). Many boulders of such rock are in the road before reaching the hills, and more in ascending them. There are a few also of the gray slate and quartzyte, and some of the Grand Portage igneous rock; nine-tenths of them, however, are of this "red granite."

644. The top of this hill, however, consists of igneous rock. This is not certainly in overflow. It may be as a dyke protruding through

No. 643. East of the Mayhew trail, following the town line between towns 62 and 63, the land rises in a ridge perhaps 200 feet above the country further south. The ridge runs about E. and W. covered with heavy forest, and formed of "red granite." This sample contains quartz and orthoclase, and is not a true igneous rock.

This range of hills, composed of this red rock, appears like a range of upheaval, and finally the country becomes wholly hilly.

645. "Red granite," like 642, from this hill-range, S. W. ¼ Sec. 35, T. 63, 1 E. on a little creek. This rock seems to be the result of higher metamorphism of the coast-line red rock, or the Palisade rock. The change seems to have been gradual. While but little of this rock is encountered along the lake shore, it here constitutes the rock of the country, and rises into considerable hills. This difference of crystallization must be due to greater nearness to the seat of upheaval and heat, which would not be in consonance with the opinion expressed by Messrs. Bell and Logan, locating the belt of greatest disturbance in the bed of Lake Superior. It seems rather to be back in the vein of the lake-basin. Most of the rock is like this number, but there is also much like No. 644, in large masses that fall from the hills, and that lie on the tops of the hills. It is difficult to separate 644 from 645. It seems to be due to a mixed condition of matter from the sedimentary and from the igneous rocks, or perhaps to a complete fusion, and flowing in igneous form, of the same rock.

These hills are from 1,000 to 1,200 feet above Lake Superior, and from 100 to 150 feet above the surrounding country.

646. "Red granite," S. E. cor. T. 63, 1 E.

647. Red rock, like 643 and 645, making hills in N. W. cor. T. 62, 2 E. and N. E. cor. T. 62, 1 E. Associated with this red rock in some way not ascertainable on account of the prevalance of surface mold and bushes, is found the next.

648. This is a darker rock, containing quartz, orthoclase, plagioclase, hornblende, magnetite, viridite, apatite, having somewhat the aspect of the Grand Portage trap hills, but not its mineral composition. It may be only a local irregularity in the lithology, as suggested under No. 645, or due to a profound metamorphism of other sedimentary beds having a different composition originally. There is abundant opportunity for this latter hypothesis, because under the red-rock which is supposed to make by further crystallization the red granite, is an immense thickness of black slates and quartzytes, as seen in the peninsula of Pigeon Point, the strike of which must pass westwardly through the country north of Grand Marais. If the upheaval and metamor-

phism of the red rock, which took place after its deposition, also disturbed with the same long-continued effect the underlying quartzytes, they would be deeply metamorphosed also, and would produce a rock different from a truly igneous rock, and from the overlying red granite. This is also further probable from the observed conformity between the red rock, or red quartzytes at least of Pigeon Point, and the underlying black slates and quartzytes. But at present Nos. 644 and 648, and other rocks like them from the same region, may be conconsidered undetermined, though with a probability of an original sedimentary condition.

649. Sample of the rock seen in loose pieces along the trail going N. between Sec. 36, T. 63. 1 E. and Sec. 31, T. 63, 2 E. A high hill runs along the east of the trail, the trail being west of the town line. This is a red syenite, but with much magnitite and hornblende.

650. Another sample of dark dioritic rock. This is so abundant that it must be in place near, but cannot be seen.

651. Magnetited dioryte, from boulders, seen along the same trail, twenty to thirty rods north of the last. This same rock forms a hill along the right of the trail. This resembles the Herman iron ore (No. 514), but it seems also associated with the dark rock No. 644 and 648, which is regarded as originally a sedimentary rock.

Across the creek which passes north near the town line where this iron occurs, is another hill made of the same rock showing a perpendicular wall facing E. rising about fifty feet, viz.:

652. Dark, heavy dioryte (?) with magnetite, from a point about one-fourth mile from the Brule river, and half a mile west of the town line.

653. Red rock, from the Brule, some west of the town line. This rock still prevails, thrown up by trees.

But immediately across the Brule, on the town line, between it and the head of Elephant lake, is a low range of trap hills, of the kind characteristic of the Grand Portage district. This rock here rises in domes, and the rock it lies on cannot be seen. Yet on the south side of the Brule it apparently lies on the red rock, rising in the hills and ranges higher than this. It is coarse, and not so much magnetited as the rock No. 652, south of the Brule.

North and west of the Brule, the country appears, viewed from a burnt knob of this trap, quite hilly, and apparently the beginning of the broken surface seen along the boundary.

Also west, in the next town, northwest from here, are seen some high hills.

About one-half mile north of the north side of Elephant lake on the town line, large pieces of the slate and quartzyte formation begin to appear, with boulders of the trap last mentioned. The country is more nearly level, but covered with tamarack or spruce in the swamps, and white pine, tamarack, white cedar, poplar, white birch, and mountain ash, on the ridges or higher flats.

A little further on, however, are many pieces of the red rock on the banks of a little creek running west, and as they probably would not have been transported north, but the quartzyte and slate may have been transported south, it is probable that the red rock really extends as far north as this place.

Secs. 18 and 19, T. 63, 2 E, the red rock comes in full force, forming a range of hills running E. and W. across the town line, without a capping of trap. This hill-range is covered with Pinus banksiana, and the ground is carpeted with moss, as in a tamarack swamp. Indeed this carpet of moss is general here. It seems to depend on the rains that are perhaps more frequent about the summits of the hills. The moist winds from the lake encounter the colder land winds coming more from the north, and transient showers are the result.

654. This sample is from a ridge rising about one hundred and seventy-five feet, crossed by the section line running east, S. E. ¼ Sec. 18, T. 63, 2 E. This is plainly an igneous rock of the usual kind seen on the shore of Lake Superior. It is fine-grained and dark.

655. N. E. ¼ Sec. 20, 63, 2. A low ridge of coarse-grained vesicular reddish rock, containing free quartz, probably a condition of the "red rock."

656. At another point, a little further east, this reddish rock vesiccular, and more evidently a condition of metamorphism, not being wholly crystalline.

657. Sec. 16, T. 63, 2 E, (on the southern line, just after the crossing of a creek) is a fine-grained, brown rock, having feldspar crystals handsomely disseminated sparingly through it, and resembling the stellar porphyries, pebbles of which are seen occasionally on the lake shore. It is a dark, brownish rock, which weathers red, but is hard, fine and compact, and shatters under the hammer in memerous preexisting joints which are iron-shot, making sharply angular fragments. This contains fine grains of free quartz, as shown in thin section, and probably comes from the sedimentary beds, associated with the rocks 648, 651 and 652.

658. Further on this ridge takes on the characters of 655 and 656.

659. This rock appears to be in place, but can be seen only in the form

of numerous loose pieces. It has the appearance of constituting the top portion of the ridge (658.) It is dark, coarsely crystalline, and allied to the diorytes (Nos. 651 and 652.) This ridge runs E. and W. nearly on the north side of the trail, and rises about two hundred feet.

On the line between Secs. 15 and 22, in town 63, 2 E. the country rock is the "red granite," but there are occasional patches of igneous rock, and also some traces of drift, shown by pieces of the quartzyte and slate, and by occasional boulders of syenite. The surface is generally moss-covered and wet. At the crossing of the Greenwood river, the boulders are nearly all of the "red granite." Following the line further east, to the little lake on Sec. 13, at the crossing of the stream, the rock is of the dioritic kind, coarsely crystalline, but there are a good many boulders of "red granite" and of slate.

At the crossing of the town line, which is on high land, is considerable good pine, perhaps 200,000 per forty on either side of the trail. The rock underlying is—

660. A gray dioryte, porphyritic, belonging to the same class of rocks as 651 and 652. The "red rock" seems to have continued along the line of the trail, as far east as to one-half mile west of the town line. East of that the country seems to have been in the next underlying beds as far as to—

661. One mile east of the town line (S. E. cor. Sec. 18, T. 63, 3 E.) is a reddish crystalline rock in place, and this continues east two miles from the town line.

662. The country seems to have considerable drift, often of clay, and does not show the underlying rock. The surface is nearly flat. This fine-grained porphyry is allied to No. 657 and is from S. W. ¼ Sec. 14.

663. S. W. ¼ Sec. 19, T. 63, 4 E, on McFarland's trail. Here is a short E. and W. ridge, rising about fifteen feet, in which the rock is the stellar porphyry seen in pebbles on the lake shore. It is fine-grained and brown, but is beautifully set with intersecting tabular crystals of flesh-colored feldspar. The mass of the rock is made up of minute tabular crystals of a feldspar and opacite, with a few grains of chlorite, and very rarely a minute grain of quartz.

In about N. E. ¼ Sec. 30, T. 63, 4 E. is another low ridge, but made of a different rock, being of a coarse porphyritic dioryte, like some already numbered.

The height of land back of Horseshoe bay, three and a half miles from Lake Superior is 960 feet above the lake.

664. At a little more than two miles from Horseshoe bay, appears

a diorite rock, in a ridge, made up almost entirely of feldspar and hornblende. A beach line is distinctly marked back of Horseshoe bay fifty feet above Lake Superior.

Passing up the hill back of Grand Marais, on what is known as the "Iron Trail," the hill is found by aneroid to be 1,063 feet where the trail passes over it, or 278 feet higher than where the Rove lake trail passes the summit. This is about one and one-half miles from the lake shore. The surface descends eighty-seven feet in passing northward to the level of the water in the south branch of the Devil's Track river.

The rock is mostly hid on this hill by drift, some of it being clay on the top, but in the southward slope, where the face is most precipitious, the rock is exposed.

665. Rock from the Grand Marais hill, eight hundred feet above Lake Superior, having a face seventy-five feet high toward the south. Rather fine-grained trap, reddish brown, evidently an igneous rock. The top of this hill seems to consist of this rock, but toward the base, on the south side, the red rock that forms the beach at Grand Marais is so abundant in old tree-roots, thrown up by the wind, that it is unquestionably in place there, though so covered by its own debris that it cannot be seen *in situ*.

The level of the general surface does not fall away again, after reaching the top of the hill, more than thirty or forty feet, when it becomes a swamp of spruce and tamarack, with the usual covering of coarse Caribon mosses. Passing over the swamp, (about three-fourths of a mile) a slight ascent begins, rising again to about the level of the first hill. After a short distance of dry land the surface descends rather abruptly to the south beach of the Devil's Track river, which is eighty-seven feet lower than the top of Mayhew's hill. No more rock is seen to this place, and here can be seen only boulders. The lake from which the south beach flows is thirty-nine feet higher than the river where the trail crosses it.

666. "Red rock," with small glassy crystals like quartz, from the N. E. side of the lake from which the south beach of the Devil's Track flows. Many loose pieces are seen, but none is to be seen in place, the country being drift-covered. Devil's Track lake is forty-nine feet above South Branch lake, or 1,064 feet above Lake Superior. No rock *in situ* appears between the perpendicular escarpment of the Grand Marais hill and Devil's Track lake, so far as can be seen along the "Iron Trail," which strikes the lake on the south shore one-fourth

mile east of the fourth meridian. The beach here shows no rock, *in situ*, but is composed entirely of small augular pieces of—

667, which is evidently the rock of the country, on account of its abundance, and the fresh angles of the outside. It is reddish-brown, compact, rather fine-grained, but porphyritic with flesh-red feldspar of the color of the moss. In the interior are seen, on fracture, green specks probably due to changed hornblende. On the surface these weather out, making a pitted exterior. It also contains free quartz, making it the equivalent of the red syenite associated with No. 1 at Duluth.

The divide N. of Devil's Track lake is 1167 feet above Lake Superior. The swamp, which is one and one-fourth miles on the portage from Devil's Track lake to Tamarack lake is 1152 feet above Lake Superior. About one-half mile N. of Devil's Track lake the trail crosses the fourth meridian, and continues in a general N. N. W. direction to Tamarack lake. The country about is not hilly, but rises perhaps thirty or fifty feet above these lakes. Tamarack lake is 1132 feet over Lake Superior. The Devil's Track rivers enters it from the N. E. and a short distance above the lake the country becomes a vast swamp of tamarack and spruce. In the swamp are occasional dry knolls of gravelly clay and waterworn drift, but in general throughout the swamp the surface is covered with a thick coating of different caribon mosses. The knolls sometimes spread out indefinitely, rising four or five feet above the swamp, making a small flat area of the same characters as the knolls. There is no rock in place. The country is covered with drift. These knolls are of drift.

The agricultural character and value of this swamp are likely to be mistaken. It seems that in all parts of this district, wherever the surface is nearly flat, and the nature of the underlying rock is not such as to allow easy and rapid escape of the surface waters, a swamp of tamarack and spruce (or perhaps in a stony area, of white cedar) inevitably supervenes; the easily drained hilly tracts, which perhaps are so stony and rocky as not to be arable, are *apparently* better for farming, and are now covered with fine timber. A settler would naturally select these uplands, whereas really the low lands are furnished with the better soil, and are freer from stones. This covering of the uplands with a more or less hardy and stunted evergreen forest, somewhat sparse, is characteristic of high northern latitudes, and here seems to be due to the severe, but moist climate which prevails.

Owl lake is about twelve feet higher than Devil's Track lake, or 1,148 above Lake Superior.

668. About one-third way across the portage from Owl lake to Little Pine lake, are low rocky mounds and ridges, twenty-five to sixty feet high, covered with pine. These ridges consist of this rock, a red syenite, with green specks and red feldspathic crystalline surfaces like several other samples obtained in this region.

The kind of country described north of Tamarack Lake, does not continue through to Little Pine Lake, but in a short distance lindens appear in the forest, then white pine, hazel, mountain ash, &c., while tamarack and spruce gradually disappear, the balance continuing to be interspersed even among the pines and in the uplands. Pretty soon the forest is nine-tenths white pine, the rest being composed of white birch, Norway piue, balsam, Mountain ash and Mountain maple, at the same time that the level of the country is elevated to 100 and 150 feet above the adjoining lakes, and is rolling and hilly, with frequent large boulders and occasional exposures of the underlying rock (668). The soil is coarse and stony, with boulders of light syenite and many of red syenite from the rock of the country. It is a rusty, loamy clay, that seems to be the direct result of the disintegration of the stones of the drift, changed by the action of vegetation.

669. Is from what appears to be a dyke, about half way between Owl Lake and Little Pine Lake, though the exposure is not sufficient to show whether a dyke or not. There is a perpendicular wall exposed, running N. and S. near the trail, on the east side, extending about 25 feet and rising five feet, sinking down to the general level on either side, facing west. There is in it a jointage that weathers out in perpendicular bands or basaltic layers, that run E. and W. from one inch to three or four inches in thickness, very much like dykes seen on the shore of Lake Superior. There. is also a blind ridge or elevation running east, through the woods, of about the same height, but showing no rock as far as traced. Toward the west, after a low gap of about 40 feet, the surface rises gradually to about eight feet, and in the top is the same rock; but it abruptly sinks away into a valley, while toward the N. W. is a considerable elevation or ridge covered with pine and containing the red granite No. 668. No. 669 seems to be a dyke cutting the red rock, and perhaps breaking through it in a number of other places. It is, indeed, one of the causes of the "red granite" which all of the time is supposed to be due to complete fusion and change of the "Palisade rock," and that to a feebler application of the same force to the red shales and sands of the Potsdam seen in the St. Louis river at Fond du Lac. No. 669 is apparently what Prof. Pumpelly has described as a *melaphyr*—a dark homogeneous trap,

globuliferous-weathering, and sometimes showing in the sunlight large reflecting crystalline surfaces in the mass of the rock, due to crystals of pyroxene that embrace all the other minerals.

A short distance north of the divide between Owl and Little Pine Lakes, on the north slope, the red rock, which is laid bare by the overthrow of a large pine by a late cyclone, shows a smooth glaciation, but no prevailing direction can be distinguished.

Little Pine Lake, which is 1,154 feet above Lake Superior by rough aneroid observations, has no rock visible about its shores, but under the water near the shore can be seen everywhere sub-angular pieces of the red syenite like No. 668. In making the portage from Little Pine Lake to Clubfoot Lake, which is 1,173 feet above Lake Superior, there is a small exposure of the red granite seen on the trail, but elsewhere the rock is either hid, or is of boulders. About the S. and W. end of Little Pine Lake are numerous foreign boulders. The same is true of the S. and E. shores of Clubfoot Lake.

Round Lake is 1,208 feet above Lake Superior, and Abita Lake is 1,349 feet.

670. From one-fouth mile S. of Lake Abita, in the large hill over which the trail passes, apparently a dioryte, consisting largely of hornblende.

671. "Red granite," from the hill near the south shore of Lake Abita, but not certainly in place. The hill rises about 225 feet above Lake Abita and 1,574 feet above Lake Superior, and is separated from the hill from which No. 670 comes by a dry valley, but which has a creek in wet seasons.

672. The same hill which furnishes No. 671 near the lake is made up of this rock toward the top, being a coarse dioryte. In what manner this is related to No. 671 does not readily appear. There can be seen large blocks of this, and some small mural faces, along the north side of the hill, but in general everything is hid by turf, forest and mosses. There is but little doubt, however, but these blocks are not far removed from their natural places.

The lakes of Brulé river, north from Brulé Mt., are 955 feet above Lake Superior, by aneroid, and Brulé Mt. in its highest part is 1,461 feet above Lake Superior. Brulé Mt. does not appear like a mountain from the south, rising but 30 feet above Lake Abita, but from the north it is very prominent as an isolated hill that rises 506 feet above the river flowing along its northern base.

673. "Red granite," top of Brulé Mt. and the rock is not well seen

in situ. Almost no rock but the red granite is seen along the trail from Lake Abita to—

674, a rather fine-grained deposit, with quartz, which occurs on the north face of Brulé Mt., forming a perpendicular wall about 20 feet high, but is only seen (so far as examined) a little east of but near the trail. It is 240 feet below the top of the mountain, and makes a more or less continuous jog or shoulder. Very few red pieces are to be seen north of this shoulder, but south of it they make nine-tenths of all the stones. Occasionally light-colored gneiss and granite are seen, and rarely a piece of siliceous slate, so that it seems as if here were the northern boundary of the red granite (V. No. 685).

675. In the northern face of Brulé Mt., 300 feet below the top about south from the east end of the westerly lake in Brulé river. This reddish granitoid rock forms a perpendicular wall of 60 feet in height. This contains much hornblende, thus causing it to approach the mineral characters of the dioryte No. 674.

676. At a lower level another perpendicular wall of rock is found on the north side, a little to the west of the section line between sections 16 and 17, rising about 78 feet. This rock resembles the rock No. 674, but the bluff cannot be said to consist entirely of this. Another exposure of rock like No. 676 is at the water level, on the north side of the lake mentioned. It runs under the lake, sloping south, and is, like No. 676, deeply disintegrated.

The top of Brulé Mt. is rounded and forest-covered, the ascent in all directions being very gradual, but most abrupt from the north. The only rock seen is boulders, generally of dioryte. The highest point is about one-eight mile east of the section corner (17, 16, 20, 21, in T. 63 N. R. 1 W.) and one-sixteenth of a mile south. From this place no higher land can be seen toward the east, but there is a high peak toward the S. W. six or eight miles, supposed to be Eagle Mt., a very high range visible a few miles north, afterward learned to be the *Misquah Hills*, and other hills to the west. About north of the peak thought to be Eagle Mt., is a high square-cut hill, like one of the Sawteeth hills; but toward the S. E. is low, flat ground, probably the course of the Brulé valley*.

On the next portage northward from the Brulé river the country is a swamp, with occasional low knolls, or short ridges, the whole covered with tamarack and spruce, and the lower parts being very stony, similar to the St. Louis valley from N. Pacific Junction northward to

*Some of these particulars were obtained of my man Mallmann who climbed a "Jack pine" eighty feet high, growing on the top of the mountain, and from it described the surrounding country.

Knife Falls, and similar to many swamps in this northern part of the State, the most of the stones here being of the rock No. 676, but with a sprinkling of red granite, as if there were still rock of that kind in place further north. Some of the boulders are banded with magnetite. At about half way to Little Trout Lake the boulders of red granite constitute about half of all.

677. A short distance further north a hill rises on the east of the trail. but near it, (about 100 feet), consisting of the rock of this number—a very fine-grained basalt, nearly black, compact. In thin section this shows a multitude of similar polarizing, rounded small crystalline grains dispersed through a ground-mass of uniform character that is apparently semi-crystalline with scattered cubes of magnetite. This would seem to make it a crysolite basalt.

But in following the trail it passes over this hill-range, which is only part of a generally hilly tract surrounding the Little lake, next on the trail, the lake itself being 244 feet above the Brule river. These hills are not large, rising about 200 feet, but the country is what may be styled hilly. The rock constituting them is of the same kind as No. 676, and of the "red granite;" large masses of the former, and many small pieces of the latter, being strewn about.

This hill extends to the Little lake, and along the S. E side, where the superposition of the strata can be made out in descending order, the highest stratum being of the "red granite." Thus: (with a dip 10 deg S W.)

Red granite (not actually seen in place.)	
No. 678, in a regular bed of the thickness of.........	15 ft.
No. 676, porphyry with red feldspar..................	4 ft.
No. 679A. porphyry with gray feldspar..............	8 ft.
No 680. Fine bedded, crumbling, seen.............	18 ft.

The foregoing does not include all the strata, some being invisible both at the top and at the bottom. These strata seem to belong to the formation of the great slate and quartzyte range, underlying the cupiferous, as developed at Grand Portage and along the boundary line, but here more metamorphosed.

678, is a dark (pyroxenic ?) rock, with no apparent feldspar. Fragments of a rock like this were seen on the top of Brulé Mt , evidently carried there by the drift movements, and could not be referred to their stratigraphic position. (V. 684)

679. Finely porphyritic with red feldspar, the ground mass being like the rock No. 678.

679A. The same as the last, with gray feldspar crystals.

680. A fine-grained, dark rock porphyroidally sprinked with feldspar of a flesh-red color. While this is in heavy beds in the stratification, it has a fine, rudely basaltic, disintegration, due to a structure of short joints and cross-planes, mainly perpendicular to the dip, by which it crumbles out so rapidly that it is not easy to get a fresh fracture. It is one of the shaly sedimentary parts of the so-called Animikie Group.

Little lake is 1,199 feet above Lake Superior, and about 200 feet below the surrounding hills. Little Trout lake is 1,272 feet above Lake Superior, being the highest on the Iron Trail in the traverse from Lake Superior to the boundary line.

The hill at the right of the portage from Little lake to Little Trout lake is made up of the numbers 681, 682 and 683 is downward order, with the thickness stated below: dip 20° S. E.

681, (seen twenty feet, may have more above.) A very fine, black rock, approaching aphanitic slate.

682, (35 feet) Porphyry, both with red and with gray feldspar crystals. This is a part of the great formation lying below the cupriferous, already mentioned, and is in beds of an inch, where weathered, or in heavy layers of five or six feet. The ground mass seems to be the rock No. 678. The red color seems to come from weathering, the original color being gray. This is shown in one of the small samples. It has free quartz.

683. (20 feet; there is a talus below of fifty feet in which the rock is unknown.) A fine-grained heavy dark rock, apparently consisting of triclinic feldspar and diallage with a little uralite and magnetite.

684. Further north is a layer of four feet of a fine black rock, evidently crystalline, somewhat like No. 678 or 683, included between some of the beds of the foregoing porphyry, near the bottom of the same.

From Little Trout lake to Misquah lake is a descent of fifteen feet.

685. Reddish-brown rock weathering red, with red feldspar crystals. This rock makes the Misquah Hills in the S. W. part of T. 64, 1 W. It is rudely and coarsely basaltic, the columns being perpendicular to a S. or S. E. dip. This number is from near the trail about a mile south of Misquah lake, near the town line between 63 and 64, on Sec. 32, where a thickness of fifty feet can be seen. It is bedded as well as basaltic, and in weathering sometimes shows laminae of one-fourth and one-half inch. It is undistinguishable from the rock frequently called red granite in these descriptions, but its geographical position seems to place it in a lower horizon. There may, however,

be several faulted upheavals of the same horizon, so that in going north one does not invariably pass on to lower beds, but sometimes from lower to higher.

Misquah lake* is flanked on the N.E. and E. by high brick-red hills. Some of them being 500 or 600 feet high. The trees, being nearly all fire-killed, and even consumed, allow a perfect view of the rock. It is the same as 685.

686. "Red granite" from the east of Misquah lake, Sec. 32, T. 64, 1 W. This rock is basaltified and massive, rising in mountain-like masses. It dips at a high angle toward the east.

687. The same rock as the last, brecciated or scorified, though still weathering brick-red.

These mountains are mainly to the east of the trail and so far as can be seen they are formed wholly of this red rock.

There is much drift in the form of large boulders along the lakeward side of these red hills, particularly near the lake where the trail goes. These large pieces are of dioryte, often magnetited, and porphyry like No. 682, or dark rock like 681, with many pieces of siliceous slate and gray quartzyte.

688. The character of the rock, and of the country, changes at once on entering Cross lake, which is thirty feet below Misquah lake. The rock when first seen is at the right of the entrance, and is mixed and irregular in structure, as if it had been a conglomerate originally. In general it is porphyritic with gray feldspar and has a little quartz, but the ground-mass, which seems to be the rock No. 678, varies greatly in its prevalence over the feldspar—also the size of the feldspar crystals varies. Hence the outward aspect of the weathered surface is spotted with dark and light colors, the feldspathic parts (and particularly the coarser-grained) becoming white, or nearly so, the rest being darker, or with fine mixture of dark and light. This rock has a basaltic structure, and a very heavy bedding, the latter dipping south, and the basaltic structure being perpendicular to the dip. (V. 701 and 702.)

Cross lake is a large lake, expanding in finger-shaped elongations east, west and southwest, and having several rock islands, as well as north and south. This lake and Misquah lake are tributary to the North Brulé river. The shores and the islands of Cross lake are low, made of the next numbered rock.

689. Similar to No. 688, but more uniform in structure. Evidently a gray dioryte, from the same formation as that, and much like the rock 682.

*So called from the Chippewa word meaning *red*, in allusion to the red walls by which it is enclosed along its east shores.

The lake through which the North Brulé flows, next north of Cross lake, is surrounded by a similar low country, and has the same rock as No. 689. This also has many arms and bays running west, and from one of them is a canoe trail and portage to "Brulé river lake," which gives source to the South Brulé and to Temperance rivers.

Cariboo lake is 1,238 feet above Lake Superior, and twenty-two feet higher than North Brulé lake. Its shores are low, mainly of bare rock like 689, which however, rises in some places from ten to fifteen feet. The timber is fire-killed, or consists of a second growth of small trees ten to twenty feet high. Between this and Poplar lake is Little lake, three feet higher than Cariboo lake.

690. Near Little lake, at the north end of the portage, is a bare dome of rock, rising in the swamp about twenty feet, represented by this number. It is dark-colored, hard and fine-grained. It is not bedded, nor visibly basaltic, but all over the rounded exterior are polygonal spaces, marked out and included by bands of harder rock that rise as low ridges above the surface, fitting exactly to each other. This rock under the microscope shows its igneous origin by its composition which is plagioclase, augite and magnetite. It also seems to hold an occasional grain of quartz.

691. Gabbro, consisting of plagioclase (assumed to be labradorite), diallage and magnetite; related to the last. This is a sample of the usual "trap" of the country. It weathers light, and is in that way in marked contrast with the last, though that difference seems to be due solely to the greater proportionate amount of feldspar in this, and of augite in that. This occurs in patches on and in the last, and especially on the north side. It also seems to cross and cut it in vanishing veins.

692. Gabbro, like the last; this forms a series of bluffs along the south shore of Little lake, of about the same hight and form as the last described, but the rock is rather finer-grained than much of the trap of the country. This makes a low hill-range along the south side of the lake.

Poplar lake is 1,221 feet above Lake Superior. The rock the whole length of Poplar lake is the same as 692.

693. Gabbro; from the west end of Poplar lake, where the portage trail leaves it going to Duck lake. It rises about twenty feet above the water all about, in undulating domes, rounded as by glaciation, though no glacial marks can be seen. The country is burnt; a few foreign boulders are strewn over the bare rock surfaces.

Duck lake, by aneroid, is found to be 1,244 feet above Lake Superior, and Portage lake 1,234 feet. Where the trail reaches Portage lake is a low upheaval of rock like No. 693. The country generally is made of this rock, nearly bare. It contains in some places considerable magnetite. Mayhew lake is 1,213 feet above Lake Superior.

The same rock as 693, or some slight variation from it, continues to the entrance on Mayhew lake (or Iron lake), with increasing frequency of drift pieces of flinty quartzyte and slaty quartzyte. The trap is more magnetited in places, but, except in that particular no change can be seen.

694. Gabbro, with much magnetite; a little east of the section line, between sections 32 and 33, on the south shore of Mayhew lake (or Iron lake.) The rock here is in even and continuous beds, that dip regularly to the south, like the quartzyte and trap of the country, undulating a little up and down. This is seen in many places. It occurs also on the south shore of Portage lake. The beds vary from four inches to twelve inches in thickness, and show weather-stripes on the exterior, due to varying composition, something like a sedimentary rock. (V. No. 814.) They suggest the query whether this trap may not be due to a change, *in loco*, of the early sedimentary rocks. The great extent, the constant dip, and this regularity of bedding, and its thinness, all coincide to point to that as its origin, rather than to the overflow of molten matter over so extensive a region. The mineral composition, however, is constant, and allies it to the igneous rocks of the "gabbro range" which graduate into the trap rocks of the Cupriferous. It seems, however, that there was a vast outflow of igneous rock in the midst of the era of the quartzyte and slate group, producing this area of the "gabbro range," and separating the lower portion from the eras of the porphyries, and the red shale and red sandstone which are characteristic of the cupriferous formation proper. There are some reasons for believing that this great igneous outflow entered the sedimentaries as "laccolites" in many places, and thus tilted and modified the overlying beds, instead of being produced prior to their deposition.

695. Magnetic ore, S. E. ¼ Sec. 36, T. 65, R. 3 W. on the north shore of Mayhew lake (also known as Iron lake.) This rock is a condition of the trap of the country, and is almost entirely made up of magnetite. A careful study of this location warrants the following generalized statements:

(1st.) The ore is in the igneous rock.

(2nd.) It varies in quality very much, even passing into rock that cannot be styled iron ore.

(3rd.) It involves with itself nodules of coarse gabbro containing considerable magnetite.

696. Sample of this nodular or concretionary rock embraced in the iron ore.

(4th.) It also embraces isolated pieces of gray quartzyte (apparently), but which in thin section are seen to consist of plagioclase, magnetite and augite; and some dark, crystalline, micaceous nodules.

697. Samples of the dark and micaceous nodules. These dark masses embrace dark labradorite (?) biotite, hæmatite, with viridite.

698. Samples of what appears like a granular, gray quartzyte, but which really consists of the minerals that go to make gabbro. This is distributed through 695 in rounded lumps like some masses of No. 696. Some masses of No. 698 are very large, where they occur on the north side of the swamp.

(5th.) It dips toward the south in beds whose aggregate thickness is at least fifty feet, but may be seventy-five feet, the actual amount being hid by a swamp.

(6th.) It involves also detached masses of coarsely crystalline gabbro nearly free from magnetite, but containing biotite.

(7th.) It sometimes gives place to a coarse trap of the same kind which is so large in amount as to constitute the rock of the place, and its connection with the ore cannot be seen.

699. Samples of this coarse, micaceous trap.

(8th.) It lies on a fine-grained rock like No. 698, which is a fine gabbro with chrysolite, resembling a fine, granular, gray quartzyte. This rock dips, so far as any dip is discoverable toward the north, and it seems to have furnished the rounded masses of No. 698 embraced in the iron ore. The northward dip is due to a deceptive appearance of columns of basalt.

700. Samples of this fine chrysolitic gabbro. This rock much resembles the chryrolite basalt No. 677.

(9th.) In seams and gashes in No. 698, the rock No. 699 is also found.

(10th.) The iron in considerable, but unknown quantity, is of fine quality, being seen in other places besides this described.*

West from this iron location, after passing the little bay running E. N. E. the north shore of the lake is made up of No. 699, which appears massive, weathers lighter than the trap usual in the country, and

*This iron ore constitutes what is locally known as the "Mayhew Iron Range," and is found in a belt about a mile wide on both sides of Iron lake, and on the south side of Portage lake, and between Portage and Poplar lakes. An analysis reported by Mr. Hause, performed by R. S. Robertson of Pittsburg, Pa., gave the following result: Silica, 2.02; Alumina, 2.68; Titanium, 12.09; Sesqui Chromium, 2.40; Mag. ox. Iron, 80.78; Lime, trace, phos. acid, 0.03.

appears like the "Rice Point Granite." It is hard and firm, and rises in domes which rarely show any dip. At one-fourth mile west of the little bay it is broken by the lake and ice in winter and over a small area shows both a horizontal jointage, and one which has more the characters of dip to the N. 45 degrees—the latter having the planes of separation at varying intervals of six to eighteen inches, and marked also by a lighter weathering, or by a pinkish stain in the feldspar. This, however, may be the remains of a former basaltic structure.

701. The rock last mentioned, resembling the "Rice Point Granite." It consists largely of a gray feldspar, is firm and massive and rounded. It also has diallage and magnetite, with occasional scales of biotite.

702 is embraced in pockets and lumps in No. 701. It is the same rock, but with much coarser crystals, and a larger per cent. of diallage (V. No. 688 and No. 1 D.).

703. Sample of iron ore at the east end of Pewabic Island containing all the ingredients of the rock, even mica. There are three or four other islands in the west end of Iron Lake. The iron here is plainly embraced in the rock 701, which is also the same as No. 696; which is the same as the rock styled trap or gabbro all the way from the south side of Little Lake. This rock of course has variations which account for its different aspects, but in all these it does not depart from the accepted characteristics of an igneous rock. Its variations are included within the range of mineral associations possible, by relative changes, in plagioclase (probably labradorite), chrysolite, augite, magnetite and it has as accessories biotite, hæmatite and a green mineral that may be derived from a decomposition of the augite, which is also frequently in the condition of diallage.

About a mile west of the end of Mayhew Lake, on the town line, is an isolated knob of the same kind of iron ore, in low ground, "30 links wide, all solid iron," so reported by Paul Morrison.

704. South of the little island crossed by the E. and W. town line, in Mayhew Lake, the rock is highly magnetited. It is also micaceous. It has plainly a dip to the south of about 25°. The jointage here is also somewhat like the apparent dip seen on the north shore four miles west of the little bay. A similar deceptive jointage resembling a N. dip is to be seen at the portage to Loon Lake, the general dip being to the south.

705. Appears like a metamorphic rock, bedded and dipping north about 45° at a point a little back (N.) from the shore, a short distance west of Mayhew's location, which underlies the iron-bearing rock, and the iron ore, and has been styled changed quartzyte. It really is a

crystalline, fine-grained rock which has hornblende changed to viridite, feldspar and magnetite, and its apparent northward dip is due to a fine basaltic jointage perpendicular to the true dip, which is about the same in degree toward the south (V. No. 700). No. 705 has a visible thickness of 10 feet, and the overlying iron rock has a thickness of about 20 feet.

706. Through the iron-rock at the location 705 run seams, three to six inches in thickness, of pinkish rock consisting of quartz, orthoclase and hornblende, in rather fine grains. These seams and veins are parallel with the basaltic jointage of the rock No. 705. Sometimes a pinkish shade of color runs into the trap, accompanied by quartz. These pinkish beds and seams, which simulate planes of bedding are probably due to contact with the underlying formation and nfusion from it.

707. In some places in the trap, where one of these red seams passes through it, the hornblende which accompanies the red rock, greatly predominates, or is very coarse, and sometimes is fibrous and radiating, coating the walls of the seam. In such places mica also can be seen, and also, mixed with the fibrous hornblende, occasionally a crystal of quartz.

Nearly everywhere about the shores of Mayhew Lake the rock is trap, or gabbro, but generally with more magetite than usual.

708. On the portage north from Mayhew Lake to Loon Lake, the rock No. 705 first appears, with a southerly dip. Then, after a low space another ridge succeeds, showing the rock No.708, similar, if not identical with No. 705. This belongs to the great quartzyte and slate formation, or the "Animiki group." From the top of this ridge the descent to Loon Lake is sudden, and amounts to 150 or 175 feet.

709. This is a range of high hills along the south side of Loon Lake, and between the bay and the lake, the top of which are made up of rock of this sample, which is like No. 708, having a thickness of 80 to 90 feet. This has the outward aspect of trap and perhaps has been designated trap in former instances, but it is to be distinguished from the igneous rock that has been described. Under the microscope in thin-section it consists of a triclinic feldspar, and some orthoclase, changed (or viriditic) hornblende, magnetite, and a small amount of quartz—a kind of dioryte. Its affinities with the great quartzyte and slate formation are evident, and it seems to have resulted from a metamorphism of the upper part of that formation. It is that which underlies the iron-bearing trap of Mayhew Lake. It is in heavy layers 4 to 10 feet thick, and has a coarse, perpendicular jointage that makes it

appear basaltic. It stands in perpendicular escarpment facing north and west, making the tops of the highest hills. It probably has not everywhere been kept distinct from the true igneous rock or gabbro which constitutes a heavy stratum lying over it (V. under No. 300.) This is taken from the hill near the base of the point separating the bay from Loon Lake.

710. Dark, homogeneous, finely crystalline, heavy rock like No. 684, underlying No. 709 in the same bluff, 5 to 10 feet in thickness. This is in beds 6 to 10 inches thick.

711 and 712. The rest of this hill is made up of alternations of these rocks, altogether making a thickness of 100 to 125 feet, down to the level of Loon Lake. The former constitutes about nine-tenths of the whole. It is black, and grayish-black, in beds from 4 to 40 inches, very fine-grained, sub-crystalline, with a felted polarization, having a conchoidal structure. The latter is of the same color but more coarsely granular, is in beds of 1 to 3 inches, and is slaty in the direction of the dip, which is S. and 10° to 15° in amount, but in other places the dip amounts to 20 degrees. This hill is only one of a series of northward-facing bluffs which extend from some point in Canada as far west at least as the west end of Gunflint Lake, and produce a sudden shoulder in the surface contour. The actual highest divide, or *Mesabi* is usually a few miles further south, and is apt to consist of the gabbro rock. While there is a sudden descent northward from the face of these bluffs, amounting to 300 or 500 feet, the general level toward the south ascends to the top of the Mesabi, though sometimes there are two or three interrupted lines of similar northward-facing hills before the Mesabi is reached.

The country along the north of Tucker Lake is low, and occupied with magnetited trap, and this character continues southwestwardly some five or six miles further.

713. From the north shore of Tucker Lake, a magnetited gabbro, embracing also masses of rock like No. 702.

On the south side of Tucker Lake is a long range of hills rising about 100 feet, constituting the red Mesabi, though the whole tract between Tucker and Loon Lakes is also on the height of land for this region.

714. Gabbro from the hill range south of Tucker Lake, in the N. part of Sec. 10, T. 64, 3 W.; being the Mesabi in this part of the State. This is the same rock already desoribed as constituting the low shores of Poplar and Iron Lakes (Nos. 693, 694 and 701). Between this hill range and Tucker Lake are several lower ridges of trap

rock. South from Iron Lake the "red rock" begins again in about six miles, according to Paul Morrison.

Duck Lake is 1,244 feet above Lake Superior. Poplar Lake, which is large and long E. and W., has numerous islands, resembling Saganaga, except that here they are of diroyte and gabbro instead of granite

715. From an island in Poplar Lake, near the portage coming from Little Lake. The usual rock about Poplar Lake.

Hungry Jack Lake is 1,069 feet above Lake Superior by this series of aneroid connections. Last year this lake was ascertained to be 1,200 feet above Lake Superior by series of observations from Grand Portage, making a disagreement of 131 feet (see the ninth annual report, p. 78, where this lake is distinguished as a "lake south of Birch Lake"). If this is all due to erroneous observations of the Iron trail south from Grand Marais, the elevations given along that route should be increased somewhat. The error is more likely to be in that route than in the boundary line route.*

716. Trap-rock, from the top of the "stair portage" which connects Duncan's Lake with Mud Lake. This forms a high basaltic bluff facing north, a little west of the portage.

717. Trap-rock from the north side of South Lake, opposite the town line between ranges 1 and 2 west. The north shore of this lake is low, and glaciated S. W. and N. E., and the south shore rises into high hills containing, presumably, the rock No. 716, at the top.

718. Fine trap-rock, south side of Gunflint river, a little east of the location of No. 305 last year. This runs obliquely down to the river, and under the water, in angular basaltic blocks like trap, presenting a face (back in the woods) toward the north much the same as the highest bluffs of the country.

*Mr. E. Le M. Hoare carried a series of aneroid elevations from Grand Marais to Iron Lake for railroad purposes, and found the highest point on the line to be 1.180 feet. His route is shown on Plate II. This height was reached in S. W. ¼ Sec. 25. T. 63, north of the Twin Lakes From that point there is a very gentle, undulating descent to Iron Lake, along his route, which was found to be about 1,175 feet above Lake Superior, or 38 feet lower than by the observations of the geological survey. His profile shows a nearly level grade from the highest point southward to a point about a mile and a half north of the Devil's Track river, where a descent begins. The crossing of the Devil's Track river is 1,015 feet above Lake Superior. For the next two miles and a half the descent is 150 feet per mile. Between two and a half and four and a quarter miles from Lake Superior the grade is 165 feet per mile, and below that it is 147 feet per mile. The crossing of the South branch of the Devil's Track river is 655 feet above Lake Superior. By spirit-level and rod a point was fixed on the S. E. ¼ Sec. 13, T. 61 N., at the crossing of the creek, which had an elevation of 1,080 feet, and by the same means Devil's Track Lake was found to be 1,025 feet, or 39 feet lower than by the observations of the geological survey. Mr. Hoare states that numerous magnetite boulders are scattered over the country between Grand Marais and Iron Lake which produce marked local disturbances of the needle, and that there is evidently a deposit of iron ore at some point between Sec 5, 61, 1 E., and Devil's Track Lake. From several assays Mr. Hoare states that he ascertained the iron and titanium together in the ore from Iron Lake to be pretty nearly uniform throughout, but that the titanium varied from 6 to 13 per cent., displacing about the same percentage of iron. The ore is in enormous quantities, in one place laid bare so that he crossed over it 30 paces. Another deposit of magnetic Iron was assayed by him, located "close to Poplar river and near Lake Superior," which produced 38 p. c iron, 1.53 p. c. manganese, and .05 of phosphorus

719. Trap-rock, having a jointed, or basaltic structure, from the easterly of the two points that enclose the little bay on the south side of Gunflint Lake into which the portage comes from Loon Lake. This point rises about 75 feet. The top, represented by this rock, containing augite, plagioclase, magnetite and a little hornblende and quartz, is of the rock that usually forms the tops of the high mono-clinals of the country—a dioryte trap, perhaps a metamorphic condition of the beds of the great quartzyte and slate formation. It faces the lake and has a high talus of fallen blocks.

720. The rock of the westerly of these points, almost identical with No. 718, essentially the same rock as 719, presenting a walled face toward the north, much jointed, or finely basaltic, rather finely crystalline, but rising but 10 feet above the lake. Thus it appears to make no difference at what horizon samples are taken from the "quartzyte" formation, if they only come from the *top beds* at the place they are obtained. They are always "changed quartzyte," or trap, so-called. Slate can be got only at a depth of 75 to 100 feet below the top. It seems as if any and all the beds are subject to this metamorphism when they happen to be superficial, unless these be unknown and unsuspected irregularities in the stratification. Hence, even at the very northern edge of the area covered by these mono-clinals, the changed rock, or trap, whichever it be, lies within a few rods of, and nearly on the same level as the talcose slate and syenite, as along Gunflint river.

721. A careful section of the hill was taken, lying a little east of the portage trail from Gunflint Lake to Loon Lake, on Sec. 26, T. 65, 3 W., for the purpose of ascertaining what relation might exist between the basaltic beds which always lie on the tops of these hills and the slaty layers that compose them toward the bottom, with the following result: No. 721, forming the top of the hill is 75 feet thick, and like numerous other samples already noted, viz., Nos. 308, 705, 708, 709, 719 and 720. The hill is 250 feet high.

722. Obtained about half way down the perpendicular portion of the bluff. The same as the last, but finer-grained. It has also a darker color. It embraces apparently triclinic feldspar, magnetite, orthoclase, viridite and a little quartz. It also shows an occasional grain of pyrite and of dichroic hornblende.

723. A dark, or gray, homogeneous rock, in general character similar to the last, though of a finer grain, resembling very much the rock No. 683. It has pyrite, and much of the magnetite is arranged in branching, foliage-like tufts, which can be seen in a thin section, from near the bottom of the perpendicular part.

724. One foot lower in the bluff than the last. Undistinguishable from the last.

725. Six inches lower; same rock but finer. This is hard, fine, dark-colored.

726. A foot lower; the same rock but finer, and tending to a slatiness.

727. Four feet lower; slate, fine, black or nearly black, of the kind commonly seen in these bluffs. The rest of the bluff is much hid by talus, but so far as can be determined consists of rock like 727. A hundred feet lower, and but a short distance north from the foot of this bluff was obtained No. 720, forming the top of a lower? ridge of rock.

The transition from the basaltic rock, or trap, forming the top of this hill (No. 721) to the slate of No. 727, is more abrupt than on the south side of Loon lake; but there is still here an imperceptible transition. There is no suddenness about the change, nor break in the bedding to indicate the former fluidity of the top of the hill. The change is complete in the space of four feet—from basaltic columnar structure to perfect, horizontal, or southward dipping slatiness. If the basaltic portion is due to igneous origin there was such a transfusion of mineral characters, and such a perfect cementation between it and the slaty portion that no line of separation where the igneous portion was superimposed on the sedimentary, can be designated.

A second visit was made to the locality No. 312, on the north side of Gunflint lake, where the flint beds appear in outcrop, about half a mile east of the outlet of the lake, at which the following conclusions were reached:

1st. The rock is a breccia in which the flint, generally black, or dark jasperoid, appears in a gray rock which weathers rusty, in angular pieces of all sizes up to two feet, or even makes continuous beds more or less tilted and broken. Sometimes also the gray rock that weathers to a rusty color on the beach is in angular pieces or patches in a mass of angular pieces of non-rusty gray rock; and sometimes the two alternate in parallel bands as if so deposited as sedimentary beds at first.

2nd. The formation, as it is, is tilted into the lake, southward, at an angle of perhaps ten degrees, on an average, though there are places where the dark jasperoid layers seem to stand nearly vertical.

3rd. The whole formation is rudely basaltified in small columns.

4th. The thickness visible, in an interrupted series of outcrops, seems to be about twenty feet.

5th. A little distance further west, and near the extremity of the point before reaching the "narrows," the exposed rock is slate again, at first horizontal, and then with a dip of eighteen to twenty degrees to the N. E. then S. again; becoming hid by trees the rock terminates, and the point too, the elevation of the hill being forty to fifty feet.

The close proximity of this flint and jasper locality to the next great underlying formation (syenites and slates) makes it one of great interest to the geologist, but so far as scrutinized, as yet the true relation of the two formations are not revealed by anything here seen, though there seems to be an unconformability between them. At the "narrows" is basaltic trap rising in characteristic bluffs and striking E. and W. with a face toward the north.

728. Rock of the island in Saganaga lake nearest the inlet from Gunflint lake, on the south side. This is a syenite with mica, containing much coarse quartz. The feldspar is orthoclase, of which the greater portion is white, but some of it is flesh-colored. It is a beautiful, light-colored syenite, suitable for ornamental purposes. This rock prevails about Saganaga lake, but also becomes darker by an increased amount of hornblende.

729. Syenite from "Cariboo narrows" N. E. ¼ Sec. 19, T. 66, 4 W.

Gull river and lake may be ascended by course to near the S. W. cor. of T. 66, 4, without portage, by passing two rapid places. Gull lake is thirty-nine feet above Saganaga. A portage is necessary at the third rapids. Gull lake is similar to Saganaga in having numerous islands based on a light-colored syenite.

W. Gull lake, which is united by a short rapid stream to Gull lake, is twelve feet higher, and is filled with the same sort of rocky islands.

730. Syenite from the rapids between Gull and W. Gull lakes.

Along the south side of these lakes, distant about two miles, runs a range of mountains which seems to be a continuation of that running west from the south shore of Gunflint lake, marking in general the northern limit of the slate and quartzyte group.

731. The rock 730 continues to form the islands and shores of W. Gull lake to near the point where the stream from Frog-rock lake enters it, near the southwest end, where the rock 731 takes its place, rising in little hills of very similar contour and size, some of each rising 50 to 100 feet. This rock is very tough, greenish, has in general an imperfectly schistose or fibrous structure, is seamed and jointed finely, some of the seams being filled with a fine-grained, siliceous, nearly white rock, or pinkish quartzyte, which is faulted frequently by other seams, making a zigzag network of joints and seams. Some of these

seams are of a pinkish color, and six to ten inches wide. But they are themselves broken and often entirely diffused and lost. The rock is not slaty, but separates under the hammer into rude rhombs. It is fine-grained. (V. Nos. 348, 355, 356, 358.) This rock in thin-section shows a matrix which is homogeneous, transparent, penetrated by the other minerals, and between crossed Nicols has a neutral color, darkening on rotation of the stage, with the quick limpid change characteristic of quartz, but not having its brilliancy. The other chief mineral is green fibrous hornblende, but it is so changed that it is rarely dichroic, and is often more like serpentine than hornblende in its optical characters. There are also a few grains of some triclinic feldspar. This composition seems to make this rock an amphibolyte. In land specimens it is not distinguishable from the amphibolyte of Littleton, N. H.*

The stratigraphic relations of 730 to 731 are not easy to make out. Sometimes they lie immediately in contact, the plane of separation being perpendicular, and sometimes they are in separate knolls, or hills, contiguous, the contact of which below the soil is not visible. In general the hills composed of the amphibolyte are higher and rougher than those of the syenite.

732. Light pinkish granulyte, or quartzyte, embraced in veins in No. 731.

733. Frog-rock lake, which is next west of W. Gull lake, is so named from the Chippewa word which signifies *spotted* or *greenish*, from the appearance of the rocks, and it is seventy-three feet above Saganaga. The mineral which gives green color to the rocks of this region appears sometimes in thin seams or in coatings on opened seams, as shown by the samples of this number.

734. This greenish rock in some places is very fine and tough, and also porphyritic.

735. At the very entrance to Frog-rock Lake is a hard, massive, speckled dioryte that forms a little fall where the water goes out of the lake. In passing the portage, white quartz is seen in pockets in this rock (731 and 734) sometimes having perfect crystalline terminations.

736. From an island in Frog-rock Lake, about half a mile southwest from its outlet; a green amphibolyte (?).

737. A talcose or chloritic rock, having a coarse perpendicular schistose structure, from the rapids between Frog-rock and Town Line Lakes, northwest from Frog-rock Lake. This is conglomeritic, some of the pebbles being six inches across and like the gray amphi-

*No. 216, of the "typical rocks of New Hampshire," or No. 3,016 of the Museum Register.

bolyte (No. 731). There is in it also considerable pyrite. The pebbles are rounded, and are intimately connected with the matrix. There may be thirty feet of this here visible, including that below the water and above. There seems to be a S. dip of about 10 to 15 degrees. The aspect of the country changes at once on entering on this conglomerate. There are no bald, rocky hills to be seen around the Town Line Lake, but the trees grow all over the rock, and down to the water. The level of this lake is 83 feet above Saganaga, and King-fisher Lake (or Ogishki Muncie) is ten feet higher. The rapids connecting them are formed by the same rock (737).

738. A fine, firm conglomerate, or grit, containing considerable pyrite which changes to iron oxide near the surface The grains are mainly of quartz, as well as of flint and feldspar. Some of the flint is black, and two inches across. This rock recalls the Gunflint beds. It seems also that the rock 737 is a part of the same conglomerate as 738, but at a lower stratigraphic horizon. It hence seems as if the Gunflint beds, which are the lowest part of the quartzyte and slate series (the lower volcano of Logan) pass by a common metamorphism through the perpendicular slaty, or schistose structure into the slates of the Huronian—but whether at first conformable to them or not, cannot be said yet. This rock (738) does not continue far west of where it appears, which is near the N E. end of Ogishkie Muncie Lake, on the south shore. It stops at the first narrows, at the east end of the lake apparently jogging off south suddenly, since the rock 731 sets in in full force on the south side of the lake on the W. of these narrows, and continues to one-half mile west of the section line between sections 13 and 24.

739. At one-half mile W. of the section line; somewhat quartzyte, firm and resembling 738. This occurs suddenly in No. 731, and it weathers into large angular blocks, while No. 731 is apt to weather out in rough schistose fragments.

Directly across the lake, on the north shore the rock 738 can be found again appearing in a similar manner as on the south side, *i. e.*, in a bluff and hill near the lake, but 731 appears soon on the south side, and with sundry variations forms the south coast to the peninsula on the south shore crossed by the line between Secs. 23 and 26 which is made up of the quartzyte and slate, having a dip to the S. S. W. of about 80 degrees. The slate alternates with the quartzyte beds, the former being in layers generally of two to three inches, and the latter in beds of six inches to two or three feet. There is in the slate, which is slaty in the direction of the true bedding, also a tendency to slatiness E. and W. perpendicularly, so that the beds are apt to separate, when struck, both in the direction of the true bedding and along the weathered planes of the E. and W. slatiness, making thin lenticular wedges. This E. and W. slatiness is not visible in the quartzyte. The same alternation of slaty and non-slaty beds is to be seen on the S. shore of Vermilion Lake, and at Thompson.

740. Slate from the above.

741. Quartzyte from the above. This is much like No. 738.

742. Dyke-rock, from a dyke cutting the great conglomerate of Ogishkie Muncie Lake, N. W. ¼ N. E. ¼ Sec. 26, T. 65, 6 W. Plagioclase, magnetite, chrysolite, a little hornblende (?), a little quartz pierced by spicules of apatite and pyrite. This dyke is six and a half feet wide and runs E. 10° S. It crosses a little peninsula, and on both sides disappears below the water of the lake. It is a dark, heavy, firm rock, not differing from numerous others seen crossing the great quartzyte and slate formation.

743. Calcareous, rusty schist, apparently talcose, and overlying the next; this has a strong resemblance to the conglomerate schist No. 737. It is coarse, and seems to disintegrate more readily than any of the rocks of this region. It is in the lower places. It has no evident dip, or bedding, but a schistose structure running E. and W. perpendicular.

746. Associated with the last is a grayish marble, which may also contain siderite. They are in the N. E. ¼ N. E. ¼ Sec. 26, T. 65, 6 W. The marble rises in an inconspicuous low ridge, in a valley. It is coarsely jointed, and has an apparent dip toward the south of about 10 degrees, and is 22 feet thick.

744. From the great conglomerate, but showing one of the indeffinite conditions of the same. The conglomeritic character is hardly distinguishable on a fresh fracture of the rock which sometimes shows different shades of green. But all over the surface, when glaciated and weathered, are visible the forms of rounded boulders, included in the rock, the different colors and grain of the boulders being brought out plainly. This is essentially the same formation as the rock 743 and 737, and it constitutes by far the greatest part of the country rock about Ogishkie Muncie Lake. Wherein the rock 737 differs from 738 which also passes into 744 by the accession of slaty structure and then the obliteration or modification of it by the accession of boulders, it may be ascribed to varying proximity to and influence of the underlying "talcose" rocks in the process of deposition and metamorphism. The rock 744 forms the little island in the central narrows of Ogishkie

Muncie Lake*, near the peninsula crossed by the line between sectinos 23 and 26, and the mainland south and north. On the island, it is a real conglomerate, with a smoothly glaciated surface, and the sections of some of the rounded stones are a foot and even more in diameter. They are very abundant. Sometimes the rounded stones make three-quarters of the whole rock, but in other cases the slaty matrix is nearly free from them, over considerable areas. The general surface rises in short, zig-zag ridges which, though often entirely bare, have boulders and a thin soil of clay and mold in the valleys between them, so as to obscure their inter-relations. In these valleys are a multitude of fallen, half-burnt trees, among which are growing small birches and willows (V. after 752).

There is a sudden change in the direction of strike of the rock of the country, in the N. E. ¼ of Sec. 26, from nearly E. and W., to N. and S. At the shore on the peninsula in Sec. 23 it is the same as the slates generally seen in the Huronian, in this part of the State, but after passing the valley in which are the calcareous schist and the marble, it is N. and S. That the change is somewhat sudden is shown by the fact that the beds running N. and S. are seen to cease abruptly and to be replaced by the conglomerate in a number of places. The conglomerate in these cases is, so far as seen, rather finer than the average.

745. Slate and quartzyte, from the rock that strikes N. and S. (as above), showing the bedding of sedimentation, the tendency to E. and W. schistose structure, and the jointage to which the whole is subject.

746. (See before 744.)

747. Directly south of 745, (on the lake shore) *i. e.* in the S. W. ¼ S. E. ¼ Sec. 26, is the hard, black rock represented by this number. It is a kind of black quartzyte, or flint, the dip of which cannot be stated. It is finely jointed or broken, nearly at right angles transversely, occupies the area of a small ridge near the shore.

748. On the portage from Ogishke Muncie lake to Dyke lake, which is a little lake southwest from Ogishke Muncie in S. E. ¼ Sec. 28, is a siliceous slate, standing vertical. It is cut by a dyke running about N. and S. thirty to forty feet wide.

749. Rock from the above dyke; dark doleryte.

750. Conglomeritic slate. This passes into the slate 748. It shows no bedding. From the north side of Dyke lake.

751. S. E. ¼ Sec. 30, T. 65, 6 W. north of the east end of Caca-

*With one exception this is the only island which has its forest yet standing; most of the country being utterly destitute from fires.

quabie lake, is Mallmann's Peak. It extends rather as a lower range toward the N. E. half a mile, terminating at the end of the lake in the northern part of Sec. 29. This rock is a peculiar porphyry. The ground mass is amorphous, and the disseminated crystals are hornblende. It is unlike any thing before seen.

752. A dyke forty feet wide, represented by this number, cuts the last. This is a doleryte with considerable magnetite and pyrite.

Further examination of this great pudding-stone on the high peninsula that projects from the north shore of Ogishke Muncie lake, on Sec. 23, shows that it is crossed by E. and W. bands due to sedimentation. These bands stand nearly or quite vertical. They are similar to those seen in the quartzyte and slate, but are coarser and more indistinct. They are seen in the finer parts of the pudding-stone, when the rock passes into a fine conglomerate or coarse quartzyte.

On this peninsula nearly one-half of the pebbles in the rock, large and small, are from the Saganaga granite. Next in frequency is a variety of greenish pebbles, apparently from the same formation, or at least from the rock 731, and some like the dyke rock 742. Next comes quartzyte, which is sometimes gray, sometimes white. These graduate into white and gray pebbles, some of which are also black and very fine, like flint, having a short conchoidal fracture. Some of these last are banded like the jasper and flint of the gunflint beds. One banded piece of black-gray flint which was noted was a foot across. These various pebbles weather into a variety of colors making the face of the bluff perfectly spotted and mottled. The conglomerate is a part of the slates of the region, and is interbedded with them.

About three-fourths of a mile north of the central narrows of the lake, the conglomerate, which continues all the way, with a dip S. of 80 or 90 degrees, (sometimes varying a little to the S. E.) contains large, rounded pieces of the "Saganaga granite," which proves the greater age of that granite, and the unconformability of this slaty conglomerate, and the beds that are its equivalent elsewhere, upon that older formation. Some of these large pieces of syenite are over two feet in diameter. The conglomerate also here contains red jasper.

At about a mile north of the narrows the red jasper becomes very common, some pieces being six to eight inches across on the face of the rock.

At about a mile and a quarter north of the narrows the conglomerate becomes finer and finer, and the slaty bedding comes in, the whole being converted to 740 and 741, and at once the hills rise in a rude range, broken by off-sets, to the height of 150 or 200 feet higher than the general level. The highest hill is about in the center of the S. W. ¼ Sec. 14, and the top consists of the rocks 740 and 741, passing to 731, with vertical bedding. The strike of the northern limit of the conglomerate is S. 35° W. and at about one and one-fourth miles N. of the central narrows. Through the whole of this distance the dip is nearly uniform (80° to 90° from the horizontal); and by the construction of a right angled triangle a calculation will make a thickness of 6,574 .8 feet, for the conglomerate on the north side of Ogishke Muncie lake, and there may be as much more on the south side.

753. Is an average sample of the most of the hill on S. W. ¼ Sec. 14, T. 65, 4 W. (as above.) It represents a vast amount of rock in this country, since much, even of the conglomerate, is of similar rock. This here is banded with finer beds, approaching slate, which, when favorably weathered, falls to pieces as slates, though very siliceous.

From this hill the mountain-range on the south side of Ogishke Muncie lake can be seen to extend east as far as the eye can distinguish, and probably to Gunflint lake. The point of observation is E. 33° N. from Mallmann's Peak. Part of Knife lake is W. S. W. Toward the N. W. is a lake one-fourth mile away. East 33° north, is another small lake one-fourth mile distant, and at the foot of the hill S. is another little lake. Toward the north is a similar tract of country, burnt over, running to Otter Track and Knife lakes, made up (probably) of the rock No. 753, as no such conglomerate was seen along there last year.

754. Jasper conglomerate, one mile north of the central narrows of Ogishke Muncie lake.

The "Gunflint beds," south of Gunflint Lake, (V. after No. 747) have been associated with the slates and quartzytes of the overlying formation, rather than with the talcose slaty beds underlying (V. 426) but observations about Town Line and Ogishkie Muncie Lakes seem to indicate that they are here a part of a schistose, slaty formation, highly inclined, which belongs to the Huronian, passing into the great conglomerate of Ogishkie Muncie Lake.

So far as can be determined by the observations made, the following statement of the order of superposition seems to be warranted, in descending order (V. after 551).

1. The nearly horizontal quartzyte and slate formation composing the hills of the Grand Portage and the International boundary as far as Gunflint Lake.

2. The coarse grit or fine conglomerate, No. 738.

3. The Jaspery and calcareous beds that are known as the "Gunflint beds," Nos. 737 and 743.

4. Gray marble, No. 747.

5. The tilted, slaty conglomerate, and the great conglomerate, about Ogishkie Muncie Lake, Nos. 744, 750 and 754.

6. The amphibolyte and the chloritic slates, Nos. 731, 753, 348, 349, 350, 355, 356 and 358.

7. Mica schists, and alternations of mica schists and syenite, Nos. 335, 337, 339, 401, 406, 408, 414 and 417.

8. The syenites and granites of Saganaga and Gull Lakes.

There is yet one very important, undetermined question relating to this generalized section which ought to be borne in mind, viz. : Is the great quartzyte and slate formation of the international boundary (No 1 of this section) the same as the highly tilted, slaty and quartzyte formation which passes into the great conglomerate? (No. 5.) There are some considerations which seem to imply that it is, though in all descriptions and sections they have been treated as different terranes. (a)Where the horizontal slates approach the syenites at the east end of Gunflint Lake there is nothing to be seen of any beds representing the tilted slates. The syenites and their associated schists come on at once. (b)Where the tilted slates and the conglomerates associated with them are traceable from the syenite upward to the gabbro as south of Ogishkie Muncie Lake, there is nothing to be seen of any beds like the horizontal black slates of No. 1. (c)The "Gunflint beds" appear to belong to the horizontal slates of the international boundary at Gunflint Lake, but their supposed equivalents at Ogishkie Muncie Lake belong to schistose and tilted slates and conglomerate. (d)Although the horizontal slates and quartzytes of the international boundary strike west and southwest across the State, forming one of the most important topographical features of the northern part of the State, and can be followed for many miles as such, yet they are lost entirely in the region of the upper St. Louis, and the tilted slates are the only ones seen where that river cuts the rock at Knife Falls and below. (e)The great gabbro belt, which surmounts the horizontal slates along the international boundary, and prevails to the east and south of their line of strike, is seen to pass to the west of Lake Superior, at Duluth, and to disappear from sight suddenly between Duluth and Fond du Lac as if its continuance depended on the maintenance of the horizontal formation with which it is associated. (f) Where the Gunflint beds become a jaspery hæmatite, as south and east of Vermilion Lake, the structure of the tilted slates passes into the iron ore as if of the same formation. (g)The formation which underlies the cupriferous at Fond du Lac is the tilted slates, and that which underlies it at Grand Portage is the horizontal slates.

A thorough examination of the hill-range between Gunflint and Ogishkie Muncie Lakes would probably reveal the facts as to any transition from the horizontal slates to the tilted slates.

In going south from Ogishkie Muncie Lake toward the mountain range, so as to strike the summit on Sec. 34, the dip and strike of the rock are seen to change several times. At the shore is a fine conglomerate, then quartzyte and slate in contorted bedding, then the same with a dip east, then the same with a dip northeast, then south, then coarsely arenaceous without any distinct dip, apparently once broken, then vertical with strike N. and S. South of the crossing of the creek, about half way from the lake to the summit, the rock is very confused (apparently brecciated and recemented), and the bedding cannot be made out. Then the dip is west, verging to southwest.

Although this is not all conglomerate, on close examination it seems to show in the field such variation as can be referred, very much of it, to an original conglomeritic condition. In approaching the summit this condition is less and less apparent, the stones gradually losing their identity in a common, more homogeneous mass.

South of the foregoing interrupted series of hills, occupied by the changes described, all pertaining to the conglomerate—quartzyte—slate formation, is the first ridge. The rock is rounded and smoothed by glaciation, though the direction of movement cannot be ascertained by any preserved striæ. There is a sudden change in the character of the rock of the hill in passing to the ridge.

755. The rock of this ridge is a greenish, tough rock, much like that of No. 731 in outward character, rather fine-grained, has numerous quartz veins and seams, and forms a large area and ridge on the mountain side. While outwardly it appears like No. 731 it has the mineral composition that more resembles a dark, fine dioryte (V. 684 and 678).

756. Passing further south, crossing a valley, another ridge is met with, rising higher, consisting of this rock—a coarsely crystalline dioryte, with a little quartz and magnetite, the hornblende being changed to viridite. It is cut by—

757, a gray, rather fine, trap-rock, in a dyke running N. W. and S. E., six feet wide.

Further south is another higher, bare ridge, broad and smooth, constituting the top of the mountain. The rock is—

758, a "trap" of a greenish color.

759. Occurs in patches in No. 758 and is like No. 756, but contains so much magnetite as to appreciably increase its weight. This is from the summit south of Sec. 35, about one fourth mile.

Of the rocks constituting the mountain east of Twin Peaks, Nos. 755 and 758, are the chief mountain-making rocks, and No. 758 is the most important, spreading a great distance still further south (judging by the form and color of the hills in view), and also probably a great distance east. Indeed, it is probably the rock that constitutes the divide, south of Gunflint and Tucker lakes, this range being visibly a continuation of that.

In passing from Ogishkie Muncie lake directly to Twin Peaks, the following observations were made by Mr. Mallmann. After a space of conglomerate, perhaps one half a mile, there is a gorge in which a creek runs S. 30° W., the rock over which it passes being—

760. A light siliceous marble, or calcarous quartzyte, undistinguishable from the marble, No. 746. On either side of the gorge is a wall of rock. On the west is conglomerate, and on the east is No.

761. which is a pyritiferous, dark aphanitic rock, one of the conditions of the slate of the slaty conglomerate.

762. Is from a trap dyke cutting the conglomerate, about one fourth mile from the lake.

South from the gorge is more conglomerate and quartzyte, then a ridge, or a succession of benches rapidly ascending. The first bench, 20 feet high, has regular bedding, and dip toward the south, but no basaltic structure. It consits of No.—

763. Which is apparently closely allied to No. 755.

764. In a higher ridge is this rock, which is the same as 763.

765. The top of the Twin Peak (E. Twin) is a fine-grained variety of the same rock. This peak, and the general average of the mountain range may be 500 feet higher than Ogishkie Muncie lake. The Twin Peaks are conspicuous because they stand isolated, further north than the rest of the high land, not because they are higher.

Fox lake, which is 141 feet higher than Saganaga, affords a fine exhibition along its south shore, of the broken condition of this quartzyte-slate-conglomerate formation. The bluff rises nearly perpendicular, but is somewhat rounded off by glaciation, and the edges of the bedding cross the face of it in a very tortuous and angular irregularity. Some of the beds which are nearly horizontal are terminated at one place by a perpendicular line, on the other side of which the beds are nearly vertical. In other places the bluff shows both synclinal and anticlinal bends.

Ash lake (or Agemok lake) is 200 feet above lake Saganaga. On the portage from Fox lake to Ash lake the formation strikes S. E. and N. W., with a dip S. W. of 60° to 80°, the most of the way. It then changes suddenly to a strike S. W. and N. E., and then soon becomes confused in a general breccia. Near Fox lake, where the beds strike S. E. and N. W., there is a ferruginous belt. Through about four feet the hard slates are rusty with hæmatite. The pieces are also feebly magnetic, but there is not enough iron to be of any value.

766. Iron ore near Fox Lake.

Gobbemichigomog lake is 210 feet above Saganaga. At its west end, just west of the town line is a northward facing hill of bedded trap, and a low range runs along the south side of the lake, but the main hill-range strikes along north of this lake, jogging a little to the north.

767. From the south side of Gobbemichigomog lake. A fine-grained heavy rock of a gray color, resembling the rock No. 677, evidently having much chrysolite.

There are several short perpendicular bluffs of bedded trap, some of it approaching the last in characters, along the south shore of Gobbemichigomog lake; and one of them is quite ferruginous. They rise from 20 to 40 feet. From one near the lake is obtained—

768. Somewhat irony trap, with chrysolite and mica.

Crooked lake is 217 feet above Saganaga, and Little Saganaga is 225 feet. About Crooked lake the country is wholly in the trap of the Mesabi. It rises in numerous knobs that make rounded, bare islands. The same rock continues to and into Little Saganaga lake where it also causes many islands. In some places it rots and crumbles easily as at Beaver Bay.

769. Trap, from the N. W. end of Little Saganaga.

770. On the south side of Little Saganaga the rock weathers white. It rises in higher bluffs, resembling the Rice Point gabbro, and even approaching the whiteness and nearly the purity of the so called "feldspar rock." It is mainly of feldspar but also contains magnetite and a little pyroxene. The hills and ridges show in general a course bedding which dips south. Ridges 10 to 50 feet high. The sample collected is weathered. Boulders of iron ore like that of Mayhew lake, are scattered about.

East-and-West lake is 231 feet above Saganaga.

771. Pinkish-red vein of syenite in rock No. 770, dipping E. 75°. It is 20 inches wide, on the south shore near the east end of East-and-West lake. This red syenite here is comparable to the red syenite asso-

ciated with the gabbro at Rice's Point. In both places it penetrates irregularly through the gabbro.

The lake in Frog Rock river is 241 feet above Saganaga. On the portage north from the lake in Frog Rock river are to be seen several veins of red syenite in the feldspar rock of the country, like 771 dipping E. The dip is generally south, about 50°, but is also S. E., E., S. W. and even N. W.

772. From a vein, one foot wide, of this rock in the neighborhood of the east-dipping red veins. This is coarsely crystalline, and consists of the usual minerals in the gabbro of Rice Point, but also here seems to have quartz and mica, perhaps derived from the red rock with which it is in close association. This whole formation resembles "Rice Point granite" in outward characters, and in mineral composition. It sometimes decays in round masses, as if at first a conglomerate, in the same manner as near the Duluth depot. (V. No. 4 A.) The last lake in Frog Rock river is 258 feet above Saganaga. Passing from this lake by a long portage toward the southwest, the Mesabi lake is reached, 338 feet above Saganaga lake.

773. Rock of the country, about the last lake in Frog-Rock river. It is a gabbro. This formation not only seems to be the "Rice Point granite," and the iron-bearing rock of Mawhew lake, but also to have furnished the feldspar masses of Castle Danger and Beaver Bay. The portage from the last lake in Frog-Rock river to Mesabi lake rises 150 feet, and passes nearly all the way over this rock. Merabi lake is 70 feet lower than the divide, and its outlet is toward the north, uniting with Frog-Rock river.

The same rock continues nearly across the portage to Duck lake, where another formation sets in, viz:

774. This comes in apparently *through* No. 773, at first, but afterward it lies on 773, and in rude lenticular and broken bedding dips to the south. It forms a range of hills about 100 to 150 feet high next west and south of Mesabi and Duck lakes. It has been molten, as evidently as 773, and in that sense it is an igneous rock, but it differs from it in its mineral composition. It is a reddish syenite, but seems to contain mica, as well as some plagioclase. In passing along Duck lake considerable confusion prevails in the relative positions of Nos. 773 and 774. Along the south side of the point that separates the lake into N. E. and S. W. parts, No. 774 plainly lies on parts of No. 773, but on the east side of the lake, there is considerable mixing, the two changing places suddenly, and either one being in patches in the other

—particularly 774, embracing masses of No. 773, and suddenly cutting No 773 like dyke-rock.

775. At the S. E. end of Duck lake 773 lies on 775, which is the well-known and so-called "red granite." This lies in even and regular beds of four to eight inches, (or in beds of three to four feet), dipping south, amounting in all to about twenty feet, the rock 773 being unconformable on it, but intimately cemented to it, as at Rice Point. Over both of these, further toward the S. E. No. 774, comes in again. (V. 776.)

Duck lake is 348 feet above Saganaga.

L. lake is 413 feet above Saganaga.

The portage is along the stream between these two lakes and is over the rock—

776, which is seamed and blotched with the red rock 775 and appears to be affected by it throughout. This rock prevails through this portage with occasionally a characteristic patch of No. 773—as seen at the south end of the portage. At the point where the portage leaves L lake is a bluff at the left made up of the following (777-780.)

777. A characteristic gabbro, seamed by red syenite, and weathering nearly white, porphyritcally, so as to appear much like No. 773. This passes downward into—

778, which was obtained about thirty-five feet below the top of No. 777 and near the next. This is apparently a form of the gabbro when in closer contiguity with the sedimentaries and has been penetrated by minerals from them. It is finer-grained than No. 777 and darker, but also seems to have orthoclase and mica. These together, make a thickness of about forty-five feet, from the top of the bluff downward. They are one in structure, dip and general characters. They dip south in heavy layers at an angle of about thirty degrees.

779. Red syenite, unconformable under 778, showing about fifteen feet. What appears like bedding in No. 779 may be coarse jointage, as there are two sets of planes, one set being perpendicular to the bedding of the gabbro overlying, and the other crossing it so as to have a dip south of about seventy degrees.

780 is a form of the rock in the same bluff about twenty feet below the top—evidently a part of the igneous rock, but affected by proximity to the underlying rock so as to appear like a dioryte.

There is a striking contrast in the appearance, form and color of the rocks 777 and 779.

Wind lake is 473 feet above Saganaga lake. On the portage to Wind lake the rock No. 777 is the prevailing rock at first, but is varied by patches of red rock, and a fine-grained rock like No. 778. Then—

781 prevails, cut by seams of red rock like the last, and having sudden variations to Nos. 777 and 778 and even to No. 774. This is a light-colored, fine, syenitic granite. The red rock continues to increase in area till at Wind lake, nearly one-half of the visible area is of red syenite, the rest being some of the rocks 777 or 781. The most of the surface is bare rock and can be examined easily. The red syenite is in the lower parts and the other rocks are in the higher. It always appears to come out *under* the others when it appears in bulk and indicates its proper relation to them. The red seams which pass upward into the dark rocks are exactly simulated by the same relations of the gabbro and the red syenite at Duluth, and this place must be at about the same geological horizon. There is much reason to regard the rocks 773, 774, 776, 777, 778, 780, as all phases of the same great formation, an igneous rock which flowed over 775 and 779, and in contact with them was modified into the various textures and degrees of fineness that they illustrate; and that the red rock, which must be regarded as the red formation ot the Brulé and the Great Palisades, in the process was fused and injected into them. This red formation, which makes red syenites and gneisses, belongs in the lower portion of the cupriferous, as hitherto classified, and seems to be the same that in Michigan has been grouped by T. B. Brooks in the Huronian.*

Along the north side of Wind lake, these formations, the red and the gray, are somewhat interbedded, and so brecciated and mixed that the bluffs are spotted promiscuously with the two colors. Sometimes, also, they seem to have been fused and blended into a rock that is neither red nor gray.

782. A micaceous quartzyte, of a light red color, from the S. E. side of Wind lake. This is less granitoid than usual, but is still a part of the red rock formation.

783. A micaceous brown quartzyte, of the same series of rocks, from the S. E. side of Wind lake. This is one of the metamorphosed sandstones of the cupriferous.

At the place where the portage trail leaves Wind lake is a bluff which in form is a duplicate of the red quartzyte bluffs at New Ulm, and in Rock and Pipestone counties.

784. Is from this bluff, and constitutes the most of it. It is a hard, red, fine, sub-granitzed quartzyte, somewhat sprinkled with darker specks, that may be chloritic or micaceous, or graphite; and having

*Am. Jour. Sci. (3), XI. p. 206.

rarely a distinct crystalline grain of orthoclase. It is in distinct sedimentary layers that dip S. at an angle of 20° to 25°.

785. In irregular patches and areas, on the face of the bare bluff, rounded off by glaciation, may be seen this rock, which is a true igneous rock, nearly black, fine-grained, a trap-rock, a form of the gabbro such as is seen along the Lake Superior shore where the molten material was rapidly cooled in contact with the sedimentaries. This is a phase of the igneons rock of the country. This bluff throws light on the geology of the southwestern part of the State. If this gabbro belongs to the cupriferous, and these red gneisses also, then may not, not only the red quartzytes (Sioux quartzyte of Dr. White, and the Baraboo quartzyte of Wisconsin), but also the contiguous red gneisses and granites of the Upper Minnesota Valley? In other words may not the red gneisses and granites of the Upper Minnesota Valley be in the extension of the great modified cupriferous, where instead of an actual molten outflow, or series of outflows, the disturbing agencies operated to produce a widespread and complete metamorphism in the contemporary strata? Those granites and syenites differ widely from the granites of Saganaga—the only ones known to lie below the great conglomerate of Ogishke Muncie. Though the rock of this bluff is not a pure red quartzyte, in other places this red rock is a pure quartzyte which can hardly be distinguished from the quartzyte of New Ulm. At the same time there are portions of the southern red quartzyte that are as much granitized as the rock of this bluff. This is particularly true of the outcrops at Baraboo, Wis.

Spotted Rock lake is 520 feet above Saganaga. This lake is so named because of the mixture of red and gray rock as described at the south end of Wind lake. Here it is all about the shores, the red gradually increasing in area, and rising into hills.

At Little Saganaga lake were a few green trees of Jack pine (Pinus Banksiana) about three or four inches in diameter, but south of that lake the country has been twice burnt over, as at Ogishke Muncie lake, so that it is almost bare of vegetation. The first burning destroyed the large trees, and the second, in burning the fallen forest, killed the new growth, which was then one to two inches in diameter. About Little Saganaga this young growth escaped the second fire; but in nearly all parts of this traverse the country north from Young Sawbill lake affords unrivalled opportunity for unraveling the geology of this much-studied but little-known horizon of the earth's crust.

Leaving Spotted Rock lake the canoe route passes over a long rough portage trail, crossing the hill range known as the *Mesabi Range.*

This range seems to be the westward extension of that in which is Brulé Mt., while that "Mesabi" which passes near Gobbemichigomog lake has been distinguished sometimes as the Giant's Range. Sawteeth Range is near the Lake Superior shore. The Mesabi range rises where the trail passes it, 676 feet above Lake Saganaga, or 1,592 feet above Lake Superior. The dark rock which is mixed with the red granite formation continues to the top of the Mesabi, having its usual changes of texture, and a few spots of red rock. But before reaching the summit the texture becomes what is shown by—

786 without much variation. This is from near the top of the range. This is rather fine, heavy and chrysolitic. After passing the summit the formation is occasionally coarser, and even takes the characters of No. 773 in small patches and veins.

787. Its prevailing features on the south slope are shown by this number, which is like other samples from the same formation elsewhere, a rather fine chrysolitic gabbro, which continues to South-side lake. From the top of the Mesabi range can be seen both the Giants range of hills and the Sawteeth mountains.

South-side lake is a tributary of Temperance river.

From South-side lake the course pursues a slow-running river to Sawbill lake, with ridges of rock No. 787 on either side rising about fifty feet, or less, occasionally with a little show of the red rock, but generally free from it. From Sawbill lake the canoe enters a swamp through which the same river flows, to a rapids, where, after a short portage, a lake is reached in the same stream, the same rock continuing. This is known as Young Sawbill lake, and by our aneroid is found to be 454 feet above Saganaga lake. At the rapids the same rock appears, but about Young Sawbill lake the country is drift-covered, and about the S. W. end of this lake the native forest is green, having escaped the fires. This, however, does not continue far, for at the south side of Rat lake the forest is fire-killed. No rock is seen on the portage from Young Sawbill to Rat lake, but where the trail leaves Rat lake for Burntwood lake the same rock as the last appears.

Rat lake is 459 feet above Saganaga, and Burntwood lake is 439. These are both tributary to Temperance river.

On the portage from Rat lake the formation is mixed with the red syenite. It shows the characters of the Rice Point gabbro, and irony patches like dykes, having much magnetite.

On the east side of Burntwood lake the same rock can be seen in place, but the prevalence of drift and the greater amount of vegetation, makes the examination of the geology of the country more difficult, and the idea one can obtain is more general than in the country north of the Mesabi range.

The portage to Temperance river passes over a range of low hills made up of rock like much of that already mentioned, belonging to the same formation, but somewhat darker colored, with magnetite and hornblende, approaching dioryte.

788. Dioryte from the E. side of Burntwood lake, the rock of the country.

789. From the portage trail to Temperance river lake, but rather darker than the average—a dioryte with much hornblende and considerable magnetite.

Temperance river lake is 417 feet above Lake Saganaga. This lake, which is nothing more than an expansion of the river is terminated by rapids which have a descent of eight feet. On the portage round these rapids almost the only rock seen as boulders are of the red syenite series. A lower rapid in Temperance river has a descent of thirty feet. Temperance river is rather a succession of lakes, or lake-like expansions. The portage round the last rapids crosses red syenite all the way, seen occasionally in place. The forest is killed by fire over the east half of the portage. At the foot of these rapids is another lake-like enlargement of the river, after which the route ascends by portage, a tributary of Temperance river, and reaches a lake in this tributary, which is found to be 419 feet above Saganaga lake. This last portage passes at first along the foot of and then ascends and continues on a ridge of morainic drift, consisting so largely of red granite masses (from one to six feet) that one could travel the whole three-fourths mile without stepping off them. There is also in the mass occasionally a boulder of dioryte like No. 788 or 789. When burnt the whole country appears red, from the prevalence of this red drift. The next portage leads to a lake in Poplar river, and the lake is given an elevation over Saganaga lake of 449 feet by connected aneroid readings. Through this portage the red morainic drift continues, and along the lake also. Near the lake appears—

790, in one of the ridges over which the trail passes. It seems to make up a large part of the ridge. It is a very fine-grained, gray, metamorphic (?) rock, or fine basalt.

Along the west shore of Poplar river lake are two exposures of the rock No. 790, and from the fact that in one place a lot of red granite is embraced in it, it is judged to be an igneous rock.

791. From one of these exposures, which is almost exactly the same as 790.

Although there is abundance of drift along Poplar river, the red boulders are almost entirely wanting.

Square lake is 444 feet above Saganaga.

Small lake is 437 feet above Saganaga.

There is still a considerable sprinkling of red syenite in the drift along these lakes. New varieties of rock also appear, such as the trap rocks of lake Superior, and amygdaloid. The forest, fire-killed generally since leaving Temperance river, is still standing. Camp lake is 425 feet above Saganaga.

Smoke lake is 411 feet above Saganaga.

Sunrise lake is 399 feet above Saganaga.

Rice lake is 394 feet above Saganaga.

Big Lake is 304 feet above Saganaga.

There are rapids between all these lakes. The long portage from Rice lake S. E. is wholly over drift, no rock in place being visible. The same is true of the three portages last before. The country is rolling and shows many boulders. The stream leaving Big lake is three times the size of that leaving Rice lake.

Sucker lake is 274 feet above Saganaga.

Poplar river, where the portage from Sucker lake strikes it, is 16 feet above Saganaga. The portage between Big lake and Sucker lake is wholly over drift, showing no rock. That also to Poplar river is over a smooth surface of drift, without once showing rock in place. After a descent by river of about five feet, rapids occur which have a further descent of 40 feet, bringing the river here to the level of 29 feet below lake Saganaga. After a further descent of three feet by river the last portage begins, leading to lake Superior, which is found by the series of observations to be 737 feet below Saganaga, or 179 feet less than the series of aneroids of 1878, from Grand Portage.

The Sawteeth Mountains through which the Poplar river passes in a narrow deep gorge, rise above the trail which runs near their base 563 feet, and 1111 feet above lake Superior.

These mountains seem to be made up, here, of the trap-rock of the shore series, but become coarsely crystalline, or porphyritic, gradually, toward the top, as shown by samples obtained at different elevations, viz:

792. From the foot of a hill facing north precipitously. N. E. ¼, Sec. 20, T. 60, 3 W. on Poplar river. This is a high, trap hill, like others in the vicinity.

793. From the foot of the last hill (or nearest Lake Superior), west

side of Poplar river, 600 feet above the lake, similar to the last. A chrysolitic trap.

794. From the same hill one fourth way up. The same rock, with an occasional crystal of twinned feldspar porphyritically displayed.

795. From the same one half way up. The same rock with coarser feldspar crystals.

796 From the top of the hill, 1111 feet above lake Superior. This is the same rock, with more abundant coarse feldspar crystals, the matrix, which constitutes about one half of the mass, being undistinguishable from the rocks 793 and 794.

There may be beds of amygdaloid in this hill, but none were seen. On the very top of the hill is red clay drift, and boulders, and the last portage trail is over a nice plain of red stony clay, gradually descending to Lake Superior—the lower half of it being suitable for farming. The actual connection of this hill with the rock of the shore is not visible along the trail on account of this drift. The only opportunity for tracing it out there would be in the difficult, if not impracticable, ascent of the river gorge itself.

Rocks from various parts of the State.

797. The trap of Taylors Falls, (V. 820.)

798. Porphyritic trap, of Taylors Falls.

The number 797 contains nothing that prevents it being classed as an igneous rock, and it may be of the cupriferous, but the latter (798) has hornblende and orthoclase, as well as epidote, and has the aspect of a metamorphic rock.

799. Light-colored syenitic granite. Saganaga lake: The first island on entering the lake from the east; same as No. 316.

800. Syenitic granite, from the falls of Gunflint river, at the first portage going north from Gunflint lake; the same as No. 315.

801. Gray, micaceous syenite. From S. E. ¼, Sec. 17, T. 35, R. 30, about two and one half miles S. E. of St. Cloud, on the east side of the Mississippi river. A large, rounded knoll of this syenite was opened in 1881 by Saulpaugh & Company for use in the piers of the R. R. bridge over the Missouri at Bismark. It is a rather coarse rock, consisting mainly of quartz, orthoclase, hornblende and black mica. The orthoclase is only in part flesh colored, the rest is nearly white. This knoll covers 25 or 30 acres and rises about 20 feet above the general surface, the longest diameter being E. and W. (a little N. of W.) but oblong. A dyke four feet wide cuts it N. E. and S. W. consisting of heavy trap rock, very fine grained, viz:

802. Trap dyke cutting No. 801 in direction S. W. and N. E.; 4 feet wide. This rock, being much jointed, would facilitate the quarrying of No. 802, had the quarry been started along side of it.

803. Red quartzose syenite from an old quarry of Breen & Young, E. St. Cloud. In general the "red granite" at E. St. Cloud is but a small part of the whole of the rock.

Between the quarry of Breen & Young and that lately opened by Saulpaugh & Co , is a ridge of high land running E. and W. (nearly), which seems to consist of drift materials.

804. Gneiss, from Granite City. (Garrison.)

805. Light colored syenite, Watab, like No. 801, but rather finer in grain.

806. Light, red syenite, Watab.

These last two numbers represent the stone going into the piers of the Bismark R. R. bridge, quarried here also by Saulpaugh & Company. The gray is changed to the red in an interval of about six inches. The north portion of the quarry is red, and the rest is gray. These two numbers seem to duplicate numbers 801 and 803. This range of syenite runs N. and S. at least two miles, and some of the knolls rise 10 to 20 feet. East of this quarry are said to be similar knolls, some of them rising 25 or 30 feet. (V. No. 835.)

At Duluth the rock No. 43, which outcrops near the railroad in the street in front of the Engine House, where it has been quarried lately for use in the basement of the new School-House, and extends N. E. to the falls of Kinichigaquag creek, makes an important member of the rock series visible on the hill-slope at that point. Much of it is bare, north-east of the Engine House, within the limits of the city, showing, on weathering, a finely and indistinctly porphyritic structure, but in the main it is a massively bedded, homogeneous, dark rock, with numerous joints, the surface being frequently glaciated.

807. Passing toward the N. W. from the line of strike of No. 43, and thus onto rocks underlying No. 43, at the distance of about one-fourth mile, (but also somewhat to the westward) a rough, blotched rock is found spreading over a considerable area, running in the same general direction as No. 43. This, in general color, is like the last, but it is much finer in grain, and owing to its rough and blotched exterior under the weather, it must have been a conglomerate at first. Were it not for this blotched exterior, which shows a variation in composition, it would be placed at first in the general class of fine basalt, or diabase—like some of the narrow dykes, or like the rock adjacent to a dyke where the heat has baked it and allowed it to cool rapidly, leav-

ing it nearly black and very fine-grained. This conglomerate, while closely connected with the gabbro range, is unlike anything seen in the Cupriferous, and recalls the great conglomerates of Ogishke Muncie lake, although no tendency to slatiness can be seen anywhere. It has occasional light quartzose nodules, somewhat micaceous, but the most of the pebbles are of the color of the rock, except on weathering. In other places, by reason of the weathering, and the fires that have prevailed, a red banding is seen rudely conformable with the supposed bedding, which, on being broken reveals a texture and fracture as well as color and hardness, of the quartzytes of Pigeon Point. This No. (807) illustrates this gray quartzyte, but not the general character of the conglomerate.

808. Underlying this supposed conglomerate is the red syenite, or at least a red quartzless rock, (which is sometimes brown rather than red) which is associated intimately with the gabbro at Duluth. This red rock is to be seen in irregular patches in the gabbro on the hill-side; and by carefully following it downward, it is seen to outcrop along the bottom of the creek in such proximity to the conglomerate, with a dip S. E. as to throw it under the conglomerate, unless there be in some way unusual irregularity in the trend and extent of these beds. The red rock is visible under the bridge, and above it in the creek, on the diagonal road going N. toward the Weller Farm, yet within the limits of Duluth. (V. Nos. 42 and 43.)

By following the strike of the red rock westwardly the following facts can be ascertained by anyone:

1. It falls away, except on the higher slopes, or breaks away so as to disappear, for the distance of about half a mile, though a lower strike appears near Superior street. (No. 42.)

2. This interval is followed by a rock showing orthoclase in the gabbro, as well as quartz, as in the rock at the Depot, (No. 5); and in the lower slopes N. E. of the the Rice Point quarry, this character is abundant. This seems to be explicable on the hypothesis that the gabbro flowed over, fused and mingled intimately with the red rock. But it may be of a lower rock horizon, referable to the horizon of the diorytes and their associates in the rocks of the northeast angle of the State. (V. Nos. 671 and 709.)

3. This "red rock" which is in much of its area, quartzless, becomes the red syenite that has been described as mingled with the gabbro, then showing quartz.* This is probably due to the complete

*See *Proceedings of the American Association for the Advancement of Science*, 1881, Cincinnati Meeting.

fusion of the original sedimentary beds, allowing the otherwise invisible quartz, disseminated cryptomerously, to become aggregated in crystalline grains. At points more distant from the gabbro the only crystals to be seen consist of orthoclase, or of orthoclase and changed hornblende. The number 808 represents the complete crystallization of the elements, and is from Newson's old quarry, at Duluth, while Nos. 7 and 42 are from the same without the crystallization of the quartz.

Owing to the great general resemblance of the conglomerate (above) in its matrix at least, to the rock No. 43, which is seen in front of the Engine House at Duluth, and which overlies the conglomerate there is reason to suppose that they belong together, and that hence they are both of the metamorphic series. If the red rock be of the cupriferous, these must be, since the former runs below the latter. The question then arises, why is this dark-blue or black, and the red rock red. This cannot be due to greater heating and baking, which sometimes has been the cause of black rocks, locally, as described on the Lake Superior shore, in No. 52, and at other points, since under such circumstances the red rock remains red. Hence this seems to be due to difference of original constitution, making it resemble the rocks of the Animikie Group.

809. At Boyle's quarry, on the railroad above Fond du Lac, is a layer of red shale, lying in the heavy sandrock, which is much like the pipestone from Pipestone county. Its greatest thickness is sixteen inches, and it extends at least thirty feet, when it disappears under the drift clay.

At the quarry on Mission Creek, a short distance above Fond du Lac, in the *light-colored parts* of the sandrock are streaks and shades of red or brown, both in those parts having oblique sedimentation, and in those having horizontal. In some cases these dark streaks embrace lenticular pieces of shale, in which case the central parts of the pieces embraced are red or brown, and the outer crust is green. In some pieces the whole is green, or has a very faint central shade of red. On the contrary *in the brown parts* such red or brown lumps of shale are wholly brown, and have no crust of green. This seems to show that the original color of the shale lumps was red or brown, and that by some chemical reaction those in the lighter beds of the formation have become wholly or partly green. Thus, green specks and sometimes large green spots, at least green lumps of shale, are disseminated through the lighter beds, and red lumps through the dark brown beds.

810. Coarsely crystalline "feldspar rock" from two and a half or

three miles below Beaver Bay, showing coarse lamination, and evident striation. (V. No. 814.)

811. "Red granite," massive, from the large red granite island three or four miles below Beaver Bay which is arched on the lakeward side.

812. The "palisade rock," two miles west of the Palisades, S. E. ¼ Sec. 32, T. 56, 7 W., resembles the gray slaty rock at the mouth of Beaver Creek. In some places the Palisade rock here has the appearance of being crumpled, and also of having been originally in some places a conglomerate. Another bluff of light-colored Palisade rock occurs about one and one-half miles west of the Great Palisades. The trap rock which occupies the coast between here and the Great Palisades, runs under this Palisade rock toward the west. It shows a broken and zigzag line of junction with the palisade rock, parts of each penetrating the other, as if each were nearly molten. A little further west it also embraces masses (say ten feet) of the palisade rock, hardened and blackened by quick cooling, showing its sedimentary (or other) closely jointed structure in marked contrast with the massive or heavily bedded, non-conforming layers of the trap. (V. No. 52.)

The west end of the Palisades rises over the greenish and reddish (and then amygdaloidal or red porphyritic) trap, very plainly.

813. (V. 140) The lowest visible part of the rock at the Great Palisades, is confused and crumpled, in the same manner as where this rock is in contact with trap a short distance further west, as noted above. Yet it is very difficult to see the underlying trap, on account of the continuous heavy talus. This number represents *the red* banded felsite from the bottom of the Great Palisades.

There is apparently a continuous belt of this rock underlying the Palisades, outcropping in a narrow belt near the water. It is mingled in various ways with a crumpling of banded rock like that of the bulk of the Palisades (139), and with crumpled bands of light color, some of which stand verticle, or are curved obliquely, some of the latter showing a porous or even a spongy condition due to the solution and removal of some of the minerals. There is also a hard, dark, brittle, fine felsite, though porphyritic like the rest, but occurring in nodules and concentrically banded masses which endure more effectually the weather. They seem a more hard-heated and burnt condition of the Palisade rock. Indeed great confusion exists at the bottom of the Palisades, due perhaps to the forcible injection (as laccolites) of igneous rock below, breaking, crumpling, baking, fusing and metamorphosing rapidly the adjacent beds.*

814. There is one place two and one half or three miles east of Beaver Bay, where the "Feldspar rock" is bedded, and dips easterly, in all respects like the usual trap of the shore. It here shows also a confused mixture with the trap, in which in other places it seems to be (and is) embraced as isolated masses, as at Splitrock Point. This bedded condition is very evident in coming from the N. E. as the conspicuous surface slopes in that direction. Narrow dykes of fine-grained, gray doleryte cut the feldspar rock. One dyke is six inches wide, and one is about nine. They are about parallel, 25 feet apart and run E. and W. by compass. The feldspar here is very coarsely crystalline and is represented by No. 810. The alternate beds consists of bands of coarse crystals, succeeded by layers of fine crystals in which are also numerous grains of a more rapidly disintegrating mineral which by becoming disseminated stains the whole of a green color. This disintegrating mineral seems to take the place of the augite seen in the gabbro, therefore, the bedding is an alternation of gray, coarse feldspar, with green, decaying gabbro. No. 814 represents the feldspar stained *with the green-weatheriug mineral.* The bands of color are from three to six inches, fading into the uncolored, clear, feldspar, above and below. About 20 feet of this bedded feldspar can be seen here. (V. 694.)

815. From the same place as 814, represents the gabbro of more massive character with which the feldspar (810 and 814) is confusedly mixed, but between which there is not seen here any gradual transitions.

From the Palisades, (and Baptism river) to Splitrock, is one great igneous bed, which by appearing and disappearing at the waterline, seems to have been the principal agent in bringing out the geology and causing topography. It lies under the rock of the Palisades, and under the red islands &c., as at Beaver Bay, and over the feldspar knobs, from both of which it has derived fragments. The metamorphosed red shales above, making the red series of crystalline and semi-crystalline rocks of the shore, were apparently brought into that condition by the agency of this igneous rock, but the relation of this igneous rock to the "feldspar rock" is not so easily ascertained. It is certain that the gabbro of Rice's Point is only the usual condition of the feldspar rock,

*The immediate proximity of igneous rock, along the coast usually, does not show the most perfectly changed and crystalline condition of the sedimentaries. nor *vice versa*; but when large bodies of either are involved the crystals are best formed The immediate contact is a place of crypto-crystalline rock, both rocks tending to suddenly become alike, and generally almost or quite black.

and hence that the gabbro range of which Rice Point is the western termination, lies below many feet of red, metamorphic sedimentary beds that apparently belong to the Cupriferous.

816. (V. 532 and 551.) Pieces of rock like the "Rice Point granite," embraced with evident feldspar boulders also, in the trap at Beaver Bay, sometimes in large blocks. This seems to be the same rock as the "feldspar rock" or a variation from it. Indeed there are here also masses of coarsely crystalline, green, trap-rock embraced as isolated blocks, in the finer green trap. *The gabbro, and the "feldspar rock" all pre-existed, and bore the same relation to an outflow of later igneous rock.* This point shows a wonderfully confused and brecciated condition prior to the final cementation.

The red rock appears, at Beaver Bay, as pebbles and boulders in the dark trap, and as strings and veins. It is in contact with masses of feldspar, crowded between it and trap. The spots and masses of red rock are distributed, in some cases with pieces of the feldspar rock, throughout the trap, showing the accession of both ingredients when the trap was molten, and even contemporaneously. The "feldspar rock" is derived from previously hardened outflows, and the red rock from the sedimentaries at the *locus* of the outflow. It is true that a long interval of time may have elapsed between the former and the later outflows; or indeed that the "feldspar rock" is of an entirely different formation earlier. Any older formation might furnish loose masses to an outflow of trap.

The interesting facts about Beaver Bay may be summarized thus:

1st. The feldspar masses are blocks detached from their parent rock.

2nd. The trap in which they are embraced is in some places much affected by the infusion of minerals from the sedimentaries, and then shows a reddish color, but it is generally of a greenish or greenish black color.

3rd. Besides this effect on the trap, as seen near the mouth of the creek on the north side, there are included masses of red syenite, and of the ashen-brown, or purple, rock seen near the mouth of the creek. (Nos. 127 and 528.)

4th. These red masses are sometimes in contact with and firmly cemented as by fusion to the feldspar surfaces, and also show a basaltified jointage.

5th. The red syenite here can hardly be called syenite in all cases, but is instead a nearly black (at least a dark purplish) fine-grained rock which in outward characters resembles the Two Harbor rock, but at the same time shows translucent, angular grains like the Palisade rock. This fine-grained condition is seen when it is near the rotting green trap.

6th. The red syenite here was apparently at first a red conglomerate, showing the irregularities of color, hardness and minerals that such a metamorphism produces.

7th. There is within a few inches a passage from the red crystalline characters of the bluff on the south side of the creek to those of the above fine-grained black rock, the rock being one continuous mass.

8th. The red rock is not only a metamorphosed conglomerate, but it was brecciated and then mingled with the trap so that angular pieces appear in the trap when worn off by glaciation.

9th. The red rock was fluidized. It runs about in belts and veins, not only between the trap and the "feldspar rock", and through the trap, but also through the "feldspar rock."

10th. The feldspar rock here passes into gabbro, or at least into a rock like the Rice Point rock, and then it is more generally mixed with the red rock.

11th. On close examination it appears that even as "feldspar rock" it must have been as completely molten as the red rock itself.

12th. This red rock also appears as the palisade rock, rising in a knob near the creek, on the north side, with the lithologic characters and jointage, and translucent grains of that rock.

13th. Under this knob lies a rotting green trap, visible on the north side. A little further east, but within the bay, this green trap, although basaltified, is beautifully mottled and striped with the red rock.

14th. Still further east, on the north shore of the bay, the green trap holds both red masses of the sedimentaries and white masses of the feldspar rock, the latter being, however, more nearly like the Rice Point rock, at least in some large masses—yet much of it is unmixed and clean feldspar.

The above observations, carefully made at Beaver Bay, seem to decide certain points that before were largely hypothetical, or were based on generalizations from a grand review of the geology of the "north shore," and not on special and minute study of the notes made or of the specimens collected.

(1.) The Great Palisades are of a rock, the equivalent, geologically, of the slaty quartzyte (Nos. 127 and 528) at Beaver Bay and below that point; and to the red syenite of the islands below Beaver Bay, and of the west bluff of Beaver Bay; and to the red (often quartzless) rock associated with the gabbro at Duluth. These beds also constitute the red bluffs at Tischer's and New London, as well as the red rocks at Baptism river, and the eastern palisades. In a number of instances the bottom of this great red (metamorphosed) shale has been found to be a conglomerate.

(2.) The feldspar masses are of the same rock (geologically) as the Rice Point gabbro, and both are the result of copious, and perhaps one of the earliest, igneous outflows of the Cupriferous. The more copious the igneous outflow, the coarser the resulting crystalization and the higher the hills formed, as well as the purer the labradorite material. The later outflows derived fragments from the "clinker fields" and from the knobs of feldspar already formed, as they passed along; and when these had been covered by later sedimentation such sedimentary beds were also involved in the later upheavals and fusions. (V. No. 817.)

(3.) It seems as if an igneous outflow,—perhaps the great labradorite—was thrust laterally under the sedimentary beds that went to form the palisades, heaving up those beds, and sometimes fusing them, and mingling with them, as seen near New London and at Beaver Bay, though no such evidence can be cited to show the laccolite formation in later strata. (V. No. 521.)

It must be admitted that it is not at all certain that the labradorite outflow was the earliest, so far as the observations go. It is simply the most conspicuous, and seems to lie nearest the Huronian. Besides this it is still a question whether the green basaltic traps, as at the east side of Beaver Bay, and as that coming out from under the Great Palisades, or the melaphyr-like traps as at Petit and Grand Marais, can be shown to pass into the gabbro without the intervention of any change but difference of proximity to the center of outflow. It is probable that such a gradation can be shown, the rock at Knife River Point being an intermediate step, and that at Encampment Island another.

To illustrate the steps in the change from the feldspar rock to the gabbro, reference may also be made to several large masses lying in the water near the red bluff at the west point of Beaver Bay on the east side of the bluff.

817. Hardened shale, from a brecciated, semi-metamorphosed reddish conglomerate at Two Harbor Bay, lying immediately over the Two Harbor rock, and immediately under heavy green doleryte containing masses of feldspar, (V. No. 525.) This shale is charged with laumontite. Certain blotches are charged with it, particularly in the

form of amygdaloid, the cavities being about one-fourth inch, and less, in diameter. The blotches, or spots, make up sometimes the most of the rock. They are without any order of arrangement. Intercallated amongst them are laminated patches and seams of red material which is fine-grained, and was probably a shale at first, disseminated amongst a coarse conglomerate in the same manner as shale is often seen disseminated throughout a conglomerate, (as at Manitou river); the laminae being parallel with the general dip. Of this conglomerate breccia thirty-five feet are to be seen.

The bottom of the overlying trap is a perfect pudding-stone of pieces of gabbro and feldspar masses. The largest mass of "feldspar rock" at the point east of Two Harbor Bay shows a bedded, at least a banded, structure running nearly perpendicular from top to bottom, similar to that described east of Beaver Bay (No. 814.) It is crossed obliquely by an old dyke, which dyke is faulted, about midway of the bluff, about two feet. A small dyke also runs near the water about horizontal, derived from the trap at the left which, near the water, seems to run below the feldspar. This lower part of the trap holds a piece of the red syenite, near the water level.

As to the "Two Harbor rock," its character and origin are still to be determined by more minute examination of the samples collected, and by further field observations. It has been referred to as a metamorphic rock, in some of these notes, but it has also very much the aspect of a fine-grained, igneous rock. It has the jointage, as well as the general homogeneity of trap, and the red bands crossing it, and the geodic spots seen on its surface, perhaps, have originated from the overlying sedimentary conglomerate. It does not have the appearance of being, exactly, the equivalent of the quartzless red rock at Duluth, but it must occupy very nearly the same stratigraphic position.

818. On the east side of Splitrock Point is a grand pudding-stone of feldspar, gabbro and dark-trap masses cemented still by a dark trap. The most of the so-called feldspar here is really gabbro, very much like the Rice Point rock. This number is from such gabbro-like pieces.

East of this point, but within the same bay, are feldspar masses that show the green banding or bedding. The bands run nearly perpendicular. The lighter-colored bands are much more coarsely crystalline than the darker, which is also true at the point two and a half or three miles east of Beaver Bay, (814.) This is also cut by dykes and generally mingled with the matrix of dark trap in great confusion.

819. From the top of the high hill back of Silver Creek—the high-

est hill near the mouth of the creek, yet on the west side, rising 415 feet above the lake, though at a mile further back it rises perhaps 150 feet higher.

At Flood Bay (next east of Burlington Bay) are frequent slabs of laumontitic sedimentary shale strewn on the beach on the east side. They are at the same time sandy, of a brick-red color, with spots of lighter red, and of green, like the Fond du Lac sandstones. The amygdules consist of calcite and laumontite, but principally the former. Some of these slabs have distinct markings of fucoidal stems, some of them being large and long. As these slabs are evidently from the formation that forms the shore line generally, though where they are found no rock bluff is exposed, they unmistakably prove the sedimentary origin of the red laumontitic amygdaloids so common on the north shore, in another line of evidence.

820. Trap rock, at the railroad cut, Taylor's Falls. This is crystalline, tough, greenish with that internal structure that Prof. Pumpelly assigns to melaphyr, i. e. there are almost imperceptible forms of crystals that permeate the rock, and are so completely filled with the other constituents of the rock that they do not appear distinctly till the rock is weathered. They are generally about one-third or one-fourth inch in diameter, but they do not show any angles, and they do not have the color of pyroxene. When they are distinctly brought out they are seen as spots that completely speck the face of the bluff. They disintegrate more rapidly than the rest of the rock, sometimes assuming a green chloritic character that causes them to make little pits as large as a pea all over the surface, due to the more rapid removal of this green mineral; and sometimes they become gray gradually, giving the appearance of nodules of siderite disseminated through the whole.

821. Shows the green-weathered spots of the rock No. 820. The change to the geen mineral takes place at depths of ten to twenty feet below the surface, in the railroad cut.

822. Shows the gray-weathered spots of the rock 820. This takes place nearer the natural surface of the ground, and at the surface.

In No. 820 are seen sometimes small pebble-like lumps of red jasper, and larger deposits of chalcedony, the latter sometimes being elongated lenticularly, some like gash veins, four or five inches. The chalcedony also appears as pebble-like masses and as filling to scattered cavities somewhat in the manner of amygdaloid. Coating the joints, which are often slickensided, is frequently a green slippery mineral like delessite. Sometimes the chalcedony is more pure quartz, and is mingled sparsely with calcite. These characters are those of an igneous rock, and at the same time this rock differs quite distinctly from the gabbro at Duluth. The jasper and chalcedony recall the disseminated red jasper and quartz pebbles of the conglomerate at Ogishke Muncie lake

823. Pebbles from the conglomerate forming the lower part of the bluff excavated by the railroad where it crosses the highway south of Taylor's Falls. The bluff here is red-spotted and composed of a curious, coarse, conglomerate. It is dark-colored generally, looking some like the trap formation about Taylor's Falls, but the jointage and the texture are different Some of the surfaces are variegated with coatings of green, radiated malachite, and some are stained green without showing evidently the mineral producing the color. Some also are nearly black and some jasper-red. It is in some spots coarsely vesicular, or like pumice, or like amygdaloid. The amygdules received quartz at first, (as shown by the perfect terminations of crystals) and subsequently calcite and chlorite. Some of it is hæmatitic, and has a streak of red. It was here evidently a shale-conglomerate, but it has the appearance of having been heated and hardened, as well as mixed perhaps with igneous matter. In some places it is fine and crumbles like a dry shale. In some places its conglomeritic composition appears on weathering, the little rounded pebbles (of hardened shale, or of fine argillaceous quartzyte), rolling out entire. The pebbles have a great resemblance to the rock itself, but there are none of quartz. They are somewhat changed by decay.

824. The upper portion of this bluff consists also of a curious conglomerate, the matrix of which is represented by this number. It is a completely crystalline dolomite (apparently, though not yet analyzed) which effervesces in acid when powdered, and which contains fossils of *Lingulæ* &c., and nodules of course calcite crystals. Every grain is a perfect crystal; but in the upper part of the bluff this matrix becomes free from pebbles, and forms beds of dolomite like that seen in numerous other places along the St. Croix valley.

825. The great bulk of this upper portion is made up of boulders contained in No. 824, of which 825 is a sample. They have been said to have come from the "trap" of the region, and perhaps they do, but they are not like the rock 820. They are sub-angular and somewhat rotted. They are porphyries, of a green color, (now) or are homogeneous, resembling some of the rock seen in the Huronian. It is in these boulders that the green coatings of malachite are seen.

This conglomerate, which has its lower portions quite different from the upper, can hardly be separated into two by any distinct line of superposition. The matrix of the upper portion runs below parts that resemble, and indeed are the same as the conglomerate of the lower, while some masses above, embraced in this matrix, seem to be like the underlying conglomerate, and crumble in the same way. The lower characters occupy a thickness, visibly, of six feet, at the highway crossing, though in ascending the hill toward the north, it probably increases, while the upper characters have a thickness of probably 75 feet, rising to the top of the hill further north. Yet this interval is not all visible.

826. At the top of the hill north from the last, in front of Mr. Folsom's house, the rock 820 shows an alternate banding that resembles stratification, and would ordinarily be taken for that. This is seen over the surface of one or two square rods. The rock in general here is smoothed off by glaciation, and this character comes out distinctly on the planed surface. It is less coarsely pitted by the weathering out of the invisible crystals than at the R. R. cut. Indeed the banding that simulates that of sedimentation, consists in finely pitted belts on the surface of the rock alternating with non-pitted bands. The dip, if this structure be due to original sedimentation, is N. E. about 45° in amount, as evinced by a thin layering that slopes in that direction, and which has a tendency to split in beds from one inch to six inches thick coincident with this banding. The rock here also contains chalcedony nodules and is scatteringly porphyritic, resembling thus the pieces found in the upper portion of the conglomerate, No. 825.

The rock that forms the rapids in St. Croix river, half a mile above the town of Taylor's Falls, is essentially the same as that in the R. R. cut, but is less coarsely and conspicuously pitted by the weathering and decay of the invisible crystals supposed to be pyroxene. It is more frequently supplied with quartz, either white or chalcedonic, than the other, and is also striped with red granite, or at least with a red mineral in blotches and vein-like deposits like flesh-red orthoclase, which is also mingled with white quartz. Along the river gorge this rock weathers and crumbles globuliferously, much like the trap-rock seen on the north shore. It has a course and irregular jointage, and sometimes a conchoidal fracture. It is not truly basaltic, even in the Dalles, like the basalt of Grand Marais; yet there are in some places frequent perpendicular joints that divide it into columns. These are cut nearly horrizontally by other joints. Hence coarse columns result from weathering, which are broken horizontally into cuboidal or rhomboidal masses. The banding which looks like sedimentation, near Mr. Folsom's, does not appear generally,—indeed is not known to occur at any other place.

827. From the lower portion of the conglomerate, showing the contained pebbles and the matrix which seems to be of the nature of igneous rock, from the top of the hill east of the R. R. crossing of the highway.

828. Samples of the finer part of this conglomerate where the cement is not igneous, from the same place.

Concerning this conglomerate certain things can be definitely stated, viz:

1. It is extensive, and spreads widely northwestward, even rising to the tops of the hills toward the shaft sunk by Mr. Taylor. It appears in the street, and in the yard of W. H. Cummings, where it is so firm and bold in its outlines, as to appear to be of the real trap formation of the region.

2. It contains waterworn boulders and trap of the region, some of them being porphyries and some not, thus showing the agency of water in its origin.

3. The cementing material is, in the main rock, very much like the boulders, but finer-grained, and sometimes amygdaloidal, thus indicating a possible igneous agency in the origination of thhse parts.

4. It is coarser in its composition near the trap-rock outcrops than at a distance from them; yet the superposition of the conglomerate on the trap cannot actually be seen.

A short distance above Taylor's Falls, at an old quarry in the bluff of the river, the upper part of the conglomerate is so fine as to make a regularly bedded rock about twelve feet thick, and passes for a sandrock. It here contains *Lingulæ*, (*Discina?*) and an occasional small trilobite. Below it becomes coarser and embraces half-rotted pebbles and boulders from the trap. The matrix here also contains grit, some of the pebbles also being of quartz.

On the Wisconsin side the trap is in outcrop in a large ridge about four miles below Franconia, along the road to Osceola. At Franconia the sandrock runs down to the level of the river; near the bottom it is greenish-blue and shaly, and sheds water. This shaly impervious stratum extends down the shore below Franconia, and is visible along near the water-level on the west side of the river, rising sometimes ten feet above it. On Lawrence creek, near the Franconia Mills, is a bluff which overhangs, on account of the crumbling out of the loose sand below. In the crumbling part are numerous laminations of bluish shale which cut the sand into lenticular beds or patches, and the sand itself is cross-bedded. In the crumbling sand are thousands of little *Lingulæ*, and *Discinæ*.

829. A mile and a half below Franconia is an isolated bluff, rising 45 feet above the river, composed of the curious conglomerate seen at Taylor's Falls. It here presents the same mingling of characters that may be referred to igneous and sedimentary origins. The great mass consists of trap boulders, considerably rotted, some of which are as large as a barrel. In the coarser portions of the conglomerate the cementing material is a finer conglomerate of pebbles of the same kind of rock, and in other portions it is a fossiliferous ferruginous, gritty or magnesian sediment, the fossils of which are the same as those seen in the crumbling sand at Franconia, and sometimes apparently an amygdaloid. The change that has taken place in the original structure of the conglomerate by partial decay, and perhaps by heat, makes it often difficult to distinguish between the pebbles and boulders, and the cementing material. The lower portions, if any, are those that seem to have been cemented by the action of heat. A specimen was here obtained of an amygdaloidal part (of the cement ?) which contained fossil shells within less than half an inch of the amygdaloid, both of which, were it not for the contradiction involved, would be pronounced to belong to the cementing material.

In conclusion, judging from the facts here recorded, this conglomerate shows evidences of some kind of metamorphic action in its lower portions, but the phosphatic shells penetrate far down into it and occur even amongst the metamorphic characters. The evidence that this conglomerate was formed under water, even its lower portions, consists in the rounded forms of the contained boulders, while the aqueous conditions of the upper portions are plainly shown by the shells, and by the fact that further up in the formation it graduates to a fine conglomerate and to dolomitic sand rock. (Samples 829 represent some of the finer portions of the conglomerate.)

830. At Sioux Falls, Dakota, may be seen a light-colored schist, of a talcose character, and pea-green color fading to nearly white, similar to that seen at Baraboo in connection with the quartzyte bluffs. It here lies in the rock and becomes a white catlimite. Below the present level of the water of the dam, but formerly exposed above the water, is a layer of white, or pinkish-white catlinite, four feet thick, embraced in the rock that produces the falls.

831. Samples of spotted-red quartzyte, like that at Sault Ste Marie, Michigan, and like some parts of the Fond du Lac sandstone, showing a probable identity of the geological horizons at those places. It is

possible that these light-colored spots are caused by the absorption of the iron through chemical change, and that by careful examination the cementing material would be found to be feldspathic.

The red quartzyte formation at Sioux Falls dips 6 to 8 degrees to the south. The beds are purple within, especially the thick ones, but toward the outside, and along the joints, they are changed in color to a rose red, or a pinkish red. None of the brick-red, heavily iron-stained color can be seen. The change that takes place by weathering not only changes the color but also the hardness, so that the rock goes into a loose sandrock again and crumbles in the hand. This takes place to so large an extent that in suitable places it is gathered and used for mortar. There are also some beds that are wholly now, (so far as can be seen) in this friable condition. The sand that results is a pure selica, nearly white, and translucent, though it is apt to show at first a slight pinkish tint rising from the remains of the cement among the grains. There is visible here, of the bedding, fifty feet, (estimated) and the river goes over the beds from south to north, producing a fine water power. In one place there is a gorge fifteen feet high and from seventy-five to eighty feet wide.

832. Spotted (amygdaloidal ?) samples of the brick-red quartzyte from Redstone, near New Ulm.

833. Red shale, the lowest rock seen in the R. R. cut at Redstone. This is four or five feet thick, the upper portions being rather slaty and tough. Some of the higher layers are sandy from disintegration as at Sioux Falls, and some are hard and quarzitic, and all are of a darker red color. Some beds are spotted, perhaps from an incipient amygdaloidal structure. Mr. Nicholas Thinnes, who first opened the quarry at Redstone in 1857, avers that some of the rock of the formation here is "granit," the same as some of that at Little Rock, a fact which, if verified, will unite the formation with that, and will show its analogy to those tilted red semi-crystalline beds in the northern part of the state (V. Nos. 783 to 785.) But this crystalline structure has not been seen at Redstone by any member of the geological survey.

834. Slab of red quartzyte from Sioux Falls, showing the finely pitted exterior of the individual sand grains on the removal of the white schist, No. 830.

835. Gray, coarse-grained granite, in color much like the gabbro at Duluth, from the E. St. Cloud quarries. This was formerly used in connection with the rocks 803 and the finer grained gray granite like that at Sauk Rapids indiscriminately for construction, but owing to its large content of quartz, it has been abandoned for those varieties

more easily wrought. All these sorts are to be seen in the trimmings of the Custom House at St. Paul. But that now generally used is to be seen in the trimmings of the New Union Depot, at the same place.

836. The pink quartzyte known as the "jasper rock" locally, from Sioux Falls, Dakota. This is a pinkish granular quartzyte, but with a cement that, on disintegration, allows the rock to become a white sand.

III.

THE POTSDAM SANDSTONE.

It is well known that geologists are not agreed on the question: "What is the western representative of the Potsdam sandstone of New York State?" The correct determination of this interesting problem has an important bearing on the interpretation of the stratigraphy of Minnesota geology, inasmuch as all the different horizons involved in the investigation are widely represented in the State. Those horizons are as follows in descending order:

1. The light-colored sandstones seen in the Mississippi river bluffs, and the bluffs of the St. Croix, from Taylor's Falls to Winona, containing species of *Lingulæ* and trilobites, generally distinguished by this survey as the *St. Croix Sandstone.*

2. The red and light-colored horizontal sandstones that bound the south shore of Lake Superior throughout most of Wisconsin, and much of Michigan, extending from Sault St. Mary to Fond du Lac, holding fucoids and *Scolithus.*

3 The red sandstones and shales, with the associated conglomerates that are involved with the trap-rocks of Lake Superior, furnishing metallic copper, lately known as the *Keweenian formation.*

At different places Nos. 1 and 2 have been seen unconformably overlying portions of No. 3, and in others No. 3 has been seen passing into No. 2, or at least into a sandrock that was taken for No. 2, while No. 2 itself seems to be the equivalent of beds that in other places represent No. 1.

While it is perhaps impossible at this time to state which of these three, or which two of these three, have the greater amount of evidence in their favor, it will conduce to the progress of the investigation to ascertain and collate some of the facts that bear on the geology of this disputed terrane, and to review briefly the progress of opinion and investigation in the Lake Superior region. In the light of late explorations in the West, and of late investigations in the East, perhaps it will be possible to reach more nearly a correct conclusion than at any other time. In the first place it will be well to summarize the opinions held by different geologists who have expressed any opinions respecting the Potsdam sandstone of the West. There was a school of geologists between 1840 and 1858 who regarded the Lake Superior sandstones as not of the Lower Silurian, and some are found even to this day. They were not united among themselves, but were divided between Jurasso-Triassic, Devonian, Upper Silurian and Carboniferous. After the investiga'ions of Dr. D. D. Owen and the report of Foster & Whitney, unprejudiced geologists very generally accepted the conclusion that they are of the Lower Silurian, and lately the facts recorded by Dr. C. Rominger seem to place their Lower Silurian age beyond doubt. Thus the question is brought within narrower limits and the doubt that still exists perta'ns only to their exact horizon in the Lower Silurian, or in other words, where in the West the Potsdam sandstone is found. It was until lately that the same uncertainty existed within the limits of an individual State, respecting the equivalency of beds in the Carboniferous age as they extended from one side to the other,* and the problem was finally settled by tracing a well-known sandrock formation from north to south, and bringing all the other strata into order above and below it. Perhaps some such process may be applied to this question.

But before entering upon that a glance may be taken at the various opinions that have been held. These opinions may be grouped under sixteen heads, but the present state of knowledge compels us to ignore many of these opinions, which reduces the groups to be considered to ten. The sixteen groups are as follows, with the names of those who have advocated them:

Summary of Opinions.

1. Those who regard No. 1 as the Potsdam sandstone —Logan, White.
2. Those who regard No. 2 as the Potsdam sandstone—Logan, Brooks.
3 Those who regard No. 3 as the Potsdam sandstone—Rogers (W. B.), Dana, Winchell (N. H.).
4. Those who regard all of them as the Potsdam sandstone—Hall, Foster, Whitney, Winchell (A), Dana, Kloos, Owen.
5. Those who regard Nos. 1 and 2 as the Potsdam sandstone—Whittlesey Chamberlin, Irving
6. Those who regard Nos. 2 and 3 as the Potsdam sandstone—Hubbard, Rivot, Rogers (W. B.), Whittlesey, Marvine, Rominger, Wadsworth.
7. Those who regard the Lake Superior sandstones as Calciferous and Potsdam —Dana.
8. Those who regard the sandstones of Lake Superior as Calciferous—Dana.
9. Those who regard the Lake Superior sandstones as Potsdam, Calciferous and Chazy—Logan.

*Ohio.

10. Those who regard the Lake Superior sandstones as Quebec – Logan, Hunt, Pumpelly, Dana, Hall.

11. Those who regard the Lake Superior sandstones as Jurasso-Triassic—Houghton, Ruggles, Jackson, Shepard, Rogers (H. D.), Owen, Marcou, Dana, Bell (or Permian).

12. Those who regard the Lake Superior sandstone as Upper Silurian—Jackson.

13. Those who regard the Lake Superior sandstone as Devonian—Locke, Bigsby and Bayfield.

14. Those who regard the Lake Superior sandstones as Permian MacFarlane.

15. Those who regard the trap and sandstones of No. 3 as Cambrian—Logan, Bigsby (Whittlesey older than No. 1).

16. Those who regard the trap and sandstones of No. 3 as Huronian—Selwyn.

References.

Opinion No. 1. Geology of Iowa I, 171; geological map of Canada, 1866.

Opinion No. 2. Geological survey of Canada. Rep. for 1846-7; American Journal of Science, 1852, XIV, 226; Geology of Wisconsin, 1873, III, 433.

Opinion No. 3. Proc. Bos. Soc. Nat. His., 1860, VII, 394; Rep. Minn. Survey, 1872, 68; *Ibid* 1876, 29; Dana's Manual of Geology, edition 1862, p. 173 74.

Opinion No. 4. Palæontology of New York III, 79; Report on the Geology of the Lake Superior Land District, Part II, p. 137; Proc. Am. Assc. Adv. Sci., 1851, V., 22-38; Am. Jour. Sci., 1864, XXXVII, 226; Sixteenth Regents' Report N. Y. State Cabinet, p. 119; Dana's Man. Geol., 1862; Geologische Notizen ans Minnesota, Zeit. d. deut. geol Gesell, 1871; Owen's Report on the Geology of Wisconsin, Iowa and Minnesota, 1852; Proc. Am. Assc Adv. Sci., 1855, X., 204; Leonhards' Jahrbuch, 1877, Erstes Heft, pp. 31, 113, and 225.

Opinion No. 5. Geology of Wisconsin, 1873, III; Geol. Wis., Iowa and Minn, 461.

Opinion No. 6. The Mineral Regions of Lake Superior, by J. Houghton, Jr., and T W. Bristol; Senate Documents, 1849-50, 31st Cong., 1st Sess, III, p. 802, 842; *Ibid,* 1845-6, 29th Congress, 1st Sess., VII No. 357, p. 2-29; Annales des Mines (5) 1855, VII, 173; 1856, X, 364; Proc. Bos. Soc. Nat. Hist., 1860, VII, 394-399; Proc. Am. Assc. Adv. Sci., XXIV, 1875, 60; Mineral Regions of Minnesota, 1866; Geology of Michigan I, Part II, 1873; *Ibid* Part III; Proc. Am. Assc. Adv. Sci. XXIX, 429.

Opinion No. 7. Dana's Man. Geol. 1862, pp. 172-74.

Opinion No. 8. Dana's Manual of Geology, 1874.

Opinion No. 9. Geology of Canada, 1863, p. 67-86: Can. Nat. aud Geol., 1861, VI, 119.

Opinion No 10. Am. Jour. Sci. (2), 1861, XXXI, pp. 216, 392; *Ibid,* 1862, XXXIII, 321; Can. Nat. and Geol., 1861. VI, p. 81; Geol. of Canada, 1863, pp. 605, 698; Geol. Map of Canada, 1866; Dana's Manual of Geology, Ed. of 1874, p. 182; Am. Jour. of Sci. (3), II, p. 351.

Opinion No. 11. Am. Jour. of Sci. (1), XLIX, 62-72; *Ibid,* p. 81-93; Assc. Am. Geol. and Nat., 6th meeting, 1845, p. 53; Bul. Soc. Geol. France, 1850-51 (2), VIII, 101; Geology of North America, by Jules Marcou, Zurich, 1858, p. 64; Rep. on

Chip. Land Dist., 1848, pp 57-58; Sen. Docs., 1847-48, VII, No. 57, p 134; Am. Jour Sci., 1843 (1), XLV, 160; Proc. Bos. Nat. Hist., 1864, II, 124; Dana's Manual of Mineralogy, 2nd Ed., 1857, p. 305; Rep Progress Geol. Sur. of Can., 1866-69, p. 321.

Opinion No. 12. Proc. Bos. Soc. Nat. Hist , III, p. 335.

Opinion No. 13. Quar. Jour. Sci. Lond., 1824, XVII, pp. 1-34, 228-269; Am. Jour. Sci., 1824 (1), VIII, 60-88; Trans. Lit. and Hist., Soc. of Quebec, 1829, I, p. 1; Locke's Beport, 1847.

Opinion No. 14. Can. Nat and Geol. (2), III, p. 256.

Opinion No. 15. Trans. Brit. Assoc. Adv. Sci., 1851; Edin. New. Phil. Jour. LIII, 55; Geol. Wis., Iowa and Minn., 461.

Opinion No. 16. Can. Nat. and Geol. (2), IX, 17; Rep. Prog. Can. Geol. Sur., 1877-78.

If we discard those whose opinions make the Lake Superior sandstones post-Silurian, and also those who regard them as pre-Silurian, of the remaining, by far the greatest weight of authority falls on proposition No. 6, which assigns Nos. 2 and 3 to the Potsdam. Proposition No. 4, which assigns them all to the Potsdam, follows next in weight of authority.

In this enquiry it will be necessary in the first place to ascertain exactly what the Potsdam sandstone is stratigraphically, lithologically and palaeontologically. This will involve an enquiry into the nature of the formations that lie below and above it in New York and New England Secondly, it will be necessary to ascertain what formations in the West approach most nearly to an equivalency with the same horizons.

1. What is the Potsdam of New York and New England? As to the lithological characters of the Potsdam in New York the following is from the annual report of Dr. E. Emmons, Jan. 1838: "This rock is a true sandstone, of a red, yellowish-red, gray and grayish-white colors. It is made up of grains of sand, and held together without a cement. Inter-mixed with the siliceous grains are firner particles of yellowish feldspar which do not essentially change the character of the sandstone, but show the probable source from which the materials forming it were originally derived, viz.: some of the varieties of granite. Unlike, however, most of the sandstones, it is destitute of scales of mica. The coloring matter of the rock is evidently oxide of iron, but unequally diffused through it, giving it intensity or deepness of color according to its quantity. In some places it is almost wanting, which makes it, when pulverized, a good material for glass. The grains and particles in its composition are generally angular, but where it takes the character of a conglomerate, as it does in the inferior layers, they are frequently rounded. The thicker strata exhibit an

obscurely striped appearance, owing to the prevalence of certain colors in the different layers." In his final report on the agriculture of New York Mr. Emmons says of this rock: "This sandstone is more uniform in its characters than most of the individual rocks in the series. At Potsdam it is yellowish-brown; at Moira and its neighborhood, and also in Mooers, it is nearly white and sandy; at Chazy it is of a deep red at the bottom, and gray towards the top, while at Whitehall, Corinth, Hammond and near Glen's Falls it is gray, and more or less crystalline. In many places it is a coarse conglomerate, as at Mooers in Franklin county, and at DeKalb in St. Lawrence county. It is of course a siliceous rock, yet it does not exclude other substances or elements; for, a true sandstone, far from being composed of pure siliceous sand, admits into its composition mica and feldspar, oxide of iron, and probably even a greater variety of the primitive minerals, as hornblende, pyroxene, &c., in a state of fine division."

Mr. Mather, in his final report on the first district, speaks of the Potsdam in the following terms: "The Potsdam sandstone is a hard siliceous sandstone, white, red, gray, yellowish, and frequently striped. It is well developed at Whitehall." * * * * "Some of the strata of this rock are covered with the most beautifully characterized ripple-marks, as perfect as if just formed on the sand of a sea beach, while the rock is of the most indurated kind of sandstone." * * * * "Fucoidal impressions are also seen in some of the strata of this rock. * * * * "It is a hard stone to dress, and is one of the most durable kinds of rock." * * * * "In some places, in its lower part in particular, it is a metamorphic rock, having more or less the aspect of gneiss, except that mica is absent. Half a mile west of Putnam's Ferry, where it overlies granitic rocks, it is in an intermediate state, having the general aspect of a primary rock, but still shows its rounded gravel and sand." Mr. Mather mentions other places where it has been changed by metamorphic agency. In the northwest part of Clinton county, and in St. Lawrence and Franklin counties the lower portion of the Potsdam is a conglomerate, which in some places reaches the thickness of 300 feet.

Where the formation appears in Vermont it runs in mono-clinal, long or short, sharp ridges, and is thus spoken of by Dr. Edward Hitchcock in the first volume of the final report on the geology of Vermont, 1861: "Its lithological characters vary very little. In consequence of a metamorphic action we reckon three varieties:

1. Pure siliceous sandstone.
2. Hornblende schist.

3. Gneiss.

"The first of the trio is what is universally known as Potsdam sandstone, a hard, compact, thick-bedded sandstone, and perfectly homogeneous in structure, unless metamorphosed. Its color is generally white in the eastern part of North America; it being red upon the shores of Lake Superior." * * * "The second variety cannot be distinguished from the hornblende schist which occurs among the azoic rocks of Vermont and New York." * * * * "The third variety very closely resembles the Laurentian gneiss. It seems to pass into it by insensible gradations. All the constituents of this rock are very small, and occasionally the feldspar or the mica may be wanting. These hornblende schists and gneiss rocks, indicate a change has passed over a part of the Potsdam sandstone, analogous to the metamorphism that has so obscured the rocks of eastern Vermont; for such rocks as gneiss, &c., are not found, except by the crystallization of the constituent minerals after the accumulation of the sediments." Dr. Hitchcock also mentions veins of "granite" in the Potsdam at West Haven, whose feldspar is labradorite. At the time of Dr. Hitchcock's report the "red sandrock" of Vermont was not admitted within the Potsdam, nor was the "quartz rock" running along the western base of the Green mountains, but an earnest discussion was then going on between Professors Hall, Dana, Emmons, Marcou, Billings, Logan and others, concerning the geological position, and the actuality of any such system as had been designated Taconic, claimed by Prof. Emmons to lie directly below the Potsdam: *Vide* Am. Jour. Sci , 1861, No. 91; and Can. Nat. and Geol., 1861, Vol. VI, p. 106.

2. As to the palæontology of the New York typical potsdam. Prof. Hall reports in the first volume of the palæontology of New York, besides *Scolithus linearis*, two spieces of *Lingulæ*, viz: *prima* and *antiqua*. To this list have been added since a species of *Hyolithes* from Keeseville. Am. Jour, Sci., July 1871, p. 32; 1873, p. 211, vol. 5; imperfect specimens of supposed *Pleurotomaria* and *Conocephalites minutus*, from Keeseville. The last may belong to the beds below the Potsdam, as described by Brooks, Am. Jour. (3) IV, 22. In the state of Vermont have been discovered several species of trilobites, as well as other species of trilobites and brachiopods at Troy, N. Y., (Am. Jour. Sci., 1873, vol. VI, p. 134; vol. XI, 1876, p. 369.) But as their position in the formation is still in doubt, while some of them, especially those from Georgia, Vt. and Troy, N. Y., have been shown to belong below the Potsdam in statigraphical sequence, none of them should be embraced in the fauna of the typical Potsdam. At the same time the term Potsdam

has been extended loosely over these strata, especially by those who are adverse to the Taconic group of Emmons. (Am. Jour. Sci., 1880, vol. XIX, p. 152; Ibid, 1880, vol. XIX, p. 153 and p. 225.)

3. One of the results of the Taconic discussion was the establishment of the essential correctness of Prof. Emmons' claim, that beneath the Potsdam sandstone was still a fossiliferous horizon, which when metamorphosed constituted the roofing slates and talcose rocks of eastern New York and northern Vermont, though he perhaps extended it without warrant over areas where he had not sufficient evidence of its actual continuance. This error however, no more invalidated his claim to the correct establishment of his system than a similar supposed error in the extension of the Hudson River rocks where they were not proven to exist in Vermont, Massachusetts and eastern New York, destroyed that system. Geol. Wis., 1862, p. 443; Proc. Am. Ass. Adv. Sci., 1877, XXVI, p. 259. The palæontological investigations of Mr. Billings, seconded by Mr. Barrande, and of Mr. Ford, have amply demonstrated that beneath the horizon of the Potsdam sandstone is a series of rocks containing a primordial fauna, consisting of argillaceous slates, black slate, and thin-bedded sandstone with some limestone. This formation, sometimes known as the Georgia Group, is probably the equivalent of the Acadian of Dawson. According to Brooks, these strata, as they occur at Keene Station in St. Lawrence Co., N. Y., consist of magnesian schists, crystalline limestone and sandrock like the Potsdam but containing beds and veins of granite, the whole amounting to a mininum thickness of 700 feet, (Am. Jour. Sci. (3) IV. 22.)

4. The fossil species, described by Mr. Ford from these lower Potsdam, or Taconic rocks near Troy, N. Y., are sixteen, and a portion are identical with fossils from the Acadian. On the strength of palæontological differences Mr. Ford states that he considers these beds to occupy a lower geological horizon than the typical Potsdam of New York, and to be of nearly, if not exactly, the same age as the Georgia slates of Vermont, and the limestones on the north shore of the straits of Belle Isle. The fauna he regards "wholly distinct specifically from that of the upper Potsdam of Wisconsin and the true Potsdam of New York," (Compare Am. Jour. Sci., (3) XIX, 152.) After Mr. Barrande had indicated the primordial character of the trilobites of the Georgia slates, and Messrs. Billings and Logan had accepted his suggestion. Prof. Hall also recognized the strength of palæontological authority and admitted that the Potsdam of the New York survey was not the true primordial base. This true primordial zone is

characterized in America by such trilobites as *Paradoxides, Conocephalus, Arionellus, Conocoryphe*, and *Olenellus.*

5. If we next inquire what formation lies above the New York typical Potsdam, we shall find the Calciferous Sandrock described by Prof. Emmons as follows:—(Final Rep.) "Considered as a totality this is one of the most heterogeneous rocks in the New York system. That part which furnished the name is well designated under the descriptive term, and is easily recognized." This is a gray mass with sparkling grains of lime, but an impure limestone, being mechanically mixed with fine grains of sand and slight interlaminations of argillaceous matter. Another variety is a fine-grained and blue limestone, and another is red or chocolate colored, consisting of sandstone slightly interlaminated with shale.

Mr. Mather thus designates this formation: "The rocks are calcareo-siliceous, and sometimes one and sometimes the other predominates, and gives character to the rock. The water-lined laminæ of deposition are very conspicuous in some of the strata of the Calciferous sandstone. * * * * There are numerous small patches where these rocks have been upheaved and exposed, that are not continuous for any considerable distance * * * *, having been fractured across and heaved out of place along faults transverse to the lines along which the *principal* disturbances have taken place." This formation in N. Y. lies under the Chazy limestone.

6. The fossils of the Calciferous in New York, as reported by Prof. Hall in the first vol. of the palæontology of New York consist of the following:

Two species of *Palæophychus.*

One species of *Buthotrephis, Lingula acuminata, Euomphalus uniangulatus.*

Two spiecies of *Maclurea.*

Two species of *Ophileta.*

Two species of *Turbo.*

Pleurotomaria turqida.

Two species of *Orthoceras.*

To these Mr. Billings has added very many species from the adjoining portions of Canada, including gasteropods, brachiopods, and cephalopods. Of trilobites are fourteen species referred to the Calciferous, viz.: two of *Amphion*, six of *Bathyurus*, one of *Asaphus*, and others of *Agraulos* and *Conocoryphe.* The rocks of the Quebec group, which are placed by Prof. Dana above the Calciferous, seem to embrace both stratigraphically and palæontologically, the whole range of beds from the base of the *second fauna* to the top of the Chazy; and over two hundred and twenty species have been described from this group. But their relation to the Potsdam is still a matter of doubt. While stratigraphically they are placed above the Potsdam by Billings, Logan, Dana and Hall, they still have many of the species that have been reported from the western so-called Potsdam, viz.:

Four species of *Leptæna.*
Fourteen species of *Orthis.*
Three species of *Lingula.*
Two species of *Obolella.*
Two species of *Stricklandia.*
Two species of *Ecculiomphalus.*
Seven species of *Pleurotomaria.*
Two species of *Murchisonia.*
Three species of *Ophileta.*
Two species of *Holopea.*
Seven species of *Metoptoma.*
One species each of *Helicotoma* and *Maclurea.*
Seven species of *Orthoceras.*
Six species of *Cyrtoceras.*
One specie of *Nautilus.*

TRILOBITES.

Three species of *Agnostus.*
Two of *Arionellus.*
Two of *Asaphus.*
Eight of *Bathyurus.*
Two of *Cheirurus.*
Eight of *Dickelocephalus.*
Three of *Menocephalus.*

And one each of *Amphion, Amphyx, Conocephalites, Holometopus, Illænus, Nileus, Shumardia* and *Leperditia.* Mr. C. D. Walcott has also lately found the following new species in the Calciferous in Saratoga county, New York, viz.: *Platyceras minutissimum, Metoptoma cornutaforme, Conocephalites calciferus, Conocephalites Hartii, Ptychaspis speciosus* and *Bathyurus armatus,* of Billings. He remarks that "the occurance of a species of the genus *Ptychaspis,* associated with *conocephalites calciferus* and *C. Hartii*—species related to *Conocephalites Wisconsensis* and *C. Iowensis* of the Potsdam fauna of Iowa and Wisconsin—relates the fauna of the Calciferous formation of New York with that of the Potsdam sandstone of Iowa and Wisconsin."

We have now stated the essential features and the stratigraphical position of the typical Potsdam sandstone of New York, as given by the best authorities, and it will be best to recapitulate briefly.

1. It is a red or gray loose sandstone, often tilted or faulted, also metamorphozed, and then having the name of quartzyte.

2. It contains but very few fossils, three undoubted species being the most that can be referred to it, but not distinctly primordial.

3. It is underlain by a series of black slates and sandstones, with some limestones, which have exhibited in Vermont, at Troy, N. Y., and at the Straits of Belle Isle, a decidedly primordial type of life.

4. It is overlain by a formation which exhibits but few fossils in New York, but which in Canada holds a diversified fauna, placed by Barrande, Billings and Logan near the bottom of the second fauna, containing, among other species, numerous genera of trilobites.

If in the same manner the formations of the Lower Silurian in the west that may possibly be the equivalents of these three of New York, be reviewed, some light may be thrown on the question of the parallelism of the New York Potsdam in its western extension.

1. The lowest formation known in the northwest, which may be parallelized with the foregoing, is that which Sir William Logan denominated at first the "Lower Volcanic Group," and subsequently the "Kaministiquia Slates," and which Dr. T. S. Hunt has named the "Animikie Group." It is the same as that which contains the silver mines of the northwest shore of Lake Superior. It is briefly described in the Seventh Annual Report of the Minnesota Geological Survey. It consists emphatically of slates, but it contains many beds of gray quartzyte, and some of dolomite. It passes downward to the Gunflint beds of northern Minnesota, and *seems* to lie unconformably on the formation that has been accepted as the Huronian. It is cut by igneous dykes, and is interbedded with what appears to be a diabase rock. No fossils have been found in it. The slatiness of this formation is due to the horizontal sedimentary lamination, so far as seen, and not to a superinduced cleavage. The extent of this formation northwest of Lake Superior is unknown toward the north but it extends east and west at least one hundred and twenty-five miles. It is believed to occur in Michigan and Wisconsin, since mention has been made in geological reports of those States of a "black slate" in the Potsdam formation. Proc. Am. Assc. Adv. Sci., IX, 208; the Mineral Regions of Minnesota—Whittlesey, 1866, p. 4. Stratigraphically this seems to occupy the place of the Taconic rocks at Troy, N. Y., and of the Georgia Group of Vermont. Lithologically it has a close resemblance, and

palæontologically the evidence of parallelism is simply negative, *i. e.,* as no fossils have been found in it, no comparison can be made on that basis.

2. The foregoing formation is overlain by the Cupriferous rocks of Lake Superior (No. 3 above), whether conformably or not is not known, but so far as the evidence goes it appears in Minnesota to graduate into the overlying formation conformably, and unconformability is not reported by the Canadian geologists at Thunder Bay. This formation is pretty well known, so far as its associated igneous rocks are concerned, and the equivalency of its sedimentary portions with the Potsdam has been the subject of much discussion. A summary of opinions has already been presented. It is only necessary here to mention its outward characters, and to compare them with the three formations of New York, to each of which it has been referred by different geologists.

It is a red formation of shale, sandstone and conglomerate, metamorphozed by igneôus upheaval and fracture, locally changed to gneiss, syenite and hard, red quartzytes, and is interbedded with doleryte and mixed with gabbro. In it have been seen only the non-characteristic *Fucoides,* but its association with repeated igneous outflow is sufficient reason for the non-existence of animal life in the era of its deposition. Still if the sandstones of Tequamenon Bay in Michigan be considered its equivalent it may be said that two species of *Lingula* have been taken from this formation. Dr. Rominger, however, who has carefully examined the Upper Peninsula of Michigan, unhesitatingly places these in conspicuous formation, as he also does the bed of breccia containing the *Dikelocephalus* on the Menominee river near Grand Rapids —Geol. of Mich., vol, I, Part III, pp. 73 and 80. The beds at Marquette containing *Pleurotomaria* are placed by Mr. Billings in the Calciferous.

The lithological characters of this formation, therefore, ally it unmistakably with the typical sandstone of Potsdam, while stratigraphically it lies above a similar series of black slates and sandstones as in eastern New York and Vermont. If it be borne in mind that the typical Potsdam has a very meager fauna, consisting of but three species not characteristic of that horizon, it has a very close resemblance in its fauna also; and it is not unreasonable to suppose that when this horizon in the northwest has been as minutely examined as the typical Potsdam has in New York, an equal number of *Lingulae* may be found in it.

3. It is the overlying formation, however (Nos. 2 and 1), which af-

fords the best material for comparison with eastern rock horizons, as it is marked by a fauna very diversified and characteristic, and is easily traced, by a series of explorations by competent geologists, from the Mississippi river to Canada, with no very important interruptions, making a very close connection with an allied, if not an identical, formation in eastern Canada. Here are placed in one formation the foregoing Nos. 2 and 1, not because there is certainly any line of separation between Nos. 2 and 3, nor the absence of one between Nos. 2 and 1, but because on comparing the described characters of 1 and 2, they seem to occupy nearly the same geological horizon, and for the present purpose can best be considered as one. They consist of light-colored siliceous sandstones with some dolomitic layers near the top. They are horizontally stratified, and are seen in different places to lie unconformably upon the tilted layers and trap rocks belonging to No. 3—or the copper-bearing rocks. This is the case at Taylor's Falls, Minn., and at Kewenaw Point in Michigan. While it would perhaps be an arbitrary line which should set them off as a distinct formation from the copper-bearing series, they still need to be distinguished from that series on account of great lithological differences and stratigraphical position, as well as on account of the rich fossil fauna they have afforded. The fossils that have been described from the bluffs of the Mississippi and St. Croix rivers by Dr. Owen (Geol. Wis, Iowa and Minn.) and by Prof. James Hall (16th Regents' Report) are all from this formation, and it requires but a glance to see their resemblance to that fauna which has been found in Canada and described as in the Quebec group. These fossils, as enumerated by Prof. Hall in the 16th N. Y. Regents' Report, are as follows:

Five species of *Lingula*.
One species of *Lingulepis*.
One species of *Discina*.
One species of *Obella*.
One species of *Orthis*.
One species of *Platyceras*.
One species of *Euomphalus*.
One species of *Theca*.
One species of *Serpulites*.
One species of *Sendrograptus*
And of *trilobites* the following:
Six species of *Dikelocephalus*.
Eighteen species of *Conocephalites*.
One species of *Arionellus* (?).

Three species of *Ptychaspis.*
One species of *Chariocephalus.*
One species of *Illaenurus.*
One species of *Triarthrus.*
Three species of *Agnostus.*
One species of *Aglaspis.*
One species of *Pemphigaspis.*
One species of *Amphion.*

With such an array of identical genera, not to say species, it is safe to assume identity of geological era for these strata with those containing such a fauna in Canada—Pal. Fossil, p. 198; Am. Jour. Sci. (2,) XXXI, 222. It is to be admitted that these fossils have not yet been discovered in the arenaceous strata extending through northern Michigan, although the same friable formation, occupying the same stratigraphical horizon, extends from Wisconsin to the east end of Lake Superior, and has been traced by Prof. Chamberlain and Dr. Rominger. They are there kept constantly distinct by Dr. Rominger, from the underlying red sandstones, which he says are generally firm, and become disturbed by igneous upheavals in their lower portion. The sandrock, cut by the canal at Sault St. Marie, he says is the lower red sandrock.*

To what eastern formation this fossiliferous belt may finally be assigned, whether to the Quebec or to the Potsdam, it certainly shows the palæontology of the Quebec; but at the same time Prof. Hall has cautiously assigned it to the Potsdam of New York. He has also assigned the sandstones of No. 3 and No. 2 to the same, and his authority, therefore, to a great extent, nullifies itself.

It seems, therefore, that so far as present available information will warrant us in coming to a conclusion, we can accept the following as probable if not certain:

1. The Taconic Group was correctly establis by Prof. Emmons, though its limits, stratigraphically and geographically, were at first wrongly defined by him.†

2. The Georgia Group of Vermont, and the Animikie Group of Thunder Bay, and the Acadian of New Brunswick, are the equivalent of the Taconic of Emmons.

3. The Taconic has the true primordial fauna of Barrande.

*See Hunt on the identity of the Calciferous and Western Potsdam, Can. Nat. and Geol. (3) VI, 87; Azoic, Rocks of Penn. 1878. Report E., pp. 107 and 108.

†Compare Dana's investigation of the so-called Hudson River Group, in Mass., Vermont and New York. Am. Jour. Science, various papers in 1872—80.

4. The Potsdam, which lies conformably above it in the east, is represented by the rocks of the copper-bearing series in the west.

5. No fossils, representing the true primordial fauna, have yet been discovered in the west, nor have any been found in the western representative of the Potsdam.

6. The "second fauna" of Barrande is found in the Quebec group of Canada, and in the St. Croix sandstone of the west, lying in each case above the Potsdam sandstone.

IV.

TYPICAL THIN SECTIONS OF THE ROCKS OF THE CUPRIFEROUS SERIES IN MINNESOTA.*

By N. H. Winchell.

In northern Minnesota the cupriferous rocks, when crystalline, consist of two distinct types. One serie is *igneous*, and one is *metamorphic*.

The former may be broadly comprehended under the term *doleryte*, as defined by Prof. J. D. Dana. The most frequent representative of this group is the rock gabbro, consisting essentially of labradorite, augite and titaniferous magnetite. It produces the dark-colored and heavy rocks of the shore, is seen as layers alternating with the non-crystalline and sub-crystalline layers of the other group, and as massive, mountain-like elevations. It is often basaltic. On weathering, it decomposes and becomes greenish when near the water, but brownish when at higher elevations. It is often amygdaloidal, furnishing various zeolitic and other minerals. It has a very intimate, and yet very distinguishable association with the rocks of the other group; but in general it is the most conspicuous rock of the cupriferous series, causing the most of the salient features of the coast, and the prominent elevations of northeastern Minnesota. When in contact with the sedimentary beds, the rocks of the igneous group are but slightly affected by the interpenetration of the minerals of the other group. Yet in some instances isolated pieces of the sedimentaries have been embraced in the igneous rock, and so completely fused with them, that the minerals, that otherwise characterize each, are closely mingled over small intervals.

The rocks of the second or metamorphic group, on the other hand, are, in nearly all cases, of a reddish color. They show all stages of metamorphic change—from red sedimentary shale and sandstone to red

*From the proceedings of the American Association for the advancement of science, Vol. XXX, Cincinnati Meeting, August, 1881.

felsite and syenite The minerals that are invariably found in this rock, when completely crystalline, are quartz, orthoclase, and hornblende. The beds from which these crystalline red rocks were derived are seen interstratified with regularity with the rocks of the other group. But when these red rocks are crystalline or subcrystalline, the alternation is less evident. The alternation in this changed condition is less frequently seen in horizontal layers, but rather appears in sudden verticle replacement. In some places they appear to have had a great thickness, and they constitute, in their changed condition, some of the most interesting features in the geology of the north shore. The red felsite of the Great Palisades containing crystals of adularia, which is underlain by a very characteristic doleryte of the igneous group, and penetrated by numerous dykes from it, can be traced, in varied steps, on the one hand to its original condition, a shale of the Potsdam formation; and in the other direction, through step after step of metamorphic change, to a hard crystalline rock of red color and of a granular texture consisting essentially of orthoclase, quartz and hornblende. It is not always possible to observe a continuity of bedding from one extreme condition to the other. The circumstances of upheaval and metamorphism have generally been unfavorable for that. Some of the links are wanting in nearly every series of observations, but they are such as are supplied at other places—such places also failing to show other links. It may be supposed that it is necessary to make a perfectly connected series of contiguous observations, on a rock, *in situ*, changing from step to step, without interruption of the beds by dip or other cause, in order to establish the series; but such is not the case. When it once becomes evident that certain mineral associations are constant, if a part of these associations are observable, the rest may be relied on. When it is understood that there are two great sources of crystalline rock, the igneous and the metamorphic, and some of their related phenomena are established, such established phenomena are indices to show the origin of other new phenomena. Such new phenomena may again be taken in the same way to point others, and these again others. So at last a whole family of phenomena can be grouped together, although at no place can a connected series of all the phenomena be observed. In that manner, step by step, the lithology of the crystalline copper-bearing rocks can be reduced to two series. When these microscopic phenomena are in concord with and are affirmed by the field geology, as in the case on the north shore of Lake Superior, the true solution of some very interesting questions is found. The rocks of the second series, the result of the crystallization of the

Potsdam shales and sandstones, are found to occupy a large area in the extreme eastern portion of Minnesota, northeast of Grand Marais, while those of the first series seem to prevail along the shore, and to cause mountain ranges at some distance from the lake.*

The following brief descriptions are intended to give a general idea of the two groups.

(A) ROCKS OF THE IGNEOUS GROUP.

1. (Survey No. 1.) Gabbro, "Duluth Granite." From Rice's Point, near Duluth; the rock of a low mountain range. Contains labradorite and changed augite, the latter being uralitic; also titantiferous magnetite.

2. (Sur. No. 49.) Behind the M. E. Church, Duluth. Contains augite, plagioclase, and magnetite, with viridite and ferrite.

3. (Sur. No. 53.) East Duluth. Coarsely crystalline. Contains plagioclase, augite, magnetite, and delessite, also some chrysolite and biotite. In some places this rock also shows orthoclase, making it resemble No. 5 of the Survey numbers.

4. (Sur No. 90.) From the E. point of Sucker Bay. Contains plagioclase, augite, magnetite, chrysolite.

5. (Sur. No. 113.) Labradorite rock, from masses included in gabbro at Split-rock point.

6. (Sur. No 116.) From the point half-way between Split-rock point and Two Harbor Bay. Shows a basaltic structure. Contains plagioclase, augite, magnetite, viridite, opacite, and an occasional grain of biotite.

7. (Sur. No 123) From the bluff east of Castle Danger; a doleryte, containing plagioclase, augite, chrysolite, magnetite, and viridite.

8. (Sur. No. 126.) This is the rock that furnishes the black sand at Black Beach, a few miles W. of Beaver Bay, one-half mile up the creek. It seems to consist of plagioclase (labradorite?) hypersthene and magnetite, making the rock hyperyte. The metalloidal surfaces of the crystals in this rock resemble those of the rock of Encampment Island.

9. (Sur. No. 128.) Section of a large crystal of labradorite, from masses embraced in gabbro at Beaver Bay.

10. (Sur. No. 141.) Doleryte: first rock east of the Great Palisades, (lies below the Palisades?) Has augite, plagioclase, magnetite, viridite (and biotite?).

11. (Sur. No. 160) The rock that protects Little Marais on the east: plagiolase, augite, magnetite, also hematite and ferrite.

12. (Sur No. 199.) The rock of Grand Marais Harbor; plagioclase, pyroxene and magnetite; hematite, ferrite, apatite.

13. (Sur. No. 200) Cupriferous gabbro; from N. W. quarter Sec. 24, T. 61, R. 1. W. (up Fall river); plagioclase, augite (diallage?) magnetite, viridite, ferrite. There are thin sheets of native copper disseminated through the mass of this rock.

*A series of fifty thin sections with samples of the rocks from which they were prepared, were exhibited, and examined at the table by means of polarized light. on a microscope kindly loaned for the purpose by Mr. W. H. Bulloch of Chicago, Ill. They were numbered successively from one to fifty, the first twenty-one being of the igneous group, and the next twenty-one of the metamorphic. The last eight, from forty-three to fifty, were selected to show a mingling of the minerals of both groups in one rock. The samples of rock were numbered in blue shellac with the field number of the survey. The labels attached to the slides name the most evident and abundant of the minerals seen in each, as they have been identified by the writer.

The rock, as a dyke, cuts a rock like that of the Great Palisades—an amorphous red, but slightly porphyritic orthoclastic felsite.

14. (Sur. No. 221.) From a short distance east of the Brulé river; plagioclase, diallage and magnetite; coarsely crystalline.

15. (Sur. No. 229.) Doleryte; Red-rock Bay; runs under the E. Palisades.

16. (Sur. No. 161.) From the hill 520 feet above the lake on N. E. quarter Sec. 25, T. 64, R. 7 E., represents the rocks of the hills about Grand Portage; a doleryte, consisting largely of diallage, plagioclase and magnetite, with chrysolite and a little prehnite.

17. (Sur. No. 275.) From the dyke at the brink of Pigeon river falls; augite, plagioclase, magnetite and chrysolite?

18. (Sur. No. 291.) From the extremity of Pigeon point peninsula; like No. 1; gabbro; plagioclase; diallage, chrysolite, viridite and magnetite.

19. (Sur. No. 297.) Gabbro(?) from the English Rapids, on the international boundary, near Grand Portage; associated with the Animikie Group; augite, plagioclase, magnetite.

20. (Sur. No. 637.) The labradorite rock of Beaver Bay from masses embraced in gabbro.

21. (Sur. No. 664.) Augite, plagioclase, magnetite; from a ridge a little more than two miles north of Horse-shoe Bay.

(b) *Rocks of the Metamorphic Group.*

22. (Sur. No. 1 B.) Brownish-red, hornblende syenite, associated intimately with No. 1. Duluth. Contains orthoclase (changed), quartz, hornblende (often changed), magnetite, apatite and ferrite.

23. (Sur. No. 3.) Brownish or reddish rock. In the Rice Point range of hills; suburbs of Duluth; interception of 5th Av. E. and 7th St.; abruptly separated from No. 1 A by a compact dyke; consists essentially of orthoclase (which makes it sparingly finely porphyritic), quartz and hornblende. It also has apatite, magnetite and ferrite

24. (Sur. No. 7.) Brownish-red rock, fine-grained. Between 2nd and 3rd avenues, Duluth, near the lake. Tabular and imperfect crystals of flesh-red feldspar (orthoclase), viridite (from hornblende), magnetite, apatite, and a small amount of quartz.

25. (Sur. No. 8 A.) Rock inclusion in Survey No. 8; very fine-grained gray rock, showing fine crystals of red feldspar, probably orthoclase, but for the most part this is an amorphous, felsitic mass embracing grains of magnetite and viridite, with other minerals.

26. (Sur. No. 8 B.) Porphyry, Duluth. Has orthoclase, chlorite, magnetite and other minute grains; plainly a rock resulting from the metamorphism of the sedimentary beds.

27. (Sur. No. 8.) Sub crystalline, showing much magnetite and quartz; also undistinguishable grains, some of which are probably viridite, hæmatite and pyrite, in a felsitic paste.

28. (Similar to Sur. No. 8 C.) Finely sub-crystalline, nearly destitute of free quartz, brownish or reddish. Duluth.

29. (Sur. No. 17.) Outwardly and microscopically, a thin-bedded red shale or sandrock; east of the Brewery creek, Duluth, at the lake shore. In thin section

hows a rusty felsitic base with much magnetite or menaccanite, and viridite; the whole clouded with amorphous inclusions.

30. (Sur. No. 33 B) Metamorphic shale. Duluth, at the lake shore; has a felsitic (?) ground-mass, showing a porphyritic orthoclase; magnetite, viridite, hæmatite, apatite, quartz.

31. (Sur. No. 67.) Metamorphic shale, London, near Duluth.

32. (Sur. No. 117.) The reddish vein from Two Harbor rock, Two Harbor Bay. Quartz grains and geodic aggregations, in a reddish orthoclase base.

33. (Sur. No. 124.) Rock of the west bluff, at the entrance to Beaver Bay. Quartz grains with impurities, in a reddish, dimmed base that seems to be orthoclastic, magnetite, apatite.

34. (Sur. No. 127.) Hardened gray shale, from near the mouth of Beaver creek. Quartz grains can be seen in an amorphous, apparently felsitic base.

35. (Sur. No. 129.) Similar to 127, but porphyritic with orthoclase and translucent grains like adularia; a few rods N. E. of the mouth of Beaver creek.

36. (Sur. No. 134.) Quartz, orthoclase, magnetite. The quartz makes up about one-quarter of the whole, the orthoclase perhaps two-thirds, but the magnetite is only in occasional grains. This is from the third island east of Beaver Bay.

37. (Sur. No. 136.) Is from opposite the fifth island east of Beaver Bay. Wholly crystalline red rock, containing quartz, orthoclase and much of a green mineral that is probably changed hornblende. This green mineral is generally fibrous, with spreading, fan-shaped radiations, but not always. Sometimes it shows simply a green felted polarization, always green at +.

38. (Sur. No. 138.) The rock of the Great Palisades; an orthoclastic felsite, porphyritic with adularia, resembling Sur. No. 129.

39. (Sur. No. 201.) Orthoclastic felsite, with a few distinct crystals of orthoclase and adularia or sanidin. This is the Palisade rock from the Copper mine up Fall river.

40. (Sur. No. 264.) From the same place as Sur. No. 263, east of Wauswaugoning Bay. Quartzite fragment embraced in gabbro, quartz and hornblende in a cement of felsite.

41. (Sur. No. 265.) From the upper part of Sur. No. 263, where in contact with the metamorphic rock. Results from the inclusion of a fragment of the sedimentary beds in the igneous. Contains quartz, orthoclase and hornblende, with ferrite and graphite.

42. (Sur. No. 668.) The "red granite" of the region northeast of Grand Marais. Consists of orthoclase, quartz and changed hornblende with magnetite.

(c) *Mixed Igneous and Sedimentary Rocks.*

43. (Sur. No. 1 A.) Gabbro. Duluth. Rice Point range, near a contact with No. 1 B. Contains labradorite, uralitic augite, and titaniferous magnetite Some of the augite is changed toward viridite Orthoclase in occasional grains.

44 and 45. (Sur. No. 5.) At the depot, Duluth; labradorite, augite, quartz, magnetite, orthoclase, apatite. The augite is sometimes viriditic and sometimes uralitic.

46. (Sur. No. 6.) Labradorite, augite, magnetite, viridite (perhaps a result of change from hornblende) and an occasional grain of quartz. This is a dark-green,

heavy, homogeneous rock, coarsely crystalline, near the bay, in front of the Clark House, Duluth. The igneous type predominates.

47. (Sur. No. 46.) Rock showing the contact between the igneous and the metamorphic groups, from Duluth. One side of the section is red, and contains: quartz in perfectly distinct and abundant grains, making up about one-third or one-half of the whole; orthoclase, which is next in amount to the quartz, these two making up most of the section; apatite in small quantity; magnetite; ferrite and hornblende (?), in a few brownish-green or greenish grains which, on rotation at +, change from bluish-green to yellowish-green, and back again.

The other side is darker, and contains: plagioclase, augite grains (altered to uralite) disposed among the plagioclase, and in larger grains, sometimes fibrous and sometimes broken irregularly; magnetite in much greater amount than in the red rock; ferrite in small quantity.

48. (Sur. No. 263.) Contains the minerals both of the igneous and the sedimentary beds. From the E. side of Wauswaugoning Bay. Its position and limited extent show its accidental occurrence, and merely local importance. The igneous minerals are labradorite and magnetite. The sedimentary are quartz, orthoclase and hornblende. Apatite spicules penetrate them all.

49. (Sur. No. 282.) From the porphyritic main axis of the north part of Susie Island, near Pigeon Point. Contains plagioclase, orthoclase, hornblende, magnetite, quartz, pyrite.

50. (Sur. No. 675.) The rock of the top of Brule′ mountain, north of Grand Marais. Orthoclase, quartz, hornblende, plagioclase (?) magnetite, viridite, ferrite, chrysolite, apatite.

OBSERVATIONS.

The orthoclase of the metamorphic rocks is more readily disseminated through the igneous rocks than the triclinic feldspars of the igneous are through the metamorphic.

The magnetite of the igneous, as at Mayhew Lake, where it forms extensive beds of iron ore, may be derived from the exceedingly ferruginous sedimentary rocks. Magnetite seems to be always present in the crystalline metamorphic, and is probably the result of partial deoxidation from the indigenous hematite that gives them their color. Chemical analysis of the red shales would perhaps show the presence of titanium with the iron before metamorphism, and would indicate the correctness of this hypothesis. Wherever titanic iron is found in Minnesota, it is where the two series of rocks are in contact or proximity, so far as observed.

A fine shale becoming heated and slowly passing toward fusion will first show crystals of the easier fusible minerals, *i. e.*, orthoclase before quartz; and if the change stop there the resulting rock would be a non-differentiated (or felsitic) ground mass sprinkled with porphyritic feldspar crystals, all the siliceons parts being embraced in the ground mass. On the other hand, a fused sedimentary rock, passing to solidification, will first show crystals of the least fusible minerals, *i. e.*, quartz before orthoclase, and hence will contain more or less perfect crystals of quartz, cutting the sides of the later formed orthoclase. Hence the same metamorphic rock may show no quartz in one stage of metamorphism, but an abundance of free quartz in another. If the rock at first held grains of free quartz they would still remain in the former case, and would be an evidence of its original sedimentary source, and in the latter they would of course be subject to re-crystallization.

The term felsite, as used in this paper, is intended to express a non-differentiated, somewhat metamorphic rock, derived from shale, without any reference to the origin of felsite rocks described in other places.

V.

THE MUSEUM.

Report for 1881, *and List of Additions.*

During the year, 955 entries have been made in the Museum register. While the most of these specimens have been obtained through the agency of the survey, as in former years, yet many have been received by exchange and by donations. Exchanges have been made with Profs. C. U. Shepherd, Geo. F. Kunz, E. S. Dana, P. H. Mill, Jr., S. Calvin and S. G. Williams. The principal donors have been Col. J. B. Clough, superintendent of the construction of the Northern Pacific Railroad, who has sent the Museum valuable mammalian and archæological specimens from Montana; Mr. W. E. Swan, who has preserved drillings from various deep wells in the State and presented them to the Museum; U. D. Watkins, fossils and other specimens from Ohio; C. E. Whelpley, preserved drillings from the Minneapolis deep well, and Prof. C. W. Hall, various rock specimens from New England. Other donors are Regents Sibley, Chute and Gilfillan, W. D. Hurlbut, J. M. Sullivan, C. M. Terry, H. A. Strong, R. F. Laythe, Prof. J. S. Clark, S. F. Heath, John A. Green, S. Deutsch, D. A. Locke, H. S. Peters and Dr. Miller, Asst. Surgeon U. S. A., Little Missouri Cantonment.

The fossils that have been collected from time to time have not been reported until their names were determined, and hence the mc of them are still unreported. They are simply registered and label sufficiently to serve for identifying their sources. The crystallir rocks embraced in the series described in the survey report have n yet been registered in the Museum. They have the survey numbe only. Of some of them numerous duplicates have been obtained.

ELEPHANT'S TEETH FROM MONTANA.

Among the donations to the Museum by Col. J. B. Clough is a larg elephant's tooth which is worthy of special mention. Its companio a small specimen, was presented by Mr. S. Deutsch. The two wer obtained in the same locality but seem not to have belonged to th same individual. Unfortunately the larger specimen has begun t disintegrate by crumbling, and it is doubtful whether it can be pre served.

These teeth were obtained near the Rosebud river in Montana, b the parties constructing the Northern Pacific R. R , but their specia stratigraphical relations to the rocks of the region it has not been pos sible yet to ascertain. It has been stated by Mr. Deutsch simply tha they were from a deep cut composed of clay and loose rock. The ad hering portions of the matrix consist of a coarse, lime-cemented sanc or conglomerate like some known to exist in the cretaceous and ter tiary, and the tooth is probably not of post-tertiary age.

The larger tooth measures 12¾ inches in length and 6½ inches i transverse perpendicular section. Across the grinding surface i measures a little more than 3½ inches. It has, distinctly preserved, 2 transverse plates. There is an appearance, on the anterior extremity of a thin, imperfect plate, partly eroded, only a double scale of ename remaining, separated from the body of the tooth by a little cement This plate with its cement does not occupy the full width nor depth c the tooth, but was especially pitted to receive the first attrition on th tooth and to maintain its form and position, as the tooth advance The posterior end of the tooth also has the appearance of having com sisted of one or two more plates originally, but they are now lost by the disintegration which has attacked the whole tooth. Thus the plates must have numbered 22 or 23. The plates existing seem to have all suffered some grinding attrition, but only the anterior sixteen are so worn as to show on the crown the double enamel ridges. The posterior ones, which are more and more inclined forward, the farther they are removed from the front, are either in the immature stage of separate denticles which are not yet united on their summits, or are so involved with the cement that they are not yet even worn so as to produce the annular ridge of enamel exhibited by those farther advanced. The bases of these plates, however, with denticles at their summits, are united together into a common complex fold, firmly binding the tooth in one mass. This therefore seems to have been the sixth or last, molar of a mature elephant, or mammoth, and from the lower jaw.

The smaller tooth has lost by disintegration and fracture apparently about four of its plates from its posterior extremity. While it was found in the same locality it was probably not from the same individual. Its crown appears to have been unequally opposed by the tooth of the other jaw, for its plates are not worn off so as to show continuous transverse ridges of enamel, except on the anterior portion, the greater number of plates being simply rounded over, the denticles standing above the surface with their natural curved contour, with no flattened, grinding sarface. From the fact that the denticles are somewhat worn they must have served for mastication. The smooth, flattened, and oppressed appearance of the anterior extremity indicates that the preceding tooth had not yet been shed, but had been thrust by mastication constantly against it. Still it was not wholly protected by its predecessor, but was exposed *on the end*, as well as on the grinding surface to the attrition of mastication, and its most advanced corner is worn off obliquely by that means. It had about fourteen plates and its length was about ten inches. It was probably the fifth upper molar of the extinct mammoth.

The region in which the teeth were found is not drift-covered, but the soil and surface debris is the result of local disintegration of the cretaceous or tertiary beds. It is hence very probable that these teeth are true fossils, of an age prior to the glacial epoch.

SPECIMENS REGISTERED IN THE MUSEUM IN 1881.

Serial Numbers.	Obtained.		NAME.	No. of Specimens.	Locality.	Formation.	Collector and Remarks.
	When.	Whence.					
3736	Aug., 1880	C. W. Hall.	Granite..........	2	Rockport, Mass..........	....	C. W. Hall, Rockport Granite........
3737	"	"	Granite..........	2	Quincy Mass..........	....	" Quincy Granite..........
3738	"	"	Petrosilex..........	4	Marblehead Neck, Mass........	Huronian	" Porphyritic..........
3739	"	"	Diorite..........	2	" "	"	" ....
3740	"	"	Diorite..........	1	" "	"	" ....
3741	"	"	Petrosilex..........	2	" "	"	" Finely Crystalline, weathering surface shows effect of pressure on the bedding........
3742	"	"	Granite..........	2	Manchester, Mass..........	Montalban	C. W. Hall, considerably weathered..
3743	"	"	Serpentine..........	1	Lynn, Mass..........	....	" ....
3744	"	"	Breccia..........	2	Marblehead Neck, Mass........	Shawmeet	" Petrosilicious..........
3745	"	"	Breccia..........	6	" "	"	" Water-worn and weath'd
3746	"	"	Dialase..........	2	Salem Harbor.......... Baker' Slam..........	Naugus H'd Series	" Showing vein of Elvanite
3747	"	"	Feldspar..........	1	" "	"	" Pyroxenic..........
3748	"	"	Beach pebbles of Petrosilex..........	5	Marblehead Neck, Mass.........	Huronian	" Showing bedded structure
3749	"	"	Beach pebbles of Petrosilex..........	10	" "	"	" " Porphyritic ....
3750	"	"	Beach pebbles of Diorite..........	4	" "	"	" ....
3751	"	"	Slag from iron furnace..........,	2	Detroit, Mich..........	....	" Form'd in smelt'g sc'p iron
8752	Oct., 1880	"	Haematite..........	1	Kewanaw, Vt..........	Huronian	C. W. Hall, Micaceous and folded by pressure..........
3753	"	"	Limestone, Glen's Table Block Marble..........	1	Glen's Falls, N. Y..........	Trenton	Presented by J. M. Sullivan..........
3754	"	"	Sandstone..........	2	Opp Fond du Lac..........	Potsdam	Used in const'n of Westminister C'h.
3755	Nov., 1880	Geol. Survey	Sandstone..........	1	Taylor's Falls..........	St Croix	C M. Terry, show'g lines of iron stain
3756	"	C. M. Terry	Shell Limestone..........	2	St. Agustine, Fla..........	Tertiary	Presented by C. M. Terry..........
3757	Dec., 1880	Geo. Nat. Hist. Sur.	Galenite, (weight 390 lbs.)..........	1	Galena, Ill..........	Galena	Purchased by Regent Chute..........
3758	Nov., 1880	C. U. Shepard	Meteoric Iron found in 1865..........	1	Bonanza. N. Mexico..........	....	By exchange with Prof. C. U. Shepard
3759	"	"	Meteoric Stone, Jan. 30, 1868..........	1	Poltusk Vasovia, Poland..........	....	" "
3760	"	"	Meteoric Stone, Jan. 9, 1866..........	1	Knyahinya, Hungary..........	....	" "
3761	"	"	Meteoric Stone, Feb. 25, 1847..........	1	Linn Co. Iowa..........	....	" "
3762	"	Alf'd R. C. Selwyn	Meteoric Stone, found in 1872..........	1	Mitchell Co., Kansas..........	....	" "
3763	"	Geol & Nat Hist Sur	Eozoon Canadense..........	3	Petite Nation, Can..........	Lan.	Presented by the Geol. Sur. of Canada
3764	Dec., 1880	"	Cubic Galenite, (slab on carb. zinc)..........	1	Galena, Ill..........	Galena	Purchased by Regent Chute..........
3765	"	"	Cubic Galenite..........	6	"	"	" " ....

Specimens Registered in the Museum in 1881—*Continued.*

Serial Numbers.	Obtained. When.	Obtained. Whence.	NAME.	No. of Specimens.	Locality.	Formation.	Collector and Remarks.
3766	Dec., 1880	Geol & Nat Hist Sur	Sphalerite	1	Galena, Ill	Galena	Purchased by Regent Chute
3767	"	"	Pyrite	4	"	"	" "
3768	"	"	Ores from Galena	3	"	"	" "
3769	"	"	Pyrite, (cylindrical stems)	4	"	"	" "
3770	1880	"	Brick	1	Marshall		Warren Upham, (W. A. Crooker, Maker)
3771	"	"	Brick	1	Jackson		Warren Upham, (Maj. H. F. Bailey)
3772	"	"	Brick	1	Marshall		Same, (James M. Lockey)
3773	"	"	Granite	6	Near W line sec 29, Posen, Y. Med. Co.		"
3774	"	"	Granite	21	1¼ m S E from Big Stone Lake		"
3775	"	"	Granite (?)	....	Redwood Falls		" (Quarried)
3776	"	"	Gneiss	25	2 m S E from Montevideo		"
3777	"	"	Gneiss	21	Granite Falls		" Excavated in Main street)
3778	"	"	Cretaceous Sandstone	20	Sec. 12, Altavista, Lincoln Co	Cret	"
3779	"	"	Granite	3	N E ¼ sec 32, Echo, Y. Med. Co.		" Nearly all this outc'p is Gneiss
3780	"	"	Hornblendic Schist	3	Sec 17, Omro, Y. Med. Co., (N W outcrop)		"
3781	"	"	Hornblendic Schist	3	" (S E outcrop)		"
3782	"	"	Cemented Drift Gravel	3	S W ¼ sec 31, Nordland, Lyon Co		"
3783	"	"	Pottery Clay	3	N part sec 3, Sigel, Brown Co	Cret	"
3784	"	"	Protogine Gneiss	3	West side Redwood river,		" Opp. Birum's mill.
3785	"	"	Cretaceous Sandstone (?) weathered)	2	N E ¼ sec 20, Eidsvold, Lyon Co	Cret	" On land of Henry Jacobs,
3786	"	"	" " (fresh)	3	" "	"	"
3787	"	"	Red Quartzyte	....	N E ¼ sec 25, Selma, Cot. Co	Potsdam	"
3788	"	"	Potsdam Sandstone, (Quartzyte range)	....	N E cor. sec 36, Germantown, Cot. Co	"	" At Mound Creek Falls
3789	"	"	Red Quartzyte	......	W p't S W ¼ sec 6, Dale, Cot. Co	"	"
3790	"	"	Red "	....	" "	"	" Containing breccia fragments of Pipestone
3791	"	"	Lignitic Sandstone	4	S E ¼ sec 2, Eidsvold, Lyon Co	Cret	" "Petrified tree."
3792	"	"	Clay containing Cretaceous shells	1	Sec 8, T 111, R 38, Redwood Co		" (Absalom Ames' well)
3793	"	"	Gneiss	1	N E ¼ sec 12, T 111, R 38, "		"

3794	1880	Geol & Nat Hist Sur	Pipestone enclosed in Quartzyte	2	S W ¼ sec 2, Amboy, Cot. Co.	Potsdam	"	(Much jointed)
3795	"	"	Red Quartzyte	2	S E ¼ sec 23, Selma, Cot. Co.	"	"	
3796	"	"	Red "	2	S W ¼ sec 18, Delton, "	"	"	
3797	"	"	Pipestone in Quartzyte	5	W p't S W ¼ sec 6, Dale, Cot. Co	"	"	Peter Schmidt's quarry
3798	"	"	Potsdam Quartzyte	2	N p't sec 31, Stately, Brown Co	"	"	Falls in E branch of Mound Cr
3799	"	"	Sandstone (Oolitic in structure)	1	N W ¼ sec 7, Eidsvold, Lyon Co	Cret	"	
3800	"	"	Lignitic Cretaceous Sandstone	1	N W ¼ sec 3, Sigel, Brown Co	"	"	Overlying pottery clay (No 3783)
3801	"	"	Gneiss (weathered)	1	N E ¼ sec 12, T 111, R 38, Redwood Co		"	
3802	"	"	Cretaceous Sandstone	2	Sec 7, Westerheim, Lyon Co.		"	
3803	"	"	Potsdam Quartzyte	2	N E cor. sec 36, Germantown, Cot. Co.		"	At Mound Creek Falls
3804	"	"	Cretaceous Sandstone	2	Sec 12, Altavista, Lincoln Co.		"	
3805	"	"	Bones and Petrified Wood	4	Shore of Swan Lake, N W Cor Redwood Co.	Drift	"	Pres. by Malcolm McNiven
3806	"	"	Lepidodendron	1	Lake Okabena, Worthington	"	"	Pres. by J. A. Phelps
3807	"	"	Quartzyte	3	Mound, Rock Co		"	J. F. Shoemaker's Quarry
3808	"	"	Cretaceous Sandstone, with leaf impressions	1	N side Cottonwood river, sec 25, North Star		"	Pres. by John F. Burns
3809	"	"	Cretaceous Sandstone, (fossiliferous)	1	" "		"	" "
3810	"	"	Brick	1	Brainerd		"	(Mr. Schwartz, maker)
3811	"	"	Sandstone	27	Hinckley, Pine Co	Potsdam	"	
3812	"	"	Trap	4	Watab, Benton Co.		"	Forming S E side of T. N. Newson's shaft
3813	"	"	Syenite	2	" "		"	Talcott, Castle & Co.
3814	"	"	Syenite	2	" "		"	land of Jos. Campbell
3815	"	"	Trap		Chengwatana, Pine Co.		"	
3816	"	"	Syenite, (very dark)	2	N W ¼ sec 33, St. Cloud		"	
3817	"	"	Syenite	3	N. E. ¼, sec 32, St. Cloud		"	
3818	"	"	Syenite	2	S W ¼ sec 17, Haven, 4 m S E of St. Cloud		"	Robbers & Barthelemy's quarry
3819	"	"	Red Syenite	3	Haven, 2 m S E of St. Cloud		"	Breen & Young's quarry
3820	"	"	Gray Syenite	4	" "		"	
3821	"	"	Gray Syenite	3	Sauk Rapids		"	Collins, Mitchell, and Searle
3822	"	"	Staurolitic Schist	3	3 m s of Pike Rpds in E bnk Miss		"	I. P. Lambert's land
3823	"	"	Syenite	2	Sec. 26, St. Joseph, Stearns Co.		"	Fred Schilplin's land
3824	"	"	Syenite	1	2 mi. W. of Cold Spring		"	
3825	"	"	Syenite	1	Cold Spring, Stearns Co.		"	
3826	"	"	Vein and Reddish Syenite	1	Sec. 27, Watab, Benton Co.		"	T. N. Newson's shaft
3827	"	"	Syenite (coarse grained)	2	Sec. 19, St. Augusta, Stearns Co		"	
3828	"	"	Syenite	1	N W ¼ sec 17, St. Cloud		"	
3829	"	"	Syenite (dark)	1	Sec. 27, Watab, Benton Co.		"	Hill 1-6 m E. of Newson's shaft
3830	"	"	Syenite (reddish)	1	Sec. 35, Watab, Benton Co.		"	H. D. Gurney's quarry
3831	"	"	Syenite (red)	1	Le Sauk, Stearns Co.		"	½ m N. of Sartell's grist-mill
3832	"	"	Granite (coarse)	2	Rockville, Stearns Co.		"	only rock at Rockville
3833	"	"	Syenite (dark)	1	Sec. 27, Watab, Benton Co.		"	N W side of hills near Miss.
3834	"	"	Syenite (grey)	1	Sec. 35, Watab, Benton Co.		"	H. D. Gurney's quarry
3835	"	"	Syenite (dark)	2	2 m s e of Richmond, Stearns Co		"	
3836	"	"	Syenite (reddish, fine grained)	1	Cold Spring, Stearns Co		"	
3837	"	"	Syenite or Granite	1	East p't sec 18, St. Cloud		"	
3838	"	"	Porphyry	1	Sec. 19, St. Cloud		"	(locality not visited)

Specimens Registered in Museum in 1881—Continued.

Serial Numbers	Obtained. When.	Obtained. Whence.	NAME.	No of Specimens.	Locality.	Formation.	Collector and Remarks.
3839	1880	Geol & Nat Hist Sur	Rock somewhat used for railroad masonry.....	2	Quarried near Thompson or Duluth	....	" (from Brainerd car-shops).....
3840	"	"	Syenite..................................	1	Sec. 21, Le Saux, Stearns Co. .	....	" at Sartell's grist-mill...........
3841	"	"	Syenite (dark)..............................	1	S W cor sec 28, St Cloud.......	....	" (In road.).......................
3842	"	"	Syenite (porphyritic, reddish).................	1	Sec. 27, Watab, Benton Co.	....	" w side of vein T N Newson's shft
3843	"	"	Agates...................................	1	Royalton, Morrison Co	Drift.	" presented by Harry Young.....
3844	"	"	Vein......................................	1	Sec. 27, Watab, Benton Co......	....	" T N. Newsons shaft...........
3847	"	"	Kaolin	1	Mouth of Two Rivers, Mor'n Co	Cret.	" Calvin A. Tuttles well..........
3848	"	"	Garnetiferous Schist.........................	...	2 m below Pike Rapids........	....	Warren Upham, W. side of Miss. R...
3849	"	"	Pebbles from Sandstone......................	....	Knife R bridge on Snake R.....	Potsdam.	" 6 m N. of Bruns'ck, Kan'c Co.
3850	"	"	Sandstone.................................	6	Knife R. bridge on Snake R.....	Potsdam.	" ....
3851	"	"	"	8	7 m. E. N. E. of Rush City, ¾ m above mouth of Rock Creek	St. Croix.	" Minn. side of St. Croix River.
3852	"	"	"	2	" "	"	" Wis " " "
3853	"	"	" containing large pebbles.............	1	" "	"	" " " "
3854	"	"	Red Shale used for paint....................	1	St Croix R bet Snake & Kettle R's	"	" a layer in sands'ne on Wis side
3855	"	"	Fossiliferous Shale.........................	5	30 rds. above Taylor's Falls Bg.	"	" West bank St Croix River.
3856	"	"	" "	5	Taylor's Falls..................	"	" ....
3857	"	"	Trap......................................	1	" "	....	" near N. C. D. Taylor's shaft..
3858	"	"	"	2	" "	....	" ....
3859	"	"	"	1	" "	....	" at Landing.....................
3860	"	"	"	1	1 m. S W. Taylor's Falls......	....	" under the conglomerate.......
3861	"	"	"	1	" " "	....	" over " " ....
3862	"	"	Cuprif. Conglomerate in trap rock.............	1	" " "	....	" Dip, 12° W S W bed, 8 ft thick
3863	"	"	Vein-matter................................	4	" " "	....	" Taylor's Falls, Mining Co.....
3864	"	"	Ore (Arseno-pyrite?)........................	1	" " "	....	" found in Trap.................
3865	"	"	Native Copper..............................	1	" " "	....	" Taylor's Falls Mining Co.....
3866	"	"	Ore (Ruby blende?)..........................	1	" " "	....	" bet shafts of N. C. D. Taylor & T. F. Mining Co.................
3867	"	"	Sandstone, fossiliferous......................	2	Franconia ½-¾ m north of Munch's mill, St. Croix......	St. Croix.	W Uph'm, in ravine of Lawr'nce Creek
3868	"	"	" "	1	At Munch's mill, Franconia ...	"	" (Mill is built of this)..........

3870	1880	Geol & Nat Hist Sur	Sandstone, fossiliferous	10	Franconia, Chisago Co	St. Croix.	W. Upham
3871	“	“	Calcareous Tufa	4	“ 1-5 m. S of Munch's Mill		“ used for lime, very large dep't.
3872	“	“	Gneiss (weathered)	1	N E ¼ Sec 32 Echo Yel Med Co.		“
3873	“	“	Granite (coarse, reddish, feldspathic)	1	“ “ “ “		“ at S. end of Gneiss
3874	“	“	Mica Schist (black) in Gneiss	1	“ “ “ “		“
3875	“	“	Gneiss	1	N E ¼ sec 12; T 111, R 38, Redwood Co		“
3876	“	“	Mica Schist (dark) in Gneiss	1	N E ¼ sec 12, T 111, R 38, Redwood Co.		“ in two or three masses, each 2or 3 feet long
3877	“	“	Gneiss	1	Redwood Falls		Warren Upham, Main Falls
3878	“	“	Trap dike	1	“ “		“ “
3879	“	“	Hornblende Schist	1	East Granite Falls		“ bet bridge and Pillsb'y's El'or.
3880	“	“	“ (jointed, traplike)	1	“ “		“ at Pillsbury's elevator
3881	“	“	Red Quartzyte	1	N W ¼ sec 29, Adrian, Wat. Co.	Potsdam.	“
3882	“	“	“ “	1	S E ¼ sec 30, Delton Cot. Co.	“	“
3883	“	“	“ “	1	N W ¼ s 28, Storden Cot. Co.	“	“
3884	“	“	Specimens of stone	....	R. R. well at Heron Lake	“	“ the red pieces from 180-220 ft., the yellow lower, 1 ft. thick
3885	“	“	“ “	....	“ “ “	“	W Uph'm, drilled thro. in 1st 180-220 ft.
3886	“	“	Red Quartzyte	2	Pipestone City	“	“ quarried by Chas H Bennett
3887	“	“	Red Quartzyte (ripple marked)	2	“ “	“	“ “ “
3888	“	“	Conglomerate	1	4 m. S. W. from Pipestone City.	“	
3889	“	“	Red Quartzyte	2	Dell Rapids, Dak., 18 m. N. of Sioux Falls	“	“
3890	“	“	“ “	2	Sioux Falls, Dak	“	“
3891	“	“	“ “	1	Devils Gulch, Minnehaha Co. Dak. 2½ m. N. E. of Palisades	“	“
3892	“	“	Pipestone	1	Palisades, Minnehaha Co., Dak.	“	“ stratum 5 ft. thick, 5 rods S. of dam and 10 feet below
3893	“	“	“ (mottled variety)	1	“ “ “	“	W. Upham, “ “ “
3894	“	“	“	1	“ “ “	“	“ ¼ m. S. W. of mill, 7 ft. thick.
3895	“	“	Sandstone (pink)	2	“ “ “	“	“ half way in location and appearance, between pipestone and “chalk rock”, all being in s. plane.
3896	“	“	“ (white)	4	“ “ “	“	W Up'm, “chalk rock”, 20 rds. E of dam, and in plane with pipestone.
3897	“	“	“ (white) a var. holding concretions	2	“ “ “	“	W Up'm, “chalk rock” grad ch to this
3898	“	“	“ (pink)	1	“ “ “	“	“ lower pt of bed of “ch'lk r'ck”
3899	“	“	St. Lawrence Limestone	1	Judson, Blue Earth Co	Lr. Mg.	“ Mrs G W Wolf's qu'y at house
3900	“	“	“ “ “ (arenaceous)	1	“ “	“	“ q ⅙ m S E of hs; lower pt of bs
3901	“	“	“ “ “ “	1	“ “	“	“ ⅓ m W of Mrs G W Wolf's hs; lower part of beds
3902	“	“	“ “ “ “	1	“ “	“	W. Upham, C. G. Swanson's quarry
3903	“	“	Jordan Sandstone	1	Near center of N W ¼ sec 12 Jud.	Jordan.	“ brink of unnamed water fall.
3904	“	“	“ “	1	Minneopa Falls, Blue Earth Co.	“	“
3905	“	“	“ “	1	N. W. ¼ sec. 17, South Bend, Blue Earth Co	“	“
3906	“	“	Shakopee Limestone	1	South Bend, Blue Earth Co.	Shakopee.	“ David P Davis' quarry
3907	“	“	“ “	2	L B'nk, Wat. R, N E of G'dn C'y	“	“ qy. on S M Folsom's estate.
3908	“	“	“ “	1	W. side Maple R., S W ¼, sec. 12; Rapidan B. E. Co.	“	“ Columbus Ballard's quarry.

Specimens Registered in Museum in 1881—Continued.

Serial Numbers.	OBTAINED. When.	OBTAINED. Whence.	NAME.	No. of Specimens.	Locality.	Formation.	Collector and Remarks.
3909	1880	Geol & Nat Hist Sur	Sandstone containing lignite-particles	1	Sec. 6 Rutland, Martin Co......	Cretaceous.	" G S Livermore's land, sometimes oolitic, like the Altavista stone which perhaps corresp'ds with this.
3910	"	"	Sandstone..	2	" " S side Elm Creek...	"	Warren Upham, G S Livermore's land.
3011	"	"	Willow leaf in sandstone (A)...................	2	Sec 25, North Star, Brown Co....	"	same, N. bank of Cottonwood River.
3912	"	"	" " " (B)....................	1	" " " "	"	" " " "
3913	"	"	Clay..	1	R R well at Wal't Grove, Red Co	"(?)	" 60- 80 feet..............................
3915	"	"	Iron Pyrites..	1	P. Crampton's well, S W ¼ sec 8, Eidsvold Lyon Co..........	"	" ....
3920	"	"	Gypsum...	1	Sec. 28, Grand View, Lyon Co.	"	" S. W. Lathe's well..............
3921	"	"	Clay in hollows of Shakopee Limestone.........	1	South Bend, Blue Earth Co.....	"	" ....
3922	"	"	Clay..	1	Red Jacket Mills, Blue Earth Co	"	" used by A Gapter at Mankato for pottery................
3923	"	"	Gravelly Clay.......................................	1	" " "	"	" thin layer in sand at base of Gapter's clay bank..........
3924	"	"	"Chalk"..	1	" " "	"	" Gapter's clay-bank..............
3925	"	"	Limestone...	1	White Earth Agency.....	Drift.	" boulders and gravel, common.
3926	"	"	Specimen of the "Three Maidens"...............	1	Pipestone Quarry, Pipestone Co.	"	" originally one gigantic boulder.
3927	"	"	Calcareous Tufa....................................	....	Camden Mill, Lynd, Lyon Co.	....	" ....
3928	"	"	Septaria...	1	Jackson, Jackson Co...........	Drift.	" from a cellar, pres. by G. C. Chamberlin..........................
3929	"	"	Septaria-like stone...............................	1	Sec. 6 Rutland, Martin Co......	"	" ....
3930	"	"	Drift gravel, cemented by calc. tufa............	1	Garden City, Blue Earth Co., 20-30 rds E of E T Nort'n's hs	"	" S E side Wat. River............
3931	"	"	Iron-cemented gravel.............................	1	Red Jacket Mills, Blue Earth Co	"	" above pottery clay (3922)......
3932	"	"	Petrified wood......................................	....	" " "	"	" found by Georgie S. Bingham..
3933	"	"	Wood, S. C. Gale's well..........................	....	Sec. 10, Gales, Redwood Co......	"	" at 27 feet, below blue till.......
3934	"	"	Hollowed pebbles..................................	....	" " "	"	" presented by S.C. Gale........
3935	"	"	Hollowed pebbles..................................	1	S. W. Minnesota.................		
3936	"	"	Efflorescence..	....	Sec 14, Iona, Murray Co........	"	" ....
3937	"	"	(Scale)...	1	Marshall, Lyon Co...............	....	" from thresher boiler used 3 mos
3938	"	Geo. F. Kunz.	Vertebra...	1	Charleston, S. C..................	Cretaceous.	By exchange..............................
3939	"	"	Chlorophane...	1	Hardin Co., Ill..., ...	....	" ....

3940	1880	Geo. F. Kunz.	Celestite and Sulphur	1	Mt. Girgenti, Sicily	Cretaceous.	By Exchange	
3941	“	“	Sphalerite and Marcasite	2	Missouri		“	
3942	“	“	Calcite, (Dog tooth Spar)	1	Falls of Ohio, Louisvile, Ky		“	
3943	“	“	Silver on Galena and Sphalerite	1	Silver City, Ark.		“	Demby mine
3944	“	“	Natrolite	1	Aussig, Bohemia		“	
3945	“	“	Gold and Silver	1	Silver City, Ark		“	Diamond Joe mine
3946	“	“	Whalebone	1			“	
3947	“	“	Aragoanite. “Sprudelstein”	1	Karlsbad, Bohemia		“	
3948	“	“	Gold and Silver	4	Silver City, Ark		“	
3949	“	“	“ “ in slate	1	“ “		“	Diamond Joe mine
3950	“	“	Aphorite	1	Lime Rock, R. I.		“	
3951	“	“	Wavellite, (white variety)	1	Bohemia		“	
3952	“	“	“	1			“	
3953	“	“	Ottrelite	1	Ottrez. Belgim		“	
3954	“	“	Magnetite	1	Port Morris, N. Y.		“	
3955	“	“	(?)	2	England		“	
3956	“	“	Monazite	1	Koralfet, Sweden		“	
3957	“	“	Elaeolite—sunstone—	1	Magnet Cove, Ark		“	
3958	“	“	Fascicolite	1	Vermont		“	
3959	“	“	Phyllite	1	Chauston, R. I.		“	
3960	“	“	Bituminous Coal	Indf	Mahoning Co., Ohio		“	
3961	“	“	Pseudovermiculite	2	Magnet Cove, Ark		“	
3962	“	“	Ore from Iron mine	2	Monroe, N. Y.		“	
3963	“	“	Pyrite and Hematite	1	Rossie, N. Y.		“	
3964	“	“	Vasite	1	Ytterby, Sweden		“	
3965	“	“	Rosettes of Nigrine	6	Magnet Cove, Ark		“	
3966	“	“	Fluorite	2	Hardin Co., Ill		“	
3967	“	“	Brookite on rock	1	Magnet Cove, Ark		“	
3968	“	“	Hydrolitanite	3	“ “ “		“	
3969	“	“	Perofskite	Indf	“ “ “		“	
3970	“	“	Schorlomite	1	“ “ “		“	
3971	“	“	Naerite on Calcite	1	Lime rock, R. I.		“	
3972	“	“	Bowenite	1	Cumberland, R I.		“	
3973	“	“	Gehlenite	1	Austria		“	
3974	“	“	Kjerulfin and Tschernakite	1	Norway		“	
3975	“	“	Ludwigite	1	Westphalia		“	
3976	“	“	Erbenstein	1	Karlsbad, Bohemia		“	
3977	“	“	Hornblende in quartz	1	Cumberland, R. I.		“	
3978	“	“	Quartz geode	1	Brazil		“	
3979	“	“	Smoky quartz	1	Minas Geras, Brazil		“	
3980	“	“	Glauconite	2	Marlboro, Monmouth Co., N. Y		“	
3981	“	“	Piece of shark's rib	1	Charleston, S. C		“	
3982	“	“	Conglomerate	1	Pennsylvania		“	oil layer
3983	“	“	Pearl Spar	1	Niagara Falls, N. Y		“	
3984	“	“	Calcite, (hexagonal)	1	St. Anthony's Nose, N. Y		“	
3985	“	“	Calcite (dog-tooth spar) and dolomite	1	Lockport, N. Y		“	
3986	“	“	“ “	1	Niagara Falls, N. Y		“	
3987	“	“	Petragotus sp?	1	Buffalo, N. Y		“	
3988	“	“	Calc tufa, replacing sticks	1	New York		“	
3989	“	“	Coral	4	Falls of Ohio, Louisville		“	
3990	“	Geol & Nat Hist Sur	Shakopee limestone	3	St. Peter, Nicollet Co	Shakopee.	Warren Upham,	Jno. Malgrien's quarry

Specimens Registered in Museum in 1881—*Continued.*

Serial Numbers.	OBTAINED. When.	OBTAINED. Whence.	NAME.	No. of Specimens.	Locality.	Formation.	Collector and Remarks.
3991	1880	Geol & Nat Hist Sur	Shakopee Limestone, (weathered)............	1	St. Peter, Nicollet Co.........	Shakopee.	Warren Upham, A. J. Lamberton's quarry, worked by Hugh Brogan.
3992	"	"	"	1	Eagle Creek, 4 m E of Shakopee	"	Warren Upham, Thos. Durose's land.
3993	"	"	"	2	Mankato......................	"	" George Maxfield's quarry, the three foot shaly cement layer......................
3994	"	"	"	1	"	"	" Geo. Maxfield's best cut stone 4 feet thick, next below the shaly layer..................
3995	"	"	"	1	"	"	" Geo. Maxfield's quarry, cut stone at 6 feet above shaly layer......................
3996	"	"	"	1	"	"	" Geo. Maxfield's, 12 or 15 feet above shaly layer; red layer of cut stone 3 feet thick....
3997	"	"	"	3	Lime S E ¼ sec 19, Blue Earth Co	"	" Joseph Kunz's quarry..........
3999	"	"	"	1	Mankato	"	" J. R. Beatty—the quarry on road to Red Jacket mill, said to yield good hydr. cement
4000	"	"	"	3	Lime sec 20, Blue Earth Co.....	"	" J. R. Beatty..................
4001	"	"	" (iron-stained)................	1	1-5 m s of Sioux City, Merriam Junction, Scott Co...........	"	" In railroad cut................
4002	"	"	"	4	Sec. 18, Decoria, Blue Earth Co	"	" Matt Ryan's quarry............
4003	"	"	Jordan sandstone..........................	2	Jordan, Scott Co..............	Jordan.	" Frank Nicolin's quarry........
4004	"	"	"	3	" "	"	" Foss, Wells & Co's. quarry....
4005	"	"	Trenton limestone.........................	3	Sec. 27, Eureka, Dak. Co.......	Trenton.	" Amund Torgerson's quarry.....
4006	"	"	Boulder containing a green mineral...........	3	Blooming Grove, Waseca Co....	Drift.	" ....
4007	"	"	Pebbles and Boulders......................	Indf	Sec. 13, Kiester, Farib. Co......	"	" from top of Kiester hills & kames
4008	"	"	Round pebbles from hollows in Shak. limestone	....	Sec 19, Lime, Blue Earth Co....	....	" At J. Kunz' quarry, probably preglacial river gravel.....
4009	"	"	Boulder (15 ft. in diameter)..................	1	1½ m. E. of Shakopee..........	Drift.	" ....
4010	"	"	Black, fetid mud..........................	1	Freeborn, Freeborn Co.........	"	" 1 foot thick in well at 95 feet...
4011	"	"	Upper Till................................	1	" "	"	" coal boring, 1880.... ....
4012	"	"	Dark, very hard Till.......................	1	Verona Star Mills..............	"	" Alex Haliday................

4013	1880	Geol & Nat Hist Sur	Dark, very hard Till, sandy portion of........	1	Verona Star Mills..............	Drift.	Warren Upham, Alex Haliday........
4014	"	"	Yellow Till..................	1	" "	"	Same " ....
4015	"	"	Brick, cream-colored.....	2	Mankota, Minn..	....	" Mankato Brick Co............
4016	"	"	Brick, red.........................	1	" "	....	" " " ....
4017	"	"	"	1	" "	....	" F. Polchow & Co...... ....
4018	"	"	"	1	" "	....	" Williams & Grothe............
4019	"	"	"	1	Sec 8, McPherson, B. E. Co....	....	" Gekler Bros..................
4020	"	"	"	1	Sec. 11, Verona, B. E. Co....	....	" Westbrook & Ferguson........
4021	"	"	"	1	Albert Lea....................	....	" Rusfeldt & Kleven,............
4022	"	"	Lignite...............................	3	Little Missouri R. Dak........	....	N. H. Winchell...... ....
4023	"	"	Silicified wood.........................	2	" "	....	Same.................. ....
4024	"	"	"	1	" "	....	Presented by Capt. Wolfalk,........
4025	"	"	Concretions of (?)........................	2	" "	....	N. H. Winchell......................
4026	"	"	Slags................	3	" "	....	Same { Produced by burning of lignite beds..................
4027	"	"	Indurated clay, (red)....................	3	" "	....	" " " "
4028	"	"	" (banded).................	3	" "	....	" " " "
4029	"	"	Limestone........................	15	Lanesboro......................	St Lawrence	" ....
4075	"	"	"	17	Near Spring Valley.............	Trenton.	" Weisbach's Dam..............
4089	"	"	" slab	1	Spring Valley..................	Galena.	" ....
4096	"	"	Silicious buhr-stone......................	1	Bennington, Mower Co.........	Drift.	" ....
4099	"	"	Limestone...............................	13	Lime City......................	Galena.	" ....
4108	"	"	Lead ore, (on the St. Lawrence Limestone)....	3	Dresbach, Minn................	St. Croix.	" Winona Co. Mining Co.......
4109	"	"	Green sand..............................	3	"	"	" " " ....
4110	"	"	Flag and sandstone, (lingula bearing)..........	12	"	"	" " " ....
4111	"	"	Iron septaria............................	2	"	....	" " " ....
4112	"	"	Freestone................................	1	"	St. Croix.	" " " ....
4114	"	"	Brick....................................	1	Sec. 34, Manomin..............	....	Warren Upham, Peterson & Benson.
4115	"	"	Mineral Paint...........................	1	Redwood Falls.	....	" Manufactured 1869.
4116	1881	H. A. Strong.	Limestone...............................	1	Decorah, Iowa................	Trenton.	{ Pres. by H. A. Strong, Decorah, "Fossil Marble"................
4117	"	Edw. S. Dana.	Danburite, Crystal groups..................	3	Russel, St. Lawrence Co., N. Y.	....	By exchange with Yale College......
4118	"	"	" detached crystals..	2	" "	....	Same..............................
4119	"	"	"Pallas Iron," meteoric.....................	1	Krasnojarsh, Siberia...........	....	" Date of discovery, 1876...... ....
4120	"	"	Meteoric Iron.............................	1	Augusta Co., Va..............	....	" Date of discovery 1858-59.......
4121	"	"	" stone............................	1	Sieele-Nowy, Poland..........	....	" Date of fall Jan 30, 1868.......
4122	"	"	" "	1	Weston, Conn..................	....	" Date of fall, Dec. 14, 1867......
4123	"	"	" iron.............................	1	Sylanieza, Hungary...........	....	" Date of discovery, 1844........
4124	"	"	" stone............................	1	Parnallee, India, (Hindostan)..	....	" Date of fall, Feb. 28, 1857......
4125	"	C. W. Hall.	" iron, showing Widmanstathian figures	1	Estherville, Emmet Co., Iowa.	....	Presented: date of fall, May 10, 1879...
4126	"	G. H. Dike.	Ammonites sp. (?), part of a cast............	1	Foot hills, Black Hills.........	....	" by Mr. Dike..........
4128	May, 1879	By Purchase.	Peckhamite...............................	Sev.	Estherville, Iowa...............	....	{ The new mineral "found in the Estherville meteorite and named by Dr. J. L. Smith after Prof. S. Peckham. (See Am. J. Aug. 1880)
4129	Oct., 1880	J. S. Clark.	Hematite.......	1	East River mines, N. S.........	....	Presented by Prof. Clark..........
4130	"	"	Fossil plants........	Sev.	{ Stil arton coal mines, Pictou Co. N. S..................	Carbonifer's	Same { characteristic plants from the N. S. coal.... ....
4131	July, 1880	Geol & Nat Hist Sur	Sandstone..................................	3	Taylor's Falls..................	....	C. M. Perry, (south of the "dike")..
4132	"	"	Orthoceras, section....	1	Shore of Star Lake, O. T. Co...	Drift.	Same...............................
4133	"	"	Blue clay................................	1	Evansville.......................	"	" (50 feet below surface).........

Specimens Registered in Museum in 1881—*Continued.*

Serial Numbers.	OBTAINED. When.	OBTAINED. Whence.	NAME.	No. of Specimens.	Locality.	Formation.	Collector and Remarks.
4134	July, 1880	Geol & Nat Hist Sur	Part of pebble.......	1	Fergus Falls..................	Drift.	C.M.Ferry,(from clay of Fergus Falls)
4135	"	"	Clay....................	1	Spirit Knob, L. Minnetonka..	"	" ....
4136	"	"	Decayed stone and concretions.................	....	Evansville.....	"	" (clay banks)..............
4137	"	"	Fine clay..	....	Mouth of Turtle R Polk Co....	"	A. P. Hendrickson..................
4138	"	N. C D. Taylor.	Copper ores, etc........................... .	Indf	Taylor's Falls....	....	N. C. D. Taylor........ ....
4139	"	Geol & Nat Hist Sur	Clay.......	1	Bed of Miss., T. 145, N. R. 35 W	....	O E. Garrison, beneath the river deposits, on flood plain [95]........
4140	"	"	Red Quartzite or Sandstone, (conglomerated)..	1	Pokegama Falls	Potsdam.	O. E. Garrison, (Upper strata where the arrow like fall begins), [96]....
4141	"	"	" "	1	" "	"	O. E. Garrison, (Upper strata, a little below the apron, 10 feet above water ledge), [97]..................
4142	"	"	Reddish sandrock	1	" "	"	O. E. Garrison. (Lowest strata visible in the perpendicular walls), [98]............... ... .
4143	"	"	Coarse sandstone..........	1	" "	"	O. E Garrison, (Lowest strata visible in the perpendicular walls), [98a].........................
4144	"	"	Rotted sandstone...........	1	" "	"	O E Garrison, (From apron, flooded in high water(, [99]............
4145	"	"	Clay.......	1	Lower landing, Pokegama Falls		O. E. Garrison, (From gully on bluff), [101].......................
4146	"	"	Coarse Quartzyte............	1	Lower falls Prairie R. sec. 34, T. 56, R. 26................	"	O. E. Garrison, (In river bed, covered in high water; cracked in all directions), [102]................
4147	"	"	Gray and pinkish quartzyte....................	1	Lower falls Prairie R., sec. 34, T. 56, R. 26...............	"	O. E. Garrison, [103], (Near [102], but not flooded.................
4148	"	"	Red quartzyte.............	1	Prairie River Falls............	"	O. E. Garrison, [104], (Highest point of exposure, and west of the trail from lower landing to lower lake.
4149	"	"	"	1	" "	"	O. E. Garrison, [105], (From a loose scale, but on exposure same as 104.)

4150	July, 1880	Geol & Nat Hist Sur	Red Quartzyte	....	Prairie R, Falls, sec. 33. T. 56, N. R. 25 W	Potsdam.	O. E. Garrison, [106], (Near the middle of the exposure, near the trail around the upper falls)
4151	"	"	Gray Gneiss	2	Upper Falls of Prairie River		O. E. Garrison, [107], (Near the highest exposure, east of the trail around the falls
4152	"	"	Coarse Granite	1	" "	Potsdam.	O. E. Garrison, []08], (Highest part of rock, east of the trail around the falls
4153	"	"	"	1	" "	"	O. E Garrison, [109], (From a fissure in the rock near the river, east of the trail around the falls..
4154	"	"	"	1	" "	"	O. E. Garrison, [110], (From a fissure near 109)
4155	"	"	Gneiss	1	" "		O. E. Garrison, [111], (Near head of the falls
4156	"	"	Iron Ore	1	Left bank of Prairie River Falls		O. E. Garrison, [112], (From a pit dug in prospecting many years ago
4157	"	"	Iron Ore	1	Right " " "		O. E. Garrison, [113], (Near landing and trail around lower falls..
4158	"	"	"	1	Prairie River Falls		O. E. Garrison, [114], (From a pit near 112)
4159	"	"	Sandstone	1	" "		O. E. Garrison, [115] (From a loose fragment in trail around lower falls)
4160	"	"	Clay	1	On Miss. R. below Prairie R		O. E. Garrison, [116], (From a bluff)
4161	April, 1880	J. B. Gilfillan.	Section of large (concretion?)	1	Minneapolis	Trenton.	J. B. Gilfillan
4162	1880	P. H. Mell, Jr.	Lircon	3	N. Carolina		P. H. Mell. Jr. By exchange
4163	"	"	Talc. "soapstone"	1	Bartow Co., Ga		" "
4164	"	"	Silicious Tufa	2	Flint River, Ga		" "
4165	"	"	Itacolumite	3	Mitchell Co., N. C		" "
4166	"	"	Clipiasters	3	Thomas Co., Ga		" "
4167	"	"	Blue Corundum	1	Towns Co., Ga		" "
4168	"	"	Garnets in Chlorite	2	Clay Co., Ala		" "
4169	"	"	Impure Agate	1	Flint River, Ga		" "
4170	"	"	Corundum in Zincite	1	Coosa Co., Ala		" "
4171	"	"	Albite	1	Clay Co., N. C		" "
4172	"	"	Brown Corundum and Magnetite	6	Coosa Co., Ala		" "
4173	"	"	Grey Corundum and Tourmaline	3	Towns Co., Ga		" "
4174	"	"	Nodules, sup'sd to be chloride f'm corundum v'n	5	Coosa Co., Ala		" "
4175	"	"	Pink Corundum	8	Towns Co., Ga		" " (from trap dike)
4176	"	"	Tantalite	3	Taleaposa Co., Ala		" " "
4177	"	"	Essonite	6	N. Africa diamond fields		" " "
4178	"	Geol & Nat Hist Sur	Section of Orthocerata	3	Vermont, Blk. R. limestone		S. F Heath
4179	"	"	Artesian-well borings, limestone 80 ft	2	Hastings, Da. Co		Bored by W. E. Swan, I (to 80 ft)
4180	"	"	" " sandrock 15 ft	1	"		By same, II (to 95 ft)
4181	"	"	" " limestone 12 ft	1	"		" III (to 107 ft)
4182	"	"	" " sandrock 8 ft	1	"		" IV (No. 1 at 102 ft), no water
4183	"	"	" " " 10 ft	1	"		" IV (No. 2 at 122 ft), "
4184	"	"	" " " 10 ft	1	"		" IV (No. 3 at 132 ft), "

Specimens Registered in Museum in 1881—*Continued.*

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4185	1880	Geol & Nat Hist Sur	Artesian-well borings, sandrock, 20 ft	1	Hastings, Da. Co.		Bor'd by W.E Swan IV, (No. 4 at 152 ft) } No water
4186	"	"	" " " 20 ft	1	"		By same, IV, (No. 5 at 172 ft)
4187	"	"	" " " 10 ft	1	"		" IV, (No. 6 at 182 ft)
4188	"	"	" " " 10 ft	1	"		" IV, (No. 7 at 192 ft)
4189	"	"	" " " 10 ft	1	"		" IV, (No. 8 at 202 ft)
4190	"	"	" " sandy shale 25 ft	1	"		" V, (to 2?7 ft)
4191	"	"	" " gray shale 43 ft	1	"		" VI, (to 270 ft)
4192	"	"	" " green shale 20 fe t	1	"		" VII, (No. 1 at 290 ft)
4193	"	"	" " " 110 ft	1	"		" VII, (No. 2 at 400 ft)
4194	"	"	" " sandy shale 15 ft	1	"		" VIII, (to 415 ft)
4195	"	"	" " sandrock 20 ft	1	"		" IX, (No. 1 to 435 ft)
4196	"	"	" " " "	1	"		" IX, (No. 2 to 455 ft)
4197	"	"	" " " "	1	"		" 1st flow, IX, (No. 3 to 475 ft)
4198	"	"	" " limestone 20 ft	1	"		" X, (to 495 ft)
4199	"	"	" " blue shale 70 ft	1	"		" XI, (to 565 ft)
4200	"	"	" " green shale 20 ft	1	"		" XII, (to 585 ft)
4201	"	"	" " limestone 5 ft	1	"		" XIII, (to 590 ft)
4202	"	"	" " sandrock 5 ft	1	"		" XIV, 2d flow, (No. 1 to 595 ft)
4203	"	"	" " " 25 ft	1	"		" XIV, (No. 2 to 620 ft)
4204	"	"	" " " 10 ft	1	"		" XIV, (No. 3 to 6?0 ft)
4205	"	"	" " " 10 ft	1	"		" XIV, (No. 4 to 640 ft)
4206	"	"	" " " 10 ft	1	"		" XIV, (No. 5 to 650 ft)
4207	"	"	" " " 5 ft	1	"		" XIV, (No. 6 to 655 ft)
4208	"	"	" " " 15 ft	1	"		" XIV, (No. 7 to 685 ft)
4209	"	"	" " " 30 ft	1	"		" XIV, (No. 8 to 700 ft)
4210	"	"	" " " 7 ft	1	"		" XIV, (No. 9 to 707 ft)
4211	"	"	" " " 43 ft	1	"		" XIV, (No. 10 to 750 ft)
4212	"	"	" " " 30 ft	1	"		" XIV, (No. 11 to 780 ft)
4213	"	"	" " " 40 ft	1	"		" XIV, (No. 12 to 820 ft)
4214	"	"	" " red sandstone	1	"		" XV, (No. 1 to 835 ft)
4215	"	"	" " "	1	"		" XV, (No. 2 to 850 ft)
4216	"	"	" " red shale	1	"		" XV, (No. 3 to 870 ft)

11

4217	1880	Geol & Nat Hist Sur	Artesian well drillings, red sandrock	1	Hastings, Da. Co		Bored by W E Swan, XV, (No. 4 to 885 ft)
4218	"	"	" " red shale	1	"		By same, XV, (No. 5 to 925 ft
4219	"	"	" " red sandrock	1	"		" XV, (No. 6 to 950 ft)
4220	"	"	" " "	1	"		" XV, (No. 7 to 1,000 ft)
4221	"	"	" " "	1	"		" XV, (No. 8 to 1,050 ft)
4222	"	"	" " "	1	"		" XV, (No. 9 to 1,060 ft)
4223	"	W. D. Hurlburt.	Crinoid joints	7	Barrens of N. Alabama	(?)	Presented by W. D. Hurlburt, lowest limestone, the rotted layers still show strata
4224	"	"	Limonite	1	Olmsted Co	Upper Trenton (?	Presented by W. D. Hurlburt, Drift, cut on Eyota & Chatfield R. R.
4225	"	"	Pentremites	10	Cumberland Mts. E. Tenn.	Carb Sand stone	Presented by W. D. Hurlburt
4226	"	"	"Mountain Limestone," showing crinoids	1	East Tennessee	Sub. Carb.	" "
4227	"	"	" " " massive coral	2	"	"	" "
4228	"	Mr. Reese.	Fossil wood, showing knot	1	Milk R. Valley, Montana		Presented by Mr. Reese
4229	1879	Geol & Nat Hist Sur	Graphite	Indf	Lake Superior		S. F. Peckham
4230	1880	"	Selenite crystals	"			U. D. Watkins
4231	"	"	Spathic Iron	1	Plymouth, Vt		"
4235	"	"	Vegetable impressions in shales	4	Cleveland, Ohio	Buyhaga shales	" coal, No. 1
4236	"	"	Non-plastic clay	1	Bohaes, Tuscarawas Co., Ohio		"
4237	"	"	Cone in cone	1	Cleveland, Ohio	Buyhaga shales	"
4239	"	"	Shales carbonaceous	sevl	" "	"	"
4240	"	"	Slickinsided coal	1	Brewster bank, Akron, Ohio	"	"
4241	1881	John A. Green.	"Anamosa stone"	1	Stone City, Iowa	Up. Silurian	John A. Green, Champion quarries
4242	May, 1881	Geol & Nat Hist Sur	Tellinomya levata (or fecunda, H)	24	Dubuque, Iowa	Mag. shales	Exchange with Prof. S. Calvin
4243	April, 1881	"	Copper	1	Stearns Co	Drift	O. E. Garrison, cut from a large mass
4244	May, 1881	Regent R. Chute.	Coquina	1	St. Augustine, Fla	Ter. (?)	Presented by Regent Chute
4245	1877	Geol & Nat Hist Sur	Building stone one foot square	1	Pipestone quarry Pipestone Co.	Potsdam	N. H. Winchell
4246	June, 1881	"	Limestone, believed to be hydraulic	2	Four miles north of Mankato	Shakopee	"
4247	"	"	White Clay, believed to be kaolinic	3	" "	Cret (?)	"
4248	"	"	Limestone, showing light blue color	2	Mankato	Shakopee	" Maxfield's quarry, deep seated beds
4249	"	"	Elephant's tooth	1	Near the Rosebud R. Mon	Cret. (?)	Presented by S. Deutsch, (per Col. J. B. Clough)
4250	July, 1881	"	Artesian well drillings, black soil	1	Lake City		Presented by W. E. Swan, (No. 1) 2 ft.
4251	"	"	" " yellow clay	1	"		By same, (No. 2) 42 ft
4252	"	"	" " sand and gravel	1	"		" (No. 3a) 202 ft
4253	"	"	" " gravel from same	1	"		" (No. 3b) 202 ft
4254	"	"	" " "Hardpan"	1	"		" (No. 4) 207 ft
4255	"	"	" " sand	1	"		" (No. 5) 210 ft
4256	"	"	" " sand	1	"		" (No. 6) 220 ft
4257	"	"	" " sand	1	"		" (No. 7) 225 ft
4258	"	"	" " coarse sand	1	"		" (No. 8) 232 ft
4259	"	"	" " sand	1	"		" (No. 9) 290 ft
4260	"	"	" " sand	1	"		" (No. 10) 360 ft
4261	"	"	" " sand	1	"		" (No. 11) 405 ft
4262	"	"	" " sand	1	"		" (No. 12) 412 ft
4263	"	"	" " sand	1	"		" (No. 13) 422 ft

Specimens Registered in Museum in 1881—*Continued.*

Serial Numbers.	OBTAINED. When.	OBTAINED. Whence.	NAME.	No. of Specimens.	Locality.	Formation.	Collector and Remarks.
4264	July, 1881	Geol & Nat Hist Sur	Artesian-well drillings, sand	1	Lake City	....	Presented by W E Swan, (No. 14), 440 ft
4265	"	"	" " sand	1	"	....	By same, (No. 15), 445 ft
4266	"	"	" " sand	1	"	....	" (No. 16), 460 ft
4267	"	"	" " sand	1	"	....	" (No. 17), 495 ft
4268	"	"	" " sand	1	"	....	" (No. 18), 500 ft
4269	"	"	" " red shale	1	"	....	" (No. 19), 505 ft
4270	"	"	" " " sand washed from	1	"	....	" (No. 20a), 525 ft
4271	"	"	" " " unwashed	1	"	....	" (No. 20b), 525 ft
4272	"	"	" " " sand washed from	1	"	....	" (No. 21a), 570 ft
4273	"	"	" " " unwashed	1	"	....	" (No. 21b), 570 ft
4274	"	"	" " "	1	"	....	" (No. 22), 600 ft
4275	"	"	" " "	1	"	....	" (No. 23a), 640 ft
4276	"	"	" " " sand washed from	1	"	....	" (No. 23b), 640 ft
4277	"	"	" " "	1	"	....	" (No. 24a), 680 ft
4278	"	"	" " "	1	"	....	" (No. 24b), 680 ft
4279	"	"	" " "	1	"	....	" (No. 25a), 700 ft
4280	"	"	" " " sand washed from	1	"	....	" (No. 25b), 700 ft
4281	"	"	" " " "	1	"	....	" (No. 26a), 730 ft
4282	"	"	" " " "	1	"	....	" (No. 27a), 773 ft
4283	"	"	" " " "	1	"	....	" (No. 27b), 773 ft
4284	"	"	" " "	1	"	....	" (28), 805 ft
4285	"	"	" " "	1	"	....	" (29), 820 ft
4286	"	"	" " "	1	"	....	" (26b), 730 ft
4287	"	"	" " black loam	1	Austin	....	" (1), 2 ft thick
4288	"	"	" " yellow clay	1	"	....	" (2), 12 ft thick
4289	"	"	" " sand and gravel	1	"	....	" (3), 20 ft thick
4290	"	"	" " blue clay	1	"	....	" (4), 22 ft thick
4291	"	"	" " gray limestone	1	"	....	" (5), 44 ft thick
4292	"	"	" " gray shale	1	"	....	" (6), 16 ft thick
4293	"	"	" " blue limestone	1	"	....	" (7), 64 ft thick
4294	"	"	" " gray limestone	1	"	....	" (8), 80 ft thick
4295	"	"	" " piece of limestone	1	"	....	" { Water rose to within 9 ft of surface, from a crevice, furnishing water at 160 ft

4296	July, 1881	Geol & Nat Hist Sur	Artesian-well drillings, soil	1	Britt, Iowa		Presented by W.E.Swan, (1), 4 ft thick
4297	“	“	“ “ yellow clay	1	“		By same, (2), 6 ft thick
4298	“	“	“ “ blue clay	1	“		“ (3), 75 “
4299	“	“	“ “ gravel	1	“		“ (4), 25 “
4300	“	“	“ “ “hard-pan”	1	“		“ (5), 14 “
4301	“	“	“ “ brown limestone	1	“		“ (6), 57 “
4302	“	“	“ “ gray shale	1	“		“ (7), 77 “
4303	“	“	“ “ limestone Mag.	1	“		“ (8), 298 “ in this was water contained in a crevice at 470 ft.
4304	“	“					
4305	“	“	“ “ brown carb. shale	1	“		“ (9), 15 ft thick
4309	“	“	“ “ light limestone	1	“		“ (10), 26 “
4310	“	“	Propidoleptus carinatus, Con	2	Owasco Lake, N. Y	Hamilteu	S. G. Williams, by exchange
4311	“	“	Discina lodensis, Vanuxem	2	Cayuga Lake, N. Y	Genesee	“ “
4312	“	“	Atrypa reticularis, var. prisca	2	Wingfield, Herk Co., N. Y	Cornif	“ “
4313	“	“	Lycopodites vanuxemi. Dawson	1	Groton, N. Y	Chemung	“ “ (1 m N E)
4314	“	“	Strophomena rhomboidalis	1	Wingfield, Herk Co., N. Y,	Cornif	“ “
4315	“	“	Pterinea avicula glabella Con	2	Owasco Lake, N. Y	Hamilton	“ “
4316	June, 1881	“	Tentaculites fissurella	1	Wingfield, Herke Co., N. Y	Marcellies	“ “
4317	“	“	Sandstone	....	Sec. 8, Middleville, Wright Co	Cret ?	C. L. Herrick, rises 2 ft above Crow R
4318	“	“	“	....	Sec. 13, (?) Frankfort, “	“	“ both sides Crow R
4319	Aug., 1881	“	Marble	1	Scranton, Vt	“	N. H. Winchell
4320	July, 1881	H H. Sibley	Hudson river shale	1	Cook's quarry, Minneapolis	Hudson R.	“
4321	“	“	Fossils	22	Mouth of Cheyenne R., Black Hills, Da		Presented by Gen. H. H. Sibley
4322	June, 1881	Geol & Nat Hist Sur	Petrified wood	1	Dakota		“ “
4323	“	“	“Molding sand,”	....	Middleville, Wright Co	Drift	C. L. Herrick, bank of Crow river
4324	“	“	Drift, characteristic of Wright Co	....	Kingstone, Wright Co	“	“ banks of Crow R. 25-30 ft
4325	“	“	Sand overlying No. 4316	....	Sec. 8, Middleville, Wright Co	“	“ “
4326	July, 1881	Geol. Survey	Rib of Manatus	1	Coosau, S. C		Prof. C. U. Shepard, obtained by exch'ge
4327	“	“	Tooth of horse	1	“		“ “
4328	“	“	Charcharadon giganteus (tooth)	1	“		“ “
4329	“	“	Charcharodon angustidens (tooth)	1	“		“ “
4330	“	“	Charcharodon megalodon, etc., (teeth)	20			“ “
4331	“	“	Phosphatic nodules	4	Coosau and Ashley R's, S. C		“ “
4332	“	“	Fluorite (emerald green,) with titanite amphibole, etc	....	Ottawa Canada		“ “
4333	“	“	Calcite, (red)	....	Grattan, Canada		“ “
4334	“	“	Deweylite, with chrysotile	3	Templeton, Can		“ “
4335	“	“	Zircon	Indf	Henderson Co. N. C		“ “
4336	“	“	Kuebilite	2	Cumberland, R. I,		“ “
4337	“	“	Danburite	3	Russel, N. Y		“ “
4338	“	“	Crocoite	1	Beresof, Russia		“ “
4339	“	“	Apatite	2	Templeton, Can		“ “
4340	“	“	Apatite crystals	Indf	“ “		“ “
4341	“	“	Apatite crystals, (reddish)	4	Gratton, Can		“ “
4342	“	“	Apatite	1	“		“ “
4343	“	“	Apatite	1	Templeton, Can		“ “
4344	“	“	Apatite, granular	1	“		“ “
4345	“	“	Amphibolite and augite	2	“		“ “
			Augite,	1	“		“ “

Specimens Registered in Museum in 1881—*Continued.*

Serial Numbers.	OBTAINED. When.	OBTAINED. Whence	NAME.	No. of Specimens.	Locality.	Formation.	Collector and Remarks.
4346	July, 1881	Geol. Survey	Augite	1	Jefferson Co., N. Y.		Prof. C. U. Shepard, obtained by exch'ge
4347	"	"	Pelhamite	1	Pelham		" "
4348	"	"	Tourmaline, (brown,) and augite, (white)	1	Governeur, N. Y.		" "
4349	"	"	Lederite and augite, (black)	1	Gratton, Can.		" "
4350	"	"	Pagodite	1	Washington, Ga		" "
4351	"	"	Apatite	1	Ural mountains		" "
4352	"	"	Margarodite	1	Trumbull, Conn		" "
4353	"	"	Lederite	1	Grattan, Canada		" "
4354	"	"	Rutile	1	Graves Mt, Ga		" "
4355	"	"	Chrysotile in Deweylite	1	Templeton, Can		" "
4356	"	"	Oligoclase	1	Georgia		" "
4357	"	"	Deweylite	2	Templeton, Can		" "
4358	"	"	Fossil wood	2	Coosau, South Alabama		" "
4359	"	"	Idocrase	2	Templeton, Can		" "
4360	"	"	Tremolite in Dolomite	1	Lee, Mass		" "
4361	"	"	Kaolinite	1	Richmond Co., Ga		" "
4362	"	"	Amphibolite	1	Templeton Can		" "
4363	"	"	Vanuxemite	1	Sparta, N. Y.		" "
4364	"	"	Pyrosmalite	1	Nordmark, Wermland		" "
4365	"	"	Augite	1	Ottawa Canada		" "
4366	"	"	Lederite, (Titanite)	2	Grattan, Canada		" "
4367	"	"	Pyrophyllite	5	Graves Mt, Ga		" "
4368	"	"	Cuprite mixed with sulphurets of copper	1	Siberia		" "
4369	"	"	Menilite with Glossecollite	1	Coosan, S. C.		" "
4370	"	"	Lazulite	4	Graves Mt., Ga		" "
4371	"	"	Topaz and margarodite	1	Trumbull, Conn		" "
4372	"	"	Amphibolite and calcite (red and blue)	1	Templeton, Can		" "
4373	"	"	Wilsonite	2	"		" "
4374	"	"	Anorthite, (Indianite) with specky Allanite	1	Pelham, Mass		" "
4375	"	"	Rutile	1	Graves Mt., Ga		" "
4376	"	"	Titanite	1	Arendal, Norway		" "
4377	"	"	Apatite in calcite, (red)	1	Grattan, Can		" "
4378	"	"	Calcite, (red) with apatite and biotite	1	"		" "

4379	July, 1881	Geol. Survey......	Orthoclase crystals with albite..................	1	Huntington, Mass...............	....	Prof. C. U. Shepard, obtained by exch'ge
4380	"	"	Asbestoid Bronzite....................................	1	Pelham, Mass.....................	....	" "
4381	"	"	Tremolite..	1	Cherokee Co., N. C...............	....	" "
4382	"	"	Apatite...	2	Grattan, Can......................	....	" "
4383	"	"	Phosph..	2	Spain.................................	....	" "
4384	"	"	Augite Chromiferous..................................	1	Wakefield, Conn....................	....	" "
4385	"	"	Phosphatic nodules, "land phosphate.".........	1	Ashley Region, S. C...............	....	" "
4386	"	"	Pyrula carica...	2	Young's Id., S. C..................	P'st Pliocene	" "
4387	"	"	Oliva litorata..	7	"	"	" "
4388	"	"	Natica duplicata.......................................	Indf	"	"	" "
4389	"	"	Artemis concentrica...................................	3	"	"	" "
4390	"	"	Arca incongrua...	5	"	"	" "
4391	"	"	Lutrasia canaliculata.................................	6	"	"	" "
4392	"	"	Terebra acuta...	Indf	"	"	" "
4393	"	"	Mactra suniles..	1	"	"	" "
4394	"	"	Sigaretus perspectivus...............................	1	"	"	" "
4395	"	"	Scalaria..	1	"	"	" "
4396	Oct., 1881	"	Squared slab of roofing slate........................	1	Near Knife Falls..................	Huronian ..	N. H. Winchell, (12 in by 26 in by 2 in)
4397	"	"	Hudson River limestone.............................	2	Clinton Falls.........................	Hud R......	" { (taken for building stone tests.........
4398	"	"	Blue sandsrock, (building stone.)................	2	Dresbach..............................	St. Croix...	"
4399	"	"	Buff sandrock. (building stone.).................	1	Dakota.................................	" ...	" ....
4400	"	"	Yellow sandrock, (building stone.)...............	16	Near Fort Snelling.................	" ...	" ....
4401	Aug., 1878	"	Basaltic columns, (triangular.)..................	3	Grand Marais.......................	....	C. W. Hall, { Fr'm the natural break-water, Grand Marias harbor.............
4402	"	"	" (four-sided.).................	4	"	....	" ....
					....	....	....
4403	"	"	" (five-sided.).................	1	"	....	" ....
4404	"	"	" (six-sided.)..................	1	"	....	" ....
4405	Oct., 1881	C. W. Hall........	Quartzyte..	2	Devil's Lake, Wis..................	Potsdam....	C. W. Hall, (from cut on C. & N. W. Ry.)
4406	July, 1881	C. M. Terry........	Kaolin..	3	Aiken, S. C..........................	....	C. M. Terry presented...............
4407	Nov., 1881	C. U. Shepard.....	Meteoric stone, (fell Oct. 13, 1879,) wt 1.75 grains	1	Soko Banjia, Servia................	....	Prof. Shephard, obtained by exch'ge..
4408	"	"	" (fell May 22, 1808,) wt 1.48 "	2	Stannern.............................	....	" "
4409	"	"	" (fell 1871.).......wt 1.4 "	2	Searsport, Me.......................	....	" "
4410	"	"	" ....wt 1.35 "	1	Little Piney, Mo....................	....	" "
4411	"	"	" ....wt 2.1 "	1	Milena................................	....	" "
4412	"	"	Meteoric Iron.................wt 14.55 "	1	Disco, Baffins Bay.................	....	" "
4413	"	"	" (fragments).....wt 2.52 "	Indf	Sarepta...............................	....	" "
4414	"	"	" ....wt 0.63 "	1	Union Co., Ga.......................	....	" "
4415	"	"	" (fell 1875).......wt 18.35 "	1	Santa Catarina, Brazil............	....	" "
4416	"	"	" ....wt 4.55 "	1	Bitburg, Prussia....................	....	" "
4417	"	"	" ....wt 24.97 "	1	Auburn, Ala.........................	....	" "
4418	"	"	" ....wt 17.5 "	1	Lexington, S. C.....................	....	" "
4419	"	"	" ....wt 8.4 "	1	Durango..............................	....	" "
4420	"	"	" ....wt 1.98 "	1	Ivanpah, Cal........................	....	" "
4421	"	"	" ....wt 2.3 "	7	"	....	" "
4423	Oct., 1881	Geol Survey......	Pink Quartzyte...	1	Sioux Falls, Dak....................	Potsdam....	N. H. Winchell............................
4424	May, 1881	"	Sassolite...	1	....	....	" ....
4425	"	"	Sandstone with lingulae and galenite...........	12	Dresbach.............................	St. Croix...	" (Dresbach's Mine)....
4426	Sept., 1881	"	Pressed brick, red.....................................	1	Red Wing............................	....	....

Specimens Registered in Museum in 1881—*Continued.*

Serial Numbers.	OBTAINED. When.	OBTAINED. Whence.	NAME.	No. of Specimens.	Locality.	Formation.	Collector and Remarks.
4428	Sept., 1881	Geol. Survey......	Fine-grained, gray granite......................	1	S. E. ¼ Sec. 34, 43, 23, Aitkin Co	....	Warren Upham.....................
4429	"	"	Granite, light-colored..........................	1	Sec. 4, 42, 23, Kanabec Co......	....	" ¼m N of the mouth of Cowan's Cr........
4430	"	"	Dark Mica-schist...............................	1	" "	....	" ⅛m N of the mouth of Cowan's Cr.........
4431	"	"	White quartzose granite.......................	1	Sec. 9, 42, 23, "	....	" Typical rock at the "Jaws of the Upper Falls," Snake River
4432	"	"	Coarse red granite, (superficially red)..........	1	" "	....	" "Jaws of the Upper Falls" of Snake R..
4433	"	"	Gneiss...	1	" "	....	" 30 rods S of "Upper Falls" of Snake River.... ....
4434	"	"	Homogeneous, fine, gray, granite...............	1	" "	....	" 60 rods S of "Upper Falls" of Snake River.... ....
4435	"	"	Red granite, enclosing a micaceous mass.......	1	Sec. 16, T. 42, 23 "	....	" 60 rods above head of Lower Falls........
4436	"	"	Fine, homogeneous, white granite..............	2	Sec. 15 & 16, T 42,23 Kanabec Co	....	" Upper part of Lower Falls of River, the prevailing rock here
4437	"	"	Mica schist.....................................	3	" "	....	" Cent'l p't Lower Falls
4438	"	"	Hard mica schist, attached to dark gneiss......	1	" "	....	" " "
4439	"	"	Fragile mica schist.............................	1	" "	....	" " "
4440	"	"	Quartz, vein in mica schist.....................	1	" "	....	" Lower Falls, Snake R
4441	"	"	Redish-gray granite.............................	3	S.E. ¼ Sec. 30, T. 40, 24, "	....	" At Ann Lake dam....
4442	"	"	" "	2	S.W. ¼ Sec. 29, T. 40, 24, "	....	" At Roll dam, Ann R
4443	"	"	Dark gneiss, (red feldspar).....................	4	N. W. ¼ Sec. 24, T. 41, 31, Morrison Co....................	....	" BellePr'ie, MorrisonCo
4444	"	"	Coarse gneiss, (white feldspar)................	9	Sec. 21, T. 41, 29, Morrison Co..	....	" "Granite City".......

4445	Sept., 1881	Geol. Survey	Fine, red granite	5	S.E. ¼ Sec.35, T.41, 29, Morrison Co	....	Warren Upham,	N. end big dam, Hillman brook
4446	"	"	Coarse gneiss, (white feldspar and biotite)	2	" "	....	"	S end big dam, Hillman brook
4447	"	"	Gneiss, (white feldspar and biotite)	2	N. W. ¼ Sec. 18, 40, 29 "	....	"	N end lower Roll dam, Hillman brook
4448	"	"	Micaceous granite, (white feldspar and biotite)	2	N. E. ¼ Sec. 9, 40, 30, Pierz, Morrison Co.	....	"	1 m E of Rich Prairie, E side Skunk R.
4449	"	"	Micaceous gneiss, " "	2	" "	....	"	" "
4450	"	"	Dark micaceous granite, (gneissic)	6	Sec's 18 and 7, T. 41, 30, Morrison Co.	....	"	1 m. W. of Platt R.
4451	"	"	Coarse, gray granite, (gneissic)	4	S. W. ¼ Sec. 17, T. 40, 30, Morrison Co.	....	"	....
4452	"	"	Fine, gray granite, (homogeneous)	17	S. E ¼ Sec. 13, T. 40, 31, Morrison Co.	....	"	¼ m. S. of Fish Lake
4453	"	"	Coarse, red syenite	4	N. W. ¼ Sec. 18, T. 39, 30, Morrison Co.	....	"	Buckman twp.
4454	"	"	"	1	Sec. 29, T. 38, 27, Mille Lacs Co	....	"	W. br. of Rum R.
4455	"	"	"	2	" "	....	"	W. br. Rum R ¼ m. N. W. from last
4456	"	"	"	2	Sec. 19, T. 38, 27, "	....	"	Stony Brook dam, W. br. Rum R.
4457	"	"	Fine, red syenite, (dyke-like)	1	Sec. 24, T. 38, 28, Benton Co.	....	"	W. br. Rum River
4458	"	"	Coarse, red syenite, (50 rods W. of last)	2	" "	....	"	W. br. Rum R., 25 rods W. of Roll dam
4459	"	"	Fine, red granulite, (compact)	2	N. E. ¼ N. W. ¼ Sec. 20, 38, 28, Benton Co.	....	"	N. of the trap dyke
4460	"	"	Fine, dark trap, (from a dyke)	2	" "	....	"	....
4461	"	"	Coarse, red syenite	2	" "	....	"	S. of the trap dyke
4462	"	"	Porhyritic, red syenite	4	S. E. ¼ S. W ¼ Sec. 18, 37, 29 Benton Co.	....	"	Clement Teller's land
4463	"	"	Coarse, micaceous syenite, (white feldspar)	2	N. E. ¼ Sec. 35, 37, 31. Benton Co	....	"	Used in Bismarck b'ge
4464	"	"	Fine, light granite	2	" "	....	"	" "
4465	"	"	Coarse, red syenite	2	" "	....	"	" "
4466	"	"	Micaceons syenite, (gray)	4	Sauk Rapids, Benton Co.	....	"	Collins, Mitchell & Searle
4467	"	"	" (showing lumbs of dark)	1	" "	....	"	" "
4468	"	"	Reddish granite, (Porphyritic with albite?)	4	1 m. E. Sauk Rapids, Benton Co	....	"	25r'sS Gilmanton road
4469	"	"	Coarse, red syenite	4	N. ½ Sec. 11, " "	....	"	Quarry of Collins, Mitchell & Searle
4470	"	"	Coarse, reddish-gray syenite	4	" " "	....	"	From the deeper parts of quarry of Collins, Mitchell & Searle
4471	"	"	Coarse, red syenite, (has some mica)	2	S.E. ¼ Sec. 11, " "	....	"	Wm. Kout's
4472	"	"	" "	3	N.W. ¼ Sec. 18, " "	....	"	E. D. Learned estate
4473	"	"	Dark, fine, trap-rock; dyke 1 ft wide	3	" " "	....	"	Cuts No. 4472, E. D. Learned estate
4474	"	"	Fine, mixed, (reddish-gray) syenite	4	S.W. ¼ Sec. 13, " "	....	"	R. W. Leyerly
4475	"	"	Fine, red syneite	4	N.E. ¼ Sec. 14, " "	....	"	Joseph Moody

Specimens Registered in Museum in 1881—*Continued.*

Serial Numbers.	OBTAINED. When.	OBTAINED. Whence.	NAME.	No. of Specimens.	Locality.	Formation.	Collector and Remarks.
4476	Sept., 1881	Geol. Survey	Coarse, red syenite	1	N. E. ¼ Sec 14, Sauk Rapids, Benton Co		Warren Upham, Joseph Moody
4477	"	"	Fine, gray syenite	2	2 m. S. E. of St. Cloud bridge		" Quarry of Breen & Young
4478	"	"	" (hammered face)	1	" "		" "
4479	"	"	Red syenite	6	" "		" "
4480	"	"	Porphyritic, coarse, gray syenite	4	20 rods S. of Sauk Rapids bridge		" W. side of Miss River.
4481	"	"	Gray syenite	4	1 m. S. of St. Cloud bridge		" "
4482	"	"	Gray syenite, (reddish)	4	S. W. ¼ Sec. 20, St. Cloud		" Nicholas Scheuer
4483	"	"	Coarse, red syenite	2	" "		" Matthias Leine
4484	"	"	Gray syenite	4	N. E. ¼ Sec. 28 "		" Jacob Streitz
4485	"	"	Reddish-gray, fine syenite	4	N. W. ¼ Sec. 28, "		" Louis Hohmann
4486	"	"	" "	4	N. E. ¼ Sec 29, "		" Fred Hartman
4487	"	"	Coarse, red syenite	4	" "		" "
4488	"	"	Fine, pink syenite	3	Sec. 7, N E. ¼, Le Sauk, Stearns Co		"
4489	"	"	Coarse, red syenite	1	Melrose, Stearns Co		" Ed Clark's mill is founded on this
4490	"	"	Dark dioryte, (6 feet below surface)	4	W. side Melrose, Stearns Co.		" W. H. Rothaermel's well
4491	"	"	Coarse, Pink syenite,	1	Sauk Center, Stearns Co		" ¼ mS.E.d'p't,E sideRy
4492	"	"	Fine, pink syenite	1	" "		" "
4493	"	"	Fine, pink syenite, including mass of mica scbist	1	" "		" "
4494	"	"	Red syenite	1	" "		" "
4495	"	"	Dark dioryte, (N. W. from last)	2	" "		" "
4496	"	"	Dark dioryte	1	" "		" From a well at Barnum's Block
4497	"	"	Pink syenite ? (containing a green mineral)	1	Sec. 17 & 18, Ashley, Stearns Co		"
4498	"	"	Greenish syenite ?	8	" "		" Contains more of the green mineral
4499	"	"	Green syenite ?	1	" "		" Contains much of the green mineral
4500	"	"	Coarse, feldespathic, white syenite	1	" "		" Contains some of the green mineral

4501	Sept., 1881	Geol. Survey	Gray syenite	9	N. E. ¼ Sec. 15, 131, 33, Todd Co		Warren Upham	
4502	"	"	Gray syenite, showing green veins	2	" "		"	
4503	"	"	Gray syenite	4	N. E. ¼ Sec. 28, 134, 32, Cass Co.		"	5 m. N. W. from Motley
4504	"	"	Micaceous syenite	4	" "		"	"
4505	"	"	Dark traprock	4	" "		"	Cutting the last
4506	"	"	Gray, hard slaty quartzyte	2	1 m. N. of Moose L. Station, Carleton Co.		"	Much jointed into rhombic masses
4507	"	"	Hydro-mica schist	7	½ m S. S. W. Moose Lake Sta., Carelton Co.		"	
4508	"	"	Traprock in schist	2	½ m. W. of Moose Lake Station, Carleton Co.		"	
4509	"	"	White quartz in Hidro-mica schist	2	½ m. S. S. W. Moose Lake Station, Carleton Co.		"	
4510	"	"	Hardened gray quartzyte, semi-crystalline	1	Little Falls, Morrison Co.		"	4 rds N. of E. end ferry
4511	"	"	White quartz in vein 1 ft wide	1	" "		"	6 "
4512	"	"	Fine-grained, staurolitic mica slate	10	" "		"	E. shore, at falls dip, 15° N. W.
4513	"	"	Mica slate, (shows sedimentation)	1	" "		"	"
4514	"	"	Granetiferous fissile, mica slate	3	" "		"	
4515	"	"	Mica schist, (fine)	4	" "		"	
4516	"	"	Dioryte, (coarse)	1	" "		"	At "the point"
4517	"	"	Gray, fine, semi-crystaliine, slaty rock	5	N. E. ¼ Sec. 7, T. 130, 30, Morrison Co.		"	Finely micaceous but not slaty
4518	"	"	" "	1	" "		"	Finely micaceous, (pyritiferous)
4519	"	"	Fine, mica slate	6	Near the mouth of Little Elk R.		"	Shows sedimentation.
4520	"	"	White quartz, (in slate)	1	" "		"	
4521	"	"	Micaceous dark dioryte	3	N. E. ¼ Sec. 13. T. 129, 30, Morrison Co.		"	W. of Little Falls
4522	"	"	" "	2	" "		"	" (light)
4523	"	"	" "	1	" "		"	" (lighter)
4524	"	"	" "	2	" "		"	" (lightest)
4525	"	"	Porphyritic, micaceous, hornblende rock	2	" "		"	W. of Little Falls
4526	"	"	Micaceous dioryte, (fine)	1	" "		"	Contains a decaying green mineral
4527	"	"	Mica schist, (with staurolite)	5	Pike Rapids, Morrison Co.		"	
4528	"	"	" "	2	N. E. ¼ 32, T. 128, 29, Morrison Co.		"	Land of C. Gilpatrick.
4529	"	"	Dark compact, (chrysolite bearing?) rock	4	S. E. ¼ 32, T. 128 29, "		"	Allen Blauchard
4530	"	"	Staurolitic mica schist, (coarse)	6	Sec's 17 & 18, Bellevue "		"	E. shore Miss. R., (I. P. Lambert
4531	"	"	Fine, mica slate	6	S.E. ¼ Sec. 4, T. 128, 30, "		"	At Ledoux bridge
4532	"	"	Dark, compact pyritiferous rock, (Dioryte?)	2	Sec. 34, T. 133, 32, Todd Co.		"	Mouth Fish trap br'k.
4533	"	"	" " "	1	" "		"	⅛ m. above mouth of Fish trap brook
4534	"	"	Mica schist, (finely garnetiferous?)	1	Sec. 34, T. 133, 32, "		"	Mouth Fish trap br'k.
4535	Oct., 1881	"	Rotting amydaloidal trap	2	Sec. 22, T. 41, 20, Pine Co.	Cupriferous	"	Northern outcrop
4536	"	"	" "	3	" "	"	"	Southern outcrop
4537	"	"	Copper strained rock	2	S. part Sec. 32, T. 40, 19, Pine Co.	"	"	At E bow of Kettle R.
4538 a	"	"	Coarse spar, (carb lime)	2	" "	"	"	"
4538 b	"	"	Laminated pearl spar, (carb lime)	12	" "	"	"	"
4539	"	"	Siliceous nodule, (parti colored)	1	N. W. ¼ Sec. 4, T. 39, 19, Pine Co.	"	"	

Specimens Registered in Museum in 1881—*Continued.*

Serial Numbers.	Obtained. When.	Obtained. Whence.	NAME.	No. of Specimens.	Locality.	Formation.	Collector and Remarks.
4540	Oct., 1881	Geol. Survey......	Melaphyr..	1	N. W. ¼ Sec. 4, T. 39, 19, Pine Co.	Cupriferous	Warren Upham, W. side of Kettle R..
4541	"	"	Fine, trap-rock.....................................	1	Sec. 17, T. 39, 19, Pine Co.......	"	" S. end of Big Island..
4542	"	"	"	2	N. W. ¼ Sec. 29, 39, 19, Pine Co	"	" W. shore St. Croix R..
4543	"	"	Core of diamond drill, (trap)...................	1	S. W. ¼, N. W. ¼ Sec. 25, 39, 21, Pine Co................	"	" Chengwatona Mining Co.................
4544	"	"	From 50 ft. vein, (said to bear copper)..........	1	" "	"	" "
4545	"	"	Calc spar in trap-rock..........................	4	" "	"	" "
4546	"	"	Greenish trap, with calc spar.....................	3	" "	"	" "
4547	"	"	Green amydagloidal trap, (has Thalite)........	2	" "	"	" "
4548	"	"	" " "	2	" "	"	" "
4549	"	"	Trap-rock, with spar crystals....................	2	" "	"	" "
4550	"	"	Calcite crystals.....................................	2	" "	"	" Eugene L. Wilcox....
4551	"	"	Red conglomerate, (3d belt).....................	2	¾ m. E of Chengwatona........	"	" Strike N. 15°, E. dip 70°, S. 75°, E 30 ft thik
4552	"	"	Pinkish sandstone.................................	2	S. part Sec, 34, T. 43, 20, Pine Co	St. Croix.	" Ravine W. of Kettle R.
4553	"	"	Coarse, pinkish sandstone.......................	3	S. part Sec. 15, T. 42, 20, "	"	" Brink of Lower Falls, Kettle R...........
4554	"	"	Coarse gritstone..................................	1	¾ m. S. of mouth Grindstone R..	"	" W. side of Kettle R...
4555	"	"	White sandstone..................................	1	S. E. ¼ Sec. 30, 39, 19, (Wis.)....	"	" E. of most sonth'n of "Thousand Islands.'
4556	"	"	Argillaceous, red sandstone......................	1	" "	"	" "
4557	"	"	White sandstone..................................	2	N. E. ¼ Sec. 36, T. 39, 20, Pine Co	"	" Used for court house found'n, Grantsburg
4558	"	"	Red sandstone, (with pebbles)....................	4	N. part Sec. 23, T. 42, 23, Kenabec Co......................	Potsdam.	" E. bank of Snake R...
4559	"	"	" (with coarse pebbles)..........	3	" "	"	" " "
4560	"	"	" (with dark and light spots).....	1	" "	"	" " "
4561	"	"	Calcareous, concretionary shale, (gray).......	4	Two Rivers, Morrison Co.......	Cretaceous.	" W. shore Miss. R, 25 rods N. of mouth of main two rivers....
4562	"	"	Ferruginous, concretionary shale, (spongy)...	1	" "	"	" " "
4563	"	"	" " " (compact)...	1	" "	"	" " "

4564	Oct., 1881	Geol. Survey......	Lignitic clay..	4	Two Rivers, Morrison Co.......	Cretaceous.	War'n Upham	S. E. side main two rivers, 1-10 m. above mouth..............
4565	"	"	Lignite lumps in lignitic clay....................	1	" "	"	"	" "
4569	"	"	Cone-in-cone..	2	" "	"	"	40 rods S. E. of mouth of main two rivers, on W. shore Miss. R.
4570	"	"	Block of bluish clay.............................	1	4 m. E. of Luverne.............	"	"	From depth of 356 ft. in Rock Co. Farming Co's well.......
4571	"	"	Pebbles of limestone and shale.................	10	" "	Drift.	"	From Rock Co. Farming Co's well.......
4572	"	"	Soil, (thought to be saline).......	1	N.W.¼ Sec. 29, 159, 48, Kittson Co.	"	"	....
4573	"	"	Coal, (contained in sand 141-157 ft below surface.	1	N. E. ¼ Sec. 29, 146, 46, Norman Co..................	"	"	From Lockhart farm.
4574	"	"	Dark concretionary mass from the soil.........	1	Sec. 26, 41, 31, Morrison Co.....	Drift.......	"	Found in plowing by J. W. Tanner.......
4575	"	"	Gray till, above the blue till....................	1	Sec. 8, T. 127, 29, "	"	"	Young Bro's mill, main two rivers....
4576	"	"	Blue till..	1	Sec. 8, T. 127, 29, "	"	"	" "
4577	"	"	Gray till.........	1	St. Francis bridge, Anoka Co...	"	"	E. bank of Rum River.
4578	"	"	Red till, (underlying No. 4577)..............	1	" " "	"	"	" "
4579	"	"	Red till..................................	1	Sec. 16, T. 121, 24, Wright Co...	"	"	Well of David Bagley, 4. m. E. Monticello.
4580	"	"	Porphyritic hornblende schist.......	2	Sec. 12, T. 140, 46, Clay Co......	"	"	From a boulder 15 ft x 12 ft. x 5 ft.......
4581	"	"	Perforated, water-worn boulder................	1	Sec. 7, 129, 29, Morrison Co......	"	"	2. m. N. W. of Little Falls R. J. Lambert's well.................
4582	"	"	Perched rock, standing on No. 4450.............	1	Sec. 7, T. 41, 30, "	"	"	Standing on 3 points, (8 ft. in diam.)....
4583	"	"	From a boulder of syenite, (like Watab)........	1	Sec. 23, T. 42, 23, Kenabec Co...	"	"	On Snake River.......
4584	"	"	Pebble of conglomerate.	1	Mout of Snake River..........	"	"	....
4585	"	"	Pebble of red conglomerate.....................	1	Sec. 6, T. 38, 19, Pine Co........	"	"	Contains red shale....
4586	"	"	Compact mottled limestone......................	1	Sec. 1, Springvale, Isanti Co....	"	"	Found in slabs 10-20 feet long...........
4587	"	"	Garnetiferous mica schist......................	4	Sec. 7, Palmer, Sherburne Co...	"	"	From a bou der 25x30 x20 ft...............
4588	"	"	Banded, red, jasper pebble.......	1	Sec. 23, Sauk Rapids...........	"	"	With other pieces, 1 ft. long... ....
4589	"	"	Pebbles, (crystalline rocks).....................	10	N. E. ¼ Sec. 26, T. 39, 24, Kenabec Co......................	"	"	From Fish Lake dam.
4590	"	"	Beach pebbles " "	45	N. W. shore of Mille Lacs, Crow Wing Co............	"	"	Characteristic of shore
4591	"	"	Hollowed pebble, (rounded).........	1	" " "	"	"	....
4592	"	"	Beach pebbles, (some limestone)................	40	N.E. side L. Alexander, Mor. Co.	"	"	Characteristic of shore
4593	"	"	Pebbles from top of Hole in the Day's Bluff....	20	N. W. ¼ Sec. 36, T. 41, 32, "	"	"	1¾ m. N. E. Littlc Falls, no limestone.
4594	"	"	Pebbles, (considerable limestone)........... ...	10	Sec. 5, 127, 29, Mor Co..........	"	"	1¾ m. N. Two Rivers..
4597	"	"	Concretionary nodule from the Cretaceous.....	8	Sisseton Agency, Dak..........	"	Thomas M. Young,	1½ m. E of school.
4598	"	"	Coarse granite, with tourmaline.................	1	" "	"	"	On Coteau de prai'e..

Specimens Registered in the Museum in 1881—*Continued.*

Serial Numbers.	OBTAINED.		NAME.	No. of Specimens.	Locality.	Formation.	Collector and Remarks.
	When.	Whence.					
4599	Oct. 1881	Geol. Survey	Annular section of concretion in pebble	1	8 m. W. Sisseton Agency, Dak.	Drift	Warren Upham, summit of Coteau de Prairie
4600	"	"	Fine, yellow clay, (for brick)	3	Sec. 26, T. 127, 34, Todd Co	"	" E. shore Big Sauk L. 3 m. N. E. of Sauk Center
4601	"	"	Dark clay, (laminated and fine)	2	" "	"	" " " "
4602	"	"	Irony, cylindrical concretions.	2	" "	"	" From Pangburn & Moore,s brick clay
4603	"	"	Limy, flat concretions	2	" "	"	" " " "
4604	"	"	Fragment of large bone	1	" "	"	" 10 feet below surface in Pangburn & Moore,s brick clay.
4605	"	"	Red brick	1	2 m. S. Rush City, Chisago Co.		" Near R.R., Spooner & Hayden.
4606	"	"	"	1	Sec. 8, T. 133, 32, Todd Co.		" H.B.Morrison, 5 m.W.Motley.
4607	"	"	"	1	S.W ¼ Sec.8 T.133, 35, Todd Co.		" Murray&Allen,7 m.S.Wadena
4608	"	"	Cream brick	1	Sec. 35, T. 131, 31, Todd Co		" G G.Howe, 1½ m.S.E.Clarissa.
4609	"	"	Well " (cream)	1	" "		" " " "
4610	"	"	Pink "	1	Sec. 26, T. 127, 34 "		" Pangburn & Moore 3 m N. of Sauk Center
4611	"	"	Red "	1	Sec. 22, St. Cloud, Stearns Co.		" Greven & Lommel
4612	"	"	Cream "	1	Sec. 26, " "		" Wm. Kruegel
4613	"	"	" "	1	" " "		" Frederick Kuhne
4614	"	"	Red "	1	Sec. 13, Otsego, Wright Co		" Ingersoll Bros
4615	"	"	Cream "	1	Sec. 20, Grow, Anoka Co		" Kelsey Bros., 3 m.N.E. Anoka.
4616	"	"	Well " (cream	1	" "		" " " "
4617	"	"	Cream "	1	Crookston, Polk Co		" Norris & McDonald
8618	"	"	" "	1	" "		" W. A. Norcross
4619	"	"	Pink "	1	Breckinridge, Wilkin Co		" Jos. Hall, E. bank Red R
4621	Aug, 1881	"	Magnesian limestone	1	Dresbach	St. Law'nce	N. H. Winchell
4628	1880	Exchange	Sassolite, lamelated & vitreous, (original No. 1.)	1	Tuscany		In a bottle
4629	"	"	Alunogen, yel'w & conretionary (" No. 2.)	1	Ariege, France		
4630	"	"	Anhydrite, violet, lamellated (" No. 3.)	1	"		
4631	"	"	Cerargyrite, on ferruginous barite (" No. 4.)	1	Chili		With gray copper and haematite
4632	"	"	Aragonite prismatic, (" No. 5.)	1	Saragossa, Spain		Crystallized with red quartz

4633	1880	Exchange	Bismuth, native, lamellated, (" No. 6.)	1	Saxony		With arsenical cobalt and arsenate of cobalt
4634	"	"	Smalttie (" No. 7.)	1	Sweden		Fragment of split crystal
4635	"	"	Apatite, white (" No. 8.)	1	Ariege		Concretionary, also brownish and amorphous
4636	"	"	Gypsum in 2 crystalline sheets, (" No. 9.)	1	Montmartre		Reflecting from an incrustation of iron.
4637	"	"	Calcite quartziferous (" No. 12)	1	Fontainbleau		Sharply rhombohedral, crystals of Fontainbleau
4638	"	"	Freieslebenite, gray (" No. 15.)	1	Hiendelaencina		Amorphous, on gneiss
4639	"	"	Noumeaite, (hyd. Sil. Nickel) (" No. 17.)	1	Noumea, New Caledona		In a network of concretionary quartz.
4640	"	"	Rhodonite (" No 18.)	1	Spain		With black sulphate of manganese and quartz
4641	"	"	Sulphur and celestite (" No 19.)	2	Sicily		Prismatic celestite, (on a bluish marl).
4642	"	"	Bornite, massive (" No. 20.)	1	Chili		Massive, variegated copper
4643	1881	Presented	Gold in quartz.	1	Black Hills		Presented by D. A. Locke, (Bengal Tiger Mine
4644	"	By Exchange	Spodumene	1	Sterling, Mass		
4645	"	"	Damourite, (sterling)	1	"		
4646	"	Presented	Slabs with Lingula Melei and Discina Newberryi	3	Berea, O.	Cuy. Shale	C. W. Hall
4647	1877	Geol. Survey	Pebbles of red quartzyte in the quartzyte	1	Pipestone quarry	Potsdam	N. H. Winchell
4668	1881	"	Mass of Selenite crystals, (original No. 21.)	1	Lit. Missouri Cantonment	Ter ?	" from Dr. Miller
4676	1878	"	Calcareous geode	1	Dakota Territory	Cretaceous	C. A. Morey
4677	1881	Exchange	Freieslebenite	1	Spain		With barite, drusy quartz and siderite.
4678	"	Geol. Survey	Ripple marked slab of red quartzyte	1	Pipestone quarry	Potsdam	Warren Upham, presented by C. H. Bennett
4679	"	"	Building stone block 1 foot square	1	Stone City, Jones Co., Iowa	Niagara	N. H. Winchell, J. A. Green's quarry.
4680	"	H. S Peters	Quartz crystals, twinning and overlying	1	Herkimer, Herkimer Co., N.Y.		Presented by H. S. Peters
4681	1880	Presented.	Graphite	1	Heath, Mass		
4682	"	"	Corundum, (Emery)		Plymouth, Ct		
4683	"	"	Granite		"		
4684	1881	Geol. Survey	Drilling from deep well, Minneapolis in glass tube		Minneapolis		Well at Washburn C mill, 205 feet, (C. E. Whelpley)
4685	1880	"	" " " in a glass tube at Emmettsburg, Iowa		Emmetsburg, Iowa		Well is 869 ft., (pres. by W E. Swan)
4690	1881	J. B Clough	Elephant's tooth, (15 inches long)	1	Near the Rosebud River, Mon.		Presented by J. B. Clough

ARCHÆOLOGICAL ADDITIONS TO THE MUSEUM IN 1881.

58. Hair of a native of the New Hebrides. Two braids.

59. Two chalcedony arrow points, from near Young Men's Butte. Dakota. Presented by D. P. Jones.

60. One chalcedony spear point, from near Young Men's Butte. Dakota. Presented by D. P. Jones.

61. Two chert arrow points, from near Young Men's Butte. Dakota. Presented by D. P. Jones.

62. One iron arrow-point, from near Young Men's Butte. Dakota. Presented by D. P. Jones.

63. Small stone hammer, withed. From Michigan. Presented by N. H. Winchell.

64. One Indian stirrup, ornamented with white beads. Presented by Col. J. B. Clough.

65. One stone slab, 18 inches in length, apparently used for rubbing and tanning skins. From Dakota. Presented by Col. J. B. Clough.

66. One hickory bow and rawhide case, with rawhide quiver containing seven arrows, five of them with iron points. From Miles City, Montana. Presented by Col. J. B. Clough.

67. An Indian weapon—a quartz pebble surrounded by a rawhide withe which is extended into a handle about three feet long, terminating with a loop for the wrist, and stiffened by a flexible stick. From Miles City, Montana. Presented by Col. J. B. Clough.

68. Small. perfect arrow-point of quartzose, oolitic, or concretionary chert. Found on the University campus by Mr. Fisher, and by him presented to the University Museum.

69. Stone ax, withed, of dark dioryte, found near Albert Lea. Presented by Rev. L. J. Hange.

70. Pangue knife, from the Ogove river, Africa, said to be made of "native iron," enclosed in a snake-skin sheath. Presented by Rev. G. C. Campbell.

71. Loom and three yards of cloth, made from bast fiber, by the *Ivilli*, of the Ogove river, Africa. Presented by Thos. Sinclair, trader on the Ogove river, through Rev. G. C. Campbell.

72. Native dress, worn by the *Ivilli*, and others up the Ogove river, Africa. Presented by Thos. Sinclair, trader, through Rev. G. C. Campbell.

73. Prehistoric Maize, from the old cemetery near Madisonville, Hamilton county, Ohio. Presented by N. H. Winchell.

VI.

GEOLOGICAL NOTES ON MINNESOTA.

BY MR. J. H. KLOOS.

[Translated by N. H. Winchell.]

[NOTE.—These notes were made by Mr. Kloos when serving as Land Agent of the St. Paul & Pacific R. R. and were published in the *Zeitschrift d. Deutschen Geologischen Gesellschaft*, p. 417. They furnish the basis for the subsequent investigations of Streng and Kloos on the crystalline rocks of Minnesota, and contain original observations on the stratigraphical relations of the formations, which differ from those of his predecessors, particularly on the trap and sandstone at Taylor's Falls. They furnish an important historical link between the surveys of Owen, Whittlesey and Eames, and the beginning of the present survey.]

Since the publication of the geological survey carried on under the direction of the American geologist, David Dale Owen, little that is noteworthy has appeared on the geology of Minnesota.

Owen with his assistants, Norwood, Shumard, Whittlesey and eight others, explored the States of Wisconsin, Iowa and Minnesota from 1847 to 1850. In his report to the government of the United States he gives a careful description of the country in respect to its geography and geology, its fauna and flora, as well as its agricultural resources. The 638 pages of his heavy quarto volume contain a vast amount of valuable and exact observations, especially upon the northern part of the district examined, in which even yet exploration is attended usually with great difficulties. A fault of the work is its petty simplicity. The detailed descriptions of many river-valleys, in respect to topography and climatology, render difficult the attainment of a general view of the geology. The description of the crystalline rocks of Minnesota, which in many respects possess a high importance, is faulty. Also the palæontological subjects are not thoroughly treated, and the illustrations of new species published by Owen possess little merit.*

In the year 1866† appeared a little pamphlet on Minnesota by Charles Whittlesey, formerly an assistant of Owen. It is confined almost en-

*Report of a Geological Survey of Wisconsin, Iowa and Minnesota, by authority of Congress, by David Dale Owen, Philadelphia, 1852.

†A report of explorations in the mineral regions of Minnesota during the years of 1849, 1859 and 1864, Cleveland, 1866.

tirely to the shores of Lake Superior, and describes the conditions and appearance *in situ* of copper and other metals.

The examinations by the State Geologist, Henry H. Eames, pertain exclusively to those parts of Minnesota in which copper, iron and small quantities of gold are found. In his report for 1866 he confines himself to the description of the occurrence of the useful metals and their ores.*

An important paper on the geognosy of southwestern Minnesota was published by Prof. James Hall in the year 1866. His design was to examine the outcrop of coal on the Cottonwood river, one of the important tributaries of the St. Peter or Minnesota river. Owen with his assistants had been only to the mouth of the Cottonwood. Hall penetrated as far as the celebrated locality where the Indians obtained the "Pipestone" for their pipes.† He shows that the coal outcropping there belongs to a younger formation—viz.: the Cretaceous—and assumes the former extension of the Cretaceous as well as the older Mesozoic strata, over that part of Minnesota. At the same time he offers some valuable observations upon the crystalline and metamorphic rocks which appear along the Minnesota river above the mouth of the Cottonwood.‡

In the following I have sought to gather together in a comprehensive survey my various notes on different parts of Minnesota; and where it has been necessary to a comprehension of the description, and I was not able personally to make examinations, I have filled them out from earlier observations of others. By means of the map I have aimed rather to aid the reader than to present an exhibition of the geological conditions. The points of observation are in the river valleys, separated by wide tracts covered by drift, and we are not at this time in condition to announce with any certainity the boundaries of the formations. I have gathered much material which is designed for a more careful investigation at some later time, and if time and opportunity are afforded me I aim to treat the separate subjects more thoroughly, which now can only be mentioned briefly.

The State of Minnesota in the geographical center of the continent

*Report of the State Geologist, Henry H. Eames, on the metalliferous region bordering on Lake Superior. St. Paul, 1866.

†Mr. Kloos has fallen into an error in respect to both Owen and Hall. Owen's assistant, Shumard, ascended the Minnesota valley as far as the mouth of the Redwood river, instead of the mouth of the Cottonwood; while Hall only went as far west as Lake Shetek, instead of to the Pipestone quarry. (N. H. W.)

‡Notes upon the Geology of some portions of Minnesota, from St. Paul to the western part of the State. By James Hall, Trans. Am. Phil. Soc. vol. XIII, p. 329.

of North America, lies between 43½ and 49 degrees of north latitude, and between 89½ and 97 degrees of west longitude. This member of the American Union is bounded on the south by Iowa, on the east by Wisconsin, north by the Winnipeg district of British America, and westerly by the territory of Dakota. The area of the state embraces 84,000 English square miles.* A wide wedge, jutting toward the east, extends between Lake Superior and the Rainy lake river which with a succession of small fresh-water lakes forms the boundary line along British America. Therefore Minnesota has a coast line of 160 miles, and a position extremely favorable for trade with the eastern States.

To the geographer, therefore, Minnesota possesses a great intrest, inasmuch as within its borders are found the spring-sources of the great rivers of the American continent. It lies to the north, in the least accessible portion of the United States. Upon the accompanying map of Minnesota can be seen two small lakes, distant but a few miles from each other, known as Itasca and Elbow lakes. In lake Itasca the Mississippi river has its source, and in Elbow lake the Red river of the North. The former flows, as is known, in a southerly direction to the Gulf of Mexico; the other turns with a sharp angle toward the north, unites in the great lake Winnipeg with the waters of the Saskatchewan coming from the Rocky Mountains, and empties with them through the Nelson river into Hudson's Bay. Lastly, the St. Louis and the Rainy lake rivers form the beginning of the extensive fresh-water system which comprises the chain of great lakes, and empties its waters in the Atlantic through the St. Lawrence.†

In Minnesota the banks of the Mississippi and its tributaries, together with the rocky shores of lake Superior, with its many short water courses, and the small lakes in the extreme northern part of the state, afford the only information concerning the age and composition of the earth's crust. As soon as one leaves the river valleys, he finds the older formations covered with heavy rolling hills of sand or clay without organic remains. These later deposits, which form a covering unbroken, except by the river valleys, are a part of the "Drift Formation," of North America. Over an extensive part of this territory it is spread out over the oldest crystalline rocks and on the sedimentary formations, and it extends south to the fortieth degree of north latitude. Even of the drift, in many parts of the state, can an idea of the

*Wherever in this work miles are mentioned, the English Statute miles must be understood, of which 4.61 make a geographic mile.

†Mr. Kloss here loosely refers to the northern waters of the state. In reality the Rainy Lake river does not flow east into lake Superior, but westward into lake Winnipeg. [N. H. W.]

composition and nature be ascertained only along the separate water-courses, because for days together one can travel without getting sight of a rock or of a hill. Either the grassy, boundless, prairies stretch out in all directions so that the eye cannot discern any tree or shrub, or vast forests, with successive meadows and lakes, cover the country. In the northern part of the state are many impenetrable cedar swamps, and through there it is only possible to pass in winter, when the swamps are frozen.

The sand and clay deposits of the drift formation are so thick that the smaller water-falls, the brooks and the rivers which have little descent, afford no additions to the outcropping rock. In southern Minnesota are cuts along the railroads from fifty to a hundred feet deep in which the bluffs show nothing but sand, loam and clay, without any organic remains. The drift forms sometimes a hilly, heavy deposit or extensive terrain, and sometimes a smooth horizontal surface as level as the sea. The depressions and valleys between the hills are generally filled with water, and thus are formed a numberless multitude of smaller and larger lakes. Their shores generally descend gradually, and show in the water-worn masses which gather there, the most varied kinds of crystalline rocks and metamorphic schists. Many swampy spots, both in the forest and on the prairie, are dried up lakes. By further draining these make excellent pasture grounds. The low grounds filled with water in the surface of the drift, are the remains of a single extensive fresh-water lake. In many places can be seen the remains of this old lake deposit. They consist of clay and loam with the same fresh-water mussel and snail shells as live at the present time in lakes and rivers. The southern shore of this lake lies probably not far from the Iowa boundary, where the highest ridges of the plateau are found. At Rochester and Mankato, points south of the Minnesota river, have been found trunks and branches of various kinds of trees, especially oak and cedar, in hills consisting of clay, twenty to fifty feet under the surface, and nine hundred and forty feet above the ocean level. These are all evident proofs that these ridges have once been the swampy shores of an ancient fresh-water basin.

The plains of Minnesota have a hight from 800 to 1,200 feet above the sea-level. The hill-ranges which run in various directions and form the water divides between the rivers and river-systems, reach in some places the hight of 1600 and 1700 feet. These are at the same time also the highest land of the country, and actual mountain ranges of rock do not exist.* The passage from the low lands to the water sheds is for the most part imperceptible, and the undulations of the plains, with the exception of the shores of the great rivers, take place altogether gradually. The highest water-shed lies in the northern part of the state, and separates the waters which flow south through the Mississippi valley, from those which have a northerly direction toward Hudson's bay. It is composed, through its whole extent, of drift; also theother divides, and greater elevations of the surface, consist of sand, loam and clay, and it is in the lower grounds and river valleys that one must seek for the older layers of the earth's crust. The shores of the Mississippi, with the range of bluffs lying nearest, consist of rocks which belong to the oldest portions of the Silurian formation. They are sandstones and dolomitic limestones which correspond to the Potsdam and Calciferous Sandstone, as well as the Trenton period, in the state of New York and in Canada. The layers are in all places nearly horizontal; but where the river has excavated the sandstone, and undermined the limestone beds, the latter are thrown down, and in many places over large areas, have apparently suffered an extensive denudation. The formations mentioned are in outcrop from the mouth of the Wisconsin river to the Falls of St. Anthony, over an extent of 210 miles. At the Wisconsin river the higher layers of the Silurian disappear, and there remain only the equivalents of the Potsdam and Calciferous sandrock, from there to St. Paul. The beds have at first a gentle southerly dip, which they maintain to Mountain Island, in the neighborhood of the city of Winona. Here is the highest part of a saddle-shaped elevation, and from there the layers have a dip, though almost imperceptible, toward the north. The elevation and depression in the hight of the separate layers make it possible to establish these conditions most clearly, as has been set forth in several profiles by Owen in an admirable manner. I had the opportunity to examine somewhat carefully the layers in the heighborhood of this saddle. The first line of bluffs rises precipitously to the hight of five or six hundred feet above the floodplain, and shows the outcroping of beds which after considerable interruption have their continuance on the opposite shore. The lowest is a sandrock, and over it are beds of dolomite. The former, which occupies the greater part of the rock-bluff, exhibits a different texture in different places. Some beds are coarse-grained, and approach a conglomerate, and others are very fine-grained. It is in general loose and crumbling with lime-cement. The dolomite,

*According to published elevations, the hight of lake Superior at its low stage is taken at 600 feet. The latest measurements give an average hight of 605 feet) The Water-level varies in different years, and changes even with the seasons.

which here may reach a thickness of ninety feet, is of a light color, vesicular-crystalline, and resembles the German *Zechstein-dolomit.* It incloses many calc-spar and flinty concretions, which often attain a considerable size. I could discover no distinct fossils. Only in one place did I find a fragment of a coiled cephalopod, which must have been of considerable size. Afterwards I found the same sandstone on the St. Croix river where some of the layers are very rich in bivalves, and I shall mention later their occurrence in describing the same rock again in the neighborhood of Taylor's Falls. The sandstone Owen has named *Lower Silurian sandstone of the upper Mississippi*, and the dolomite he distinguishes as the *Lower Magnesian limestone.* The former answers to the *Potsdam Sandstone*, and the latter to the *Calciferous Sandstone*, of New York. The characteristic fossils are trilobites, which for the most part belong to the genus *Dikelocephalus*, also *Lingula* and *Orbicula.* In Minnesota it is difficult to find any large fragments of trilobites in the crumbling sandstone. Relying on observations made in Wisconsin, Owen distinguishes in this sandstone six trilobite-beds, which are separated from each other by other beds from ten to a hundred and fifty feet thick. In the magnesian limestone have been found up to this time only inconsiderable, and hardly recognizable, remains of fossils. They are a small *Lingula*, casts of the interior of shells which are related to *Euomphalus* and *Ophileta*, also fragments of trilobites like those in the sandstone. The geological horizon, therefore, of the lower dolomite must be determined at present from its position between the Potsdam Sandstone and layers of the Trenton formation.

Before reaching the mouth of the St. Croix river above which both banks of the Mississippi belong to Minnesota, the lower sandstone disappears, and the shores, which have a hight of 200 or 300 feet, consis entirely of dolomite, which exhibits most remarkable water-worn forms, and presents many changes in its outer contour. The bluffs frequently pass back from the water, and the banks become lower. At Red rock, six miles below St. Paul, the hills are half a mile back from the river, while the shores rise but a few feet above the water level, and form a plain which is fertile but exposed to frequent inundations. Small exposures of the dolomite are still to be seen. The bluffs consist almost entirely of the next higher layers, the equivalents of the Trenton formation. At St. Paul the same rocks outcrop by the river, and form a rugged rock bluff from 90 to 100 feet high. From here the Trenton group continues, till, above the falls of St. Anthony, all the layers disappear together under a heavy covering of drift.

At St. Paul the bluffs have a thickness of 65 feet of sandstone, covered by 15 to 25 feet of heavy limestone layers, a repetition, therefore, to a certain extent of the bluffs below. Yet the sandstone hardly deserves this name, in that a cementing material is entirely wanting, and the rock can be dug into as easily as a sand bank. Indeed it is nothing but a vast bed of quartz grains that hardly hang together, in some places, of unusual clearness and transparency. For this reason it has been recommended by Shumard, one of Owen's assistants, for the manufacture of glass. The shining white walls of this sand rise perpendicularly from the water, and reach at Fort Snelling, an old fortification against the Indians, at the mouth of the St. Peter river, its greatest height. From here to St. Anthony the height, as well as the thickness, of the sandstone gradually diminishes. I have never yet succeeded in finding any fossils in this sand, and Owen regards it as entirely destitute of fossil remains. As it everywhere appears in close connection with the overlying limestone beds, which contain a great number of fossils characteristic of the Trenton of New York and the Llandeilo Flags of England, it must for that reason be placed with them in the same group, and is regarded by American geologists as the western equivalent of the Chazy limestone.

It seems at first a remarkable circumstance that so old a sandstone, covered by limestone beds, should possess so little firmness, but on examining carefully the stratification, a shale bed is discovered between the limestone and the sandrock, by which a supply of limy cement must be entirely cut off. Indeed in the upper part of the sandstone are shaly layers, and they attain, under the limestone, a thickness of one and a half to two feet. The shale has a dull blue color, efferœsces with acids, on being dried falls away in long shaly fragments, and is converted to a thick paste when exposed to the influence of water and air.

Concerning the stratification of the Trenton, as it is displayed on the upper Mississippi, I shall speak in a later work.* The cities of St. Paul, Minneapolis and St. Anthony are built upon the same rock-beds, and in St. Paul especially are found numerous outcrops. The limestones are clayey or dolomitic. The middle portion, which is the greatest, furnishes a very good building material, of which the stone

*The layers of the Trenton have had formerly a much greater extent. In southeastern Minnesota are many isolated patches of limestone and of the St. Peter sandstone yet to be brought to light and described. The fine sand which has so great an extent in the banks of the St. Peter river is derived from the weathered and scattered debris of sandrock.

structures of the cities mentioned are built. The best known fossils are:

Orthis tricenaria. Conrad.
Orthis testudinaria. Dalm.
Leptaena sericea. Sow.
A smooth *Pentamerus* and a *Strophomena.*
Murchisonia bicincta.
Bellerophon bilobatus. Sow.

All characteristic shells of the Trenton, and partly also of the Llandeilo Flags of England.

In the higher layers are added corals and brachiopods as well as a trilobite, which are not seen in the lower layers. They are for the most part the following:

Rhynchonella recurvirostra. Hall.
Rhynchonella increbescens. Hall.
Petraia corniculum. Hall.
Stenopora fibrosa. Goldf.
Calymene senaria. (*Blumenbachii.*)
Ptilodictya sp.—

fossils which altogether have been assigned to the Trenton by Logan in Canada.

Six miles above St. Paul the Minnesota or St. Peter's river empties into the Mississippi, having its source in a lake on the boundary line of Dakota. In its banks the lower beds of the Silurian again outcrop. Still its banks remain much lower than those of the Mississippi, and the lower sandstone nowhere reaches a greater thickness than 35 feet above the water.*

Between Minneapolis and St. Anthony, which lie opposite each other, the Mississippi forms at the present time a water-fall which, in a manner similar to Niagara, only at a greater rate, is kept in constant recession. The white sandstone, or rather the sand bank, is exposed unceasingly to the influence of the falling water. It is washed out, and the overlying limestone beds are broken off in great sheets which fall down. This process can be observed everywhere in the neighborhood of the falls. In the midst of the river-channel lie the limestone masses scattered here and there in wild confusion. The falls are now but twenty feet high, yet must have had formerly, when the water plunged from the limestone beds, further down the river, a much greater height. Plans have been sought for to keep the falls in the

*The "Lower Sandstone" here referred to is the Jordan sandstone, and is not the "Lower Sandstone" seen in the Mississippi bluffs. [N. H. W.]

same place by means of dams, canals and locks, since both St. Anthony and Minneapolis are manufacturing cities, and the timber from the northern part of the State is here sawed in a large number of mills.

Every little stream that enters the Mississippi over its high bluffs exhibits in a small way the same phenomena. Hence arise a number of smaller very picturesque water-falls, which are met with in the neighborhood of both the cities mentioned, among which Minnehaha (Laughing-water) is best known.

The Trenton limestone is the youngest member of the Silurian formation that I have as yet been able to find in the banks of the Mississippi.* In southern Minnesota it seems also that the equivalents of the Hudson river and Clinton formations are found. During the writing of this sketch I have seen in an American teacher's monthly journal a little treatise on the geology of southern Minnesota, in which the author mentions in the banks of Root river, a tributary of the Mississippi, a hundred and forty feet of beds of shale and shaly layers overlying the Trenton limestone, and covered by still other beds of sandstone with a thickness of a hundred and fifty feet.† Still I have not been able to learn anything in detail concerning these layers; and inasmuch as no fossils from these beds were mentioned their age still remains questionable, although it is not unlikely that the younger members of the Silurian pass from northern Iowa to this side of the Minnesota boundary. I have exhibited the boundaries of the Upper Silurian and Devonian in southeastern Minnesota on the accompanying plate, according to the representation of Mr. Hurlbut.

Above St. Anthony the older formations are covered by sand and drift for a distance of sixty miles, and the banks of the Mississippi show no outcrops. A few miles below the city of St. Cloud the area of the crystalline rocks begins. The stratigraphical relations of the sedimentary formations in respect to these outcrops of granitic rocks unfortunately cannot be ascertained. The most southerly point at which I found the granitic rock was on the Sauk river, one of the important tributaries of the Mississippi river in this region. Also between these rivers low outcrops of granite rock suddenly appear in the midst of the forest. In the banks of the Mississippi itself no outcrops of granite are known so far south. The strike of the crystalline rock seems, for that reason, to run in a north northeasterly direction. It forms low hills, and flat, or somewhat rounded, knolls, which rise sud-

*The Hudson River beds can be seen at St. Paul, with a thickness of about 100 feet. [N. H. W.]

†W. D. Hurlbut, in the Minnesota Teacher, February, 1871.

denly above the swampy plains. The Mississippi continues twenty miles in this way—toward the north then it enters on a belt of metamorphic schists of about the same width, of which I only had information of a mica-schist containing a great number of beautiful staurolite crystals.

The crystalline rocks of the Upper Mississippi show a great difference in their structure. They consist, for the most part of hornblende, orthoclase, oligoclase and mica. Quartz, indeed, is generally also present, though often in very small amount. Real granites, disregarding several fine granite-porphyries, are apparently rare, as well as real syenites. These rocks are in many respects interesting and I am preparing a more special work on the subject. The syenite-granites, as I shall provisionally designate them, show numerous changes from hornblende to mica. Many parts are hornblendic on the borders, and others are completely covered over with mica scales. The hornblende is greenish-black, lustrous or earthy, the mica dark-brown, and very glistening.

Quarries have lately been opened in different rocks of this range; they are to be used as building-stone, which, till now, has been confined to the bluish dolomitic limestone of St. Paul and St. Anthony. At St. Cloud a rock has been opened, which shows uniformly a clear-blue color which is derived from the bluish-white, translucent, feldspar. The United States Custom House, in St. Paul, is now partly built of it, and it has also been used a little in smaller buildings. At Sauk Rapids is a similar rock, bearing less quartz and more hornblende, used in the construction of a dam, and for bridge-piers. Further north has been opened for several months a quarry in a very fine decided granite. The greatly predominating orthoclase has, in fresh condition, a glistening white color. Next to that in amount comes the quartz, in grayish grains, and then black mica. This rock is also known as "Watab white granite," and, as soon as the railroad which now only reaches as far as Sauk Rapids, is extended further, will be largely transported to Chicago and St. Louis for large buildings.

In the whole Mississipi valley, from New Orleans to St. Cloud, no crystalline rocks are found, and it has been necessary to use, until now, limestone and sandstone, of rather inferior quality, as material for building. The quarrying of these granite rocks on the upper Mississippi promises for Minnesota in the future to become an important industry.

In a south south-westerly direction appears a similar region of crystalline rocks, exposed on the Minnesota river, where Owen observed granite and syenitic rocks over an extent of 45 miles, between the Cottonwood and Redwood rivers. The region between these points furnishes no outcrops. It consists partly of rolling prairie, and has many lakes on the shores of which water-worn drift-boulders are heaped up. The drift here is very thick; and as the leveling for the building of the Pacific railroad has been carried over it, it is found to constitute a high plateau between the Sauk and Minnesota rivers.

While on one side the hight of the first plateau at the Mississippi reaches 750 to 800 feet above the sea level, and lake Traverse on the Dakota boundary on the other side lies 825 feet above the sea, the line of divide through this high plateau, in the strike of the granite range, is from 1,100 to 1,250 feet above the sea.

According to Whittlesey who has passed repeatedly over the region, there is a connection between the granites of the upper Mississippi and those of the Minnesota. He even goes further, and continues the range northeastwardly along the watershed north of lake Superior. The crystalline rocks observed by him on the upper course of the Rum river, south of Mille Lacs lake, lie in the same prolongation. The slight elevation of the ridges and the thickness of the drift, make it, nevertheless, as yet impossible to demonstrate the connection.

Also Norwood, on the map of the geological survey, in the atlas to Owen's report, extends the line of the crystalline rocks from the upper Mississippi to the Minnesota river. Further, he unites it with the area of granite and crystalline schists in the extreme northern part of the state, which apparently correspond in age and composition to the Laurentian system of Canada. Prof. Hall says that the rocks in the neighborhood of the Redwood river have a gneissic character, and belong to the laurentian system. The metamorphosed sandstones and quartzyte which outcrop in the region and are extended widely over southwestern Minnesota, he places in the Huronian. The relations which these systems sustain to each other are at present not yet ascertained.

Yet all the present indications are that a wide zone of Laurentian rocks goes diagonally through Minnesota, and is accompanied on both sides by Huronian rocks. Until now, the latter were known only to the north of lake Superior. Their presence, however, in southern Minnesota, Prof. Hall has called attention to, where he has also assigned the celebrated "Pipestone Quarry" to the same age. As I shall show in the course of this work, the roofing slates on the St. Louis river must also be reckoned in the Huronian formation.

The interval between the Mississippi and the Red river of the North, amounts to 120 miles. Over this whole extent no outcropping rock has been known with certainty. It is nevertheless probable that the regular succession of Silurian rocks which are displayed on the east of the granites and crystalline schists, returns again on the west. Besides, Owen mentions a spot on the Red river in the neighborhood of the present town of Breckenridge where the Lower Silurian limestone is exposed.* As far as my knowledge goes, this is at the present time the only spot on the Red river, this side the international boundary, where an outcropping rock has been observed. Waterworn pieces of Silurian limestone are, however, of very frequent occurrence in the drift of the Red river valley. Whittlesey mentions Potsdam Sandstone at the falls of Pokegama on the Mississippi in north latitude 47° 15′, northwest of the Laurentian belt. This observation had, indeed, also been made by Owen, and this seems to be the reason why Norwood extends the oldest members of the Silurian on his chart to this place.

A very interesting portion of Minnesota to the geologist, is the eastern; viz.: the shores of lake Superior and the bluffs of the St. Louis and St. Croix rivers. The St. Croix valley which forms the boundary line of Wisconsin, lies, for the most part, in the lowest beds of the Silurian. The principal fossils of the Potsdam Sandstone, and of the lower dolomite are found in this valley. The greatest thickness of this sandstone above the water reaches 170 feet; also the dolomite here reaches the thickness of 100 feet. The beds are apparently horizontal, but in general they have a gentle dip toward the south.¶ Forty-five miles above its mouth the river is contracted, and suddenly its banks take on a different character. In place of the regular contour lines of the sandstone, are rough jagged rocks which outcrop close by the water. Here one stands on the rocks of the celebrated and picturesque "Dalles" or *Felsenhallen* of the St. Croix. The rock has been named by American geologists "porphyritic trap," and it resembles the Norwegian porphyry, which can be seen at Bogstadt on the west side of the Christiana Fiord. Several beds of this rock are cut through by the river, and alternate in the banks with the layers of the Potsdam Sandstone. As yet, I have had the opportunity only to examine this interesting rock over a small area in the neighborhood of the town of Taylor's Falls, near the falls of the St. Croix. Here it is exhibited as a beautiful, quartzless porphyry, or porphyryte, and constitutes the shores of the river and the hill-ranges.

I reached the river from the west side. After I had traveled for hours from St. Paul over the beautiful prairie, suddenly the deep and

*No one else has ever seen this outcrop of limestone.—[N. H. W.]

widely cut valley presented itself right before me. It was a surprising sight. With the greatest regularity of hight, lay several terraces above each other, and with the same hight they were visible also along the opposite bluffs on the Wisconsin side. Taylor's Falls is built on the first terrace, at the foot of which the water boils over the rock crags with the noise of thunder. Right opposite lie the falling ruins of a town in Wisconsin named St. Croix Falls, which owes its hasty bloom and its short, ephemeral existence to the speculation of several enterprising Yankees. Taylor's Falls is what is called in the west, a *lumbering-town*, that is, a place where the lumbermen of the St. Croix buy provisions, and from which, every winter, the men depart for the pineries. The high hills which enclose the place consist of porphyry. Further down the river appears the Potsdam sandstone.

The river here does not cut through a single ridge of the crystalline rock, but several diagonal ridges of an area of porphyry. The rock has a pretty uniform character throughout its whole extent. The ground-mass is crypto-crystalline and has a dark-green color. Under the loop can be seen a dark, non-translucent mineral, which in many places is formed in fibrous particles [stangligen partien], and a translucent mineral having the color of olivine. The feldspar crystals, which vary from dark-brown to black, give the rock a characteristic spotted appearance. The feldspar shows very evident striation and twinning, and seems to be the same as that in the brown porphyry of lake Superior. I have found iron-pyrites only as an accessory portion. In several places the rock holds amygdules, the only material of which seems to be white translucent quartz.

The relation of the porphyry to the sandstone beds is interesting. Owen assumes that the latter have been broken through and cut by the trap, although, thereby neither their texture nor their horizontal position have been changed. I cannot confirm that view, but believe the relations of these rocks at Taylor's Falls must require that the porphyry is older than the sedimentary beds.*

Indeed, the layers of the sandstone, wholly undisturbed, as can be seen on both shores, demonstrate that. Furthermore, I observed on the right bank of the river, the rock-profile, seen in Fig. 1.

The sandstone beds here lie horizontal over the porphyry, and continue in this manner over an extended area. They contain a number of fossils which are very beautifully preserved, and prove, even as much as the texture of the sandrock, the insignificant influence of any later outbreak of plutonic rock. A better proof of the greater age of

*Mr Kloss is supported in this by Mr. Sweet, of the geological survey of Wisconsin. [N. H. W.]

the porphyry was afforded me by a conglomerate which consists of nothing but large water-worn masses of the porphyry, the position of

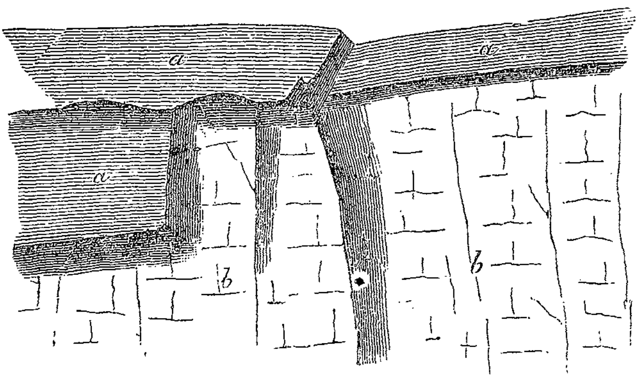


Fig. 1.

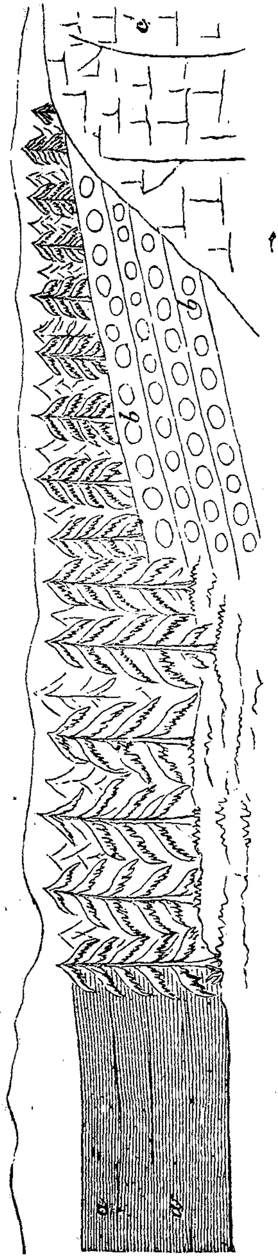
a a. Potsdam sandstone; the projecting beds which lie under the first river-terrace, on which Taylor's Falls is built. *b b*. Porphyry.

which is between the porphyry and the sandstone. This singular rock, which I saw only in one spot, but in a considerable thickness, descends from the porphyry down to the neighborhood of the sandstone. The water-worn masses, which occasionally reach a considerable size, lie immediately in contact with each other, and have but a slight cementing material between them. Still the rock is very hard, and plainly bedded. The rounded masses and the cementing material consist altogether of more or less decomposed porphyry. Unfortunately the spot where the conglomerate lies under the sandstone, is covered with vegetation. (See Fig. 2.)*

The character of the different beds which compose the sandstone at Taylor's Falls changes greatly in short intervals. The layers on the Minnesota side form a more continuous, projecting terrace than on the Wisconsin side, where, between the porphyry ranges, are several shallow or flat troughs. Going along the shore, I passed over several small hills, outrunners of the main hill range which forms a belt parallel with the river. Between these small hills lie the layers of sandstone, which descend on both sides level to the middle of the trough. If one ascends the main hill-range, nothing can be seen of the sandstone. How far the porphyry extends on each side from the river is unknown. In Minnesota, it disappears soon under the drift.

*Whittlesey mentions several spots in the neighborhood of lake Superior where the beds of the Potsdam sandstone lie upon the porphyry, both on the southern shore, at Keweenaw Point, in Wisconsin, and along the northern coast. But yet there can be no doubt that there is a porphyry and melaphyr of the age of the Potsdam sandstone, the layers of which it broke through and upturned. It seems that the outflow of this quartzless porphyry began in Huronian time, and continued through the first part of the Silurian. The inclusion of the sandstone within the porphyry, mentioned by Owen, I have not been able to find at Taylor's Falls, though I have made diligent search.

Fig. 2.



a a Sandstone; b b Conglomerate; Porphyry.

In one of these troughs the rock consists of thin layers of dolomitic marl. It has a clear-gray color, a smooth, conchoidal fracture like limestone, and crumbles in the air, and at the same time it assumes a dazzling white color At the first glance one is apt to take it for a limestone; yet as it does not effervesce at all with acids, it must be principally dolomitic. Further up the river lie dark, iron-stained, firm crystalline layers of a sandy limestone; also the same in thin layers. At the same level on the Minnesota side is a clayey sandstone which does not effervesce with acids. It varies from fine to coarse grained. The latter prevails in the lower portion of the confused mass, and forms a high bank which rests immediately on the porphyry.

All these rocks carry the known species of *Lingula*. Those with the narrow extended beak (*L. antiqua*), and those which are shorter and wider (*L. prisca*) are very abundant, and completely fill some of the layers. Specimens of the former frequently reach five-eighths inch in length. Besides *Lingula* there are also species of *Orbicula* and *Obolus*, and trilobite shields as large as peas (*Conocephalites minutus?*). The shells seem to be distributed in certain belts in the layers; especially is this the case in the coarse, conglomeritic sandstone.*

The varied composition of the beds in their general relations is remarkable. It is true a simple layering one over the other can be seen; on the other hand they all seem to

*The large wedge-shaped *Lingula* Owen has described as a new species, naming it *L. pinnæformis*, on account of its resemblanse to a *pinna*. Nevertheless his illustration of it cannot be distinguished from *L. antiqua*, and in his description he does not bring forward the difference between it and the older species. Another peculiar species which Owen cites from the Taylor's Falls beds is the *Orbicula prima*, a very well defined shell, but which still may be identical with species of *Orbicula* described before from other places. I have no opportunity here to investigate the specific differences, and I shall return to it again later.

occupy the same level; both sandstone and dolomitic shale outcrop opposite each other in the banks of the river at the same hight, and they vary but little from the horizontal.

In order to obtain an examination of the relations of the sedimentary beds to the porphyry and melaphyr-like rocks of the north shore of Lake Superior, I made a trip the past fall to the west end of that lake. The railroad which connects St. Paul with this great American lake was completed the first of August of the former year. An iron track of 155 miles now connects the end of navigation from the Atlantic Ocean with the head of navigation of the Mississippi Till within a short time it was very difficult to travel from there to the head of Lake Superior—now one rides there in a few hours The commencement of the autumn storms made it impossible to carry out my plan, and I was compelled to confine my observations to the St Louis river and the immediate neighborhood of the railroad.

Except a few cuts in the Trenton limestone in the suburbs of St. Paul, the tract of country crossed by the Lake Superior road affords no outcrops of rock till one reaches the valley of the St. Louis river. A vast forest, for the greater part consisting of pine, covers over the whole region. The land is generally flat and swampy. The railroad surveys have established the highest point at 567 feet above Lake Superior, or 1,167 feet above the ocean This point is 120 miles from St. Paul and 35 miles from the lake. On all sides the plateau is flat, descending gently in both directions.

The first outcropping rock appears in low ridges in the midst of a cedar swamp near the St. Louis river, and at this place occurs the first opportunity since leaving the Mississippi, to behold the bedded rocks.* From here to the lake there is much rock, which offers an extended and little explored field for geological studies. During my short visit I could only make obeervations at a few points. The region is for the most part difficult to travel over. Extensive forests and swamps conceal the rock from view. There are no roads—even between the different stations and new places on the railroad it is necessary to travel on the railroad itself. When the rivers and streams are no longer passable for canoes, it is necessary to scramble from rock to rock in order to be able to look at the neighboring country. A slippery red clay forms the surface covering, wherever the black soil is torn up. Wherever the trees have been cut and the brush burnt, wherever roads have begun to be laid out, it is entirely impossible to travel after the

*The bedded rocks, however, also appear in outcrop at White Bear Lake, at Hinckley and at Moose Lake [N. H. W.]

occurrence of a few showers of rain. The whole region bears, more than any other in Minnesota, the stamp of wildness and primitiveness. It has been asked, what can be made of it. It will require immense resources and great labor to make it habitable and productive.

The St. Louis river comes from the north, from a region of granite gneiss and mica schist about Vermilion lake, and turns, just before its waters reach Lake Superior, with a sharp angle to the east. Here the railroad company has constructed a high bridge over the river, and a new town is established which has been named Thompson, from one of the officers of the company. The water has broken through the steepey tilted beds, and here forms a long succession of falls and rapids, which in a few miles produce a descent of 370 feet, and are known as the *Rapids of the St. Louis River*. The valley is narrow and shut in by high picturesque cliffs. A dark fir-tree forest covers the hills about —indeed no region of America has reminded me so forcibly of the valleys of the Hartz mountains, and especially of the Bode and a part of the Okerthales.

The rocks also are similar to the rocks of the Hartz. The various strata consist alternately of dark-blue crystalline layers, frequently in the form of roofing slates, and a light firm sandrock or quartzyte which looks like many German graywacke sandstones.*

There has been formed a company for the manufacture of the roofing slates. Two quarries have been opened which promise good results. The slate is carried to St. Paul by the railroad; and this may become in the future a profitable industry. Norwood also mentions other slates on the St. Louis which are of a talcose and chloritic nature. Since they are found further up the river, they are in age earlier than the roofing slates. He has also noted a steep dip in the layers in opposite directions, which he ascribed to the injection of igneous rocks. But these he did not find. I also found no crystalline rocks, and I am not of the opinion that at the falls of the St. Louis river any local cause appears that produced the disturbance of the layers. So far as known to me the bedded rocks of northern Minnesota which are older than the Silurian, have been upheaved in the same manner. The beds are broken in a jagged form, and stand out boldly in little rock-islands in the very channel of the river, by which the quartzyte and slaty layers are always easy to distinguish, because the former constitute the elevated parts and the latter the troughs of the outcropping layers, as they are eroded and excavated by the water. No fossils have yet been found in these beds. The inclusions consist

*This quartzyte seems to have been taken for greenstone both by Norwood and Eames.

of little sulphur nodules. The principal quartzyte beds are penetrated by veins which are composed of quartz and calc-spar. Lines of feld-spar are also of frequent occurrence in the slates.

Probably this whole formation belongs to the Huronian system which on Lake Huron and in the upper Peninsula of Michigan, appears between the Laurentian system and the lower Silurian. The position here exactly corresponds to that horizon. Credner in his work* on the pre-Silurian formations of the Upper Peninsula of Michigan, regards as a member of the Huronian a series of clay-slates and quartzyte beds of which the description applies equally well to these rocks. Chloritic slates constitute there as here a portion of the formation. The Potsdam Sandstone lies upon the outcropping beds in Michigan in the same manner as it can be seen to do on these beds further down the river at Fond du Lac. I have not examined this point myself, but quote Norwood's report, as to the facts, as follows: "Not far from the village of Fond du Lac the clay slates and chloritic slates are lost under the conglomerates and red sandstones of Lake Superior, the lower part of the Potsdam system. The latter lie upon the outcropping edges of the slates, with an inclination of six or seven degrees, but dip in the same direction." The place where the two systems lie unconformable to each other does not exceed three miles from the railroad bridge at Thompson, according to the statements of Norwood. From the position of the clay slates, one can infer the presence of the iron-bearing beds which in Michigan characterize the lower part of the Huronian. Perhaps these are the iron beds at Vermilion lake, in the neighborhood of which the metamorphic layers of the Laurentian begin.

Only at one place is the red sandstone to be seen near the railroad in the neighborhood of Lake Superior. This can not be far from the spot where this rock, in connection with the coarse conglomerate, lies unconformably upon the Huronian. The beds here lie nearly horizontal, with a slight inclination toward the south. The upper cuts of the railroad are in red clay before mentioned which, with varying beds of shale, sand and gravel, covers the older formations north and south from the great lake. It embraces a great extent of territory, reaches the height of 600 or 700 feet above the water level, and fills the valleys intervening between the ridges of the clay slates and quartzytes.

At the end of the railroad, where at the present time the streets of the new city of Duluth are being laid out on a steep hillside with an outlay of unprecedented expense, are large exposures of different kinds

*This Journal, 1869, p. 528.

of crystalline rocks. These form the shores on the left of St. Louis Bay and of the Bay of Superior. The former consists of a widening of the mouth of the river, the latter of a part of the lake shut in by a narrow strip of land, forming a fine harbor. The conformation of the west end of Lake Superior is in the highest degree remarkable. Two small tongues of land project parallel with each from the shore, and are met by narrow points extended in the same way from the Wisconsin shore. Narrow channels or passes only are left so as to admit to the waters enclosed between them. The outermost of these strips of land, Minnesota Point, is six miles long, and has a mean width of only 600 feet. It consists of beach-worn material, or shingle, and it rises but few feet above the level of the water. These pieces have an oblong, generally flattened form, and consist for the most part, of melaphyr, porphyry, and amygdaloid with calc-spar geodes, both large and small.

Connor's Point in Wisconsin and Rice's Point in Minnesota separate the Bay of St. Louis from Superior Bay. Between them is a channel affording fifty feet depth of water, through which the waters of the St. Louis reach the lake. Superior Bay has its greatest depth near Minnesota Point. Along the opposite shore in Wisconsin it was necessary to build out more than a hundred feet into the bay to find nine feet of water, while on the Minnesota side the water had a depth of 15 to 18 feet. A street from Duluth extends now along Minnesota Point, and the railroad company have begun to cut through it in the neighborhood of the place where it is joined to the mainland, for the purpose of making a fine harbor, sheltered by this natural breakwater. The natural approach, six miles further south, is exposed to much drifting sand, and has also been worked by the people of Wisconsin in order to improve it for an entrance.

In the vicinity of Duluth I have observed three different kinds of rock, but nowhere could I make out the connection which they have to each other. The first, which rises from under the red drift clay and is finely exposed in the vicinity of the railroad depot, the Americans style "granite," to which, however, it has no resemblance. It consists principally of a feldspar of a dirty white color, which is in the form of fine large crystalline grains, which show three cleavage directions. Two of these stand almost at right angles to one another, one of which has a marked greasy luster, and the other a strong glassy luster with fine twinning-lines. The third cleavage direction is only made apparent by fractures which cut both of the others at acute angles, and seems to appear very rarely. I took the feldspar for labradorite. The second ingredient is a dark green to black mineral, of a greasy appearance, which it is difficult to distinguish, because the color is like that of the predominant feldspar. It is indistinctly fibrous, and I took it for diallage or hypersthene. A black, shining mineral, in irregularly shaped grains, which have a strong metallic luster, is sprinkled abundantly in this rock, and stands out beyond all the others on the surface of the weathered crust. On a fresh fracture of the rock it is hard and brittle. Yet under the action of the atmosphere it becomes softer, and then if it is scratched with a knife, small black particles of it remain attached to the blade. Before the blow pipe it behaves like pure magnetic iron. It disintegrates only after a long time, and very seldom is it seen to become oxidized on the outside and changed to a brown ochre. No trace of titanium was discovered.

For the most part this rock has a resemblance to gabbro, or hypersthenyte, although it shows in its whole extent a tolerably uniform structure, and generally a coarsely granular texture. In this rock a quarry has been opened, and the stone is being worked and polished for monumental purposes.

The second rock is cryptocrystalline to compact. In the black groundmass lie brightly glittering needles of feldspar with evident twinning striation. It is exactly like the rock from small veins in the syenite at Sauk Rapids on the Mississippi, and is to be considered, probably, with the greatest degree of exactness, until a more close examination can be made, as a black porphyry or melaphyr.

Next to this a beautiful porphyry forms the first rock at the shore of the lake. This rock is different from the porphyry of the St. Croix river, and in the main resembles the porphyry from Ilfeld in the Hartz. In fresh condition the groundmass is an exceedingly fine-grained mixture of a clear and a dark-brown mineral. The feldspar crystals appear only by reason of their luster, upon the commencement of disintegration of the rock, because of their presenting a somewhat brighter color. Magnetite is sparsely disseminated, and still more sparsely a little pistazite. But the latter mineral is very abundant in the seams, and veins of calc-spar with which the rock is very much intersected. In the same manner also laumontite occurs, and in fact as a pseudomorph after calc-spar. In company with this brown porphyry is found an amygdaloid with a somewhat decayed groundmass. The cavities, which are somewhat elongated, are filled with quartz, calc-spar, chlorite and a decayed iron-bearing mineral. The crystals of feldspar in the porphyry are also in process of decay. A regular variation or interchange between these two rocks is nowhere to be seen. On the other hand the undecayed massive porphyry goes over to the amygdaloid Apparently the decaying of the groundmass and the crystals has gone on step by step with the filling of the amygdaloidal cavities. As already remarked, I have observed the above described rocks nowhere in contact. The works in the city of Duluth will, however, soon furnish fine exposures. The beds of the Lower Silurian which appear further down on the Lake Superior shore, and upon the river, are not found at Duluth nor in the immediate vicinity. Similar reddish-brown porphyries appear to be very widely distributed on the north shore of Lake Superior. The lateness of the season prevented an excursion in a sail boat for observation along the coast. The above described crystalline rocks are grouped together by all American geologists under the name "trap." Whittlesey mentions an augitic, quartziferous and amygdaloidal trap. In other places he speaks of a brown, decayed trap, and of a firm trap, both cut through by dykes of basalt, without giving any further definition of these different rocks.

The Potsdam sandstone forms the north shore of Lake Superior, as well as the south shore. The dip of the beds forms an anticlinal, and the lake consists of a basin of fresh water in the layers of the Lower Silurian. The breaking out of porphyries and melaphyrs, sometimes in the form of dykes and at other times alternating in layers with the sandstone, makes the geological relations very complicated. Along the north shore runs a range of hills which consist of metamorphic and plutonic rocks belonging to the Huronian formation. Five or six miles inland it attains its greatest hight of 600 to 1,000 feet above the level of the lake. Then this terrane is wanting, for the most part, along the coast, and the Silurian beds overlie the Huronian.

A number of streams have their sources in this hill-range, and often winding through the bedded and massive rocks, with rapid descent bear their waters to the lake. They give rise to many outcrops and lay bare the bedding and such like conditions of the melaphyr-masses. Several have attained a positive reputation for their promise of profitable mining of copper, and are valued highly for the future mining of this metal. This is especially the case at the French and Knife river districts.

Whittlesey says that the trappean rocks which bear metallic copper, are of the age of the Potsdam sandstone, and that those that contain the sulphuret ores belong to the Huronian formation.* Also that the cupriferous beds become barren when they change from trap to sandstone. I am still too little acquainted with the appearance of copper

*Whittlesey's report of 1866, p. 5.

on the north shore of Lake Superior, to presume to have an opinion respecting those beds that may be valuable for mining, but I do not believe that the first of these statements has any general validity. I had opportunity to examine somewhat closely some fragments from a vein in a rock designated "trap," from the north shore. It was obtained from a bay between Encampment Island and Kinewabic river, and hence from the area occupied by the rocks of the Potsdam. This place is 30 miles from Duluth, and in the vicinity of Knife river. The rock has a resemblance to a bright, clay-slate, with many strings of calc-spar cutting it in all directions. The calc-spar is crystallized in veins. Its weight certainly indicated that it contained copper or iron. Upon a careful examination can be seen also a sulphide, and black specks of a substance having a metallic luster on the outside, finely scattered through the mass. The latter shows before the blowpipe, the reactions of a mixture of chalcopyrite and pyrite. It contained no native copper, and I could not discover in the wet way any trace of silver.

The above mentioned rock is said to have a thickness of forty feet, and rises perpendicular from the shore, and can be followed inland a short distance. Only the smallest portion of this mass embraces those sulphides and metallic compounds. Similar exposures, showing a little metallic content, a layering and a network of a small mineral vein, are a frequent occurrence in these massive rocks, and point with certainty to a very general diffusion of copper. Yet it has not been found in sufficient quantity to support mining with profit. The best prospects are located at French river, in melaphyrs interbedded with sandstone.

Immediately after the conclusion of a treaty with the Indians in the year 1854, by the terms of which the north shore of Lake Superior was opened to the whites, agents of eastern capitalists explored the region for mineral deposits, Upon superficial observations of men who had but slight acquaintance either with geology or mining, large tracts here were set forth as mineral lands, and as such were disposed of by the government to companies and private individuals. In 1858 the land was surveyed, and many "claims," which had been made before were relinquished. A few years ago a company was formed in Buffalo which began to explore the regions of French and Knife rivers more carefully. A shaft was sunk to the depth of 48 feet, and a quantity of copper ore was found in the deeper lying beds. Nevertheless, these works are now suspended.

At different places on the St. Croix river and its tributaries, copper has been found. Especially is Taylor's Falls and that vicinity, as well as Kettle river, forty miles further north in Minnesota, regarded as a region which some time will be celebrated as a copper.producing district. What has been found thus far consists, in the first place, of large massive pieces in the river-bed, and in the water-worn material of the drift which covers the river banks, and secondly of veins and layers in the porphyry, which produce both metallic copper and copper-glance and copper-oxide, from a heavy but decayed gangue.

Massive, irregularly-shaped, but rounded pieces of native copper have been found in several places in the valleys of streams coming from the north. I saw at Taylor's Falls a heavy specimen weighing fifteen pounds, which was found in the digging of a well several feet below the surface, in the drift. These copper masses in every instance have been exposed for a considerable time to the action of water, and I do not believe that their place of origin should be considered as being in that vicinity. In this opinion I was afterward strengthened, since I found in the drift and gravel which lie on the St. Peter sandstone, as large and equally rounded a piece of metallic copper in the eastern part of the city of St. Paul. It is most probable that along with the drift, metallic copper is brought hither from the southern shores of Lake Superior.*

What I have seen of the copper-bearing rocks of Taylor's Falls, shows the presence of this metal in small quantities near the surface, affording, therefore, some expectation of profit on deep mining. I was conducted to two old shafts and several pits which some time before had been sunk on the summit of a range of porphyry. The shafts were filled with water to the top. The material lying about contained no native copper. It was a porphyry in process of decay, with veins of quartz and feldspar. A six-inch vein of feldspathic, decayed rock had given rise to the exploration. The feldspar vein can be followed for a distance of several hundred feet, and, according to the statement of my companion, under whose instigation the work had been undertaken, had a thickness of two and one-half feet at the depth of twenty. The samples brought from this depth consist of a much changed feldespathic snd calcareous rock Copper strikes through the mass in slender leaves and threads. Fine black threads, of a black metallic luster; were found to be copper-sulphide, before the blowpipe, and did not exhibit, in the wet way, any content of silver, so far as I could judge. A second place, which had been pointed out by the residents

*Masses of metallic copper are found occasionally in the northern drift in Michigan, Wisconsin and Ohio.

as an outcrop of a copper vein, is at the mouth of a creek which passes down the steep bluffs through the midst of the town. It was a sort of contact-vein between the porphyry and the sandstone. What I could see of the gang-mass in the neighborhood of the very imperfect exposure, consisted of an earthy, much changed amygdaloid. It was asserted to me that copper is to be found, although I saw in the amygdaloid itself not a trace; and I expect that it is one of the erratic pieces from the drift, which is disseminated in the bed of the creek between the larger blocks of porphyry.

Similar feldspar veins as those above mentioned are a very frequent appearance in the porphyry. They always have at the surface only a few inches thickness.

More promising appears the copper outcrop on Kettle river. In 1865 it was pronounced a true vein with a width of 22 feet by Prof. James Hall. I obtained several pieces of the gang. They consist, first, of a brownish dense melaphyr-amygdaloid without apparent crystals. The cavities are filled with quartz, calcite, epidote and copper. It is cut through by numberless fine slits which are filled with the same minerals. The copper is in threads, thin sheets, and also in net-work and knot-like forms, and is always accompanied by quartz, calcite and epidote. The color of the groundmass changes from brown to green, and several specimens approach the color of green, although more distinctly colored through. This is a bluish-green rock, with heavy groundmass, though without evident crystals still carrying the same cavities and amygdaloidal minerals.

A third rock is much changed, mainly feldspathic, but interspersed with a dark mineral. Its prevailing color is derived from copper-salts. The copper is metallic, and is desseminated in extremely fine threads through the whole mass. In this rock appear outcropping veins of copper-glance and earthy malachite. At least there are, among the material derived from this locality, two handsamples which show both these ores in the same groundmass.

The copper-bearing samples of rock from Kettle river, collectively, have the aspect and the characters of vein rocks.

How far the above described appearances may warrant the hope of profitable mining of copper, must be left undetermined till more exact investigations shall have established the extent, the range and the content of copper. The lands of Kettle river have been taken possession of by speculators, in the same manner as those of the north shore of Lake Superior some time before. Here and there examinations have been made in order to learn something of the particulars of the region, yet always in a hasty way and generally by people without sufficient geological knowledge.

From Vermilion lake I have become acquainted with gneisses and firmly crystalline clay slates with much interspersed pyrites, which apparently belong to the Laurentian system. A number of quartz veins cut through these metamorphic schists, which contain a little portion of copper pyrite. The pyrite has been shown to be gold-bearing. A short time ago arose a real *excitement*, of the American type, over Vermilion lake, because it was believed that here had been found a new gold field. There were formed in Chicago, New York, and other cities, several companies; and caravans with furnaces, stamp-works, and amalgamating mills, pressed forward into the wilderness. Large sums of money were soon sunk in Vermilion lake. The government itself laid out a road from Duluth, and the works were in progress till a short time since. Several shafts were dug, among others one 70 feet deep by a New York company. As yet the costs have far exceeded in amount the value of the small quantity of gold which has actually been taken out. I have seen a number of samples of the gold-bearing quartz of Vermilion lake, but have not yet found even a speck of native gold. Likewise I have not been able, in spite of the most diligent enquiry, to find any one who has seen it. There is now no doubt at all that so long as the region remains inhabited by Indians and fur-animals, separated seventy miles from any railroad, the amount of gold taken out cannot pay any one.

The same must be said of the iron ores outcropping in the neighborhood of Vermilion lake, concerning which the reports brought by travelers are very favorable; the profitable mining of which, nevertheless will not be entirely feasible without a railroad connection with Lake Superior. The description which Eames gives of these* agrees with the red iron-rocks of the Huronian on the south shore of Lake Superior in the State of Michigan.** The iron ores from Vermilion lake that have been brought to St Paul consist of a very pure, glittering haematite, of a steel-gray color.

It is probable that further search in Minnesota, on both sides of the zone of Laurentian rocks, will show the presence of Huronian iron ores. There have this year new surveys been made along the branch line of the Pacific railroad which runs along the Mississippi, extending further toward the north. I hope by this means to learn of interest-

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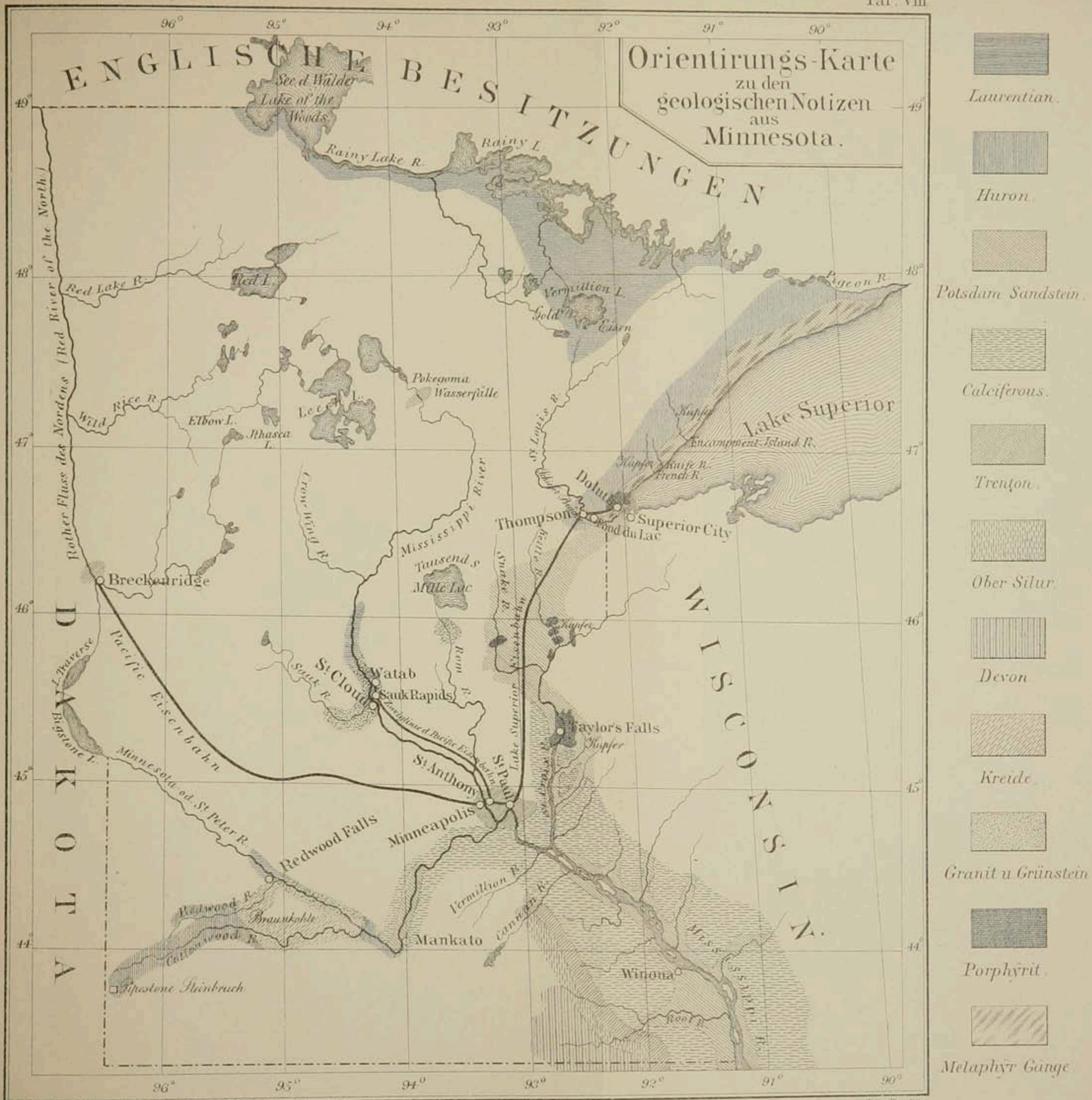
*Report of Henry Eames 1866, p. 11.

**Credner: *Zeitschr, d. Deutsch, geol. Ges.* 1869 s. 527.

ing facts concerning the relationships of the Laurentian, Huronian and Silurian rocks in the upper portion of the Mississippi valley.

Besides the rocks and formations described above, I have marked upon the plate (Taf. VIII.) a small area south from the St. Peter river lying between Laurentian and Huronian rocks. This small area belongs, according to the investigations of Prof. Hall, to the Cretaceous formation. It is an old fresh-water basin in which has been found a considerable quantity of brown coal. As I have not examined the region myself, and I know nothing further about it, I shall give here nothing further concerning its appearance. Much effort has been made continually to find stone coal, or brown coal, in Minnesota, because in a large part of the State there is a lack of forest, and therefore of fuel. The small Cretaceous area on the Cottonwood river is as yet the only spot where real coal-bearing beds have been found in outcrop. All former discoveries have proved to be "drift coal," or erratic pieces in the diluvium.


Orientirungs-Karte
zu den
geologischen Notizen
aus
Minnesota.
ENGLISCHE BESITZUNGEN
DAKOTA
WISCONSIN
See d. Wälder
Lake of the Woods
Rainy Lake R.
Rainy L.
Red Lake R.
Red L.
Vermillion L.
Gold
Eisen
Pigeon R.
Pokegoma Wasserfälle
Leech L.
Elbow L.
Jthasca L.
Wild Rice R.
Rother Fluss des Nordens (Red River of the North)
Lake Superior
Kupfer
Encampment Island R.
French R.
Duluth
Thompson
Fond du Lac
Superior City
St. Louis R.
Crow Wing R.
Mississippi River
Tausend s Mille Lac
Breckenridge
Pacific Eisenbahn
L. Traverse
Bigstone L.
St. Cloud
Sauk R.
Watab
Sauk Rapids
Rum R.
Snake R.
Lake Superior
Taylor's Falls
Kupfer
St. Anthony
St. Paul
Minneapolis
Minnesota od. St. Peter R.
Redwood Falls
Redwood R.
Braunkohle
Cottonwood R.
Pipestone Steinbruch
Mankato
Vermillion R.
Cannon R.
Winona
Root R.
Mississippi R.
96°
95°
94°
93°
92°
91°
90°
49°
48°
47°
46°
45°
44°
Laurentian.
Huron.
Potsdam Sandstein.
Calciferous.
Trenton.
Ober Silur.
Devon.
Kreide.
Granit u. Grünstein.
Porphyrit.
Melaphyr Gänge.

VII.

CHEMISTRY.

ANALYSES BY PROF. JAMES A. DODGE.

Analyses have been reported by Prof. Dodge of substances for the survey, from Nos. 69 to 83, both inclusive, of the Chemical Series. This list is from the following localities:

No. 69. Efflorescence on the surface of the ground ("alkali"), Sec. 14, Iona, Murray Co. Mus. Reg. No. 3936.

No. 70. Light-colored pipestone, or "chalk-rock" so-called, Palisades, Minnehaha County, Dakota, two rods east of the dam, in the plane of the pipestone. Mus. Reg. No. 3896.

No. 71. Light blue calciferous sandrock, from the lower part of the quarry of Maxfield and Mather, Mankato, showing non-hydrated (unoxidized) natural condition of the deeper beds of the Shakopee formation.

No. 72. Rice Point granite, No. 1 of the Survey Series. To determine the alkalies and the lime of the feldspar.

No. 73. Rice Point red granite, No. 1 B, of the Survey Series. To determine the alkali of the feldspar.

No. 74. Limestone, supposed to be hydraulic the equivalent of the shale layer at Maxfield's quarry, at Mankato. From the quarry of J. R. Beatty & Co., near Mankato.

No. 75. Light-colored, nearly white clay, supposed to be kaolinic, from the same place as the above, but probably Cretaceous.

No. 76. Water from Mille Lacs, needing filtering.

No. 77. Water of the Mississippi river from above Minneapoli about one mile, right bank.

No. 78. Water of the Mississipi river from below Minneapolis about one mile, right bank.

No. 79. Limestone of the Hudson river Group at Clinton Falls, near Owatonna, quarry of Lindersmith & Son.

No. 80. Limy sediment in a layer in the till, on Nicollet Island, Minneapolis.

No. 81 Ore supposed to contain copper, from near Beaver Bay. From T. 56, R. 8, S. W. ¼ Sec. 22, on North river, Wieland Brothers.

No. 82. Lime City limestone, Filmore county. Mus. Reg. No. 4099.

No. 83. Concretionary Cretaceous. Two Rivers, Morrison county. Mus. Reg. No. 4561.

ANALYSES.

No. 69, Chemical Series. Museum Reg. No. 3936.

"*Alkali*" Efflorescence, with soil adhering.

Whole substance powdered, air-dried, digested with water:—

	Per cent.
Dissolved by water	48.6
The residue digested with hydrochloric acid:—	
Dissolved additional	3.1
Total dissolved matter of the whole substance	51.7

Portion dissolved by water contained:

MgO, 22.5 per cent. } ......67.3 per cent. sulphate magnesia
SO_3, 44 8 " }

Water ....not determined

SiO_2, Fe_2O_3 ....traces

Organic matter ....traces

The sulphate of magnesia was therefore not present in the form of Epsomite, as MgO, SO_3, $7H_2O$.

Would require MgO, 16.26 per cent. } ....48.78 per cent.
" " SO_3, 32.52 " }

" " $7H_2O$ ....51.22 "

Portion (additional,) dissolved by hydrochloric acid contained:

SiO_2	18.6 per cent.	
Fe_2O_3, Al_2O_3 and phosphoric acid	58.3 "	(mainly Fe_2O_3)
MgO	20 5 "	
CaO	traces	
Organic matter	"	
Alkalies	"	

The residue, insoluble in H Cl, fused with carbonate of soda, gave:

SiO_2	75.8
Al_2O_3	11.1
Fe_2O_3	2.1

CaO	.86
MgO	.66
Organic matter	considerable
Alkalies	trace

This residue was in fact simply a dark soil, with fragments of roots &c.

Carbonic acid, and chlorides were almost wholly absent from the substance. Potash and soda were present in slight traces. Lime also was present in slight traces.

No. 70, Chemical Series, Museum Reg No. 3896.

SiO_2	50.4	per cent.
Al_2O_3	33.3	"
Fe_2O_3	2.8	"
CaO	0.6	"
MgO	0.17	"
Na_2O	3.5	"
K_2O	0.6	"
H_2O	9.6	"
	100.97	

The composition agrees fairly with that of Catlinite, which the rock resembles in physical properties except color, being white with tinge of yellow.

No. 71. Rock, a limestone of light-gray color, containing silica.

Ten grammes of the powered and dried mineral were digested with hydrochloric acid; a residue was left which weighed 1.552 gms., making 15.52 per cent. of the rock; the portion dissolved was therefore 84.48 per cent.

Analysis of portion dissolved by hydrochloric acid:—

Fe_2O_3 with small amount of Al_2O_3 and SiO_2	3.14	per cent.,	being	2.65	per cent.	of	whole rock.
CaO CO_2	55.47	"	"	46.86	"	"	"
MgO CO_2	39.73	"	"	33.56	"	"	"
	98.34			83.07			

Analysis of portion left undissolved by hydrochloric acid:—

SiO_2 -	77.9	per cent.,	being	12.1	per cent.	of	whole rock.
Al_2O_3 -	19.24	"	"	2.99	"	"	"
CaO -	.34	"	"	.05	"	"	"
MgO -	.12	"	"	.02	"	"	"
Alkalies,	traces.						
Organic matter,	traces.						
	97.60			15.16			

It appears, therefore, that the rock is a magnesian limestone, with about 12 per cent. of silica and somewhat over 2½ per cent. of oxide of iron.

No. 72. A granitic rock of bluish-gray color, from which the feldspathic portion was selected (by mechanical means) as clean as possible. This portion, which was still, however, not wholly unmixed with other constituents of the rock, was analyzed with the following result:

SiO_2	49.78	per cent.
Al_2O_3 and Fe_2O_3*	32.36	"
CaO	11 55	"
MgO	1.43	"
K_2O	.41	"
Na_2O	3.39	"
H_2O	1.83	"
	100.76	

No. 73. A granitic rock of reddish color; this was analyzed as a whole, the grain being too fine to permit mechanical separation of its constituents.

SiO_2	75.78	per cent.
Al_2O_3	11.09	"
Fe_2O_3	2.09	"
CaO	.86	"
MgO	.65	"
K_2O	1.06	"
Na_2O	6.43	"
H_2O	1.82	"
	99.78	

No 74. Rock a siliceous limestone. Digested with hydrochloric acid, a residue was left amounting to 19.67 per cent., the dissolved portion was therefore 80.33 per cent.

Analysis of portion dissolved by hydrochloric acid:—

SiO_2	.27	per cent.,	being	.21	per cent.	of	whole rock.
Al_2O_3	.15	"	"	11	"	"	"
Fe_2O_3	3.03	"	"	2.43	"	"	"
$CaO\ CO_2$	55.62	"	"	44.68	"	"	"
$MgO\ CO_2$	39.13	"	"	31.59	"	"	"
	98.21			79.02			

*NOTE.—The amount of oxide of iron is quite small.

Analysis of portion not dissolved by hydrochloric acid:—

SiO_2	78.27 per cent.,	being	15.29 per cent. of whole rock.
Al_2O_3	18.33 "	"	3.61 " " "
CaO	.48 "	"	.09 " " "
MgO	.23 "	"	.04 " " "
Alkalies	traces.		
Organic matter	traces.		
	97.31		19.03

A determination of water in the dried powder gave 4 per cent. (of whole rock.)

This is therefore a magnesian limestone, containing about 15 per cent. of silica, and but a moderate quantity of oxide of iron. It would appear likely to make a good hydraulic lime. No. 71 might also serve that use.

No. 75. A very light-colored clay, from Mankato. This was pulverized, without grinding up the particles of gritty matter that were to some extent intermixed with it; the powder was then mixed with distilled water, the suspended portion poured off and allowed to settle for a day or two; the settled portion was then collected, dried at 212°, and submitted to analysis by the common methods for silicates.

SiO_2	87.7	per cent.
Al_2O_3	7.24	"
Fe_2O_3	traces	"
CaO	.67	"
MgO	.07	"
K_2O	.49	"
Na_2O	3.17	"
Organic matter	traces	
Water	traces	
	99.34	

No. 76, of the Chemical Series. As received this water showed some turbidity, and had deposited a brownish sediment in the can. It was filtered, and a large quantity evaporated. In the course of this evaporation a similar brown flocculent matter separated out. It consisted of organic matter mixed with oxide of iron.

The residue from evaporation was submitted to analysis, and found to consist of the following substances, in the amounts stated:

Silica............	3 85	per cent. of total residue from evaporation.
Carb. lime.......	28.07	" " " "
Sulph. lime.....	.95	" " " "
Carb. Mag......	28.62	" " " "
Oxide of iron....	1.26	" " " "
Carb. potassa...	3.03	" " " "
Carb. soda......	11.09	" " " "
Chl. sodium	.74	" " " "
Organic matter..	22.40	" " " "

The weight of the residue from a given quantity of water was found to be in the proportion of about 10 grains to the gallon. Reckoning the above specified constituents in grains per gallon, I found:—

Silica....................................	.2499	grains	per gallon
Carbonate of Lime........................	3.1355	"	"
Sulphate of Lime.........................	.1051	"	"
Carbonate of Magnesia....................	3.1589	"	"
Oxide of Iron............................	.1389	"	"
Carbonate of Potash......................	.3346	"	"
Carbonate of Soda........................	1.2241	"	"
Chloride of Sodium.......................	.0817	"	"
Total Mineral matter...................	8.4287	"	"
Organic matter...........................	2.4458	"	"
Total residue..........................	10.8745	"	"

In regard to the above figures, it is to be noted, that the amount of solid residue taken as a whole is not great, compared with that from many waters in this State; that the amounts of lime and magnesia (existing in the water as bicarbonates,) are but moderate; that sulphates and chlorides are almost wanting, and that the water is *alkaline*, by virtue of the presence of the carbonate of potash and soda. Upon concentration of this water, in a platinum dish, a ready and decided test is obtained by litmus and turmeric papers.

Further, it was found that nitrates and phosphates are absent.

No special examination of the organic matter was made.

Nos. 77 and 78 of the Chemical Series.

MINNEAPOLIS, MINN., March 13, 1882.

Prof. N. H. Winchell:

DEAR SIR:—I hereby report the results of my analysis of the water of the river made at your request with a view to determine what difference might show itself in the water above and below the city. Two samples were procured, at the same time and in the same manner, the one (No. 77,) at a point on the west bank about half a mile above the upper bridge, (Plymouth Ave.,) and above all apparent considerable sources of contamination, the other (No. 78) at a point, also on the west bank, below the brewery, at the small grove near the Fair Grounds.

These two samples of the river water have been submitted to precisely the same course of analysis. A quantity of each sample, amounting to eight litres—somewhat over two gallons—was evaporated to dryness, and the composition of the residue ascertained. In addition, the method of determining organic matter in water by the distillation process of Wanklyn, was applied to each sample of water.

The samples of water were procured by me about the 20th of December. They were immediately filtered, and kept in suitable glass vessels; that part of the work of analysis which needed to be done without delay, in order to avoid the effects of change in the water by keeping, was done. The remainder has been carried on with other work during great part of the winter.

1. Composition of the residue from evaporation of the water of the river above Minneapolis:—

Silica. SiO_2	.78256	grains	per gallon
Carbonate of Lime, $CaO\ CO_2$	6.39532	"	"
Carbonate of Magnesia MgO, CO_2	3.15307	"	"
Carbonate of Iron, $FeO\ CO_2$	.05504	"	"
Chloride of Sodium, $NaCl$	.16352	"	"
Potash, K_2O	.10162	"	"
Soda, Na_2O	.17462	"	"
Sulphuric Acid, SO_3	.16445	"	"
Nitric Acid, N_2O_5	traces		
Total Mineral matter in the residue	10.99020	"	"
Organic matter	1.40228	"	"
Total Min'l & Organic m't'r in residue	12.39248	"	"

2. Composition of the residue from evaporation of the water of the river below Minneapolis:—

Silica, SiO_2	.97090	grains	per gallon
Carbonate of Lime, $CaO\ CO_2$	6.13722	"	"
Carbonate of Magnesia, $MgO\ CO_2$	2.42827	"	"
Carbonate of Iron, $FeO\ CO_2$	.15560	"	"

Chloride of Sodium, NaCl	.18408	"	"
Potash, K_2O	.15826	"	"
Soda, Na_2O	.15126	"	"
Sulphuric Acid, SO_3	.17462	"	"
Nitric Acid, N_2O_5	traces, more than in No. 1		
Total Mineral matter in residue	10.36021	grains	per gallon
Organic matter	1.96219	"	"
Total Min'l & Organic m't'r in residue	12.32240	"	"

3. Results of Wanklyn's method for determining the organic matter, in water from above city:—

Free Ammonia,	.0175	milligrammes per litre,
	or .0175	parts per million.
Albuminoid Amonia,	.0625	mgm. per litre,
	or .0625	parts per million.

4. Results of Wanklyn's method for determining the organic matter, in water from below city:—

Free Ammonia,	.0266	parts per million.
Albuminoid Ammonia,	.1550	parts per million.

I would like to call attention to the following points: First, the amount of matter, mineral and organic together, differs but little, in the residues from the evaporation of the two waters; but the amount of organic matter in the water from below the city is appreciably larger than in the water from above; on the other hand the amonnt of mineral matter is larger in the water from above. This latter result was to me wholly unexpected, but I am certain of its correctness. The water of the river below contains a little less carbonate of lime and magnesia than the water above. The difference, however, is wholly immaterial in a practical point of view, and may be accounted for by the influx of several creeks which bring in softer water than the river; also by the consideration that what lime finds its way into the river from factories and from masons' use, may serve to precipitate a small part of the carbonate of lime and magnesia that are in the river. Second, the difference in the amount of organic matter in the two samples, is quite material, in sanitary respects. The results of the determination of free ammonia and albuminoid ammonia are such as to place the water from above the city under the head of good drinking water, while that from below would be excluded from that class. It is to be observed that the water below shows somewhat more of all ingredients except lime and magnesia. In the case of nitrates, a quantitative determination could not be made. Qualitative tests showed somewhat more in the water below.

Very respectfully,
JAMES A. DODGE.

Chemical Series, No. 79, a Siliceous Limestone.

Soluble in hydrochloric acid:—	per cent. of whole rock.	Insoluble in hydrochloric acid:—	per cent. of whole rock.
Silica	2.88	Silica	10.74
Oxide of iron	2.56	Oxide of iron and alumina	.80
Calcium carbonate	58.09	Lime	traces
Magnesium carbonate	19.90	Magnesia	.63
Alkalies	traces	Alkalies	traces
Sulphric acid	traces	Organic matter	not determined
	83.43		15.17

Chemical Series No. 80.

Calcareous rock, with iron pyrites distributed through it, and having a vein mainly of pyrites.

Main rock:—

Assayed ½ oz. gold, $\frac{1}{10}$ oz. silver per ton.

Vein:—

Assayed 1 oz. gold, $\frac{1}{10}$ oz. silver per ton.

Chemical Series No. 81, Calcareous Layers in Drift, Nicollet Island.

Soluble in hydrochloric acid:—	per cent. of whole rock.	Insoluble in hydrochloric acid:—	per cent. of whole rock.
Oxide of iron	2.69	Silica and silicates	35.53
Calcium carbonate	55.55		
Magnesium carbonate	4.95		
	63.19		

Chemical Series No. 82, Limestone.

Soluble in hydrochloric acid:—	per cent. of whole rock.	Insoluble in hydrochloric acid:—	per cent. of whole rock.
Oxide of iron	.73	Silica, etc	4.57
Calcium carbonate	70.53		
Magnesium carbonate	23.49		
	94.75		

Chemical Series, No. 83. A siliceous rock, to a great extent soluble in hydrochloric acid.

The rock was analyzed as a silicate, and its composition found to be as follows:—

Silica	19.81	per cent.
Alumina	52.43	"
Oxide of Iron	1.32	"
Calcium Carbonate	1.64	"
Soda	0.44	"
Water	23.23	"
	98.87	

In appearance this rock bears a considerable resemblance to compact gray limestone. Its hardness is a little less than that of limestone.

VII.

THE GEOLOGY OF THE DEEP WELL DRILLED BY C. C. WHELPLEY AT MINNEAPOLIS, AT THE "C" WASHBURN MILL.

BY N. H. WINCHELL.

(READ BEFORE THE MINNESOTA ACADEMY OF SCIENCES, JANUARY, 1882.)

I have just seen for the first time the record and drillings of this well (Dec. 1881), though the well was drilled some years ago, and the record and drillings were preserved at my request. The set sent me by Mr. Whelpley was lost in some way by being miscarried. The set on which these notes are based was encountered in the late moving of the effects of the Academy to new rooms, and I take the first opportunity to bring before the Academy what I deem important information concerning the strata that underlie the city, derived from an examination of this tube.*

In order to appreciate the bearing of the new facts on the geology of the region, it will be necessary to review briefly the former knowledge we had of the strata underlying the city. In the report of the geological survey for 1876, will be found a description of the geology of Hennepin county, by which it will be seen that the strata of the Lower Magnesian formation, represented by the Shakopee limestone extends under the St. Peter sandstone, occupying, conjecturally the surface of the western and central parts of the county. In the same report is a section of the deep well drilled in East Minneapolis, as furnished by the city engineer, Col. J. B. Clough, the designations of the strata being his, or of the party who drilled the well. The drillings of that well were not preserved, and it was found impossible to verify the designations by a comparison with them. It will be seen by that section

*The drillings from the well were exhibited in a glass tube about three feet long, in the order of their places in the strata.

that a "red limestone" was reported as penetrated, beginning at 234 feet and extending a depth of 102 feet farther. Under this is reported a "gray limestone." Below these, followed alternating, gray and white sandstones and shales with some sandy limestones, to the depth of 1074 feet. At that point the drill entered a red shale and sandstone which seems to have varied very little, if any, up to the time the work ceased at a depth of 1421 feet. This red shale and sandstone is the same formation in which the deep well stopped at Belle Plaine, and at other places in the State, the equivalent of the red shales of the Lake Superior region, the probable true Potsdam of the northwest. The well reported by Mr. Whelpley only goes to the depth of 205 feet, but as the drillings are presented with the recorded designations, it throws light on the geology of this part of the State which has a bearing on the proper interpretation of the deeper well of 1874. It is as follows, as given correctly by Mr. Whelpley:

1.	Peaty black soil	2	feet
2.	Drift sand and stones	8	"
3.	Limerock, (gray and blue)	24	"
4.	Blue clay, (shale)	2	"
5.	White sandrock	44	"
6.	Yellow sandrock	7	"
7.	White sandrock	41	"
8.	Yellow sandrock	3	"
9.	Fine, white sandrock	22	"
10.	Yellow sandrock	5	"
11.	White sandrock	2	"
12.	Pipestone clay, reddish brown	2	"
13.	Coarse, white sandrock, (water to top of ground)	21	"
14.	Coarse, gray sandrock	17	"
15.	Hard, gray sandrock	4	"
16.	Red rock, (grit) penetrated only	1	"
	Total depth	205	"

On comparing these records it will be seen that the former well penetrated the two feet of pipestone clay at about the depth of 197 feet (of its own record,) without any notice being taken of it. This supposition is more probably correct than that this clay was not encountered, judging from a general looseness of designation that seems to pervade the earlier part of that record, and from the nature of the stratum and the proximity of the wells to each other, (about one-third mile apart). Furthermore, the record of white sandrock continues alike in each well down to the depth of 204 feet in one, and 234 in the other, which, calculating from the top of the Trenton limerock, makes the "red rock," in one well (Whelpley's) appear at 195 feet, and in the other at 191 feet. This shows that there could have been no such disturbance in the bottom of the ocean as to have changed the detritus and caused the omission of the pipestone clay in the East Minneapolis well; which is also indicated by the fact, that the pipestone clay was extensive enough to confine under hydrostatic pressure, a volume of water which rose at once to the surface of the ground on being pierced by the drill.

All the sands underlying the blue clay below the Trenton limestone are essentially the same in character, being composed of rounded grains of pure quartz. These grains differ in size, the largest being about as large as a mustard seed, and the smallest too minute to distinguish with the unaided eye. They differ in color somewhat, passing from a pure limpid glass to snowy white, and to a buff color, and to a smoky gray. These colors are not due to the cement in which they were enclosed, but to an actual difference in the quartz itself. This difference of color implies some change in the source of the material, and suggests the enquiry whether that change were not in the waters of the ocean rather than on the land. On the supposition that this pure quartz were the result of chemical precipitation, these different colors in the same formations are easily accounted for by such changes as may have occurred in the ocean by shifting currents, allowing the mingling of certain other substances in solution, with the precipitated silica so as to stain it as it is. On the supposition that this sand is derived from the preexisting land as a sediment of detritus, it is very difficult to understand how such a source of pure silica, almost absolutely free from other sand and impurities, could be obtained and disseminated as widely as this sand is known to extend, and to change its inherent color from time to time.

The pipestone clay No. 12, is undistinguishable from similar clay and shale seen in the Potsdam formation at Fond du Lac. It is somewhat schistose in one of the fragments, and also has spots of green similar to the green spots seen in the same clay at Fond du Lac. In its schistose character it resembles some of the schistose, soapy, clays seen in the formation at Baraboo, Wisconsin, and at Sioux Falls, Dakota. It generally is a shale and has an angular fracture. In the midst of one of the fragments is seen a little grit cemented by the same substance that cements the red rock of No. 16.

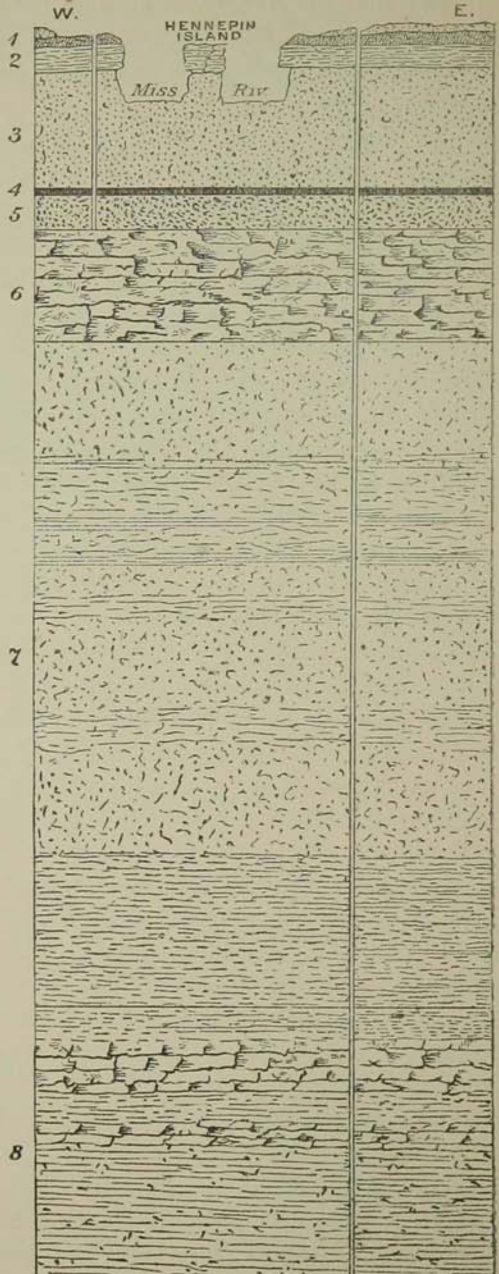
No. 16, which is the red limestone, so-called, of the East Minneapolis well, has not any of the qualities of a limestone. It is a coarse, red grit-stone, or arenaceous felsite, the grains being pure white silica, and the cement itself an amorphous red feldspathic substance seen to result in many cases from incipient metamorphism of the shales of the formation, disturbed by igneous eruptions, at Lake Superior. In other words it is a layer of the red quartzyte formation seen at New Ulm and at Baraboo, Wisconsin. The East Minneapolis well found this layer to be 102 feet thick, and to be underlain by other sands and shales, some of them being blue and gray to the thickness of 722 feet. Thus we find an interbedded red quartzyte in the Potsdam formation similar to those seen in the same formation in the Black Hills, and in several other places in the Rocky Mountain region.

I wish to call attention particularly to the occurrence of the red pipestone clay No. 12. This shows that the continuance of the disturbing causes, centering in and radiating from the region of Lake Superior, were still able to send a muddy agitation through the ocean sufficient to deposit a copious red sediment to the exclusion, almost entirely of the white quartz. This is within 127 feet of the bottom of the Trenton formation, and as nothing but white sandrock separates it from the Trenton formation, it demonstrates the absence of the entire Lower Magnesian formation. Thus we find the Trenton brought into contact with continuous white sandstone beds, which are shown, at least below 127 feet, to belong to the Potsdam formation. How much of this 127 feet may be of the St. Peter it is impossible to state, because there is no change in the character of the sandrock, but it is just as reasonable to suppose that the Potsdam continues upward to the Trenton at Minneapolis, in the same manner as it is reported to in Eastern Michigan, as to suppose the St. Peter sandrock, which is well known to exist between the Shakopee and Trenton further south, is brought on to the Potsdam, because in both cases it necessitates what might be styled an invisible unconformability between the Potsdam and the next overlying formation.

The question naturally arises—in what part of the Potsdam formation do these white sandstone layers belong? The answer must be, near the top, and probably quite at the top. This is evident from three considerations: First, there is an immense thickness of red sandstones and shales underlying them, as demonstrated by the East Minneapolis and by other wells in the State, which must belong to the formation, and which are the equivalent of the Lake Superior red shales and sandstones. Second, but a small thickness of sandstone supervenes before the Trenton formation is found overlying. These upper light sandstones must be older however than the layers which at Taylor's Falls lie unconformably on the trap rock, since there the formation had progressed far enough to admit of animal life, and dolomitic beds; and it is likely that the period of upheaval exhibited about Lake Superior had entirely ceased before the deposition of the Taylor's Falls sands and dolomites, setting off those and all succeeding layers into an era of comparative quiet.

In order to make the relations of these wells to each other, and to the geology of the region more evident, they are placed beside each other in perpendicular section, in figure No. 3.

FIG. 3.



Explanation of Figure 3.

1.	Drift	10	feet.
2.	Trenton limestone	24	"
3.	Light, crumbling sandstone (St. Peter?)	125	"
4.	Brown-red pipestone clay	2	"
5.	Potsdam sand	42	"
6.	Red quartzyte, Potsdam	102	"
7.	Light-colored Potsdam sand and shales	722	"
8.	Red Potsdam sandstone and shales, at least	347	"

VIII.

PAPERS ON THE CRUSTACEA OF THE FRESH WATERS OF MINNESOTA.

BY C. L. HERRICK.

[NOTE.—The author feels it but justice to himself to state that part of the material here presented has been in its present form for some time. The work was begun in 1879.]

I. Cyclopidæ of Minnesota, *with notes on other Copepods.*

CALANIDÆ.

It eems that recent authors have sufficient ground for uniting the families *Calanidæ* and *Pontellidæ* under the single name; the value of these terms as subfamily names even may be questioned.

The family is represented in our limits by two genera and by three, or doubtfully more species.

The fifth pair of feet furnishes, by its modifications, the best criteria for distinguishing genera and species.

Genus Diaptomus, Westwood.

Body elongated, compressed; head destinct from the thorax, anterior antennæ 25-jointed, those of the male geniculate on the right side; posterior antennæ and mouth parts as in *Calanus;* inner branches of all the swimming feet three-jointed except the first, which is two-jointed; fifth foot consisting of two unequal branches, prehensile; abdomen of male with five-joints, of female three-jointed.

Diaptomus castor.

(Plate I, figs. 1-7, Plate II, figs. 1-2, 16.)

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Cyclops lacinulatus, *Muller, Ramdohr, Latreille, Bosc, Baird,* Trans. Beow. club.

Monoculus lacinulatus, *Manuel, Gmelin.*

Cyclops rubens, *Muller, Latreille, Bosc. Baird.*

Diaptomus castor, *Westwood, Baird, Baker.*

Cyclopsina castor, *M. Edwards, Baird, Claus.*

Glaucea rubens, *Koch,* Deutschlands Crust.

Glaucea cærulea, *Koch,* " "

Diaptomus castor, *Baird,* Brit. Entom.

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The species which, after careful study, has been considered identical with the European *D. castor* is that described previously as *D. longicornis* with the remark that it might prove too near *D. castor*. *D. sanguineus*, Forbes, seems to be the same thing nearly. If the amount of variability admitted by Brady to prevail is allowable I see no reason for separating this species. It is very variable as to size and coloration, and even in the configuration of some of the parts, as antennæ, etc., a certain amount of latitude is to be given; (See plates of Claus, Zur Anatomie und Entwicklungs-geschichte der Copepoden Arch. f. Naturg. XXIV Jahrg., B I.) $\frac{14}{100}$-$\frac{18}{100}$; cm. in length. The following points are variable:—length of caudal stylets, structure and thickness of male geniculating antenna, size of claw of fifth male foot and spinous armature of feet. How far such variations may extend and how much they are dependent on peculiarities of habitat, etc., farther study must demonstrate. Some interesting facts meanwhile are suggestive. A second and gigantic form which may be known as

Diaptomus giganteus.

(Plate II, figs. 3-11-15.)

with the reservation that it is doubtfully of more than varietal value, was found under such circumstances as to suggest that it might be only a curiously magnified condition of *D. castor*. It is known to occur only in a small marshy pool of about two square rods extent and which annually dries up nearly completely. A few yards away is a second pool of a somewhat greater size and which less frequently dries up in summer. These two pools within the memory of the writer were united, but in the gradual dessication which has been observed in all Minnesota, they have been isolated. The former pool in June was found to contain *mature* males and females of the *D. giganteus only*, few other copepods being present, while the other pool contained *all stages* of the common *D. castor*. There are no neighboring waters, the nearest being half a mile, and that (L. of Isles) has only *D. castor*.

The smaller pool soon completely dried up so that this form was, for the time, exterminated. The conclusion seems almost resistless that the stagnation incident to evaporation produced circumstances favorable to the development of this enlarged form. At any rate it is an interesting fact in local distribution.

This variety is $\frac{3}{10}$ cm. long or more, and is much the largest fresh water copepod known to me; it is a deep red in color and very compactly framed. Although so much larger than *D. castor*, it is almost impossible to find any structural differences. The male fifth foot differs somewhat, but mainly in the enlargement of one part at the expense of the others. The thorns on the feet are strongly pectinate and the larger ones bear short spines instead of bristles.

Diaptomus armatus, sp. n.

(*See accompanying cut.*)

A second form is imperfectly known, but presents some clearly marked distinctions which may have specific value.

Length about as *D. castor*; body slender; antennæ reaching base of abdomen only; female differing otherwise but little from *D. castor* (?); male considerably smaller; caudal stylets narrow; antennæ peculiar, shorter than the body; thickened portion of the geniculate antenna short; two last joints very short; one preceding the second long, bearing a hook at end; fifth foot with a very long claw to longer ramus (nearly as long as the ramus itself) with a tooth on the inner margin near the base, not perfectly arcuate, reaching, when extended, to end of caudal setæ.

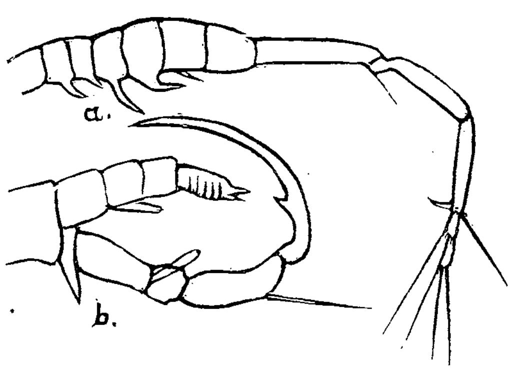

Fig. 1.
Diaptomus armatus.
a. part of male antenna. b. fifth foot of male.

Genus POTOMOICHETOR,* Gen. nov.

Cephalothorax six-jointed as in *Diaptomus*, but with the distal segment more evident; abdomen, in the male, five-jointed, *in the female*

*River inhabitor.

four-jointed; antennæ *twenty-four* jointed, the right geniculated as in *Centropages* (=*Ichthyophorbia*); first pair of feet with the rami *both three-jointed*, like the following; feet of the fifth pair, in the female, like the preceding, but with a spine of the joint preceding the terminal one enlarged and divaricated somewhat as in *Centropages*; in the male, the right with a two-jointed outer ramus, the terminal joint of which is spined and bears near its base a blunt expression of its inner margin; outer ramus of left foot three-jointed, armed with unequal spines; inner branches smaller, similar, three-jointed; the terminal joint bearing curved spines; ovary and testes as in *Diaptomus*, with which the mouth parts agree in the main; eyes medium, confluent; no lower or secondary eye-spots.

POTOMOICHETOR FUCOSUS, sp. nov.

(Plate II, Figs. 12-14. Plate III, Figs. 1-8, 13-14.)

Rather slender, and in size, as well as general appearance, resembling the smaller forms of *Diaptomus castor*; antennæ rather stout, reaching but little beyond the feet, appendaged as in D. *castor*, in the male strongly geniculated, but somewhat variously so; the six joints preceding the terminal four are thickened; those preceding the joint or hinge are arcuate on the distal margins; the secondary antennæ are about as in Diaptomus; mandibular palp two-branched; the outer three-jointed, the inner two-jointed; the terminal joint of the shorter branch bearing seven setæ, of the other four, the proximal joint of the former with three stout spines; the maxillæ nearly like *Diaptomus*; the processes have respectively the following numbers of setæ: the basal plate eight, the small process at base of posterior branchial appendage one, the appendage itself twelve, terminal portion three groups, first containing nine, the second three and the third four or five, the upper of the anterior processes two and the lower three; fifth feet nearly like the others in size; the right in the male having the outer branch but two-jointed by the coalescence of the two outer to form an arcuate and deformed appendage armed at the end with three stout equal spines; corresponding branch of left foot three-jointed; the terminal joint bearing three unequal spines, each of the preceding but one; inner branches similar, three-jointed; terminal joint being short and armed with three short lanceolate setæ and three longer ones, two of which are curved so as to be slightly prehensile; fifth foot of female with both rami three-jointed; inner ramus much smaller; antepenult segment of the outer ramus extending into a large lanceolate process; ova sac long-elipsoidal reaching to nearly the end of caudal setæ.

This species prefers running water or estuaries of streams. Crow river, Meeker county, and a brook between Minneapolis and St. Paul.

NOTE ON CANTHOCAMPUS.

Claus says (*Freilebenden Copepoden*, p 121) that he could not find the coiled "shell gland" in Canthocampus, though it is described by Leydig. I have found it in a European species, (*C. minutus?*) and think it constant. Canthocampus also has a singular area of nervous hairs upon the forehead, and in the same situation, pits which seem rudimentary eye-spots and sometimes appear to be pigmented. The pentagonal area mentioned is bounded by a raised line.

CYCLOPIDÆ

Contains five genera, viz.: *Thorellia*, *Cyclops*, *Oithona*, *Lophophorus* and *Cyclopina*; passing, by the genera *Misophria* and *Pseudocyclops*, into the *Calanidæ* or marine copepods. The affinities of these little studied genera need further study, as they are very interesting, the question being still open in how far the cyclopoid forms are altered by adaptation to saline habitat, if such an adaptation takes place at all.

The following is Brady's definition:

Cephalothorax ovate and usually much more robust than the abdomen; anterior antennæ seldom longer than the cephalothorax, those of the male alike on both sides and modified for the purpose of clasping; posterior antennæ branched (i. e. palpus wanting); palps of mandibles and maxillæ usually well-developed; foot-jaws mostly less developed than in *Calanidæ;* first four pairs of feet as in *Calanidæ*, fifth pair rudimentary, alike in both sexes, and usually one-jointed; ovisacs two.

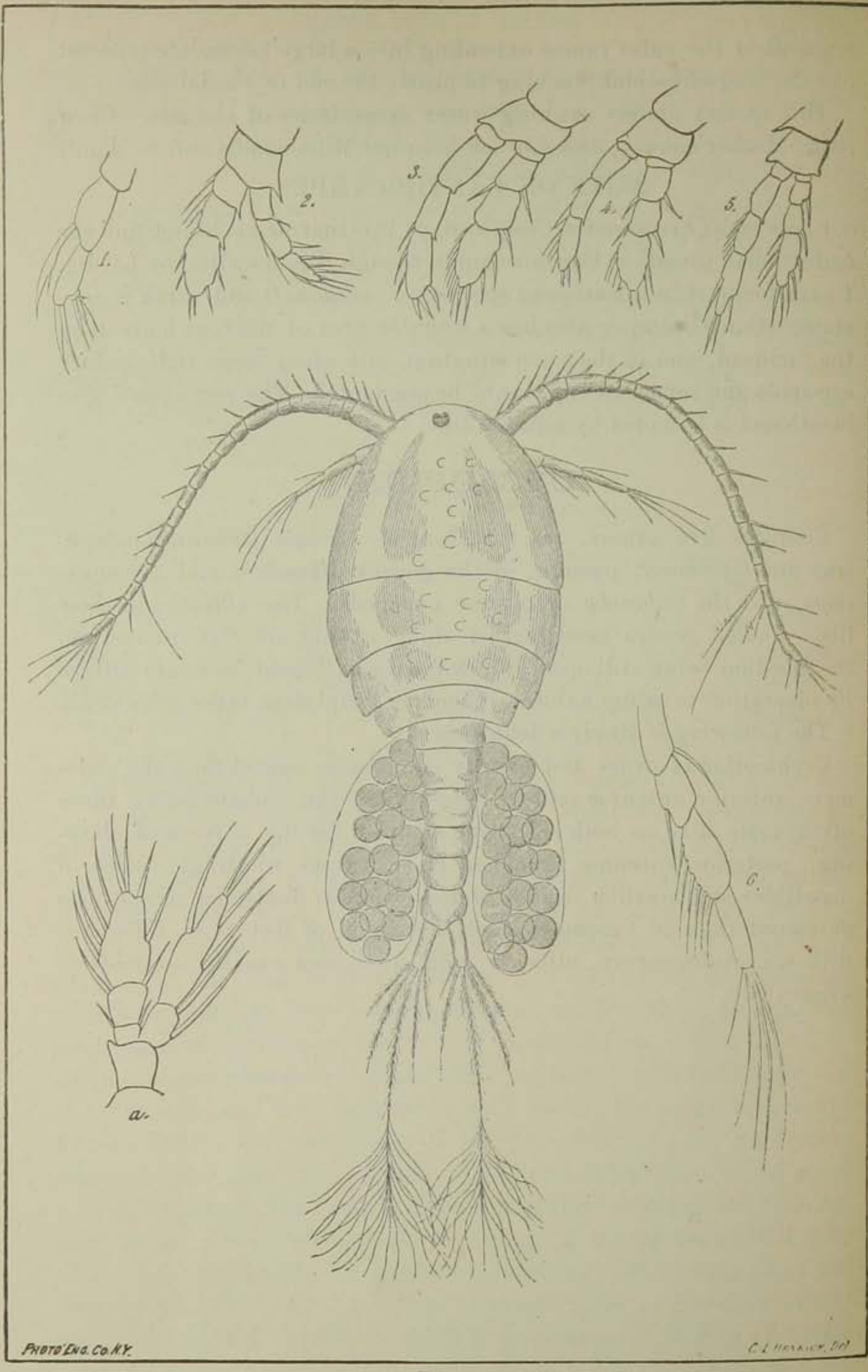

Fig. 2.

A Cyclops with abnormally pectinated caudal setæ.

Genus CYCLOPS.

Brady well says of this genus: "As regards discrimination of species it is, perhaps, the most difficult and puzzling of all the Copepoda." He also states that "the only safe rule in this state of things is to accept no specimens as types which do not show amongst them ova-bearing females." It is necessary, however, to limit the matter more closely, as will be shown farther on, for not only do immature females become fruitful even while the antennæ are yet incompletely developed, but the species are subject to a sort of dimorphism which it is interesting to parallelize with that in the males of *Cambarus*. The species are all fresh-water, so far as it is at present known, though it may be that salt-water forms exist under other names.

The characters of the family with some limitations apply to the genus.

The following species are probably but few of those which occur even in Minnesota, but they are so clearly defined, for the most part, as to be unmistakable and their description it is hoped will form a foundation upon which to lay later study.—Observations extend over a term of about four years.

Species with seventeen-jointed Antennæ.

CYCLOPS TENUICORNIS, Claus.

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Plate VI, figs. 1-11, 20. Plate V, fig. 14.

Cyclops tenuicornis, *Claus*, Das Genus Cyclops.
Die Frei-lebenden Copepoden.
Sars, Oversigt af de Indenlandske.
Ferskvands Copepoder.
Uljanin, Reise in Turkestan.
Brady, British Copepoda.
Cyclops signatus, *Koch*, Deutschlands Crust.
G. O. Sars. *Uljanin*. *Brady*.
Cyclops coronatus, *Claus*. *Fric*.

We feel confident that the two forms distinguished by Claus as *C. coronatus* (=*signatus*) and *C. tenuicornis* should be united, as the only distinction which is at all reliable, is the knife-like serrated ridge on the last joint of the antennæ. The last joints are frequently longer in *tenuicornis* form, as are the stylets in *coronatus*, but this varies. In the same gathering (for in so far as we have observed they occur together where circumstances permit a full development,) the *coronatus*-form is larger and carries more numerous eggs. No young with the serrated antennæ have been seen, though searched for diligently. On the other hand young forms of *tenuicornis* abound, and we have seen females with incompletely grown antennæ with egg-sacs. In view of these and similar facts, we feel justified in considering *coronatus* probably a post-imago of *tenuicornis*.

Cephalothorax broad; abdomen rather slender; antennæ reaching about to base of throax, attenuated at the end; terminal joint with a knife-like ridge; formula — ⏑ ⏑ — ⏓ ⏑ — ⏑ ⏑ ⏑ ⏑ ⏑ ⏑ — — —; fifth foot composed of a long basal joint bearing a long spine and a terminal three-spined division; caudal stylets over twice as long as last abdominal segment; setæ all nearly terminal, inner one much longer than usual, length $\frac{25}{100}$ cm.

Common in America, England and continental Europe.

CYCLOPS ATER, n. sp.

(Plate III, figs. 9-12.)

Length about $\frac{21}{100}$ cm; antennæ as long as cephalothorax, $\frac{12}{100}$ cm., slender and gradually tapering; formula* — ⏓ ⏑ — — ⏑ — ⏑ ⏑ ⏑ ⏑ ⏓ ⏓ ⏑ — — —; terminal joints rather short; the last joint furnished with a knife-like ridge as in *tenuicornis*; second antennæ much as in *tenuicornis*; maxillipeds rather large; fifth foot one-jointed, armed with three subequal spines; abdomen rather short, last segment very short; stylets somewhat elongated; setæ rather short, lateral seta near the end; eggs pale; color deep blue or gray.

This beautiful and very distinct species is found in "Mud Lake" in Hennepin county, with *Cyclops signatus*. The large very dark cephalothorax and shortened abdomen make it conspicuous. The one-jointed fifth foot, shape of the operculum vulvæ in connection with the shortened joints of antennæ and characters of the caudal stylets, make the species sufficiently distinct from any other.

CYCLOPS INGENS, sp. nov.

(Plate IV, figs. 1-8.)

A large species perhaps too near *C. gigas*, or *C. brevicornis* Claus, but differing from the former as to the length of antennæ and stylets

*NOTE. The accent marks are used to signify that joints represented by them (counting from base) are either long —, short ⏑, medium ⏓.

and in not having the distal margins spined (except in some cases?) and from the latter in size and arrangement of caudal setæ.

Thorax large; abdomen rather slender; stylets rather slender with the lateral seta well towards the end; second and third setæ alone long, weakly pectinate; last joint but one of abdomen sometimes toothed along the distal, under margin; maxillipeds as in *C. gigas*; jaws with large teeth; antennæ very short not reaching to the base of the first cephalothoracic segment; formula — ⏓ ◡ — ⏓ ◡ — ◡ ◡ ◡ ◡ ◡ ◡ ◡ ◡ ⏓ ⏓; fifth foot two-jointed, the proximal joint very broad with a strong spine, second joint cylindrical with a long seta and a very short spine near the end; operculum vulvæ somewhat heart-shaped; egg sacs oval-elongated, reaching beyond the end of abdomen; length $\frac{40}{100}$ cm. including stylets and setæ.

This is one of the largest and finest as well as rarest of our forms and loves, as it appears, lakes having outlets.

Small forms with seventeen-jointed Antennæ.

CYCLOPS NAVUS, sp. nov

(Plate V, figs. 6-13-15-17.)

Closely related to *Cyclops pulchellus*, Koch, and to *Cyclops strenuus*, Fischer.

Rather slender; abdomen long; stylets about three times as long as last segment of abdomen; lateral seta rather stout; outer and inner terminal setæ minute; middle ones of moderate length; antennæ short, reaching barely to or but little beyond the end of first segment; formula — ⏓ ◡ — ⏓ ◡ — ◡ ◡ ◡ ◡ ◡ ◡ ◡ ⏓ ⏓ ⏓; fifth feet two-jointed, terminal joint large, with two considerable spines; operculum vulvæ of peculiar shape; length $\frac{11}{100}$ cm. excluding setæ.

Quite abundant and perhaps passing into the following.

CYCLOPS PARCUS, sp. nov.

(Plate VI, figs 12-15.)

Almost exactly like the last but not yet found in the same waters. Distinguished by the broad and short basal joint of the fifth foot which extends into a process carrying a spine, the slender second joint with a single long spine and a short thorn, and by the oval shape of the operculum vulvæ.

The caudal setæ are naked for about a third of their length. These distinctions seem constant.

Section with twelve-jointed Antennæ.

CYCLOPS SERRULATUS, Fischer.

(Plate V, figs. 1-5, Plate VII, fig. 10.)

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Fric, Die Krusten thiere Böhmens.
Uljanin, Reise in Turkestan.
Brady, British Copepoda.
? Cyclops minutus, *Claus*, loc. cit. (= young.)
? Cyclops macrurus, *Sars*, loc. cit.
? Cyclops spinulosus, *Claus*, loc. cit.

Typical Form.

Cephalothorax oval, compact; abdomen slender and short, suddenly enlarged previous to its union with the thorax; antennæ slender, reaching nearly, but not quite to the last thoracic segment; the last three joints are attenuated and furnish the most evident character of the species; formula — ⏓ ⏑ — ⏑ ⏑ ⏓ — ⏑ — — —; during life the antennæ tend to assume the form of a rude Z, the proximal four joints forming the base; antennules small, reaching about to the sixth joint of antennæ; jaws small with large teeth: the single segment of the fifth foot with three equal spines; egg sacs oval, as long as the abdomen; eggs few, dark; caudal stylets very long and slender, spined along the outer margin; lateral setæ small and approximated to the upper one: outer terminal seta short, spine-like, in life set nearly at right angles to the others, spined or beaded on one margin and bristled on the other; the next seta is as long as the abdomen, being somewhat exceeded by the following one; inner seta insignificant; upper seta very small; length less than $\frac{1}{10}$ cm

A larger form occurs with an elongated body and abdomen and with extremely attenuated antennæ and caudal stylets, but it is not a variety induced by alpine habitat as suggested by Brady, occurring as a "post imago" form with the ordinary type. Claus' description of *Cyclops spinulosus* suggests that this form may be the basis of his species though the form of the male antenna is different from any yet seen. *Cyclops minutus*, Claus, is most certainly the young of some Cyclops, as is indicated both by the description and figures in *Die Freilebenden Copepoden.* Though placed among the twelve-jointed forms the antennæ are eleven-jointed. The fact that the females may have had egg sacs is no proof of their maturity as I have seen undoubted larval forms of *serullatus* with the sacs. Moreover *two-jointed branches of swimming* feet is a larval character. This is a cosmopolitan and very abundant species, occurring in almost all pools and lakes about Minneapolis. The form and structure of the stylets, antennæ and feet make it an easily recognized species.

CYCLOPS FLUVIATILIS, sp. nov.

(Plate VII, figs. 1-9.)

A very small and distinct species of the section with 12-jointed antennæ was found in an estuary of the Mississippi river, (also later in L. Minnetonka) with the following characters:—

Body elongated; thorax very long; abdomen slender; stylets about as long or longer than last abdominal segment; setæ all very short, not pectinate; lateral and dorsal setæ very small; outer one spine-like, short and stout, two middle short, inner one very small and inconspicuous; antennæ reaching nearly to the base of abdomen; formula, — ⏓ ⌣ — ⏓ — — — — — — —; the three joints following the six basal are much elongated while the terminal ones are but moderately so, a character which is peculiar to this species; terminal segment slightly but evidently hinged, and together with pair preceding somewhat curved; feet with the terminal spines strongly toothed; fifth foot very small, one jointed, bearing three small setæ; operculum vulvæ heart-shaped; egg sacs subquadrangular; eggs large; abdomen in the young much elongated; color deep indigo, length $\frac{7}{100}$ cm.

CYCLOPS ADOLESCENS, sp. nov.

(Plate VI, figs. 16-20.)

The form figured under the above name seems closely allied to *C. affinis*, Sars, from which it differs chiefly in the arrangement of the joints of antennæ.

The body passes without marked transition into the abdomen which is abnormally shortened; caudal stylets very short as is the last segment of the abdomen; setæ exactly as in *C. parcus* with which it was found; antennæ eleven-jointed; formula — ⏑ — ⏑ ⏑ ⏓ ⏓ ⏑ ⏓ —; a semi-circular series of spines upon the basal joint; fifth foot obsolescent, the three spines appearing to spring directly from the last thoracic segment which also bears a series of teeth; egg-sac reaching to base of abdomen, with rather numerous eggs; feet heavily spined on one margin; length $\frac{11}{100}$ cm., male $\frac{9}{100}$ cm.

This species, together with all others of this sort with eleven-jointed antennæ, is perhaps but an immature and abnormally modified form of some of the common species If this be true the rarity of these nominal species is explained. *C. minutus*, Claus, is certainly but a larval form, as is shown by the two-jointed branches of swimming feet.

Section with 8-jointed Antennæ.

CYCLOPS CRASSICORNIS, Müller.

(Plate IV, figs. 9-14.)

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Uljanin, Reise in Turkestan.
Brady, British Copepoda.
pauper, ***Fric***, Die Krustenthiere Böhemens.
? magniceps, ***Lilljeborg***, De crustaceis ex ordinibus tribus, etc.

A small species characterized by its small size and the eight-jointed antennæ; body depressed and passing gradually into the rather uniform abdomen; first cephalothoracic joint large; abdomen rather slender; stylets of moderate length, spined along the outer margin somewhat as in *C. serrulatus*; outer seta lance-shaped, short; the next one as long as stylets and last two segments; the following one nearly twice as long; inner one very small; last joint of abdomen spined; the preceding one fringed on distal margin with weak sètæ; antennæ short, not reaching the base of first segment; formula — — ⏓ — ⏑ ⏑ ⏑ ⏓; the basal joint with a semi-circular set of fine bristles, and with the following is furnished with pectinate setæ; second antennæ short; terminal joint short, with two curved, strong spines and other weaker ones; fifth feet small one-jointed with three unequal spines, bordered above by a spined plate of the last thoracic segment; length about $\frac{11}{100}$ cm. excluding setæ.

This species appears not to be very abundant, or at least from its small size it is not often encountered. A few particulars distinguish these western forms from the description given by Brady, among them being the spinous armature of the stylets, the bristles on the penultimate segment of the abdomen, pectinate bristles of the fifth feet, and the greater length of the abdomen, yet I see no reason for separating them. I have not seen the male and can not be sure that there is no further development, but the fact that the feet in this form are three-jointed, and its peculiar characters, clearly distinguish the species from any other known to me.

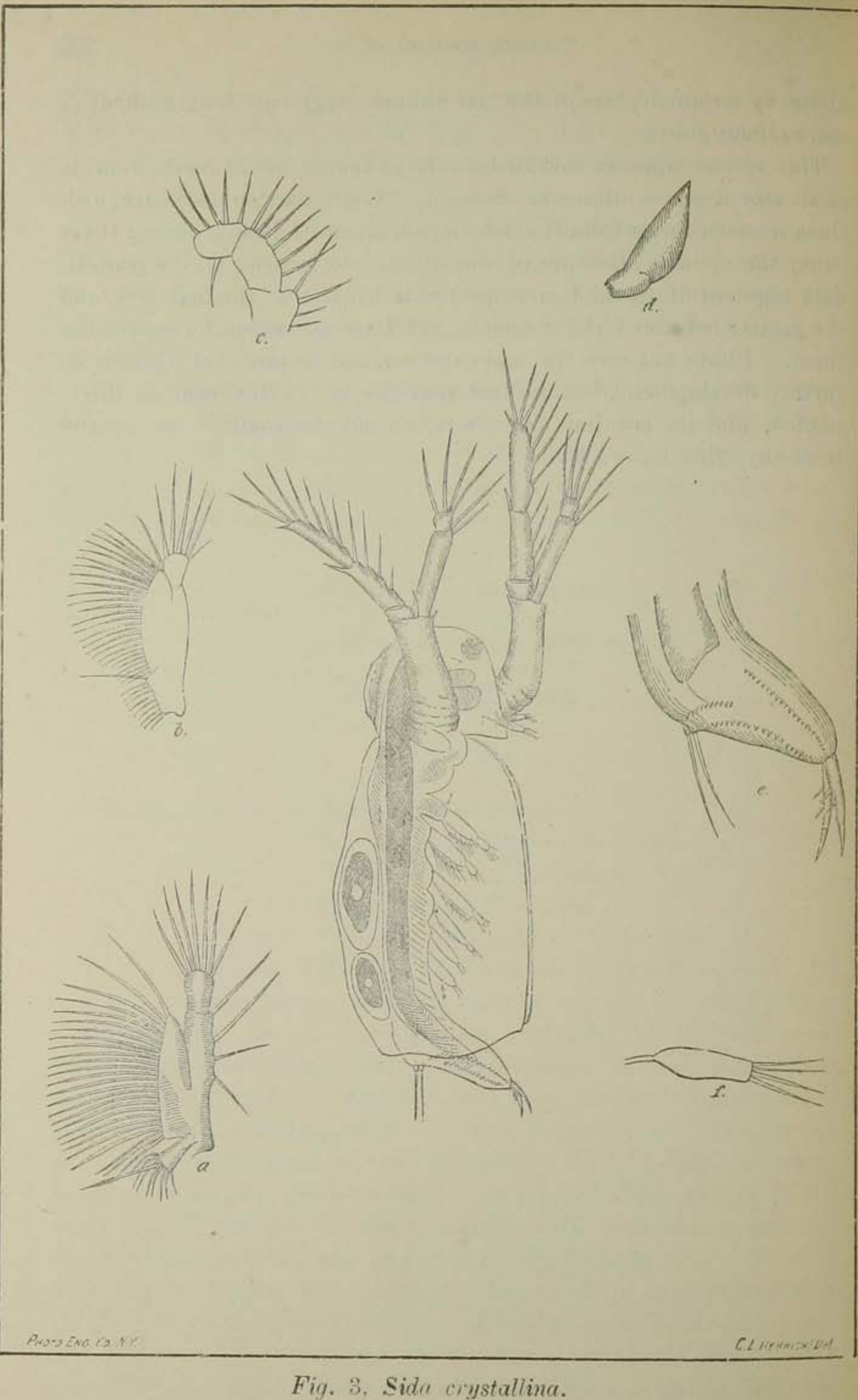

Fig. 3. Sida crystallina.

II. Notes on some Minnesota Cladocera.

Tribe I Ctenopoda.

SIDIDÆ.

Antennæ of second pair with unequal rami, superior larger; last joints compressed and setose; intestine simple.

Of this family two species are certainly identified in America, both of which are abundant in certain favorable locations at the proper seasons. No species of the *Holopedidæ* are known to occur here.

Genus SIDA Straus.

Superior ramus of second antennæ three-jointed; posterior margin of post-abdomen with numerous spines (20-30.)

Sida crystallina, Müller.
(Fig. 3.)

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Monoculus elongatus *De Geer*, Mém. servir Hist. Ins.
Sida crystallina, *Lievin*, Branch. d. Danziger Geg.
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Fischer.
Schödler, Die Branch. d. Umg. v Berlin.
Neue. Beitr.
Leydig, Naturg. d. Daph.
Sars, Norges Ferskv—Krebsdyr.
elongata *Sars* " " "
Sida crystallina, *P. E. Müller*, Danmark's Cladocera.
Kurz, Dodekas Neuer Cladoceren.
Birge, Notes on Cladocera.
Herrick, Microsc. Entom.
Lutz, Untersuch, ü. d. Cladoceren d. Umg. v. Bern. 1878.
Weismann.

I note this cosmopolitan species, of which a nearly complete bibliography is given above, simply to mention that I have recently found for the first time specimens of *Sida* reaching the size mentioned by P. E. Müller ($\frac{30}{100}$ cm.)

In smaller pools, when present our *Sida* is much (often $\frac{1}{2}$) smaller, and only in L. Minnetonka does the species attain its ultimate development.

Genus DAPHNELLA.

Superior ramus of second antennæ apparently 2-jointed, narrow; post-abdomen destitute of spines.

DAPHNELLA BRACHYURA Lievin.

(Plate VII, 11-16)

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Daphnella brandtiana, *Sars*, Norges Ferskv.—Krebsdyr.
Daphnella brachyura, *P. E. Müller*, Danmark's Cladocera.
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(Compare also *D. expinosa*, Birge, Notes on Cladocera p. 3.)

The species of *Daphnella* found about Minneapolis, occasionally abundant, seems not to differ in any important character from European types of *D. brachyura* although I formerly regarded it as distinct (*D. winchelli.*)

Head less than one-half the body (about $\frac{27}{1000}$ cm. while body is $\frac{6}{1000}$ cm. long); eye about $\frac{1}{4}$ head; antennæ when reflexed extend a little beyond $\frac{2}{3}$ the length of body. Male $\frac{7}{100}$ cm. long; antennæ reflexed reaching base of shell; anterior antennæ extremely long; copulating organs reaching nearly to end of claws. Having carefully compared our specimens with the description and figures given by Birge for his *D. expinosa*, the evidence seems to indicate not only that they are identical but both are really *D. barchyura.* The distinctive characters of *D. expinosa* are a greater indentation between head and body, absence of caudal teeth, greater length of male appendages, and the opening of the vasa deferentia in the "instep" of these appendages.

The absence of teeth upon the post-abdomen is of even generic importance according to Sars, who gives it in his synopsis of genera as typical for *Daphnella.* In our specimens the claws are at least pectinate if not serrate, while the appendages of the male reach generally nearly to the middle of the claws. The relative length of these appendages and the antennæ of male is variable.

Tribe II, ANOMOPODA.

DAPHNIDÆ.

Rami of antennæ 3 and 4-jointed; feet of five pairs; intestine with anterior cœca not convolute.

Genus MOINA, Baird.

A transition between *Sididæ* and *Daphnidæ* is made through this genus.

Head separated from the body by a depression; macula nigra absent; antennæ of female large, movable, of male very long, curved; first foot of male with strong hook: valves short, truncate behind.

MOINA BRACHIATA.

We believe with P. E. Müller that this and *M. rectirostris* are identical. The most complete discussion of the merits of the three species (the above and M. paradoxa) is found in Weismann's paper, *Ueber einige neue oder unvollkommen gekannte Daphniden*, Grüber and Weismann, 1877, which see for bibliography and elaborate, not to say labored, distinctions. This species is not common, but when found (in muddy pools in late summer) frequently appears in great numbers. For embryology see *Grobben,* Entwicklungsgeschichte der Moina rectirostris.

Genus DAPHNIA.

This genus as limited by Müller is well distinguished from the remaining genera of the family--*Simocephalus*, *Scapholeberis*, *Ceriodaphnia* and *Moina*.

As remarked by Birge, this is not the typical representative of the group but is a very divergent member of it, worthy, probably, of forming a distinct section or sub-family. The most remarkable feature is one which appears in a comparatively early embryonic period and, in some cases, nearly disappears in later life This is the development of a long spine from the dorsal, posterior end of the shell. This is the real diagnostic test and has not yet been incorporated into the definition of the genus The occurrence of a crista is more variable apparently, but may be of some importance.

The following is suggested as a revision of the diagnosis:

Shell more or less oval or sub-quadrate and reticulate; head rounded anteriorly, but sometimes with a crest, prolonged below into a beak which is truncate posteriorly and bears the antennæ near the apex; upper dorsal corner of shell in young of both sexes and mature males prolonged into a long spine; the macula nigra is present but not always pigmented; the post-abdomen spined behind; opening of rectum at the end.

The female with two age-forms (heterogenetic and dimorphic); the second form frequently scarcely spined; antennæ small, not movable, furnished with sense-hairs; ephippium with two ova, separable from remainder of shell along the latero-median suture; the brood-cavity closed by more than two unequal processes of the abdomen.

Male with long movable (almost two-jointed) antennæ furnished with prehensile stylus; first foot bearing a curved claw; swimming antennæ very long; vas deferens opening at the end of post-abdomen. Embryo with second antennæ palpate; a curved appendage to shell which becomes the spine of adult.

DAPHNIA PULEX.

This species is mentioned here simply to remark concerning *D. pulex*, var *denticulata* of Birge, (Notes on Cladocera, p. 11, plate I, fig. 11,) that the European as well as all the American specimens of *D. pulex*, have a fine series of spines on the claws of the post-abdomen. A glance at Tafel XII, fig. 39, of the Zeitschrift für Wiss. Zoöl. Bd. XXXIII, with Weismann's plate of the end of the abdomen of this species, is sufficient evidence of this fact, though as the animal is a male and quite young, the spines are less evident; moreover the number of caudal teeth is known to be variable with age. Some other peculiarity must be found to give this varietal distinction validity.

DAPHNIA sp?

(Plate X, figs. 15-16).

From a cold marsh a gathering in June, 1882, contained several females like that represented by fig. 16. They were far from being abundant, however, and the pool contained no other Daphnia showing that it was unfavorable to the growth of these animals.

These females differ from *D. pulex* chiefly in their small size, ($\frac{14}{100}$ cm.) being the smallest Daphnia seen with an evidently mature appearance. The caudal spine is sickle-shaped; post-abdomen as in *pulex*; antennæ short; the animal beautifully clear and varigated by the brilliant contents of ovary, eggs and intestine. I hesitate to regard it as a destinct species.

Figure 15 represents a single specimen of Daphnia found with the above which was somewhat injured during its moult. This resembles *D. apicata*, Kurz. and *D. pellucida*, Müller, and is perhaps the male of the species represented by fig. 16. Our knowledge of the variations induced by environment is yet too meager to draw up definitions of species with certainty from a single gathering, but these forms are peculiarly interesting.

See also the accompanying figure, (fig. 4,). These forms merit closer study.

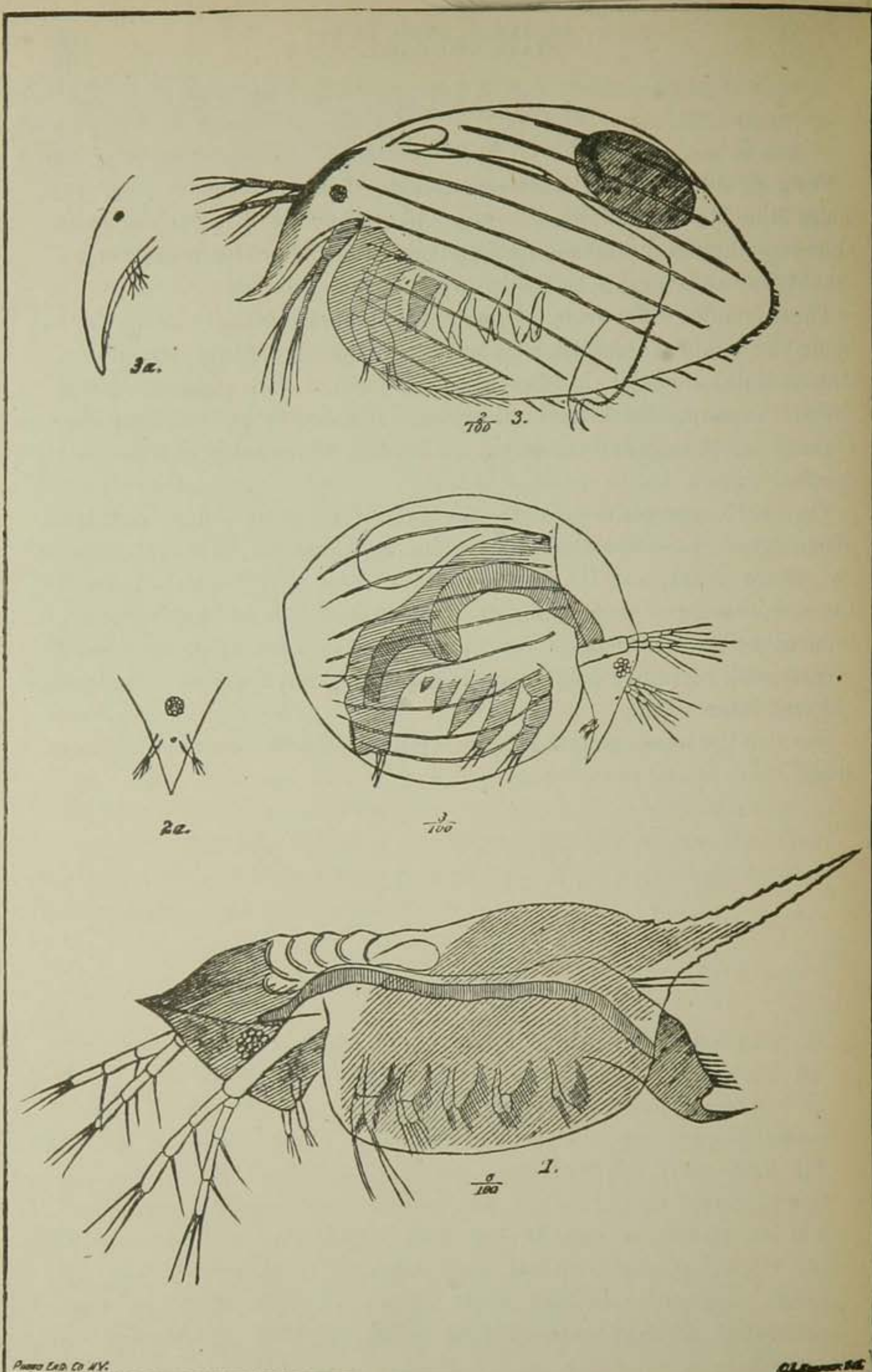


Fig. 4. Daphnia longispina (numbered 1) etc.

SCAPHOLEBERIS, Schödler.

In a former paper *S. mucronata* was reported from this locality with the remark that only the unhorned variety seems to occur here. A rather diligent search has failed to find var. *fronte cornuto*, though our waters have been carefully searched at intervals for several years and at different seasons. Birge quotes only this variety. However, the species is not common and the other form may yet be discovered. See Fig. 5.

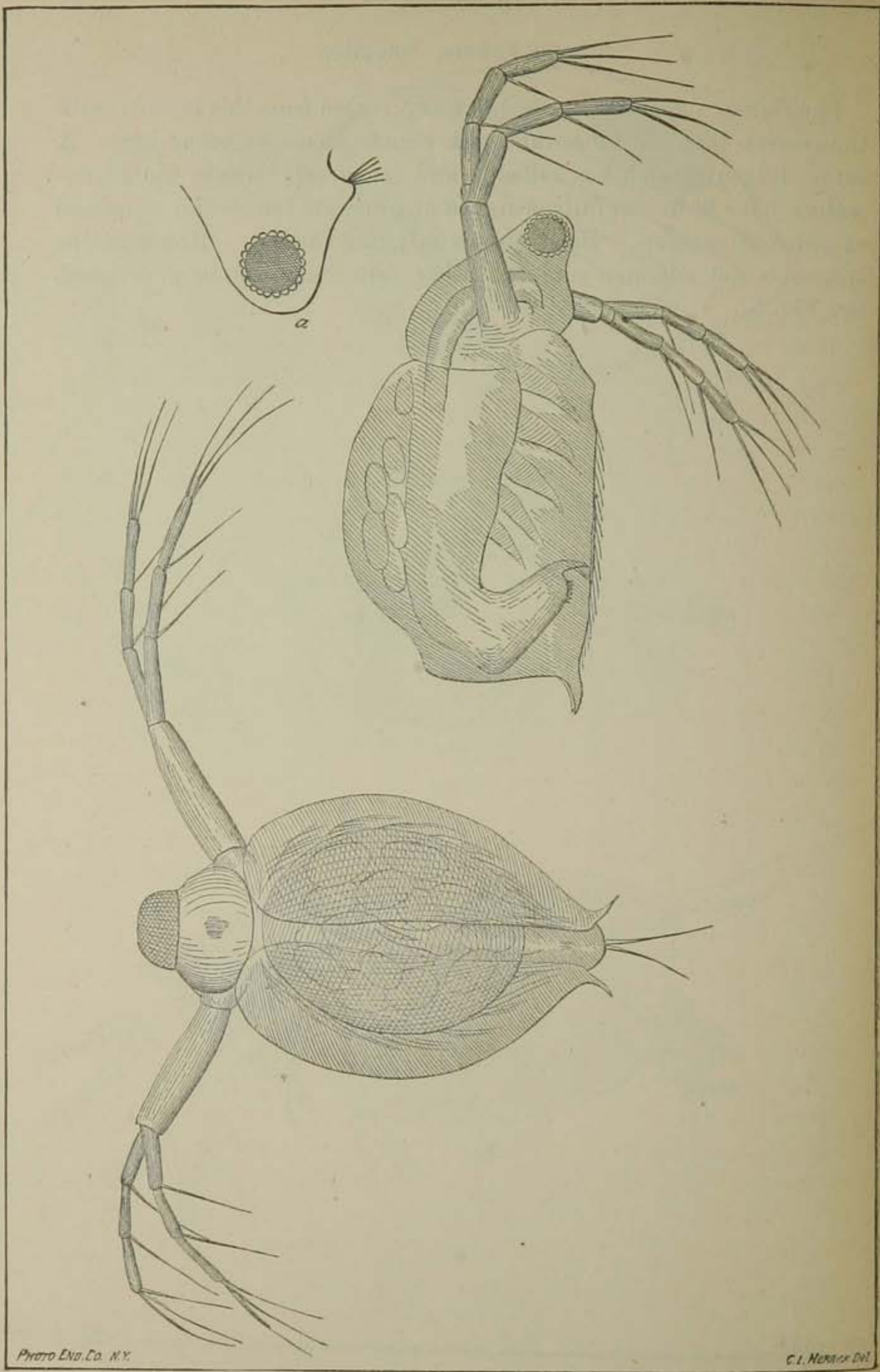


Fig. 5. Scapholeberis mucronata.

A second variety or species has been found which differs somewhat from typical *mucronata*, but does not appear to be *nasuta* of Birge. Is not the latter a variety simply?

SCAPHOLEBERIS ARMATA var.? nov.

Length $\frac{7}{100}$ - $\frac{8}{100}$ cm.; much as *S. mucronata* in form; but the spines are greatly elongated in old as well as young individuals; and in individuals having winter as well as summer eggs, though the winter form seems to have longer spines which are nearly equal in some cases to the hight. Antennæ are short and transparent. The head is separated from the body by a marked depression; but is curved forward so that the beak lies generally between the valves. The antennules are of medium size. Nowhere reticulate (?) nor tuberculate. The shell is marked by impressed lines, especially anteriorly and below. The lower margin is straight and beaded anteriorly, but toward the base of the *mucro* are several long bristles which stop abruptly and are followed by a few very weak hairs. The post-abdomen has three teeth at the base of the claws, which are smooth.

This variety is much like *S. nasuta* of Birge, perhaps, but differs perceptably in several points. Most conspicuous are the greatly elongated spines and the short antennæ. This variety is about as large as *mucronata* but less than *nasuta*.

BOSMINIDÆ.

Genus BOSMINA.

First antennæ many-jointed; intestine straight. Sole genus of the family, and one which Kurz characterizes as "one of the most difficult of the genera of Cladocera."

There are three species known in the United States, two of which are found from the Eastern States to the Mississippi and westward, and are identical with European forms. The third may not prove distinct

BOSMINA LONGIROSTRIS.

(Plate X, fig. 2.)

Differs from the following in having the terminal claws not toothed, and from *B. striata* in the shorter antennæ and reticulate shell.

BOSMINA CORNUTA.

(Plate IX, figs. 3–5.)

$\frac{35}{000}$ cm. long; shell reticulate with hexagonal meshes; antennæ curved backward and outward at the tip; claws with several teeth near the base. In embryonic specimens the antennæ are straight.

BOSMINA STRIATA, sp. n.

(Plate IX, fig. 1).

$\frac{25}{1000}$ cm. long; shell marked with anastomosing longitudinal striæ; antennæ very long; frontal seta about midway between eye and the sense-hairs of the antennæ: posterior inferior angle of shell spined as in the previous species.

The species resembles *B. maritima* greatly. The members of this genus have been little studied owing to their small size and comparative rarity, and it is even possible that some of the species will prove invalid.

All three of the above species were found in one gathering from Lake Minnetonka. Only one other locality (for *B. longirostris*) is known to me in this State.

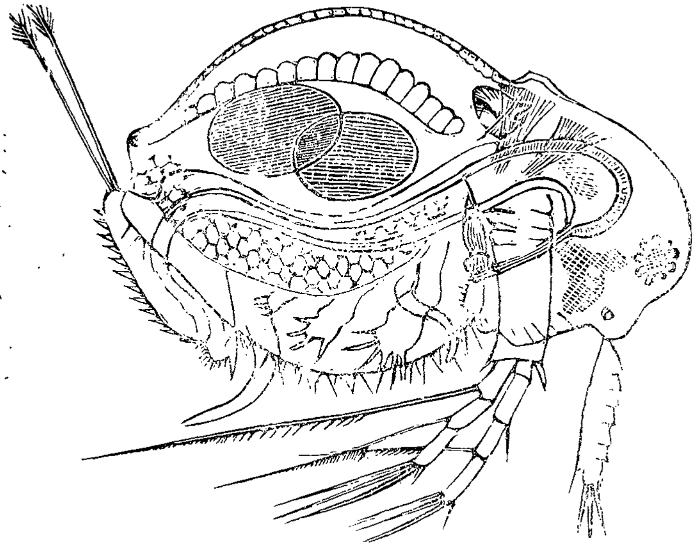
LYNCODAPHNIDÆ.

Genus MACROTHRIX.

Aside from *M. roseus* and *M. tenuicornis* (to which, perhaps, *M. agilis* of a previous report may be referred) a single species of macrothroid crustacean was collected at Lake Minnetonka, which is very remarkable. The specimen was apparently somewhat injured in moulting, and it is not possible to tell how much of its peculiar shape may be due to this fact, but some of its characters are sufficient evidence that it constitutes at least a new species.

It resembles in outline *Simocephalus vetulus*; the antennæ are very narrow and curved in a lateral as well as posterior direction; the second or swimming-antennæ are long as in other members of the genus; *macula nigra* present but small; eye small; post-abdomen short, triangular; claws pectinate; a dorsal sucking-disc is present;

length $\frac{10}{100}$ cm. For this species the name MACROTHRIX PAUPER is provisionally offered. (Plate VIII, fig. 1.)



(FIG. 6.)

MACROTHRIX TENUICORNIS, Kurz.
(FIG. 6.)

The description given by Kurz is very full and agrees very well. The peculiar arrangement of the movable spines at the margin of the valves is characteristic. I have observed that *this species forms an ephippium.* Müller says destinctly of the series of genera including *Macrothrix, Drepanothrix, Lathonura, Bosmina, Acantholebris and Iliocryptus,* "*Testae abjectæ corporis, nullo ephippio, ova hiberna obtegunt.*"

Bosmina is little related to the *Lyncodaphnidæ* and, however it may be with regard to other species, in *M. tenuicornis* an evident ephippium is formed in much the same way as in *Ceriodaphnia.* In *Daphnia* this egg-cover is produced by an alteration of part of the inner layer of the shell which becomes turgid and secretes a thick coating. The ephippium simply extends over the brood-cavity, being marked off from the rest of the shell by the median suture of the valves. In other *Daphnidæ* and in *Macrothrix* nearly the whole of the valves are thus modified. The shell of *M. tenuicornis* is normally smooth, but in the ephippial female, that portion of the inner layer of the shell bordering the egg-cavity and a little beyond, is composed of large and very deep cells; the space between the outer and inner layers is much greater than in *Daphnia.*

Genus LATHONURA.

Although no species of this genus has been found in Minnesota, it is to be expected that it will eventually be discovered that the cosmopolite *L. rectirostris,* Müll. occurs in our limits. It occurs in Mass. according to Birge. The figures (Plate VIII, figs. 11-12) were drawn from specimens found in Leipzig, Saxony, illustrating a tendency, especially common in the *Lyncodaphindæ,* to abnormal growth of the spinous appendages—in this case the anal setæ.

Genus ILIOCRYPTUS.

A genus represented by a single European species. Our form may differ somewhat in some respects from the generic diagnosis, but certainly belongs here. There are no anterior cœca (as indeed there are probably not in the European *I. sordidus* though so stated by Müller,) and no permanent cœcum or dilation of the intestine before the rectum. The marginal spines are straight, long and movable without branches.

ILIOCRYPTUS SPINIFER sp. nov.

(Plate VIII, figs. 2–6.)

Short; depth nearly equaling length of body excluding head; rounded behind; free edges of valves beset with slender ciliate spines which are not branched; antennæ exactly as those of *I. sordidus,* as is the post-abdomen, save that the anus seems to be situated higher; ova three or more.

This species occurs in Silver lake, east of Minneapolis. It swims quite well, while of the European species it is said this is not the case. It does, however, frequently load itself with filth so as to be too heavy to swim freely.

LYNCODAPHNIA, Gen. n.

(Plate IX, figs. 1-3.)

Form much as is species of *Alonella*, etc., truncate behind; superior antennæ like *Macrothrix*, attached movably to the end of a blunt prominence beneath the head; second or swimming antennæ slender; four-jointed ramus with three long setæ at the end of terminal joint where is also a stout spine; joint following the basal joint also with a spine above; middle joint unarmed (?); three-jointed ramus as in *Macrothrix*; the basal segment armed with a much elongated seta; eye relatively small; pigment fleck present; *intestine twice-convoluted*, expanded in front of colon, opening in the "heel" of the post-abdomen; post-abdomen slender, sub-triangular, margined behind with a double series of spines; terminal claws large, straightish and furnished with a long and short spine near the base, also very minutely feathered behind; shell marked alone by the so-called "stuzbalkein;" lower margin with movable spines.

Few more interesting forms have been noticed than this, since it combines the characters which have hitherto been considered as very clearly forming the boundaries of distinct families.

Kurz says, (*Dodekas neuer Cladoceren nebst einer kurzen Uebersicht der Cladocerenfauna Böhmens*, p. 30:) "Keine Cladocerenfamilie bildet eine so streng in sich abgegrenztes natürliches ganze, wie eben die Lynceiden," and this even after recognizing the relationship of *Macrothrix* and *Lathonura* to the Lynceids by placing them in the sub-family *Lyncodaphnicæ*. The form for which I propose the name *Lyncodaphnia* is quite as much like such forms as *Alona* and related Lynceids, as any species of the *Lyncodaphninæ,* while at the same time the characters of antennæ and head are almost identical with *Macrothrix*. This furnishes but another example of the fact that possibility of distinguishing families and genera lies alone in the meagerness of our knowledge.

LYNCODAPHNIA MACROTHROIDES, sp. n.

Form sub-rectangular, greatly elongated; length $\frac{12}{100}$ cm., hight $\frac{5}{100}$ cm. or less; first antennæ long and slightly curved, bordered behind by about ten spines and terminating in two unequal sword-shaped spines and several sense-hairs, about $\frac{17}{1000}$ cm. long; swimming antennæ very slender as in *Macrothrix*, $\frac{6}{100}$ cm. long; head not marked off by a depression from the body, small and extending below into a blunt elevation for attachment of antennæ; labrum rather large; eye small; macula nigra conspicuous but not large; anterior feet strongly armed with curved spines. The intestine anteriorly is furnished with cœca, is twice convoluted, broadened before entering the rectum and opens a little distance beyond the oval seta in the heel of the post-abdomen; post-abdomen rather slender, toothed behind with a double series of about twelve prominences, becoming distally sharp, strong teeth; terminal claws curved at the end only, pectinate and bearing two unequal but large processes near the base; eggs much like those of *Macrothrix.*

Occurs in Lake Minnetonka, Hennepin Co., Minnesota, rare.

LYNCEIDÆ.

But few of this large family, furnishing the majority of the Cladocera fauna of any locality and at any time of year, have been carefully studied here. The following are mentioned as of particular interest:

SUB-FAMILY EURYCERCINÆ.

The single species *Eurycercus lamellatus* which constitutes this sub-family has been mentioned and figured in a previous paper. It is quite abundant and constant.

Eurycercus is connected with the true Lynceids by the following genus which has quite as many affinities with *Eurycercus* as any Lynceid. Schödler seems to be the only writer who has laid sufficient stress upon this similarity, though it may not be best to unite the two forms as he did.

Genus LEYDIGIA, Kurz.

LEYDIGIA QUADRANGULARIS, Leydig.
(Plate VIII, 7-8.)

The Minnesota species is referred to *L. quadrangularis* under the belief that there is no specific distinction between that species and *L. acanthoceroides*, Fischer.

Our form does not agree in every particular with the very minute description of Kurz and does agree very well w th what is said of *L. acanthocercoides*. However, Kurz says of the latter species, "Diese Art is von der vorangehenden (*L. acanthocercoides*) im weiblichen Geschlecht schwierig zu unterscheiden," and immediately adds that the male is unknown to him. In P. E. Müller's time both males were unknown. Müller says of *acanthocercoides*, "ungues caudales inermes," of *quadrangularis*, "ungues caudales dente minuto." Kurz on the other hand says of the former, "der Basaldorn ist kurz," of the latter "die Endklauen haben keinen Basaldorn."

Our species has no spine on the claws, and has a small spine on an eminence on the dorsal part of the abdomen, as well as two ciliated prominences between it and the oval setæ; length $\frac{9}{10}$ cm.; color red.

Silver Lake, east of Minneapolis.

CAMPTOCERCUS MACROURUS.

(Plate X, fig. 9.)

This large species occurs rather sparingly at Lake Minnetonka. It is probably widely distributed in America as well as Europe. It is known in Cambridge, Mass. and Madison, Wis. (Birge).

CAMPTOCERCUS ROTUNDUS, sp. nov.

(Plate VIII, figs. 9–10.)

Short, quadrangular, dorsally nearly uniformly arched; antennæ of first pair long, curved outward, with long terminal bristles; abdomen long, nearly uniform in width; teeth of post-abdomen few, inconspicuous; terminal claw nearly straight; basal spine large; the claw also has a series of spines beginning a little beyond the middle and shortening proximally; length $\frac{7}{100}$ cm. This resembles *C. rectirostris*, Schödler, a little in outline of body but the head is like *C. macrourus*, except that there is a slight beak directed anteriorly (not shown in the figure); the post-abdomen is much as in *C. macrourus*, but is less heavily spined. In size it is somewhat less than *C. lilljeborgii*, and the shortest species known to me.

ACROPERUS sp?

(Plate X, fig. 10.)

Resembles *Camptocercus macrourus* greatly. Are these two genera really distinct?

PLEUROXIS PROCURVUS, Birge.

(Plate X, fig. 6.)

Very characteristic. Found in Shady Oak lake, and elsewhere abundant.

PLEUROXIS UNIDENS, Birge.

A species which agrees best with this is quite abundant. It is, however, always of a deep brownish color, and the beak is long and curved inward; it may be distinct.

A third form of *Pleuroxis*, probably *P. denticulatus*, Birge, is abundant also.

GRAPTOLEBRIS INERMIS, Birge.

(Plate X, figs. 8, 11–12.)

Resembles *Alona testudinaria* very closely; the antennæ are peculiar; each joint has a median circlet of fine bristles; the upper ramus is terminated by two long setæ, one shorter seta and a stout spine; the joint preceding the terminal one has a stout seta. The description given by Birge is otherwise complete. Lake Minnetonka.

CREPIDOCERCUS SETIGER, Birge.

This is exceedingly rare, and by reason of its small size, difficult to distinguish. It has been encountered but once in Minnesota. This species is easily recognized when found, and though our specimens differ a little from the figure given by Birge, they are doubtless the same.

ALONA OBLONGA, P. E. Müller.

The specimens examined differ somewhat from Müller's description. The caudal claw is pectinate; the spine at its base is large and covered with a tuft of hairs; the teeth of post-abdomen are large, emarginate and hairy; otherwise the agreement is very close; length .07 cm. Found in Grass Lake, Richfield.

TRIBE III ONYCHOPODA.

POLYPHEMIDÆ.

POLYPHEMUS PEDICULUS.

(Plate IX, figs. 4–6.)

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Polyphemus pediculus, *Lilljeborg*, De Crust. ex ord. trib.
Polyphemus oculus, *Leydig*, Naturg. d. Daph.
Polyphemus pediculus, *Schödler*, Neue Beitr. zur Naturg. d. Cladoceren
Polyphemus kochii, " " " "
Polyphemus oculus, " " " "
Polyphemus pediculus, *P. E. Müller*, Danmark's Cladocera.
Kurz, Dodekas neuer Cladoceren.
Weismann, Beitr. z. Naturg, d. Daphnoiden.
Birge, Notes on Cladocera.

I have collected from various sources what I could of the extensive bibliography of this, the sole species of the genus. One of the most characteristic and pleasing figures given is that of Weismann in his article on the "Schmuckfarben der Daphnoiden," though we believe that author in the wrong in the deductions made. Our specimens rarely approach the brilliancy of the plate, and there seems to be a more legitimate way of explaining these secondary colors than by sexual selection. This species is never abundant, nor is it very rare; found in Lake Minnetonka, and the larger lakes with their outlets.

III *On Notadromas and Cambarus.*

CYPRIDÆ.

This group is one of the most difficult and perhaps least studied. A number of species some of which, perhaps most, are new, occur in Minnesota, and among them is a *Cypris* which exceeds any described form in size. I only mention one genus which is cosmopolitan.

NOTADROMAS, Lilljeborg.

Carapace differing in male and female; eyes two; antennæ similar to those of *Cypris*, the superior having seven and the inferior six joints; setæ of inferior antennæ reaching beyond the apex of the terminal claws; second pair of jaws without a branched appendage, in the male pediform; abdominal rami rather long.

NOTADROMAS MONACHUS, Müller.

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Brady, British Ostracoda.

Females of this widely distributed species were collected near Minneapolis, presenting in as far as could be seen no material points of distinction from English types.

DECAPODA.

But two species of *Cambarus*, *C. virilis*. Hagen, and *C. signifer*, occur in Hennepin county, except, perhaps, in the Mississippi. The following localities for the former species are known in the State: Mississippi river, Minnehaha creek, Bassett's creek, Cedar lake, Lake Minnetonka, Lake Independence, Lake Superior.

It is possible to recognize three age-forms in the males of this species.

A. The immature male (II Form, Hagen). Reaching two to three inches in length, this stage has the chelæ proportionally smaller, and the spinous armature less developed; the first abdominal foot is simply bifid at the end.

B. (Form I of Hagen,) usually over two and one-half inches long; chelæ larger; branches of abdominal foot destinct; inner branch grooved but lance-linear.

C. Very large (four inches); inner branch of abdominal foot spatulate at end; the two rows of tubercles on the inner margin of the "hand" with six or seven in a row instead of five.

Male of Form II, A stage, 2½ in. long,	Chela.	7 in.,	thumb	.49 in.
" " I, B stage, 2½ in. long,	"	1 in.,	"	.6 in.
" " I, C stage, 4 in. long,	"	1.8 in.,	"	1.1 in.
" " II, A stage, 3 in. long,	"	1.2 in.,	"	.75 in.

It will be seen from the above that size does not govern the transition from the first to the second form entirely. This differs either in different localities or at different seasons of the year. A large gathering from Cedar lake showed no specimens of the form I, while a similar gathering at Lake Independence contained but one of the form II. A male from Minnehaha creek had rudiments of a third tooth on the carpus of the left claw, thus indicating an approach to Hagen's Var. A.

CAMBARUS SIGNIFER sp. nov.

(FIG. 7.)

A slender, graceful species of rather marked colors, belonging to the section having a hook on the third pair of legs but not on the fourth. The rostrum is not carinated nor toothed at the apex; acumen moderate, lateral borders curved, moderately excavated. Cephalothorax arched and not depressed above, densely punctate; areola linear; chelae slender, straight; thumb deeply excavated on the inner margin for the proximal one-third; opposite finger with an impressed groove on the inner but not on the outer margin.

Male, I Form. Color reddish-(crimson) brown, not obviously figured; tail lighter; fin chestnut, marked with gray; chelæ bright crimson below there are green markings on the body and legs, and some yellow below.

The hands are rather narrow and straight, while the "thumb" is deeply excavated for one-third its length, and the notch thus formed is armed with three or four teeth; the finger opposite has a tooth half way from the apex, and others near the base; the ange at base of thumb is densely hairy. The penultimate and previous joint of second foot bears a very dense and thick tuft of hairs on the inner margin which it particularly noticeable in living specimens. The antennæ are short about as long as the thorax when reflexed.

The first pair of abdominal feet resemble those of *C. virilis* somewhat, but are stouter and less divided. They are more strongly curved than in *C. propinquus.*

The laminæ of antennæ are much as in *C. troglodyles* but wider at the base.

The second form has the two branches of the abdominal foot united almost to the end. The young males have the chelæ greenish-blue and mottled, while the coloration of the body is like the females.

The females have shorter chelæ, and broader abdomen marked with chestnut bars on each segment above.

A male 3.3 in. long was still in form II, while another 3.2 in. long was in the form I. Found by hundreds in a shallow pool known as Grass Lake, in Richfield, Hen. Co.

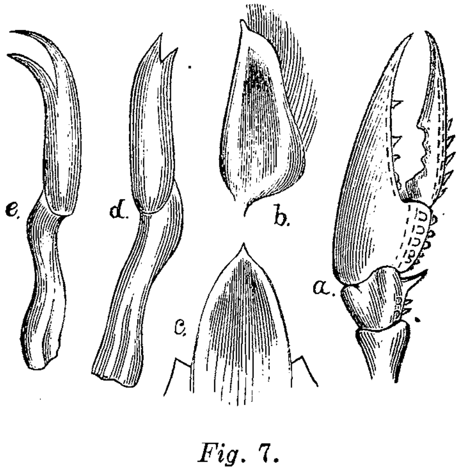

Fig. 7.
Cambarus signifer.

a chela. *b* lamina of antenna. *c* rostrum. *d* abdominal foot of form II. *e* abdominal foot of form I.

INDEX OF GENERA AND SPECIES.

INDEX

TO THE

GEOLOGICAL REPORT FOR 1881.

PUBLICATIONS OF THE GEOLOGICAL AND NATURAL HISTORY SURVEY OF MINNESOTA.

I. ANNUAL REPORTS.

THE FIRST ANNUAL REPORT OF THE GEOLOGICAL AND NATURAL HISTORY SURVEY OF MINNESOTA, FOR THE YEAR 1872. 8vo. 112 pp , with a colored geological map of the State. *By N. H. Winchell.* Published in the Regents' Report for 1872. Out of print.

THE SECOND ANNUAL REPORT ON THE GEOLOGICAL AND NATURAL HISTORY SURVEY OF THE STATE, FOR THE YEAR 1873. *By N. H. Winchell and S F. Peckham.* Regents' Report; 148 pp. 8vo., with illustrations.

THE THIRD ANNUAL REPORT ON THE GEOLOGICAL AND NATURAL HISTORY SURVEY OF MINNESOTA, FOR THE YEAR 1874. 41 pp. 8vo , with two county maps *By N. H. Winchell.* Published in the Regents' Report for 1874.

THE FOURTH ANNUAL REPORT ON THE GEOLOGICAL AND NATURAL HISTORY SURVEY OF MINNESOTA, FOR THE YEAR 1875. 162 pp. 8vo.; with four county maps and a number of other illustrations. *By N. H. Winchell*, assisted *by M. W. Harrington* Also published in the Regents' Report for 1875.

THE FIFTH ANNUAL REPORT ON THE GEOLOGICAL AND NATURAL HISTORY SURVEY OF MINNESOTA, FOR THE YEAR 1876. 8vo. 248 pp.; four colored maps and several other illustrations *By N. H. Winchell.* Also published in the Regents' Report for 1876, with Reports on Chemistry by *S. F. Peckham*, Ornithology by *P. L. Hatch*, Entomology by *Allen Whitman*, and on Fungi by *A. E. Johnson.*

THE SIXTH ANNUAL REPORT ON THE GEOLOGICAL AND NATURAL HISTORY SURVEY, FOR THE YEAR 1877. Three geological maps and several other illustrations. 226 pp. 8vo. By *N. H Winchell*, with Reports on Chemical Analyses by *Prof. Peckham*, on Ornithology by *P. L. Hatch*, on Entomology by *Allen Whitman*, and on Geology of Rice County by *L. B. Sperry.* Also published in the Regents' Report for 1877.

THE SEVENTH ANNUAL REPORT ON THE GEOLOGICAL AND NATURAL HISTORY SURVEY OF MINNESOTA, FOR THE YEAR 1878. With twenty-one plates. 123 pp. 8vo., by *N. H. Winchell*, with a Field Report by *C. W. Hall*, Chemical Analyses by *S. F. Peckham*, Ornithology by *P. L. Hatch*, a list of the Plants of the north shore of Lake Superior by *B. Juni*, and an Appendix by *C. L. Herrick* on the Microscopic Entomostraca of Minnesota. Also published in the Regents' Report for 1878.

THE EIGHTH ANNUAL REPORT ON THE GEOLOGICAL AND NATURAL HISTORY SURVEY OF MINNESOTA, FOR THE YEAR 1879. 178 pp. 8vo. One plate of Castoroides. *By N. H. Winchell*, containing a statement of the methods of Microscopic Lithology, a discussion of the Cupriferous Series in Minnesota, descriptions of new species of brachiopods from the Trenton and Hudson River formations; the Geology of Central and Western Minnesota, by *Warren Upham*; report on the Lake Superior region by *C. W. Hall*; lists of Birds and of Plants from Lake Superior by *Thomas S. Roberts*; Chemical Analyses by *S. F. Peckham*; Report by *P. L. Hatch*; and four Appendixes. Also in the Regents' Report for 1879 and '80

THE NINTH ANNUAL REPORT OF THE SURVEY FOR THE YEAR 1880. Three appendixes, two wood cut illustrations, and six plates. 8vo. 392 pp., by *N. H. Winchell*, containing field descriptions of 442 crystalline rock samples, with notes on their geological relations, from the northern part of the State; new brachiopoda; the water supply of the Red River Valley, with simple tests of the qualities of water; Reports on the Upper Mississippi Region by *O. E. Garrison*, on the Hydrology of Minnesota by *C. M. Terry;* on the Glacial Drift and its Terminal Moramis by *Warren Upham;* chemical analysis by *J. A. Dodge;* a list of the Birds of Minnesota by *P. L. Hatch*, and of the Winter Birds by *Thomas S. Roberts.* Also in the Regents' Report for 1879 and 1880.

II. MISCELLANEOUS PUBLICATIONS

1. CIRCULAR NO. 1. A copy of the law ordering the survey, and a note asking the co operation of citizens and others 1872.
2. PEAT FOR DOMESTIC FUEL. 1874. Edited by *S. F. Peckham*
3. REPORT ON THE SALT SPRING LANDS DUE THE STATE OF MINNESOTA. A history of all official transactions relating to them, and a statement of their amount and location. 1874. *By N. H Winchell.*
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9. CIRCULAR NO. 5. To Builders and Quarrymen Relating to the collection of two-inch cubes of building stones for physical tests of strength, and for chemical examination, and samples of clay and brick for the General Museum. 1880.
10. CIRCULAR NO. 6. To owners of mills and unimproved water powers. Relating to the Hydrology and water-powers of Minnesota. 1880.

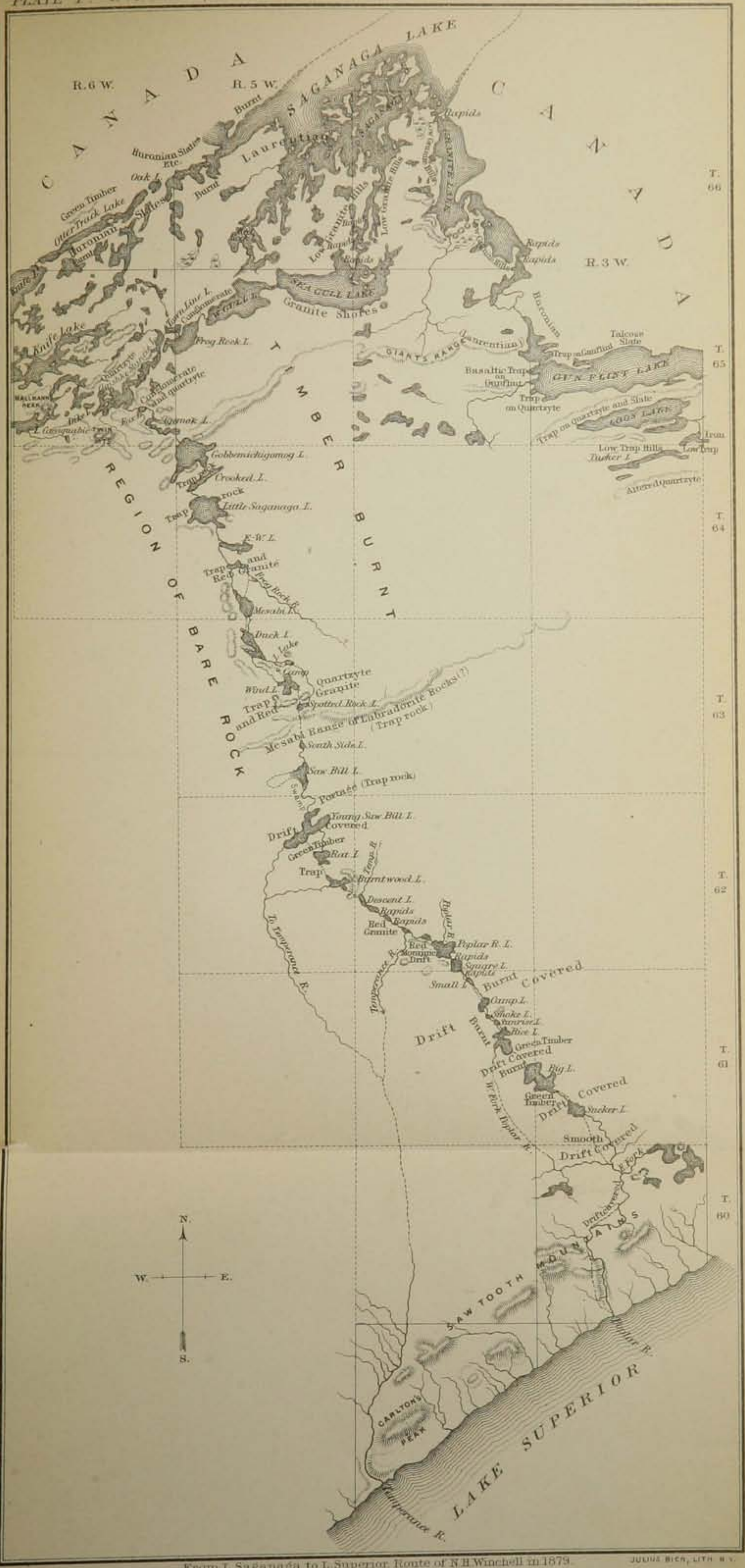
ERRATA.

Page 42. Third line—for *sawthuth*, read Sawteeth.
56. Twelfth line—for *tubes*, read talus.
65. Twenty-third line—for *tract*, read trail.
67. Seventeenth line—for *vein*, read rim.
89. Twelfth line—for *land*, read hand.
99. Twenty-fourth line—for *Merabi*, read Mesabi.
119. Twenty-ninth line—after *trilobite*, add a foot note, as follows: **Conocephalites minor Shu.?*
133. Twenty-sixth line—for *conspicuous*, read calciferous.
134. Fifth line from the bottom—for *Sendrogroptus*, read *Dendrograptus*.
147. Twenty-sixth line—for *oppressed*, read appressed.
175. Sixth line—after *p.* 417, add in 1871.
187. Thirtieth line—for *have*, read has.
191. Eleventh line—for *steepry*, read steeply.
239. Fifteenth line—for *apicata*, read *spicata*.

PLATE I.

Sketch Map of the Canoe-trail from Ogishke Muncie Lake to the mouth of Poplar river.

Route of N. H. Winchell in 1879.



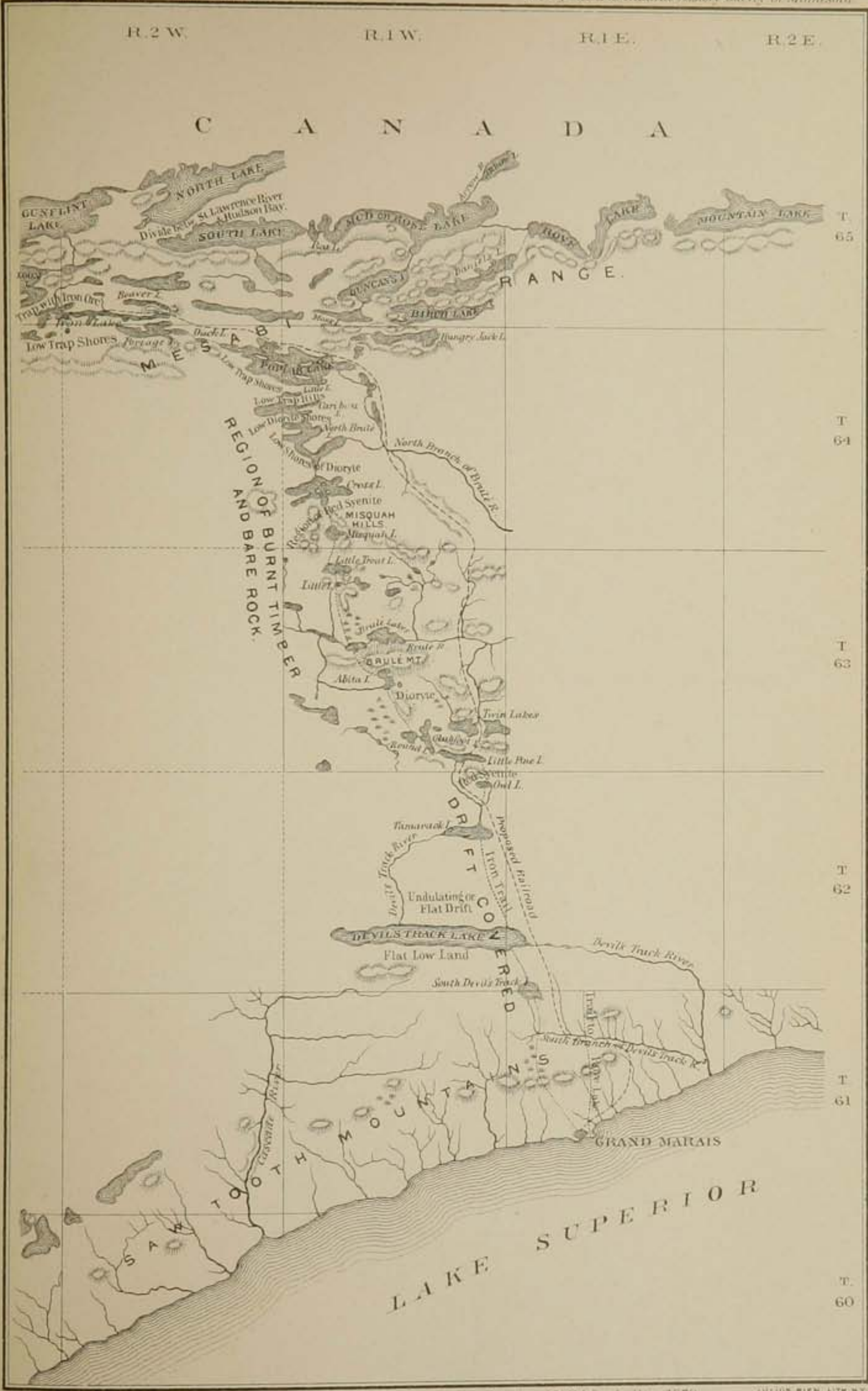
From L. Saganaga to L. Superior. Route of N. H. Winchell in 1879.

JULIUS BIEN, LITH. N.Y.

PLATE II.

Sketch Map of the Iron-trail for Canoes from Grand Marais to Iron Lake.

Route of N. H. Winchell in 1879.



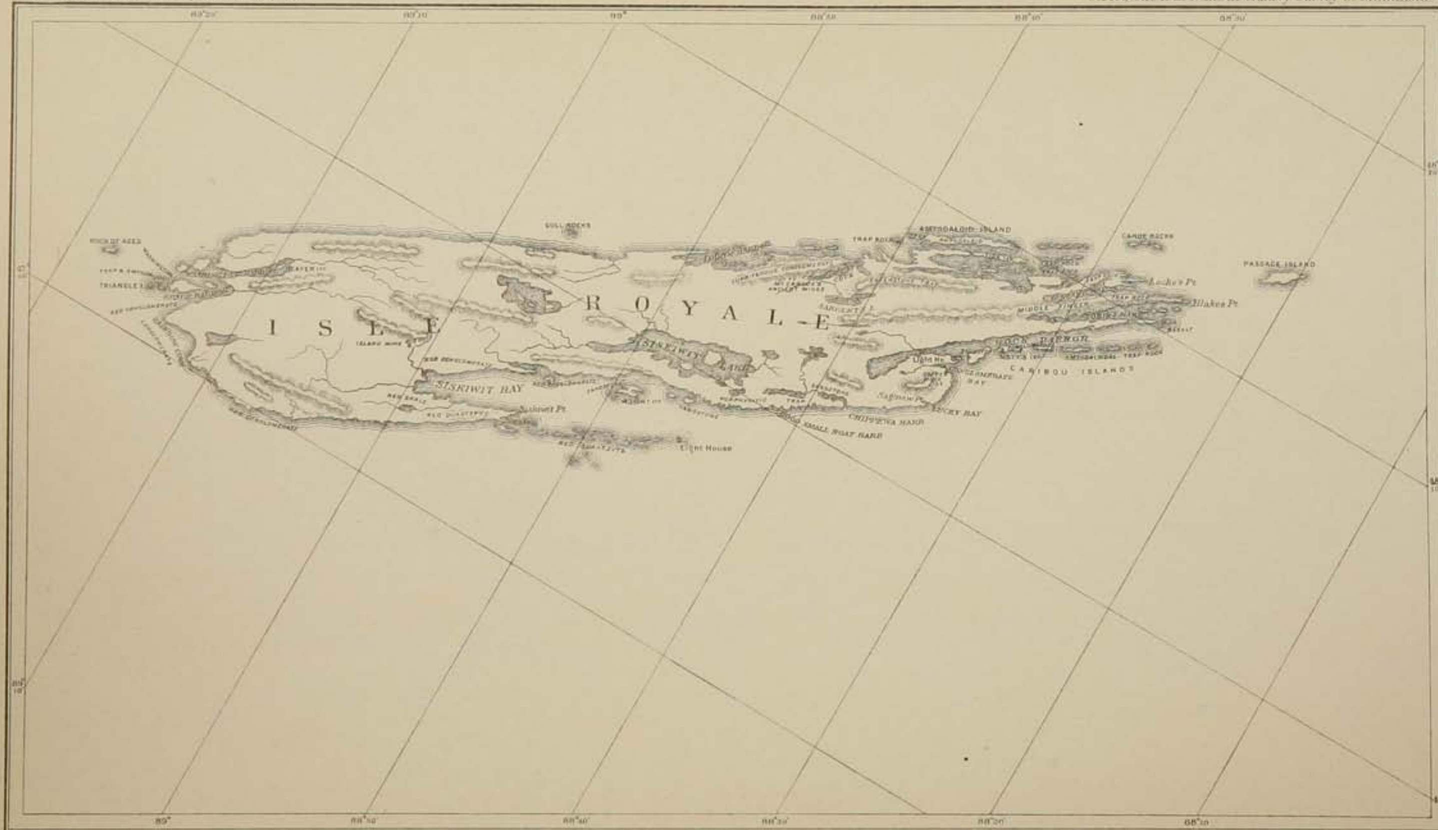
From Grand Marais to Iron Lake Route of N.H. Winchell in 1879.

JULIUS BIEN, LITH. N.Y.

PLATE III.

Sketch Map of Isle Royale.

To illustrate notes on the Geology by N. H. Winchell in 1879.



Julius Bien, lith. N.Y.

PLATE I.

Diaptomus castor.

1. Male, antennæ not yet fully developed, showing shell, gland, heart, reproductive, alimentary and muscular systems.
2. Female, antennæ and appendages removed except fifth feet.

3 and 4. Nauplius stage.

5. Male foot of fifth pair, (a) "thumb" of larger branch.
6. Female foot of fifth pair.
7. Mouth parts etc.

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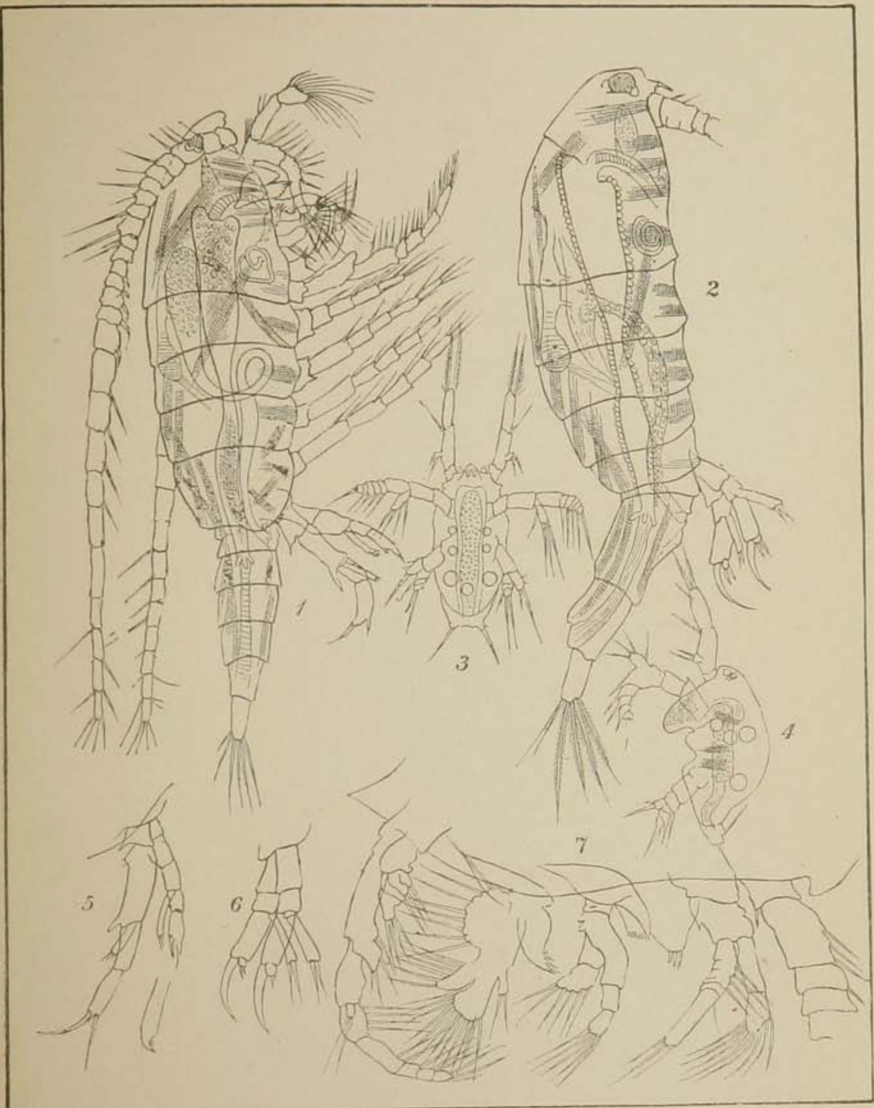

PLATE II.

Diaptomus castor.

1 End of male antennæ.

2. End of abdomen.

Diaptomus giganteus.

3. Caudal stylet.
4. One pair of feet.
5. Maxilliped.
6. Maxilla.
7. Mandible and palp.
8. Antennule.
9. Male fifth foot.
10. Female fifth foot.
11. Spermatic tube.

Potomoichetor fucosus.

12. Female fifth foot.
13. Female abdomen and egg-sac.
14. Abdomen of young.
15. First foot of *Diaptomus giganteus*, one branch drawn reverse.
16. " " *castor*, " " ".

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PLATE II.

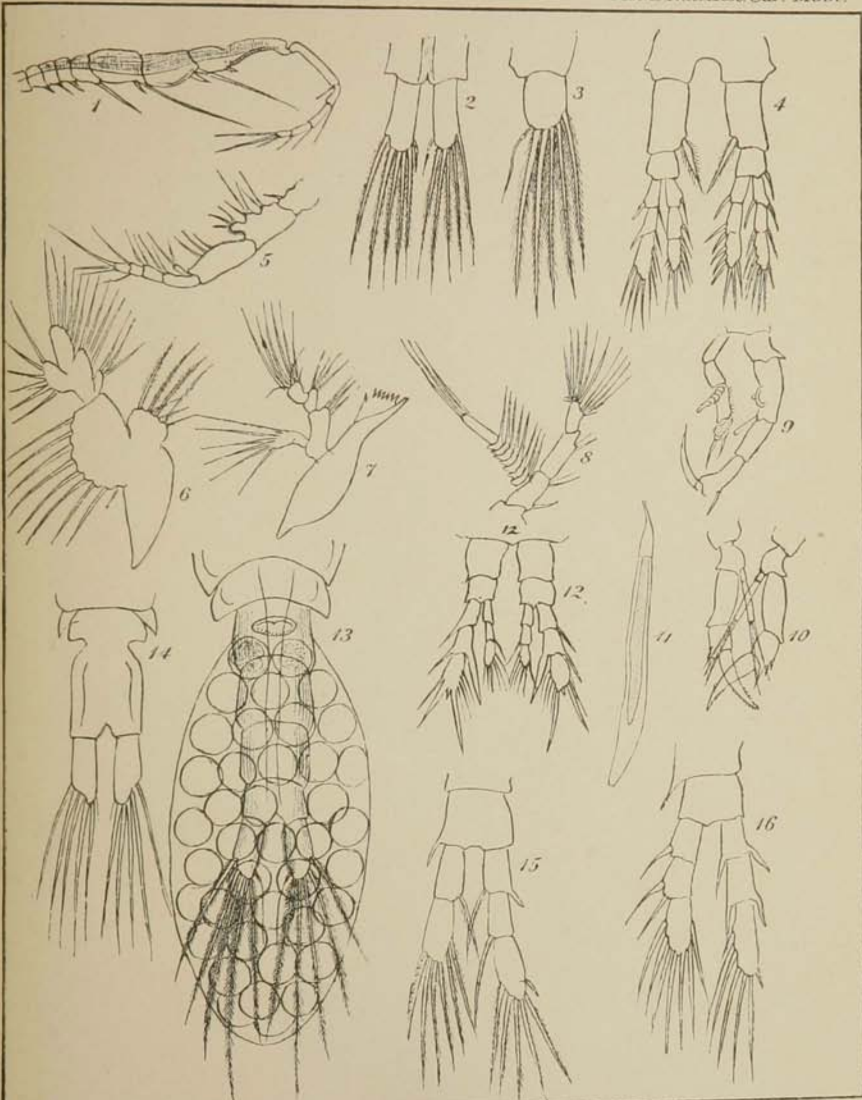

PLATE III.

Potomoichetor fucosus.

1. Male.
2. Antennule.
3. Maxilliped.
4. Male fifth pair of feet.
5. Palp of mandible.
6. End of abdomen.
7. Feet of first pair.
8. Eye.

Cyclops ater.

9. Female
10. Abdomen.
11. Maxilliped.
12. Antenna.
13. Maxilla of *Potomoichetor fucosus.*
14. Mandible of " "

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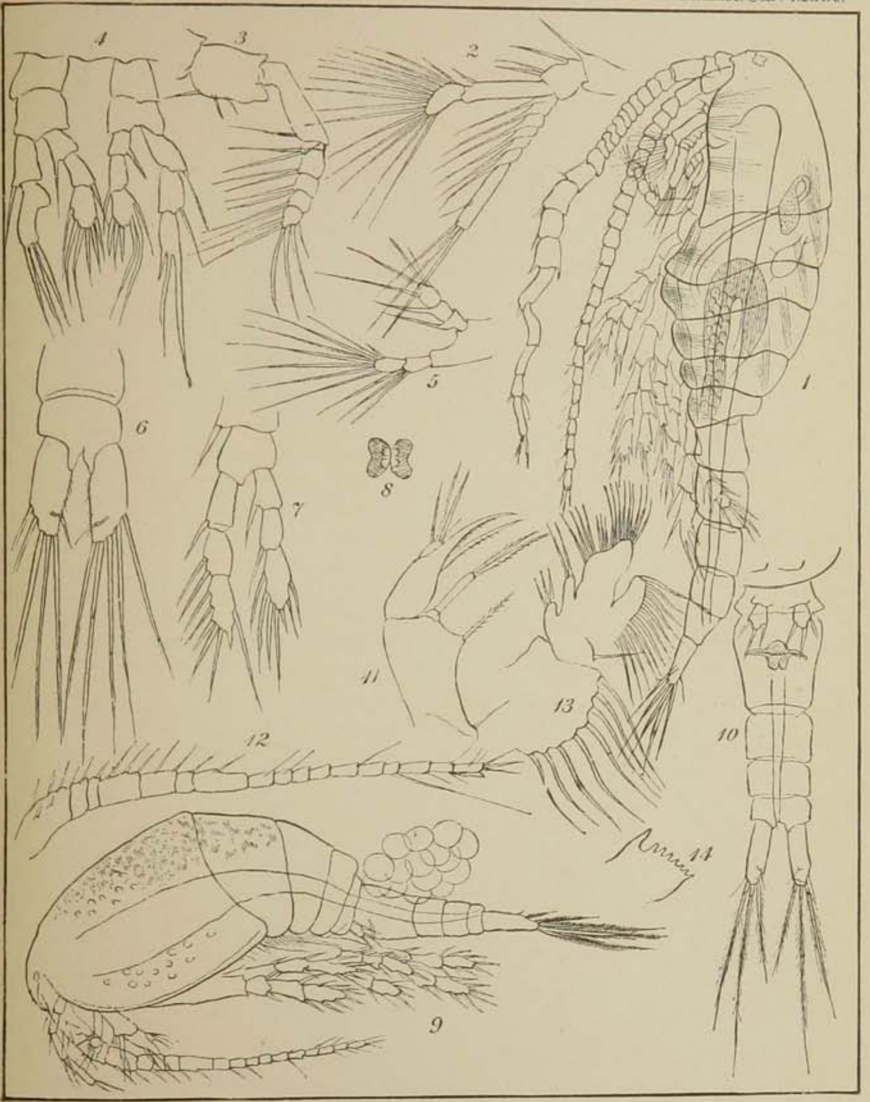

PLATE IV.

Cyclops ingens.

1. First segment of abdomen of female.
2. Antenna.
3. Fifth foot.
4. Antenna of young male.
5. Stylets of mature female.
6. " young male.
7. Maxilliped.
8. Mandible.

9. *Cyclops crassicornis*, Female.

10. Antenna.
11. Terminal portion of abdomen.
12. Female fifth foot.
13. Second antenna.
14. Nauplius form.

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PLATE IV.

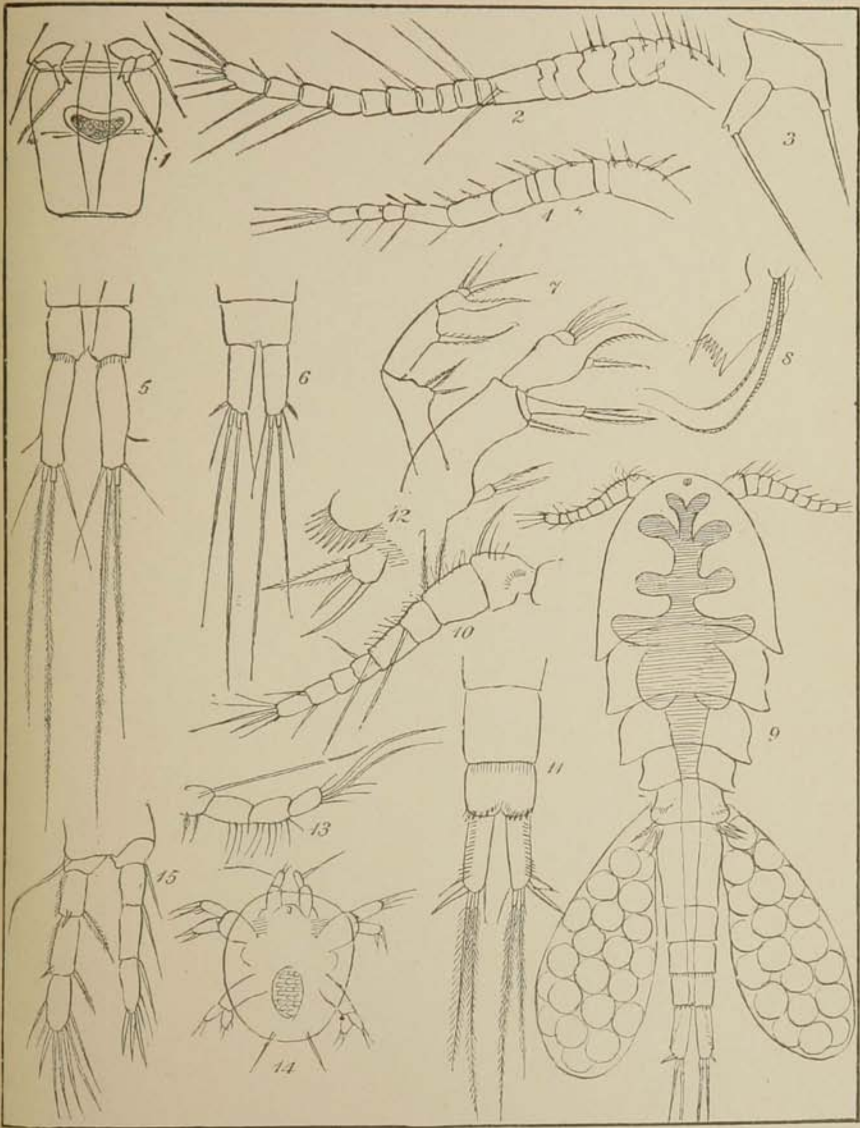

PLATE V.

Cyclops serrulatus.

1. Female.
2. Antenna of elongated form.
3. Stylet of ordinary form.
4. Antenna of very young.
5. Stylet of elongated form.
6. *Cyclops navus*, antenna.
7. Furca.
8. Abdomen of young.
9. Abdomen of male.
10. Opening of spermatophore.
11. Fifth foot.
12. Antenna of young.
13. " male.
14. *C.* "*signatus*," maxilliped.
15. *C. navus*, swimming foot of first pair.
16. " " " second pair.
17. Maxillipeds.

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10th Annual Report **PLATE V.** *Geol. & Nat. Hist. Sur. Minn.*

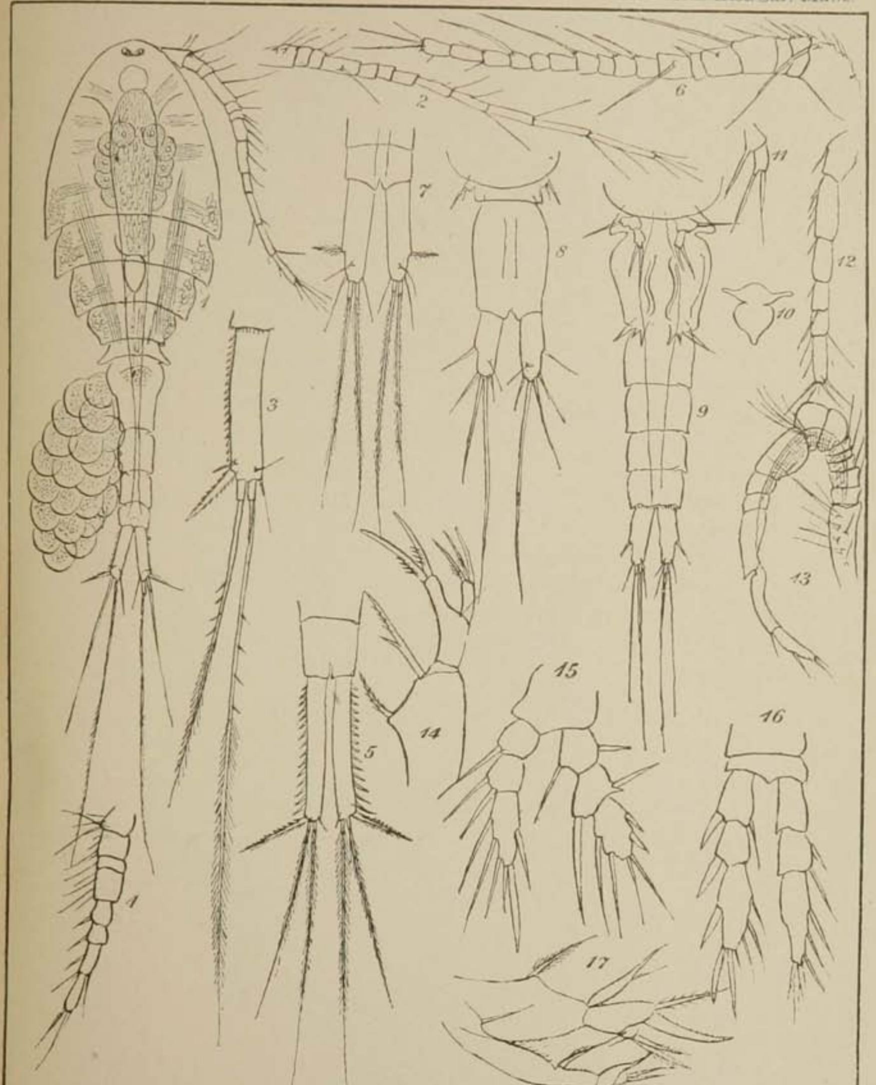

PLATE VI.

Cyclops tenuicornis.

1. Female.
2. Mandible
3. Maxillæ.
4. Stylet.
5. Fifth foot.
6. Maxillipeds.
7. Antennule.

C. "signatus."

8. Abdomen.
9. Antenna.
10. Fifth foot.
11. Male antenna.

Cyclops parcus.

12. Abdomen.
13. Antenna

1 . Fifth foot.

Cyclops adolescens.

15. Opening of spermatophore.
16. Abdomen.
17. Foot.
18. Female antenna.
19. Eye.
20. Male antenna.
21. End of antenna of a form of *C.* "*signatus.*"

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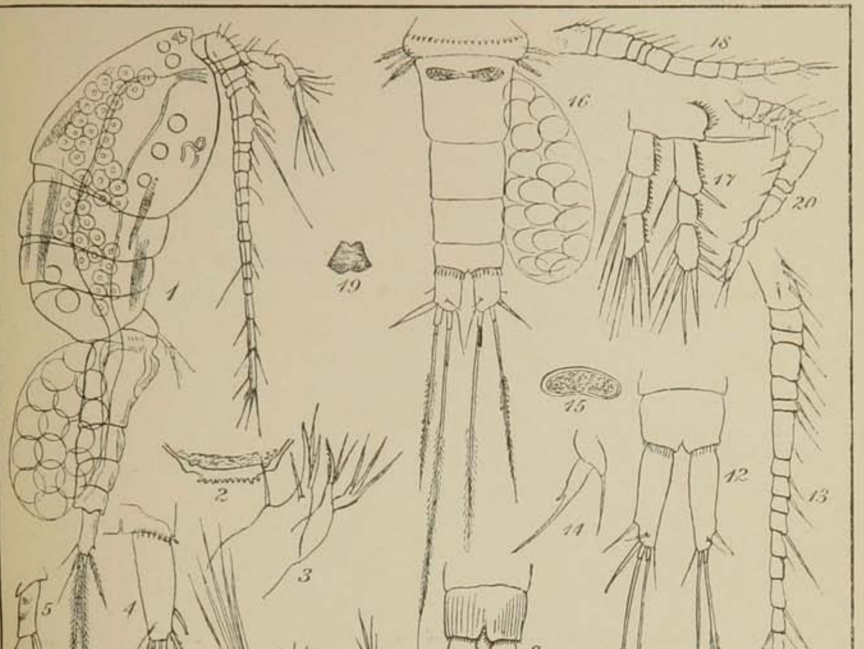

PLATE VII.

1–9. *Cyclops fluvialitis.*

3. Antenna of young. 4. Abdomen of young. 10. Young of *C. serrulatus.*

11. *Daphnella brachyura*, female.
12. " " male.
13. Part of edge of valves.
14. End of male abdomen.
15. End of female abdomen.
16. Antenna of male.

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PLATE VII.

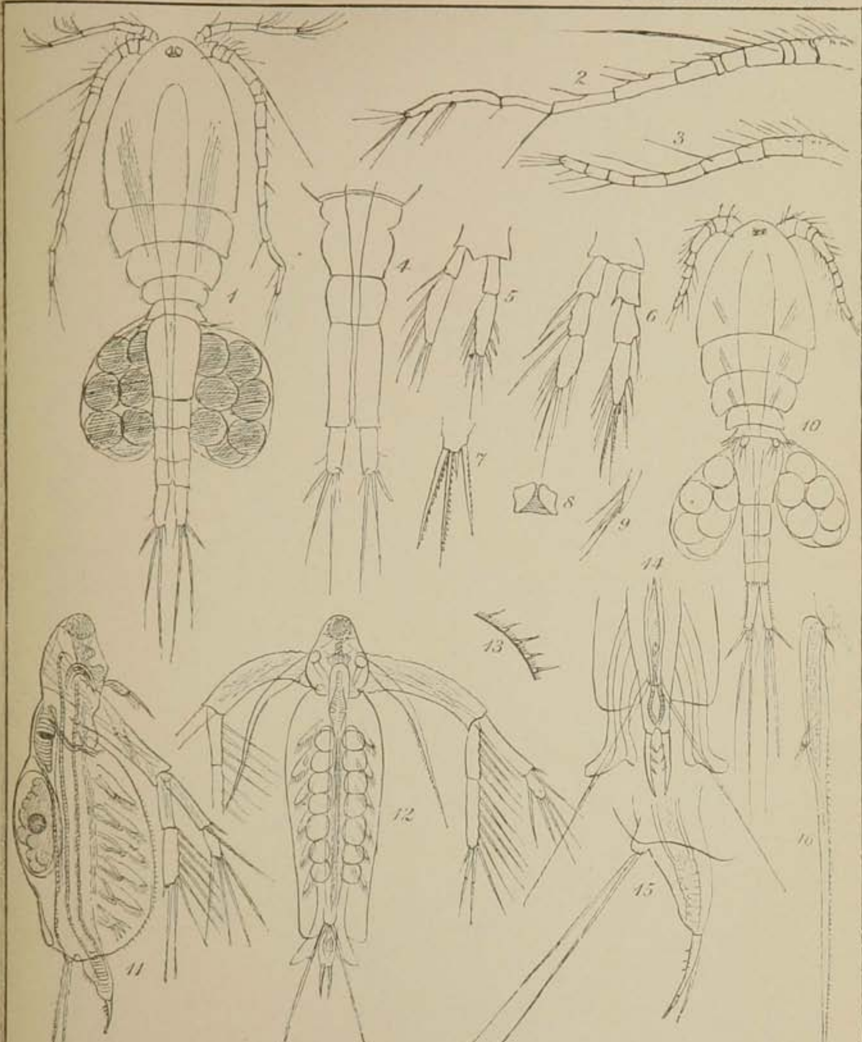

PLATE VIII.

1. *Macrothrix pauper,*
2–6. *Iliocryptus spinifer.*
7–8. *Leydigia quadrangularis.*
9–10. *Camptocercus rotundus.*
11–12. *Lathonura rectirostris.*

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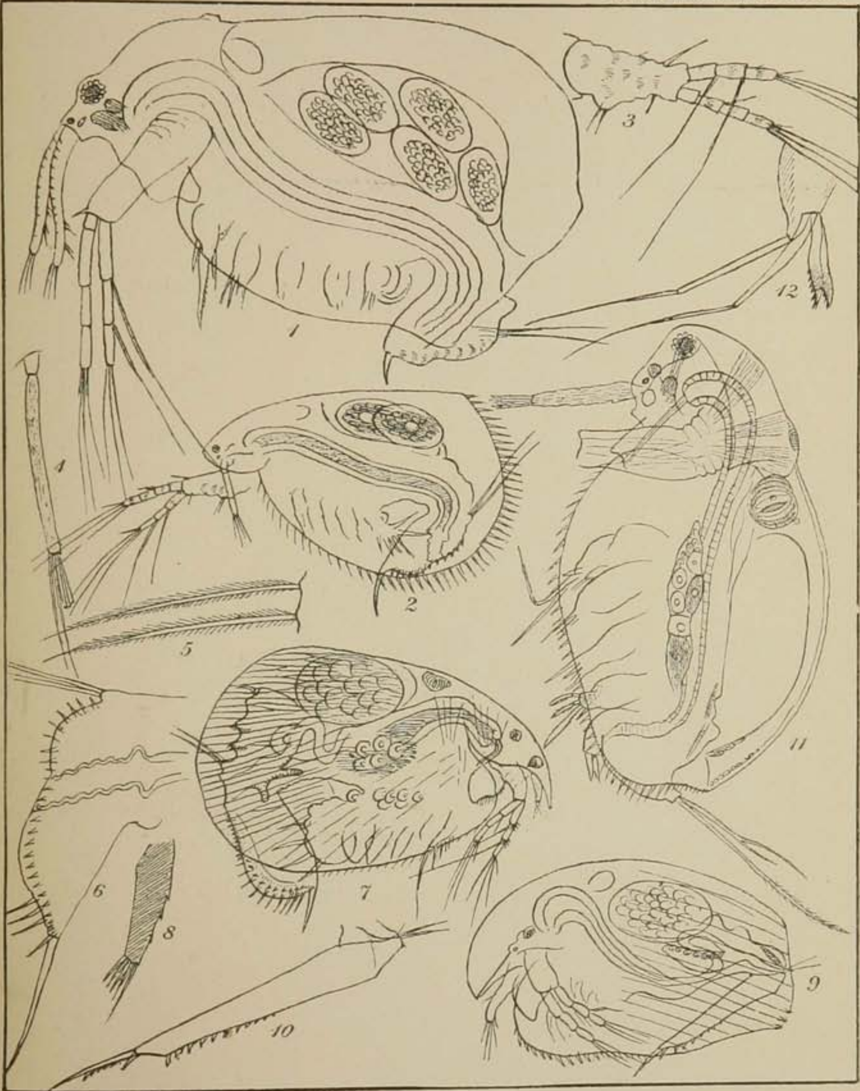

PLATE IX.

1–3. *Lyncodaphnia macrothroides.* 4–6. *Polyphemus pediculus.*

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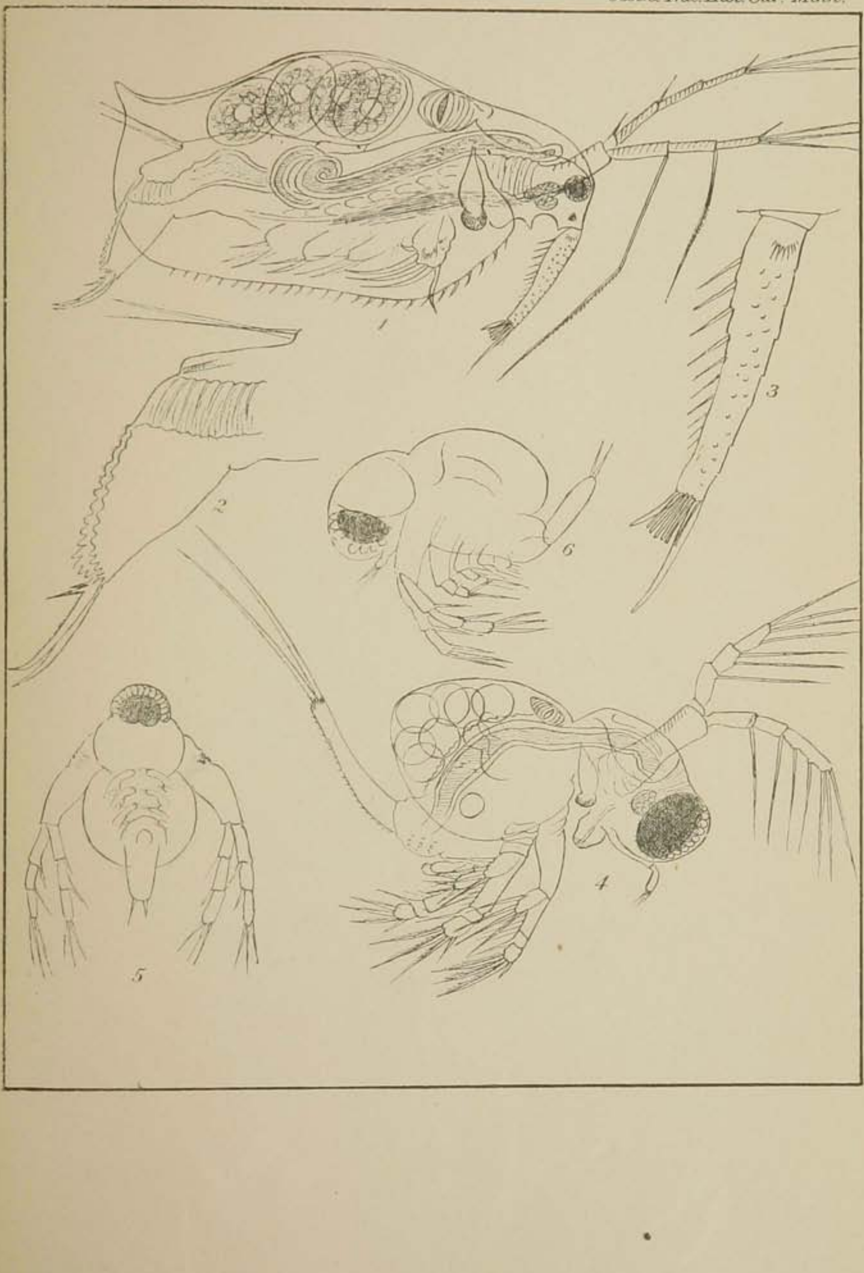

PLATE X.

1. *Bosmina striata.*
2. " *longirostris.*
3-5. " *cornuta.*
6-7. *Pleuroxis procurvatus.*
8. *Graptolebris inermis.*
10. *Acroperus sp?*
11-12. *Graptolebris inermis.*

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PLATE X.

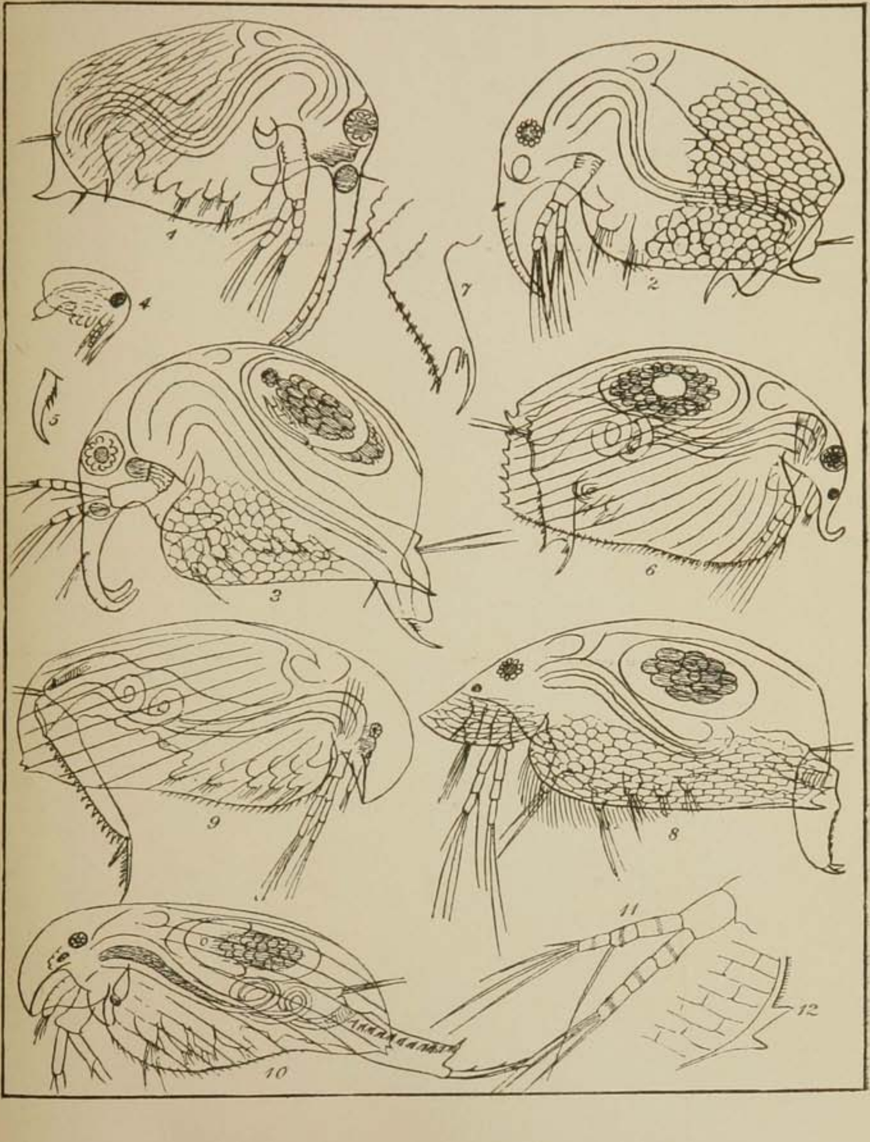

PLATE XI.

1. *Limnetes* sp ? male.
2. First foot of male.
3. Antenna.
4. Mandible.
5. Maxilla.
6. Mandibler teeth.
7. Caudal appendages of female.
8. Head, labrum etc., of female.
9. Antenna (2d) of female.
10. Foct of female.
11. Exterior of whole animal from in front.
12. Modified (sexually) foot of female.
13. End of process of same.
14. Magnified spines of lateral limbs of same.
15. Daphni sp. ?
16. Daphni sp. ?

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PLATE XI.