The information they were gaining will also be a direct help to us in making our reports more complete. Therefore I have felt amply justified in my cordial approval even though it did mean some delay for us.

W. H. Sherzer has practically completed the field work about Wayne county, and is now only waiting for the completion of his base, which will be constructed from the contour maps prepared in co-operation with the U. S. Geological Survey above mentioned.

CO-OPERATION.

As the country grows more closely knit together and the activities of the Federal government expand it becomes more and more necessary to enter into close relations of co-operation with its various departments, if there is not to be wasteful duplication of efforts. The exact researches which can best be handled by the general and local organizations remain to be determined by experiment.

There are great advantages in a uniform method of collecting and treating data throughout the country, and yet there are lines of work which can best be undertaken by one who is in close touch with local conditions, and in any case one who is so in touch can render important services. It has seemed to me that so long as our knowledge of the value of the State was being enlarged it was of comparatively little importance as to whether the State or the nation was the organ through which it was published. Yet it seems to me possible that some of the lines of work undertaken by the Federal government could better be handled by a chief close at hand and in close touch with local conditions. On the other hand tests and laboratory experiments are very well centralized. There is an opportunity for more continuous use of expensive apparatus and closely comparative study. The following is a list from memory of Federal authorities with whom we have been in correspondence and co-operation with some indication of the extent:

U. S. Geological Survey. Topographic division. H. M. Wilson, in charge, Messrs. Cooke, Williamson, and others, employed in joint topographic survey of Detroit quadrangle.

Geological Division. Information furnished H. Ries, and material for tests; information and computations furnished Leverett and I. C. Russell regarding the Ann Arbor folio; map of surface geology of State planned in co-operation with F. Leverett, and Prof. I. C. Russell employed for the summer in connection; joint excursion over the Iron Ranges.

Hydrographic division. Correspondence with R. B. Dole, M. L. Fuller, clippings furnished and maps and information on our files, Cooper, Davis, Gregory and Sherzer spared for special work in regard to wells.

Correspondence with R. E. Horton, assistant Beebe, and others with regard to Lansing gage, records, photographs in connection with stream measurements.

Correspondence and interviews with E. F. Lines and W. C. Alden and clippings and other assistance with regard to deep wells, the Ypsilanti well especially.

U. S. Division of Agriculture. Division of soils, W. E. Hearn and others. Access to soil maps of Bay and Saginaw counties, and contour maps of Bay and Tuscola counties, and sundry other maps.

Division of road inquiry. Material for tests.

As usual a part of our staff of helpers comes from the College of Mines, others from the University and State Normal College. The arrangement which you have sanctioned[1] that I shall give lectures at the University does not begin until next year.

U. S. Coast and Geodetic Survey. Unpublished maps and reports.

U. S. Department of Engineers. Maps and report.

After a few years more experience I think I shall be able to make some definite suggestions as to the wisest line of demarkation between the Federal and State activities.

In other directions we have tried to maintain friendly relations with those engaged in allied ways,—and have furnished articles as desired to the Michigan Miner,[2] The Gateway,[3] etc., and have presented appropriate results of our work to the Michigan Engineering Society and Academy of Sciences, thus making up in part for delay in issuance of our own reports.

Additional notes on the occurrence and development of a number of materials, upon which we have recently issued special reports, may be appropriately grouped as notes on the development of substitutes for wood.

SUBSTITUTES FOR WOOD—SHALE, CLAY, PLASTER, CEMENT, COAL AND PEAT.

Wood was formerly used in this State for: shelter in shingles, siding, and joists; paving, in corduroy and plank roads and cedar block; and fuel as hardwood, charcoal and slabs. In the first capacity it is becoming replaced by brick of the common kind or paving brick and sand brick, building stone and artificial stone, or concrete block. For paving it is replaced by paving brick, asphalt block, and macadam, especially that form of tar macadam known as bitulithic. For fuel coal, and perhaps peat are assuming greater dominance.

We will take up first clays and shales.

CLAYS AND SHALES.

A number of samples have been sent to this office for examination.

Samples near Petoskey seem to have the properties usual to the Antrim shale,[4] and will probably be a valuable shale. In the northern part of the State near Norwood and Bellaire, there appears to be more green shale or blue shale and less black shale at this horizon. Yet there is some which is still at times taken for coal, or a sign of coal, in spite of my repeated warnings that no coal exists in these regions.[5]

It will be remembered that we have made some tests of the Valley Coal Co. clays (the Dutch Creek Coal Mines is the popular name of the location.)

A small brick plant was started here some years ago. This has recently been extended and enlarged, and the Michigan Vitrified Brick Co. having purchased the mine and the Pierce dry pressed brick plant adjoining has gone into the business of making high grade paving brick.[6] They mine for use 4½ feet of white shale (fire clay) and 6 of shale half and half. A

[1] "That in view of his long service and experience with the Survey and the increase in expenses, and the advantages that such lectures would be to the State University in which the whole state is interested, the State Geologist be permitted to give a course of two lectures per week on Economic Geology at the University, being paid therefor by the University, without deduction from his salary of $2,000 per annum for the year 1904-5.

Provided, however, that expenses incurred in going to Ann Arbor and delivering these lectures shall not be charged against the Survey.

And provided also that one month be deducted from the vacation heretofore allowed him."

[2] December, January, February, March, April, May, and July numbers.

[3] October.

[4] Volume VIII, p. 45. Antrim was formerly called St. Clair.

[5] Petoskey Evening News.

[6] Michigan Investor, 1904, p. 186.

Bonnet No. 4. pug mill and stiff mud machine can turn out 50,000 to 70,000 brick a day, automatically side cut by wire and repressed. They are dried in from 24 to 48 hours in five foot tunnels 126 feet long having a slope of 1 foot in 7, so that the bricks run through in cars by gravity, while in the other direction there is a forced draft by a 180 inch fan using largely the waste heat from the kilns, but 9,000 feet of radiation are provided in case there is not enough waste heat.

Near Omer the Michigan Paving Brick Co.[1] are putting in a modern plant to make shale brick. The shale is exposed along the river bank, the section being:

11 sand and clay, 17½ shale etc.

A bank of white clay suitable for pressed brick[2] is said to have been found on Sec. 20, T. 16, W., R. 1 S. on the bank of the river two miles east of Maple Grove. It is probably a calcareous clay except where it has been leached at the surface.

Two miles south of Union City a bed of 40 or more acres and 80 feet thick, practically of the Coldwater shale, is said to have been discovered, and to be suitable for fire brick and tile. Throughout this region exposures of Coldwater shale are likely to occur, often softened down into clay, and their value we have already remarked.[3]

A number of samples of the common blue surface clays containing a good proportion of dolomitic flour and apparently good for nothing but common brick have been sent.[4]

An important test for paving brick or brick of any kind is the porosity. A rough test I have seen is simply in spattering ink on a brick and seeing how it spreads. An experienced man can form some idea from this of the porosity of a brick. But a much better idea comes from the weight. An absolutely non-porous brick should weigh about 2,600 ounces to the cubic foot, and if we weigh and estimate the dimensions of a brick, finding what its weight is per cubic foot, we may estimate that what it falls short of 2,600 is to 2,600 as is the pore space in per cent. of volume.

Besides paving brick there are new factories of common brick to be made from the surface clay going up continually from time to time at appropriate places. Concerning these pink clays which also occur abundantly north of Bessemer and at other points, see Prof. Russell's report and that on Bessemer and Black River.

SAND BRICK.

Another important industry is that of making sand brick. There are a number of factories under slightly differing patents. The essential feature of all these brick is that they are made of sand and a little slacked lime, which are mixed, with coloring matter if desired, pressed and steamed. Two plants are working at Saginaw, and there are others at Holland, in connection with the Sibley quarry at Trenton, etc.[5]

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[1] Detroit News, 4:27: 1904.
[2] South Haven Tribune, 4-25-1904.
[3] Quincy News, 8: 19: 1904; Detroit News, 8-16-1904.
[4] May 11.
[5] Also near Michigan City and Jackson. See annual report for 1903. An important series of articles by S. V. Peppel are running in the Clay Record and in the Statistics of the Clay Working Industries of the U. S. in 1903, (curious places, for there is practically no clay in the brick). He says that the best grades of sandlime brick having crushing strengths of 5,000 pounds or more per square inch will absorb 8 to 11% of their weight and has known some with 14 to 15% absorption. One sample which I tested from a new location has 12.3 % ratio of absorption, specific weight 2.64. I understand that one of the difficult points of manufacture is to get sufficient compression.

A sand making a spotted brick which was sent me to see what was the matter, though I rather liked the color effect, proved to be pyritic. I have seen a number of Michigan brick very nicely colored.

Another form of brick is made with cement, but generally speaking when cement is used larger forms are employed, and concrete block. Wherever there is good gravel is a suitable place for the manufacture of concrete block. The particular gravel to be sought is one that while freed from clay has otherwise a good variety in the size of its particles.[1]

The test is to see how much water can be absorbed in the voids. In the samples tested by Pierson it was from 25% to 23% and the average weight of the sand and gravel particles (specific gravity) was about 2,650 ounces per cubic foot. As with brick the shortage of weight per cubic foot indicates the porosity. The various brands of Michigan Portland cement are used in making this concrete block at very low prices.

CEMENT.

The year has been one of severe competition in the cement business and that has not favored the exploration of new deposits. G. W. Berger[2] has furnished us maps and plans of the Lakelands deposits which will be of interest perhaps later in showing the rate of growth of such deposits and of filling of marl lakes. Tallman Lake, Mason county, is said to have 15 feet of bog lime. Round Lake, Mason county, is said to have 20 feet of bog lime.[3]

Work has been done southwest of Manchester, Mich., where the Toledo Portland Cement Co. has 500 acres of beds of bog lime from 12 to 60 feet deep around Wampler's, Iron Creek Mill Pond, Louise Lake, Half Moon, Black and Mud Lakes. They have 300 acres also of the ordinary surface clay. The White Portland Cement Company have erected a kiln plant at Four-mile Lake in Washtenaw county.

Hancock and Calumet people are planning to use waste stamp sand from the copper mines for concrete building block.[4] It must not be forgotten that for such purposes the crushed conglomerate is likely to prove far more durable than the crushed amygdaloid. The Franklin Junior (formerly Albany and Boston, and Peninsular), the Allouez (old mine), the Calumet and the Tamarack are the mines which have used conglomerate rock to any great extent.

L. L. Kimball prepared for the U. S. Geological Survey a report on Portland cement in Michigan in 1903. He reports ten companies using "marl" or boglime and three limestone. The quality of the cement, unless it is put out too green, is almost uniformly excellent. The critical thing for the plants using boglime is the cost of drying. "The problem of utilizing waste heat to dry the marl is one that engages the attention." In addition to water if there is much organic matter, and there is likely always to be some calcium succinate as Davis has shown, it may be impossible to make a profit, for the output will be too small.[5]

Limestone avoids this cost and if not too hard and if low in magnesia will probably be found more suitable. Certain beds in the Traverse are well suited. These strata occupy the north part of the peninsula from Alpena to Charlevoix and the Alpena and Elk Rapids plants use limestone. A plant has also been talked of near Rogers City.

In addition to the data which I have given in previous reports, we may

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[1] See Michigan Engineer for 1904, p. 126, article by Geo. S. Pierson.
[2] See sixth report Michigan Academy of Sciences.
[3] Ludington Record, October 6, 1904.
[4] Marquette Mining Journal, Apr. 30, 1904.
[5] See Hale's remarks, pp. 167-168. Vol. VIII, Part II.

include extracts from the following report which we owe to the kindness of Mr. F. D. Larke.

REPORT OF A. UDDENBERG ON LIMESTONE NEAR ROGERS CITY.

Fred Denny Larke, et. al.
Rogers City Michigan.

Gentlemen:—

I hereby submit the following report based on the examinations made by me[1] on the region lying west of Rogers City in Presque Isle county, Michigan.

As to the geology of the country, only a very short description can be given, taking in consideration the time allowed for such examinations and the few outcrops and sinkholes from where any studies could be made.

The whole formation in the country examined is a limestone formation, with but a subordinate development of shaly beds belonging to the Hamilton group of limestones. The thickness of the formation could not be ascertained., but it is in all probability several hundred feet. As to the extent, it goes through the whole peninsula to the shore of Lake Michigan appearing in ridges, in many places cut off by ravines. The country seems to consist of several terraces but though, on many places, one might by a hasty judgment think there is no rock, one will almost surely find the same rock formation when digging down.

The mass of rock is a fine grained pure limestone of a sometimes bluish gray color sometimes a little darker or lighter with interstratified seams of shales which are black or dark gray and very rich in fossils. It contains streaks or seams of a nearly white crystalline limestone all over sprinkled with very fine specks of iron pyrites. The rock is covered by a more or less considerable coating of drift material, consisting of a gravelly loam of a very fertile nature, making it very good for farming purposes.

It was thought that the iron pyrites found in this rock would carry some gold or silver, but in the numerous samples collected by me and assays thereon, it is clearly shown that these precious metals are not to be found in said pyrites. Anyhow there is not pyrites of sufficient quantity to warrant any exploring for said metals even if traces of silver should be found which is not probable. I found several boulders on the surface richer in pyrites which may carry some gold or silver, but as they do not belong to the formation, but are carried there by moraines, they are of no value.

Some of the limestones seem to appear in pretty solid blocks, as could be seen in an exploring pit on Ritzler's farm and it is supposed that said stones would make a marble. Specimens of marble have been taken out and polished and they had a splendid appearance, fully showing the great number of fossils that this formation contains. The specimens collected by me and polished at the marble works in this city do not show up as good. It is true that the stone shows the fossils very nice, but it takes polish very uneven, depending on that some parts are harder and some looser, whereby these different parts take more or less polish and making the cost of this work higher.

The question is also, if in going down the blocks hold out to be solid or

[1] From the shale at Crawford's quarry and from Roger's City, 2½ miles back at each place, and also two miles west of Rogers City.

if they are more or less shattered. I hardly believe that the rock has the compactness and homogeneous qualities requisite for marble.

To find out if this limestone was suitable for manufacture of cement analysis was made by me and is as follows:

Carbonate of lime	97.83
Carbonate of magnesia	1.29
Sulph. of iron	.49
Organic matter	.39
	100.00

As it is necessary for making cement that the rock contains silica, not less than 10%, this limestone will not do for making cement,[1] but will make an excellent white quick slaking lime, which in combination with the clay found in the drift formation and which furnishes an excellent material for brick manufacturers ought to be opened up and would, I am sure, become a paying business employing a great number of men and thereby build up quite a large city. With the railroad facilities that will soon be at Rogers City, when there will be communications the year around and also a market, it cannot fail. As to the cost of taking out the rock for any purposes it will be very cheap if it is managed right. The best way is to strip the surface so as to get at a large space of the rock and work it from top as much as possible, thereby getting rid of the water, which would be of great trouble when working in shafts and thereby go down deep encountering more water.

The cost of taking out this rock if worked as a quarry and for manufacture of lime would not exceed 50c a ton.

Respectfully yours,
(Signed) ARTHUR UDDENBERG.

Marquette, Mich., Nov. 10, 1888.

Judging from the analysis the rock would be suitable for chemical work (beet sugar and soda manufacture) and to mix with shale for Portland cement.

Dr. Grabau is still working up the limestones of this district from an economic as well as paleontologic point of view, and I hoped to be able to present a few plates of fossils herewith.

We have no new data to add in regard to building stones or slate. Dr. H. Ries of Cornell is making some tests of the fire resisting powers of some stones.

In regard to road metal uses we would call especial attention to the papers and discussion in the 1904 Michigan Engineer. A good deal of paving has been done this year, and paving brick and bitulithic macadam appear to be widely favored.

PEAT.

In another direction wood is being replaced and that is by fuels. The Capac plant for peat manufacture seems not to have been a success. The Bancroft and Chelsea plants are now producing some fuel[2] and others are in contemplation. Prof. C. A. Davis and others are continuing researches for me at Ann Arbor.

[1] Except for grinding with clay shale, in which case it would make excellent Portland cement.
[2] Detroit Free Press, April 13, 1904.

The main results appear to be:

1. The different kinds of peat so called are largely only different stages in the development of a peat bog and its decay.

2. A good plastic peat is likely to be more workable and acceptable even holding somewhat more clay (ash), than one which retains too much of the sedge fibre.

3. A peat may take up as much as 15% moisture from the air after being thoroughly dried, as the figures below show. While therefore it is likely that when compressed this action will be slow, it is doubtful if it is worth while to reduce the moisture below 15% unless it is to be actually coked, and fuel gas made.[1]

PEAT TESTS BY L. KIRSCHBRAUM.

University laboratory of Prof. E. D. Campbell, Ann Arbor, Mich., May 17, 1904.

No.	Peat.	Sample wet.	Dried.	Wt. Dried.	Moisture.
1.	Jackson Bog I	5.0036 gr.	100–110°	.7339	85.33 %
2.	Jackson Bog I	5.1971	Over H_2So_4	.7709	85 17
3.	Jackson Bog I	5.1447	150° C	.7213	85 98
4.	Capac Peat Co	4.7013	100–110°	.5175	88 99
5.	Capac Peat Co	4.7350	H_2 So_4	.5081	89.25
6.	Capac Peat Co	5.9224	150° C,	.5418	90.86

No.	Exposure.	Wt. after 12 hours.	% gain.	24 hours.	% gain.	36 hours.	% gain.	48 hours.	% gain.	72 hours.
1.	Sat. Atm. 34° C.	......	......	.7811	6.43?	......	......	.7832	6.73	......
*2.	Sat. Atm. 19–26°	......	......	.8817	14.34?	......	......	.9127	18.93	.8848
3.	Open air	.8099	12.28	.8296	15.01	.8163	13.17?	......	......	......
4.	Sat Atm. 34° C.	......	......	.5399	4.37?	......	......	.5409	4.50	......
*5.	Sat. Atm. 19–26	......	......	.5606	10.33	......	......	.5740	12.96	.5605
6.	Open air	.5821	7.44	.5977	10.32	.5814	7.31	......	......	......

3 and 6 were exposed during a rain storm between 12 and 24 hours.
*% Gain 72 hours. No. 2. 14.77. No. 5. 10.33.

MORENCI PEAT.

June 14, 1904.

"I enclose a report of test of peat from Morenci, Mich. This sample was recently submitted to us by Prof. Davis, and was tested in a saturated atmosphere at room temperature. This held fairly constant during the day at 21 degrees C., but at night probably fell off some."

Sample wet.—5.05069. Loss wt.—3.7010. Moisture—73.28%. Dried sample.—1,3496.

Exposed in Sat. Atm. at room temperature.	12 hrs.	24 hrs.	36 hrs.	48 hrs.	84 hrs.
Gain	.1770	.1752	.2000	.2058	.2020
Per cent	13.11	12.98	14.82	15.25	14.98

L. KIRSCHBRAUM.

[1] Some remarkable success in this direction is reported from Prof. Norton of the Mass. Institute of Technology.

PEAT ANALYSES.

From letter October 3, 1903.

	Capac pressed.	Capac air dried.	Jackson.	Bronson.	Bronson.
Moisture	14.54	12.32	14.59	12.95	11.90
Volatile Comb	62.48	64.96	54.62	60.81	62.95
Fixed Carbon	17.90	19.93	15.60	16.32	18.16
Ash	5.08	2.79	15.19	9.92	6.99
Sum	100.000	100.000	100.000	100.000	100.000
Total S	.08	.07	.63	.78	.76
Iron	.50	.39	.51	.35	.49
Heating Power	47.00	49.75	41.00	45.50	49.50

E. E. WARE.

During the summer I had a chance to visit Lexington, an early home of the peat industry. I found a cousin of mine had an old fashioned slane, or peat cutting spade, and Dr. G. C. Jenkins was at work there making peat rolls as they may be called.

He said that he had had experience abroad in manufacturing them and found that for grates considerable attractiveness was added by mixing a little salt or copper sulphates to produce colored flames.

COAL.

The other substitute for wood is coal. Much information regarding the development of our coal field can be found in the quarterly bulletins of the Commissioner of Labor.

Some of the more important features geologically are the extension of the area and depth explored, mainly in Bay county.

The new Foss shaft,[1] the What Cheer Mine, in Merritt township is 206 feet deep, 96 feet to rock. It was sunk 103 feet in 15 days, by W. E. Williams, and between that and 173 feet struck, it is said, eight distinct seams of coal, the main coal seam to which they are sinking, a Saginaw seam, being at 200 feet. It is beyond question that a large part of the early coal drilling was not deep enough to prove that coal did not underlie the land, the holes not passing through the coal formation. This shaft was fortunate in not finding much water gravel, a formation it is well to avoid in sinking a shaft.

The Auburn Coal Co.[2] shaft, 200 yards north of the Auburn road, about 7 miles from Bay City, 620 feet from the railroad, had much more difficulty. The first 50 feet was clay from 18 to 40 feet stony, then below at 50 feet a smooth brown interglacial clay then to 84 feet was a heavy bed of sand and gravel with a big stone at 70 feet, and a large flow of water (50° F. or 52° F. at pump). The total depth to bed rock was 91 feet. It took some two months to get through the water gravel. Within the city limits are the United City Coal Co.[3] shaft and that of the Cass River Coal

[1] Bay City Tribune, July 27, 28, Aug. 14, Aug. 21, Started July 9, 113 feet July 27, 175 feet Aug 14, finished Aug. 21.
[2] Bay City Tribune, June 9, 1904; Aug. 3, 1904.
[3] Detroit Free Press, Aug. 27, 1904; June 23, 1904.

Co.[1] The former is in West Bay City near N. Union street, and between Center street and Williams street, occupied by the R. R. This had a till clay almost from the start, and as is so usual with the Verne coal is said to have a two foot seam separated by a foot of shale. The latter is in East Saginaw, at the south end near the water works, and the 136 feet is said to have been accomplished in 28 days working time. This is an extension of the field of the Standard, Saginaw, and Pere Marquette No. 1. A section of the seam is:

12 inches, coal and slate high in ash.
19 inches, coal, clean and bright, no sulphur.
5 inches, some sulphur and slate and rush impressions.

As to the quality of the Bay county coal, the following analyses are of interest, which indicate that as stated in my coal report the Bay county seams are mainly the Verne seams.

BAY COUNTY COAL ANALYSES.

Number	1	2	3	4	5
Location	Wolverine. 3	Wolverine. 2	Wolverine. 2	Wolverine. 2 pt.	Salzburg.
Moisture	4.14	6.18	6.76	8.92	6.50
Volatile Comb	45.70	46.10	42.67	36.49	43.61
Fixed Carbon	42.14	40.88	42.01	51.92	47.82
Ash	8.02	6.84	8.65	2.67	2.07
Sum	100.000	100.000	100.000	100.000	100.000
Total S.	3.53	2.27	3.50	1.49	.89
S from Fe	(3.77)	(2.59)	....	....	....
Iron	3.30	2.54	....	....	....
Fe_2O_3	(4.72)	(3.63)	....	....	....
Clay (Ash-Fe_2O_3)	3.30	3.21	....	....	....
Pyrite	7.07	5.13	....	....	....
Combustible Matter	87.84	86.98	84.68	88.41	91.43
Ratio of fixed Carbon and combustible	.48	.47	.497	.587	.523
[2] Is iron present as carbonate? Numbers in parentheses are calculated.					
Heating Power B. T. U	12.520	13,335	12,295	....	....
Calculated Lane	13,871	13,690	13,390	....	....

1. From H. M. Randall for Handy Bros., by Dickman and McKenzie.
2. From H. M. Randall.
3. Dickman and McKenzie for Wickes Bros., carload dried at 100 C.
4. L. Kirschbraum, part of Wolverine No. 2 seam supposed to be cannel but not very good.
5. L. Kirschbraum, Salzburg mine.

Coal exploration is spreading to the northern part of Bay county and over into Midland[2] and Gladwin counties. Coal undoubtedly exists, but how much of value remains to be seen. In the forthcoming Bay county report a large number of records are compiled. It is a question whether the present exploring is always deep enough. In this connection the following is of interest:

[1] Saginaw Courier-Herald, Sept. 2, 1904.
[2] Gladwin Record, Aug. 5, 1904. Geneva and Larkin townships. Saginaw News, Sept. 26, 1904.

RECORDS FOR THE BORINGS FOR COAL ON THE PENINSULA COAL AND SALT COMPANY'S LAND AND VICINITY.

(As taken from the Bay City Tribune under dates April 1, 10, and 13, May 11 and 13, and June 30, at the time the tests were made.)

The first hole bored was to a depth of 120 feet, and while a vein of only 6 inches in depth was struck and the miners discovered vast quantities of slate and fire clay, which by many is supposed to be as great a source of wealth as the coal. We sub-join a statement of the thickness of the different veins:

Surface clay	12 ft.	Black slate	4½ ft.
Sand and rock	30 ft.	Coal	½ ft.
Light gray slate	7 ft.	Fire clay	1½ ft.
Dark gray slate	3½ ft.	Light shale	8½ ft.
Light slate	3 ft.	Black slate	4½ ft.
Fire clay	4½ ft.	Light gray slate	3 ft.
Gray slate	3 ft.	Black slate	13 ft.
Black slate	7 ft.	Light slate	6 ft.
Fire clay	5 ft.		

And below this something that is supposed to be lead.

After shifting from the first hole struck a vein of coal only 11 feet below the surface, continuing the vein the boring was found to be 2½ feet in thickness, below it five feet of slate was found and under this another vein of coal 5 feet in thickness. This is thicker than the average vein and taken in connection with the one 2½ feet just above would return large profits by mining twice as far below the surface. This is only 28 feet from the top of the ground. Its value is double because of the ease with which it can be mined.

April 13, 1875, telegram from E. G. Sovereign from Sterling that they had struck a vein of 6 feet in thickness. This is the fourth hole bored. In the first hole 6 inches of coal was struck, in the second 18 inches, in the third hole 5 feet, and 2½ feet respectively in the last 6 feet. The latter vein is 19 feet below the surface. There being above the coal 18 feet of clay and 9 feet of slate.

It has already been stated that there exists a vein of 7½ feet of coal of excellent quality within 25 feet of the surface. The company have nearly 3,000 acres.

On May 10th E. G. Sovereign came down from the Rifle River and reported that the shaft is down four feet into the 7 foot vein. The miners are taking out large quantities of the black diamonds and have already taken out 15 tons. Mr. James F. Joy president of the Michigan Central, telegraphed that he would give an excursion to the mines. May 13, excursion to Rifle River. Explorations made by business men and persons from abroad. Successful tests of the coal in grates and forges. On this excursion a special train was sent and 100 persons availed themselves of the opportunity. Left Bay City a little before 2 and arrived at Sterling at 9:15. There were 90 passengers found teams and the balance walked over to the mine. The mine was kept running until June 30th.

I sent to Capt. R. M. Burlington three tons of the coal to try on his steam tug. I herewith enclose you a paragraph of his letter, in answer to the same. "We burned the sample of coal, giving it a fair test and find it all right. It burns up cleanly and makes good steam, no clinkers. We burn it in the boiler of the Lake Breeze. It was as good as any coal we used that season."

CAPT. R. M. BURLINGTON."

The following is an extract of a letter from Smith Bros., Jackson Michigan: "We have disposed of the coal from your Rifle River mine and it has given first rate satisfaction. We are having inquiries for it every day. Our trade calls for about 500 tons. If you can supply us please answer."

A most favorable analysis of the coal for gas manufacture was given by Geo. F. Sherwood, superintendent and engineer of the Jackson Gas Works as follows: viz.

Charge of coal 4,800 pounds.
Gas made, 15,600 cubic feet.
Yield per pound, 3.25.
Burns freely, no clinkers, makes very hot fire."

* * * * * * * * *

Coal has been reported near Bellevue from eight to ten feet thick and 80 to 100 feet below the surface.[1] Bellevue itself is just outside the coal basin but a very few miles north coal is liable to occur in workable thickness. The above report is almost certainly exaggerated at least.

After what I have heretofore said I need hardly express my disbelief in coal near Norwood or anywhere far outside the coal basin as I have marked it out,[2] but it might occur at Howard City.[3]

TOPOGRAPHIC SURVEY.

We have mentioned that the field work for the Detroit quadrangle is practically complete.

A few elevations may be inserted here for reference.

The elevations in the following list are based upon a Coast and Geodetic Survey bench mark at Edward Hall's residence, Gibraltar. The elevation of this is accepted as 587.609 feet above mean sea level., the result of the Coast and Geodetic Survey adjustment of 1903.[4]

The leveling was done in 1901–02 under the direction of Mr. Robert Muldrow, topographer, by Mr. R. Wipfler, levelman.

All permanent bench marks dependent on this datum are marked with the letters "GIBRALTAR" in addition to the figures of elevation.

Gibraltar west along road to Flat Rock thence northwesterly to New Boston thence east to Trenton thence south to Gibralter.

	Feet.
Gibraltar, Edward Hall's residence; U. S. Coast Survey bench mark	587.609
Gibraltar, 2.5 miles west of; T. 4 S., R. 10 E., Sec. 36, near southwest corner of; 40 feet east of crossroads, northwest abutment of bridge	575.29
Gibraltar, 3.1 miles west of; T. 4 S., R. 10 E., Sec. 35, at southwest corner of; 90 feet south of crossroads, on large boulder	590.51
Flat Rock, in front of Dr. Turner's residence; on root of large maple tree	602.66
T. 4 S., R. 9 E., Sec. 27; at ¼ corner north side of bridge over Huron River, northeast corner of, on top of bolt in bed plate of	605.07
New Boston, .5 mile south of; T. 4. S. R. 9 E., Sec. 8, near center of northwest corner of bridge over Huron River, on top of bolt in bed plate of	625.16
New Boston, high bridge over Huron River; north east pier of, on top of rivet	620.54
T. 4 S., R. 9 E., Sec. 10, northwest corner of; 400 feet east of crossroads, north side of road, on root of tree	631.00

[1] Detroit News, 11: 25: 1904. Battle Creek Journal, Sept. 24, 1904, farm of Chas. G. Avery.
[2] Cheboygan News, 4: 5: 1904, slate 8 foot and coal? on Haak branch of M. C.
[3] Detroit News, Sept. 21, 1904.
[4] Which makes high water of 1838 of Lake Huron 584.69 that is .35 higher than the old value.

	Feet.
T. 4 S., R. 10 E., Sec. 11, northwest corner of; 400 feet east of crossroads, northwest corner of culvert, on top of bolt	596.63
T. 4 S., R. 11 E., Sec. 7, northeast corner of; at Sibley's station, at junction of River and Mud Roads, on top of stone post marked "U. S. H. L.-38 A"	588.24
Trenton corner of Washington and Pine streets, on top of hydrant	603.03
New Boston along road northwesterly via Ypsilanti to Ann Arbor, thence south to Saline thence east to New Boston.	
Ypsilanti, corner of North and River streets; on top of hydrant	713.90
Ypsilanti, corner of summit and Cross streets; in stand pipe, north side, bronze tablet marked "797 GIBRALTAR"	797.443

The following shows the condition of the work at present, and the cost. It will be noted that the U. S. Geological Survey has been very generous toward us.

Washington, D. C., Dec. 13, 1904.

Dr. Alfred C. Lane,
State Geologist, Michigan,
Lansing, Michigan.

Sir:

I have the honor to make herewith a preliminary report of the results of the co-operative topographic survey in the State of Michigan, for the year 1904-5:

Arrangements were made for the prosecution of this work under the terms of an agreement entered into between us on May 27, 1903, for the two years 1903 and 1904. On March 31, 1904, there remained a balance of government funds from the appropriation of the previous year of $453.75, and in addition $3,200 was allotted for the approaching year, making $3,653.75 of government funds available for the co-operative topographic surveys within the State. This, together with the $1,000 alloted by the State made a total of $4,653.75 available for the work of the season 1904-5.

From the expenditures made under the above, there has resulted a complete and accurate map of 252 square miles of the area of the State, which will be represented on the Detroit and Grosse Point sheets, scale 1:62500, and contour interval 20 feet, covering portions of the counties of Macomb, Oakland and Wayne. Incidental to the mapping of the Detroit sheet, the city of Detroit was surveyed on the large scale of 2,000 feet to the inch. with a contour interval of 20 feet, and will be published as a special map, There were run during the season 777 linear miles of road traverse; 302 miles of spirit levels, with 724 elevations, and 2 permanent bench marks.

After careful consideration it has been decided to publish the work done in co-operation, in southern Michigan at least, on the large scale, that of 1:62500, instead of the folio scale of 1:125000, on which the Ann Arbor sheet was published. Accordingly, four sheets, covering the Ann Arbor quadrangle, have been prepared on the larger scale and have been transmitted to the engraver; namely, Dexter, South Lyon, Saline and Ypsilanti; and the other three sheets than Detroit, covering the Detroit River two-mile sheet of last year, have been re-arranged for engraving on the larger scale under the names of Northville, Romulus and Wyandotte.

Very respectfully,

(Signed) H. C. RIZER,
Acting Director.

SURFACE GEOLOGY OF THE UPPER PENINSULA.

We have had considerable correspondence with Leo Geismar and others regarding maps of the surface geology and soils of the Upper Peninsula. The following is a sample letter:

Wells, Delta Co., Mich., Jan. 9, 1904.

ALFRED C. LANE, State Geologist, Lansing, Michigan:

My Dear Sir:

Your letter of Dec. 8th was duly received, and contents noted. In reply, would say that all we want in this connection is the general survey you outline in the latter part of your letter, giving the different types of soil and the different areas in which they are liable to occur, and pointing out their valuable qualities. We are compiling soil reports on each forty of land we own, made by our cruisers who go over the land from time to time, and this gives us all the information we need regarding one particular forty. We are getting up and sending out over the country pamphlets describing our lands and their value as agricultural lands; and we wish the survey made by your department to embody in same, as an official confirmation of what we say in regard to the region where our lands are located, viz, Delta, Marquette, Dickinson and Menominee counties. We have had brought to our notice a soil map of Wisconsin, made by the Geological Department of the state, which covers the matter as we would like to have it for this part of Michigan; and we therefore started the correspondence with Mr. Geismar and Mr. Fuller, to see if we could obtain something of the same kind. We would appreciate anything you can do for us in this regard; and we are sure you will recognize the good to this part of the State, outside of our previous interests, which would come of this work. We are earnestly endeavoring to combat the popular ideas which exist further south of us, that the Northern Peninsula is situated somewhere in the polar regions, and the land there is valuable only for minerals and timber.

We would be pleased to receive the atlas of Volume I part 1, of your reports, which you mention in your letter.

Yours truly,
(Signed) DANIEL WELLS,
Land Commissioner.

You accordingly employed Prof. Russell as a special expert in physiography and surface geology to cover that part of the Upper Peninsula which would be included in a nine sheet map with the Lower Peninsula, and his report is appended.

STRATIGRAPHY OF THE IRON BEARING ROCKS.

During August I was with a committee organized for the purpose of agreeing so far as possible as to the facts of "the succession and stratigraphy in the west half of the Lake Superior basin, including in the area, Michigan Minnesota and Western Ontario." The following is a letter regarding the same and the joint report:

Madison, Wis., March 10, 1904.

My Dear Dr. Lane:—

I had not written you of the contemplated international boundary work because I supposed that Dr. Hayes, chairman of the committee, would give you information in reference to our plans.

This committee consists of Dr. Bell and Dr. Adams on behalf of the Canadian survey, and Dr. Hayes and myself on behalf of the United States survey, with the understanding that interested geologists are to be invited to participate.

In reference to the Lake Superior work, it was decided that you as State Geologist of Michigan, or representative appointed by you, and Professor Coleman of the Bureau of Mines, should be invited to take part in our work. Or, if you desire, I have no doubt that Mr. Hayes will consent that both you and Mr. Seaman take part.

The plan for the coming summer is for the party to meet in the Marquette district as early in August as practicable, probably about the 2nd or 3rd, and spend all of that month, and as much of September as may be necessary to agree, if possible, upon the succession and stratigraphy in the west half of the Lake Superior basin, including in the area, Michigan, Minnesota and Western Ontario. I surely hope it will be practicable for the State survey of Michigan to have a representative on this joint field work.

Leith will also accompany us as having charge of the iron ore work for the United States survey.

Very truly yours,

(Signed) CHARLES R. VAN HISE,

REPORT OF THE SPECIAL COMMITTEE FOR THE LAKE SUPERIOR REGION.[1]

TO C. WILLARD HAYES, ROBERT BELL, FRANK D. ADAMS, AND CHARLES R. VAN HISE, GENERAL COMMITTEE ON THE RELATIONS OF THE CANADIAN AND THE UNITED STATES GEOLOGICAL SURVEYS.

INTRODUCTORY NOTE BY C. R. VAN HISE.

The report below of the special committee on the nomenclature and correlation of the geological formations of the United States and Canada is the first joint report of the geologists of the two countries. Before the death of Dr. G. M. Dawson, formerly director of the Canadian Geological Survey, I had correspondence with him in reference to joint field-work in the Lake Superior region. It was agreed between us that such field-work should be undertaken, but his untimely death occurred before anything was done.

After Dr. Dawson's death I continued correspondence upon the subject with Dr. Robert Bell, acting director of the Canadian Geological Survey. As a result of this correspondence, December 22, 1902, Dr. Bell wrote to Dr. C. D. Walcott, director of the United States Geological Survey, suggesting a conference in reference to the mutual interest of the two Surveys. This letter led to the appointment of a committee—consisting of C. W. Hayes and C. R. Van Hise, for the United States Geological Survey, and Robert Bell and Frank D. Adams, for the Canadian Geological Survey—to consider all questions as to the successions of formations, and as to nomenclature, which concerned the two surveys.

This committee, with C. W. Hayes as chairman, met for the first time at Washington, January 2, 1903. At this meeting several special committees were appointed to consider different districts along the international boundary. For the Lake Superior region the following committee was appointed: for the United States, C. R. Van Hise and C. K. Leith, of the United States Geological Survey, and A. C. Lane, state geologist of Michigan; and for Canada, Robert Bell and Frank D. Adams, of the Canadian Geological Survey, and W. G. Miller, provincial geologist of Ontario.

August 3, 1904, this special committee met in the Marquette district of Michigan, and during the six weeks following visited successively the Gogebic, Mesabi, Vermilion, Rainy Lake, Lake of the Woods, Animikie, and original Huronian districts. After finishing the field-work, a report in preliminary form was drawn up.

In December, 1904, another meeting of the special committee was held at Philadelphia, further to consider the report, all members of the committee being present except C. R. Van Hise. At this meeting the report of the sub-committee was completed as given below.

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[1] First printed in the Journal of Geology, pp. 89 to 104.

REPORT OF THE COMMITTEE.

Your special committee on the Lake Superior region, during the months of August and September, 1904, visited various districts in the Lake Superior country, their purpose being to ascertain, if possible, whether they could agree upon the succession and relations of the formations in the various districts, and could further agree upon a nomenclature appropriate to express the facts. The districts visited were the Marquette, the Penokee-Gogebic, the Mesabi, the Vermilion, the Rainy Lake, the Lake of the Woods, the Thunder Bay, and the original Huronian of the north shore of Lake Huron. Aside from the regular members of the special committee, for parts of the trip other geologists were with the party. Dr. C. W. Hayes, geologist in charge of geology, United States Geological Survey, and a member of the general committee, was with the party for the Marquette, Penokee-Gogebic, Mesabi, Vermilion, and Rainy Lake districts. Professor A. E. Seaman was with the party for the Marquette, Penokee-Gogebic, Rainy Lake, Lake of the Woods, and Thunder Bay districts. Mr. J. U. Sebenius was with the party for the Mesabi district, Mr. W. N. Merriam, for the Mesabi and Vermilion districts; Mr. W. N. Smith, for the Thunder Bay district; Mr. E. D. Ingall and Mr. T. D. Denis, for the Lake Huron district. The knowledge of these men was of great assistance to the committee.

In the following pages we shall give the successions and relations of formations which we believe to obtain for each of the districts visited, and give our opinion as to the major correlation of the rock series of the various districts, so far as this can be safely done, and the nomenclature which seems to best express the facts.

For each district, unless otherwise specified, the succession will be considered in descending order. In giving the successions for the various districts, we shall use, for convenience, the names suggested by geologists who have done the detailed work in the districts, without thereby expressing any opinion as to their appropriateness or their advisability.

In the Marquette district we found the upper series there exposed to be as follows: (1) Michigamme slate and schist, and (2) Ishpeming formation. Locally within the Michigamme slate, and apparently near its base, is an iron-bearing horizon. The Clarksburg volcanics, said to be a local phase of the Michigamme formation, were seen at Champion. The basal member of the Ishpeming formation is the Goodrich quartzite. This series, called the upper Marquette series by the United States Geological Survey, has at its base a pronounced unconformity, marked by extensive beds of conglomerate having materials of diverse character. The dominant fragments of the conglomerate at the localities visited are from the Negaunee formation to be mentioned below. The next series is the Middle Marquette series, consisting of (1) the Negaunee formation, (2) the Siamo slate, and (3) the Ajibik quartzite. In the publications of the United States Geological Survey this series was not separated from the series next mentioned, but the work of Professor Seaman has shown that there is a pronounced unconformity, marked by strong basal conglomerates at the bottom of the Ajibik. Below this unconformity is the Lower Marquette series, consisting of (1) the Wewe slate, (2) the Kona dolomite, and (3) the Mesnard quartzite. At the places where we saw the succession there is a belt of slate between the Kona dolomite and the Mesnard quartzite of such thickness that it might possibly be mapped as a formation if the exposures were more numerous. The members of the United States Geological Survey think that this slate is probably general for the district, as it shows whereever the exposures are continuous from the dolomite to the quartzite. At the base of the lower Marquette series is an unconformity, marked by conglomerates bearing fragments of all the kinds of rocks seen in the underlying series. Two classes of fragments are especially abundant. These are (1) tuff, greenstone schist, and many kinds of greenstones which belong to the so-called green-schist series of the district, and (2) various kinds of granite and gneissoid granite. Adjacent to the state road south of the city of Marquette the actual contact was seen between the two series, the basal conglomerate resting upon the green schist. The great variety of materials in this conglomerate and the well rounded character of the fragments left no doubt in the minds of the members of the party that there is a great structural break at the base of the lower Marquette series.

The lowest group of the Marquette district is a very complex one, which has been designated as the Basement Complex. It consists of two classes of material—the greenstone-schist series, and the granites and gneissoid granites. The greenstone schist series is especially well known through the description of the late George H. Williams, found in *Bulletin* 62 of the United States Geological Survey. This series is designated on the maps of the *Marquette Monograph* as the Kitchi and Mona schists. Intrusive in the green schist series are great masses of granite and gneissoid granite. No evidence was seen by the party that any of the granites intrude the sedimentary series above the green-schist series, although Seaman thinks in one place a small mass of granite does intrude the Lower Marquette series. It is believed that the great masses of granite of the district antedate the three series here called Upper, Middle and Lower Marquette.

In the Penokee-Gogebic district the highest rocks seen are the Keweenawan traps and interbedded sandstones, the bedding of which dips at a high angle to the north. No actual contact between the Keweenawan and the next underlying series was seen, but north of Bessemer, below the Keweenawan, the next formation is the great Tyler slate formation of the Penokee series, while at Sunday Lake the Keweenawan rests directly on the iron-bearing formation which is stratigraphically below the slate. This relation led the party to infer the existence of an important unconformity between the two. The Penokee-Gogebic, or iron-bearing series, consists of (1) the Tyler slate, (2) the Ironwood formation, and (3) the Palms slate. This Palms slate was seen to rest directly upon granite south of the Newport and Palms mine. At the former locality there is no conglomerate at the base. At the latter locality there is a conglomerate at the base of the slate which, besides containing granite detritus, also contains many cherty fragments supposed to be derived from the next underlying sedimentary series.

East of the Presque Isle River the lower sedimentary succession of the Penokee-Gogebic district was visited, here consisting of (1) cherty limestone and (2) quartzite. The quartzite dips to the north at a moderate angle and rests upon green schist. The two formations were seen in direct contact for a hundred feet or more. The cleavage of the green schist abuts against the bedding of the quartzite at right angles. The quartzite near its base passes into a conglomerate, which, just above the contact becomes very coarse and contains very numerous well-rolled fragments of the immediately subjacent schist. The unconformity at the base of the quartzite could not be more pronounced.

The party nowhere saw the relations of the limestone-quartzite series just described and the Penokee-Gogebic series proper, but they have no reason to doubt the conclusion of the United States Geological Survey that the limestone-quartzite series is the inferior one.

The relations of the green schist, called Mareniscan by the United States geologists, and the granite, which together constitute the basement upon which the determined sedimentary series of the district rest, were not studied by the party. The United States geologists[1] hold that the relations are perfectly clear, and that the granite rocks are intrusive in the green schist.

In the Mesabi district the succession of the Mesabi series is as follows: (1) Virginia slate, (2) the Biwabik iron formation, and (3) the Pokegama quartzite. This series dips at a gentle angle to the south. At the base of this series at Biwabik is a conglomerate which rests upon a series of slates and graywacke, the latter in nearly vertical attitude. The unconformity between the two is most pronounced. The slate and graywacke where crossed has a considerable breadth. It flanks a green-schist series. The slate and graywacke formation adjacent to the green-schist is conglomeratic. Many of the fragments of the conglomerate are from the underlying green schists. At the locality visited it could not be asserted that the break between the slate-graywacke formation and the green-schist series is great, although nothing was seen which is contrary to this view. The granite constituting the Mesabi range is reported by the United States geologists as intruding both the green-schist and the slate-graywacke series, but not the Mesabi series. At the east end of the district a newer granite is reported as intruding both the Mesabi and the Keweenawan series, and in the central portion of the district small areas of granite porphyry are reported as antedating the slate-graywacke series.

In the Vermilion district the Upper series, where seen, consists of (1) Knife slates and (2) Ogishke conglomerate. The Ogishke conglomerate contains very numerous fragments of all the underlying formations noted—porphyries, green schists, iron formation, granite—and we have no doubt that there is a great structural break at the base of the Ogishke. The series below this unconformity, the Vermilion series, consists of (1) the Ely greenstone and (2) the Soudan formation. The Ely greenstone is the dominant formation. It is mainly composed of green schists and greenstones many of which show the ellipsoidal structure described by Clements. The other important formation of the Vermilion series is the Soudan iron formation. The structural relations of the Ely greenstone and the Soudan formation are most intricate. No opinion is here expressed as to their order. The Ely greenstone and the Soudan iron formation are cut by porphyries, and, according to the reports of the United States Geological Survey, are cut in a most complex way by the great northern granite, but the localities illustrating this were not visited. It is worthy of mention that the United States geologists report granite as intruding the Knife slates and Ogishke conglomerates in the central parts of the district, especially in the vicinity of Snowbank Lake, but this locality was not visited by the party.

In the Rainy Lake district the party observed the relations of the several formations along one line of section at the east end of Shoal Lake and at a number of other localities. The party is satisfied that along the line of section most closely studied the relations are clear and distinct. The Couchiching schists form the highest formation. These are a series of mica-

[1] My observations agree. See the rocks under the Ironwood water tank.

ceous schists graduating downward into green hornblendic and chloritic schists, here mapped by Lawson as Keewatin, which pass into a conglomerate known as the Shoal Lake conglomerate. This conglomerate lies upon an area of green schists and granites known as the Bad Vermilion granites. It holds numerous large well-rolled fragments of the underlying rocks, and forms the base of a sedimentary series. It is certain that in this line of section the Couchiching is stratigraphically higher than the chloritic schists and conglomerates mapped as Keewatin. On the south side of Rat Root Bay there is also a great conglomerate belt, the dominant fragments of which consist of green schist and greenstone, but which also contain much granite. The party did not visit the main belts colored by Lawson as Keewatin on the Rainy Lake map, constituting a large part of the northern and central parts of Rainy Lake. These however, had been visited by Van Hise in a previous year, and he regards these areas as largely similar to the green-schist areas intruded by granite at Bad Vermilion Lake, where the schists and granites are the source of the pebbles and bowlders of the conglomerate.

In the Lake of the Woods area one main section was made from Falcon Island to Rat Portage, with various traverses to the east and west of the line of section. The section was not altogether continuous, but a number of representatives of each formation mapped by Lawson were visited. We found Lawson's descriptions to be substantially correct. We were unable to find any belts of undoubted sedimentary slate of considerable magnitude. At one or two localities, subordinate belts of slate which appeared to be ordinary sediment, and one belt of black slate which is certainly sediment, are found. In short, the materials which we could recognize as water-deposited sediments are small in volume. Many of the slaty phases of rocks seemed to be no more than the metamorphosed ellipsoidal greenstones and tuffs, but some of them may be altered felsite. However, we do not assert that larger areas may not be sedimentary in the sense of being deposited under water. Aside from the belts mapped as slate, there are great areas of what Lawson calls agglomerate. These belts, mapped as agglomerates, seem to us to be largely tuff deposits, but also include extensive areas of ellipsoidal greenstones. At a number of places associated and interstratified with the slaty phases are narrow bands of ferruginous and siliceous dolomite. For the most part the bands are less than a foot in thickness, and no band was seen as wide as three feet, but the aggregate thickness of a number of bands at one locality would amount to several feet.

We could discover no structural breaks between the above formations of the Lake of the Woods. The various classes of materials—slates, agglomerate, and ellipsoidal greenstones—all seem to belong together. In short these rocks in the Lake of the Woods seem to us to constitute one series which is very largely igneous or volcanic in origin, but does, as above mentioned, contain some sediments. This series in the Lake of the Woods area is the one for which the term "Keewatin" was first proposed for the greenstone series, Lawson giving as one reason for proposing this name the statement that there is no evidence that these rocks are equivalent with the rocks of Lake Huron described by Logan and Murray as Huronian.

The ellipsoidal greenstone-agglomerate-slate series is cut in a most intricate way by granite and granitoid gneiss, which constitute much of Falcon Island at the southern part of the Lake of the Woods and a great area north of the Lake of the Woods. These relations between the granite and Keewatin were seen on the northwest part of Falcon Island and on a small island adjacent. They were also seen north of Rat Portage. At the latter place the rocks adjacent to the granite are banded hornblende and micaceous schists, very similar to the banded rocks of Light House Point, at Marquette. At Hebe Falls the granite and Keewatin series are seen to be in actual contact, the Keewatin being apparently intruded by the granites, although the relations have often been interpreted as conformable gradations. Going north along the Winnipeg River, the relations between the two series become perfectly clear. Great blocks of the Keewatin are included in the granite, the masses varying from those of small size to others of enormous bulk. Also the two have intricate relations, which have perhaps been best described as *lit par lit* injection. In short, the relations are those so well described by Lawson for this area.

In the Thunder Bay district we visited especially the areas about Loon Lake and Port Arthur. In the Loon Lake area the succession is as follows: The top series is the Keweenawan, here consisting of sandstone above and conglomerate below, with interbedded basic igneous flows or sills. Below the Keweenawan is the Animikie. The contact between the Keweenawan and the Animikie was seen at two places. At one of these there is an appearance of conformity, but at the other the eroded edges of the Animikie iron-bearing formation are traversed by the Keweenawan beds. At one contact the base of the Keweenawan rests on the Animikie slate, interstratified with the iron formation, and at the other on one of the members of the iron-bearing formation. At both localities the conglomerate at the base of the Keweenawan bears detritus from the underlying series, including both the slate and the iron-bearing formations of the Animikie. The Animikie succession which we saw near Loon Lake includes two phases of the iron-bearing formation with an interstratified belt of slate. The Animikie here has in general rather flat dips, although locally they become somewhat steeper.

Near Port Arthur the higher slate member of the Animikie was visited by a portion of the party, and on previous occasions had been visited by the other members. This is the formation which is agreed by all to rest upon the Animikie iron formation. It is notable as containing the intrusive sills called by Lawson the Logan sills.

At one place near Loon Lake a test pit has been sunk to the bottom of the Animikie, and here at the base of the formation is a conglomerate bearing fragments of the next underlying series—a graywacke slate. This graywacke slate covers a large area, shows cleavage at a high angle, and is evidently an important formation in the district.

The party has no doubt that there is considerable unconformity between the Keweenawan and the Animikie and a very important unconformity between the Animikie and the graywacke slates.

A portion of the party went north from Port Arthur to see the green-schist and granite series. This was found, but seen only in small volume at the particular area visited. At other times several members of the party have visited larger areas of this green-schist and granite complex north and northwest of Port Arthur in Gorham, Conmee, and other townships, and in the green schists they found an iron-bearing formation analogous in character to the Soudan formation of the Vermilion district. The granites are intrusive in the greenstones.

At no place were the relations between the graywacke slate series below the Animikie and the green-schist granite complex observed.

In the original Huronian area—i. e., the area described by Logan and Murray as extending from near Sault Ste. Marie along the north shore of Lake Huron to Thessalon and northward—we examined a number of crucial localities. At the first of these about five miles from Sault Ste. Marie, near Root River, we studied the relations of the conglomerate, mapped as lower slate conglomerate by Logan, with the granite. The conglomerate is in a vertical position. We found the upper horizon of the conglomerate near the road to be of moderate coarseness, and to contain many fragments of green schist, greenstone and granite. The granite fragments increase in prominence and size toward the north, and at the north end of the exposure we have a great granite conglomerate. After an interval of a few paces we found to the north a red granite similar to many of the fragments of the conglomerate. The party has no doubt that the conglomerate rests unconformably upon the granite. This conglomerate, while mapped by Logan as lower slate conglomerate appears to be above a limestone next to be mentioned, and has been connected by Van Hise and Leith with rocks like the red quartzite belonging above the limestone, and they believe it to be the upper slate conglomerate rather than the lower slate conglomerate, although the overlapping recent lake deposits prevent the connection by actual areal tracing. A short distance east of the point where the conglomerate is next to the granite and north of the great mass of the conglomerate is a belt of limestone which continues east for perhaps half a mile. North of this limestone is conglomerate, and still to the north, granite. This northern conglomerate is very similar to the conglomerate south of the limestone, and two interpretations are possible as to its position: it may be regarded as the lower slate conglomerate under the limestone, or it may be regarded as an equivalent to the conglomerate south of the limestone, being repeated by an anticline or possibly a fault. The limestone has a steep dip to the north, and, accepting either alternative, it must be regarded as overturned.

We next visited the abandoned limestone quarry north of Garden River station. Here we found the conglomerate, marked by Logan as the upper slate conglomerate, within a few paces of the limestone. This conglomerate is in all respects similar to the average of the conglomerates before mentioned, except that it contains very numerous limestone fragments. The party has no doubt that the limestone formation was laid down, and that a considerable erosion interval occurred before the deposition of the conglomerate upon the limestone. The slate conglomerate belt north of the limestone was examined, and while it was not found in contact with the limestone, it was seen to increase in coarseness as the limestone is approached, and across the little ravine which separates the conglomerate from the limestone it was found to contain numerous limestone fragments. We therefore conclude that the rock on each side of the limestone is the upper slate conglomerate, the structure probably being anticlinal, possibly with faulting. This conclusion suggests that the same relation obtains at the Root River locality above described.

On the limestone point on the east side of Echo Lake we found the following ascending succession, with monoclinal dip to the southeast: (1) white or gray quartzite, grading through graywacke into (2) a thin belt of conglomerate not exceeding twenty feet in thickness and containing numerous granite fragments. Above the conglomerate is (3) limestone in considerable thickness, and over this (4) the upper slate conglomerate. This last is a thick formation. The upper conglomerate is very coarse near the limestone, and becomes finer in passing away from the limestone along the lake shore. Like the conglomerate near Garden River, it bears very numerous limestone fragments, the evidence of which is beautifully seen at the lake shore, where the water has dissolved many of them completely and others in part. The ledge thus presents a deeply pitted surface, many of the pits being several inches in depth.

On the west side of Echo Lake we ascended the prominent bluff next north of the west limestone point, and here found the formation nearly horizontal, but dipping slightly into the hill. The quartzite in this position composes the greater part of the bluff. A short distance from the top we found the quartzite grading upward into a graywacke-like rock, and this into a conglomerate which contains granite and green-schist fragments; indeed, it is typical slate conglomerate. This conglomerate is only a few feet in thickness, and above it appears a siliceous limestone, and above this, normal limestone like that of Garden River and the east side of Echo Lake. The total thickness of the limestone here seen was probably not more than fifty feet, and of the conglomerate below, not more than thirty feet. The lower five hundred feet or more of the bluff is the white quartzite.

The other bluffs on the west side of the lake were not visited by the party, but Leith, Seaman and Van Hise have examined each of these bluffs, and found the succession above given to obtain upon each prominent bluff, with the exception that on the next bluff to the north the limestone is wanting, so far as observed. The limestone is also in greater force on some of the other bluffs, but is always subordinate in thickness to the quartzite. It thus appears that the great formation on the west side of Echo Lake is the quartzite; that the limestone above appears, not as a single belt, but as a number of synclinal patches often capping the hills; and that the conglomerate showing both north and south of the limestone is a very thin formation between the quartzite and the limestone, and is, therefore, the lower slate conglomerate.

Our observations from Root River to Echo Lake convince us that there is a considerable structural break in the Huronian. The upper series includes the following formations of Logan, viz.: white quartzite, chert, and limestone, yellow chert and limestone, white quartzite, red jasper conglomerate, red quartzite, and upper slate conglomerate. The lower series includes the lower limestone of Logan and the lower slate conglomerate, white quartzite, and gray quartzite. North of Thessalon the two series are represented by Logan and Murray as being separated by a fault. Here the distribution may be explained by the unconformity mentioned, but it is also entirely possible that the relations are due to faulting or to both unconformity and faulting.

Four miles east of Thessalon on several islands off the coast is a great conglomerate, mapped by Logan and Murray as gray quartzite. This conglomerate was found to rest unconformably upon the granite, the actual contact being observed upon one island opposite the northwest quarter of Sec. 12 of the Township of Thessalon. The fragments in the conglomerate are well rounded and are largely granite, but there are also numerous pebbles and bowlders of greenstone and green schist. On several islands adjacent to the conglomerate the massive granite includes many fragments of greenstone and green schist, showing the granite to be intrusive into a greenstone formation. Thus in the complex against which the conglomerate rests we have a source both for the granite and greenstone pebbles and bowlders. To the northwest the conglomerate grades up by interstratification into a quartzite. About a quarter of a mile west of the conglomerate, near the north end of a point, the quartzite is found to become a fine conglomerate, and to rest against greenstone which is cut by a large granite dike. The greenstone shows ellipsoidal parting. The granite dike strikes toward the conglomerate and the quartzite, but it dies out into a depression showing no rock, which continues to the quartzite some fifty or sixty feet distant. The quartzite and conglomerate strike directly across this depression, showing continuous exposures, and are not cut by granite. The relations here are believed by certain members of the party to show clearly that the quartzite and conglomerate rest unconformably upon the greenstone, but other members felt that this conclusion is not certain. The conglomerate and gray quartzite are cut by greenstone dikes. Similar rocks also cut the Thessalon series referred to below.

The rocks called green chloritic schist by Logan (3*c*) will here be called the Thessalon series. This series consists of ellipsoidal greenstones, amygdaloids, agglomerates, and massive greenstones. No undoubted sediments were observed in the series. The relations of the Thessalon series to the granite were observed southeast of Little Rapids, and it was found that the granite cuts the greenstone series in an intricate fashion. The belt of gray quartzite, mapped as extending inland for a number of miles between the Thessalon series and the granite, was found to be absent at this locality. Two or three miles east of Thessalon, felsite and granite in considerable masses were found to intrude the Thessalon series. At one place several felsite or granite dikes were observed to cut both the agglomerates and ellipsoidal greenstones. From the relations observed, the party had no doubt that the conglomerate islands east of Thessalon belong unconformably upon the granite, and they think it probable (Van Hise would say highly probable) that the quartzite and conglomerate rest unconformably upon the Thessalon series, mapped as green chloritic slate by Logan and Murray. It is regarded as probable that the white quartzite below the lower slate conglomerate northwest of the Thessalon series which is adjacent, and is shown by its dip to rest upon the Thessalon series, is separated from that series by an unconformity, but no direct evidence of such relation was observed.

The Thessalon series should be excluded from the Huronian if, as believed, the unconformity just mentioned exists. If this series be excluded, the Huronian of Lake Huron consists of two series, an Upper Huronian and a Lower Huronian. The Upper Huronian extends from the top of the series as given by Logan and Murray, downward to and including the upper slate conglomerate; and the Lower Huronian extends from the main limestone formation to the gray quartzite, including its basal conglomerates. In the area mapped by Logan on the north shore of Lake Huron the Laurentian consists of granite and gneissoid granite, with subordinate inclusions of greenstone.

We do not feel that our examination of the Lake Superior region was sufficiently detailed to warrant an attempt at correlation of the individual formations of the various districts. There are, however, certain general points which seem to be reasonably clear, and about which there is no difference of opinion between us. These are as follows:

There is an important structural break at the base of the Keweenawan. The term "Keweenawan" should include substantially all of the areas which have been thus mapped, or mapped as Nipigon, by the Canadian and United States Surveys, and the State Surveys of Michigan, Minnesota and Wisconsin.

Below the Keweenawan is the Huronian system, which in our opinion should include the following series: In the Marquette district, the Huronian should include the Upper and Lower Marquette series, as defined in the monographs of the United States Geological Survey, or the Upper, Middle, and Lower Marquette series, as given in the previous paragraphs. In the Penokee-Gogebic district, the Huronian should include the series which have been called the Penokee-Gogebic series proper, and the limestone and quartzite which have local development, and which we visited east of the Presque Isle River. In the Mesabi district, the Huronian should include the Mesabi series proper, and the slate-graywacke-conglomerate series, unconformably below the Mesabi series. In the Vermilion district the Huronian should include the Knife slates and the Ogishke conglomerates. In the Rainy Lake district, the Huronian should include that part of the Couchiching of the south part of Rainy Lake which is limited below by basal conglomerate as shown at Shoal Lake. In the Thunder Bay district, the Huronian should include the Animikie and the graywacke series in the Loon Lake area. In the original Huronian area, the Huronian should include the area mapped by Logan and Murray as Huronian, except that the Thessalon greenstones should probably be excluded.

Unconformably below the Huronian is the Keewatin. The Keewatin includes the rocks so defined for the Lake of the Woods area and their equivalents. We believe the Kitchi and Mona schists of the Marquette district, the green-schist (Mareniscan) of the Penokee-Gogebic district, the greenstone series of the Mesabi district, the Ely greenstones and Soudan formation of the Vermilion district, the part of the area mapped as Keewatin by Lawson in the Rainy Lake district not belonging structurally with the Couchiching, and probably the Thessalon greenstone series on the north shore of Lake Huron, to be equivalent to the Keewatin of the Lake of the Woods, and, so far as this is true, they should be called Keewatin.

For the granites and gneissoid granites which antedate, or protrude through, the Keewatin, and which are pre-Huronian, the term "Laurentian" is adopted. In certain cases this term may also be employed, preferably with an explanatory phrase, for associated granites of large extent which cut the Huronian, or whose relations to the Huronian cannot be determined.

The following succession and nomenclature are recognized and adopted:

CAMBRIAN—Upper sandstones, etc., of Lake Superior

Unconformity

PRE-CAMBRIAN

Keweenawan (Nipigon)[1]

Unconformity

Huronian:
- Upper (Animikie)
- *Unconformity*
- Middle
- *Unconformity*
- Lower

Unconformity

Keewatin

Eruptive contact

Laurentian

Alphabetically signed by the committee as follows:

FRANK D. ADAMS,
ROBERT BELL,
A. C. LANE,
C. K. LEITH,
W. G. MILLER,
CHARLES R. VAH HISE,
Special Committee for the Lake Superior Region.

PERSONAL COMMENTS,—KEWEENAWAN.

It remains to add certain comments on the same.

The committee did not examine the relations of the Keweenawan to the Lake Superior sandstone (Cambrian), having occasion only to note at Loon Lake its unconformity upon the Huronian, and the intrusion of sills of basic rock, presumably Keweenawan, into the Animikie (neo-Huronian).

I am inclined to believe personally with Prof. Seaman that the Keweenawan is Cambrian, and as my predecessors have classed it as Cambrian[2] I do not see that it is wise to change. However, I realize that the evidence

[1]Mr. Lane dissents as to the position of the Keweenawan as follows:
"The use of pre-Cambrian above does not imply unanimity in the committee with regard to the pre-Cambrian correlation of the Keweenawan—a topic the committee as such did not investigate."

[2] Rominger (Hubbard) Volume V., part 1, p. 90. Wadsworth. Report 1891–1892, p. 85.

upon which I depend is not coercive, and that it is possible that the Keweenawan may antedate in part or in whole the Acadian fauna. And as the U. S. Geological Survey have for the past twenty years consistently classed the Keweenawan as pre-Cambrian, I should not expect them to change their classification, unless morally certain they were right in so doing.

Thus for the present we must agree to disagree, but use the unambiguous term Keweenawan so far as possible.

Let us look a moment at the evidence:

1. The Keweenawan is *very thick*, but this thickness is composed of rocks which may accumulate with extreme rapidity, sandstones, conglomerates, and sheets of trap, single flows of which are hundreds of feet thick. So that geologically it may represent no greater time than the Iceland deposits.
2. Its lithological character is such that fossils would hardly be expected.
3. Intense volcanic activity, characterize its middle and lower part. Intrusions occur in the lower part. Conglomerates and sandstones are often derived from material of the formation itself. We even find pebbles of lower Keweenawan agates and intrusives in the upper Keweenawan.
4. We are therefore prepared to find, as we do, that the lower part has steeper dips, more faults with greater throws and was evidently much disturbed before the upper Keweenawan was laid down.
5. The lower Keweenawan, which is overlain very unconformably by the horizontal Lake Superior (Potsdam) sandstone, also stands in the same relation to the upper Keweenawan.
6. There is a fairly steady approximation in dip, lithological character, geographical distribution and degree of disturbance, from the base of the Keweenawan, through its upper members, to the Lake Superior sandstone.
7. This points to one great volcanic epoch gradually dying out, and one great generally continuous movement of depression. I do not know of any evidence of uplift and erosion of the upper Keweenawan, before the laying down of the Lake Superior sandstone, which may be conceived as a normally following enveloping mantle and generally contains practically no material which must, and but little that may, be derived from this Keweenawan.
8. But along the southern contact of the Copper (Keweenawan) Range motion along a great fault line took place, disturbing the unconformable contact between the Lake Superior sandstone and the base of the Keweenawan, probably down to the time of the Niagara which is caught in the Limestone Mountain synclinal. Thus the upper Keweenawan and Lake Superior sandstones are not entirely undisturbed.[1] To sum up I have not been able to find other strata or unconformities or indications of time interval to represent the middle and lower Cambrian between the Lake Superior sandstone and the upper Keweenawan.

It will be noticed in the geological map, Pl. III, that the upper Keweenawan follows the Lake Superior (upper Cambrian) sandstone pretty closely in its distribution, while in contrast the Animikie or neo-Huronian[2] black slates wind around into a number of other folds and synclinals in which the Keweenawan does not partake. Thus between Keweenawan and Animikie there is a marked break.

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[1]In fact the Lake Superior basin has probably been a concave portion of the earth crust and therefore incapable of accumulating notable stress through all geologic time, and thus always susceptible to slight adjustments. See Chamberlin & Salisbury, Geology, Vol. I, p. 561.

[2]To avoid confusion between the new and older division of the Huronian, I will here speak of the neo-, mio- and eo-Huronian.

MARQUETTE RANGE.

In regard to the Marquette range the stratigraphic succession is the same as has been held for some time by Prof. Seaman and myself. In the revised map of the region which the U. S. Geologists are preparing there will be a larger recognition of faults than heretofore, and were I drawing the map, there would probably be more yet. I also spent a week with Prof. Seaman in the region about Goose Lake in the early spring. The mapping there will need to be extensively revised. The Ajibik formation with the conglomerate at its base runs diagonally across the bed of the Ajibik hills, the main part of which is apparently Mesnard, eo-Huronian. The south side of the hills is a fault scarp and according to Mr. A. Formis a 1,400 foot drill hole just south passes through quartzite (the Goodrich, neo-Huronian) and then ore all the way. A fault probably also runs northeast and just east of the Volunteer mine. The three over-lapping quartzites and conglomerates make a complex which no one can be blamed for mistaking at times.

Along the edge of the bluffs east of Teal Lake in Sec. 31, T. 47 N., R. 26 W. the Mesnard series is terminated by the Ajibic which runs nearly east and west, while the latter is more nearly N. 70 degrees, and is I think badly faulted, blocks of slate and of Mesnard quartzite, being let in irregularly. I believe there are small faults also where the Carp river emerges on the sand plain and where the road on Sec. 31 passes through the wall made by the upturned quartzites. Prof. Seaman's class is engaged in working the former set out. According to Seaman the column of the eo-Huronian or Mesnard series is, beginning at the top:

Unconformity
Kona dolomite, massive
Thin shabby dolomite
Cherty quartzite
Slate
Quartzite
Slate belt
Main Mesnard quartzite
Quartz slate or flags
Conglomerate
Main unconformity.

The county has been subject to a stress such that the east and west shearing is made by a movement of the north side to the east generally, while along certain northwesterly joints the north side is thrown west. Such a fault I think comes down the Carp in Sec. 33, T. 47 N. R. 26 W.

There is a great fault running from Sec. 6, T. 48, R. 25, to Sec. 11, T. 47, R. 26 and the big mass of intrusives in Sec. 10.

The maps of the Marquette Monograph, while extremely useful, were drawn particularly with the iron question in view, and might be improved in many ways, and will be by the U. S. Geological Survey in the forthcoming Monograph, especially so far as they concern the iron bearing rocks. But there are certain classes of changes which I do not expect that they will make, though they should be made sometime. For instance the basic igneous rocks they have distinguished almost solely in connection with the Negaunee formation where they assume an especial economic importance. But they are of course quite abundant in the other formations.[1]

The question whether they are intrusive or effusive has not been touched. To a considerable extent they are intrusive and perhaps coeval with the effusives of the Clarksburg formation of the neo-Huronian and the green tuffs of the Palms formation, way over in the Gogebic range. Others are older effusives. Others are probably even Keweenawan in age. Section 26, T. 47, R. 27 is also a section where faults probably occur. The general dip is to the north and the succession from above.:

Siamo slate
Amphibolite (intrusive?)
Greenstone schists
Quartzite
Greenstone schist much disturbed and near a fault or intrusion.

These maps have paid little attention to the Marquette brownstone and other outliers of the Lake Superior sandstone which have no especial interest to the iron miner. They are of interest to the quarryman and may be so to the gold miner.

I think it quite desirable to prepare in co-operation with the U. S. Geological Survey at least in the topographic base, a map, more thorough in all respects, of the Marquette quadrangle, which would be of use to the Marquette Normal school and also the College of Mines.

THE LAURENTIAN PROBLEM.

South of the Cascade Range and thence west is a great area of rocks, largely granite, mapped by Brooks and Pumpelly in Volume I of our reports (Plate 1) as Laurentian, which the U. S. Geological Survey include as Archean and mainly granite. That a large part of the area is composed of intrusive plutonic rock there can be no question, but its relation to other formations has been a subject of controversy. Some granites were discovered by Brooks and Rominger to be intrusive in undoubted Huronian. The contact with the greenstone schist (Kitchi, Mona, Palmer gneiss) series is apparently always intrusive, and it is possible that the Palmer gneiss south of the Volunteer mine is but a granitized arkose quartzite possibly equivalent to the Mesnard. 'Thus Rominger[1] saying that the lower granitic and gneissoid portion of the rock group in the Marquette region exhibits the character of an eruptive and not of an altered sedimentary rock, expunged the term Laurentian from his column.

Seaman has found on Sec. 26, T. 48, R. 27, indications that the granite does intrude the quartzite.

According to many of the Canadian geologists, and they have had remarkable opportunities to see the facts, these granites are however the softened base of the geological column, more or less squeezed up into the overlying strâta, and Rominger agrees with them as to the facts.[2]

Now no one would deny that they come from somewhere below the strata

[1] For instance in the Kitchi schist at Lighthouse Point Marquette, also on Ropes mine road 1750 N. 510 W. Sec. 33, T. 48, R. 27.
[1] Volume V, Part 1, page 2.
[2] Volume V, Part 1, page 3.

into which they are intruded, but so do the intrusives which we find everywhere in the geological column, and that these granite gneisses should be entitled to a permanent place in the stratigraphic column of rocks below some other, to my notion it should be necessary to show that they were indeed the next underlying formation and not from some layers of the crust much farther down, and in part in some places to some extent at least the crystalline texture should almost surely antedate the intrusion.

There is, so far as I have observed, no trace of superficial structures of any kind in these rocks. Apparent fragments (not counting those obviously faulted in) are probably more or less absorbed parts of the strata into which they were intruded, possibly sometimes secretions or clots of the earlier formed crystals aggregated in the crystallizing magma, though some might consider them non-liquified remnants of old strata. Crystallization under pressure in the presence of water and heat, this appears to me to be the dominant factor. Throughout our trip I had this question in mind and desired particularly to see what indications there might be, from the variation of grain, of a difference in conditions between the intruding and intruded rock, for if the Laurentian granites are but a softened and intruded basement, we should imagine that there would be no great difference in conditions between them and the rock into which they were intruded. Now I have shown[1] that, other things being equal, the grain at the center of a great intrusive mass if it is fairly uniform is coarser the nearer the conditions of the country rock and those of the mineral whose grain is studied are, (g inversely proportional to the square root of u). The grain at or near the margin may be greater or less than that of the uniform grain at the center, the size it will attain depending in a rather complex way both on the distance from the margin and also on the initial conditions (temperature) of formation of the country rock and the mother rock relative to the intrusion of the magma: a coarser grain for a given mineral immediately at the margin than farther in indicating that the country rock is nearer the range of formation of the mineral than the intruded rock originally was.

The degree of extra coarseness at or near the margin may be used to find in a numerical way the relative nearness of country rock and intruded rock to the conditions of formation of the mineral studied.

Now from such studies as I was able to make, I inferred especially from the grain of the feldspar that: (1) The so-called Laurentian granites were reasonably fine grained far from the margin, whether intrusive in the Upper Laurentian (Keewatin) or Huronian, and apparently were more separated from the rocks they intruded in conditions of consolidation than many pegmatite granites, and as much as many granites. They are for instance finer grained than a 15-foot tourmaliniferous dike with 30 mm. feldspars, that we found cutting a trap dike on the Loon Lake range. Granite dikes are often coarser than the great batholites. (2) On the other hand the country rock was distinctly nearer the conditions of consolidation of the granite (at least the quartz and feldspar thereof) than it has generally proved to be to those of the consolidation of the augite and feldspar of traps and diabases, such as the Logan sills, so that the granites were probably deep seated rocks, and *the rocks into which they were intruded may have been nearly softened, but the granite magma itself appears to have been materially deeper seated and more fluid.* (3) Not infrequently, in fact I think gener-

[1] Report for 1903, pp. 205 to 234.

ally, there was a porphyritic appearance of the granites near the margin due to more conspicuous feldspar crystals near the margin, which is an indication that the original condition of the country rock was nearer that of feldspar formation than the original condition of the granite magma, (when it came to rest and perhaps after enclosures had materially cooled the margin more than the center) the latter being hotter, the former cooler.

I do not pretend to be the first by any means to have noticed this tendency to a porphyritic appearance of the Laurentian granite gneisses, which for instance in this very Lake Superior region has been remarked by Rominger,[1] Winchell and Grant and Lawson[2] and Rosenbusch even in his 1887 edition (p. 41) alludes to the porphyritic marginal facies. But I do not think they have drawn the inferences from it that I do, nor have they called attention to the fact that the porphyritic feldspar for instance often gradually develops in size as one approaches the margin and is therefore not an early intratelluric product but a true margin crystal (oriocrystal) coarse because there was an extra long time that the interchange of conditions between the hot mother rock and the country kept the margin within the range of their formation.

Just for illustration suppose the gneiss consolidated at a depth of 5 to 10 miles and a pressure of 2,160 to 4,050 kilos per square centimeter, and the rocks into which it was ejected were previously at a temperature of 200 degrees to 420 degrees C.[3]

Suppose also that the orthoclase was formed at 500°C a temperature at which it has been made in the presence of mineralizers. Then I think it probable that the granite magma has an original temperature of not less than, and probably not very far from, 500°+(500–200° or 420°) 800° to 580° corresponding to an original greater depth of four miles or more.

The following detailed observations seem to me to substantiate what I have said. The rock at International falls (Couchiching or Koochiching) and Fort Frances, where Rainy river plunges over some 20 feet, has been described by A. N. Winchell[4], Winchell and Grant[5] and Lawson.[6]

"The rock is a medium gray biotite syenite; the component minerals are white feldspar and biotite with a little hornblende and epidote." "A section of this rock shows it to be a granular aggregate of orthoclase, plagioclase, and biotite with a little necessary hornblende and quartz, in which are embedded porphyritic crystals of orthoclase. Other accessory constitutents are sphene, apatite and magnetite. The...... plagioclase ......is probably oligoclase."

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[1] Geol. Survey of Mich., Volume 5, Part 1, p. 4, and 6.

[2] Lake of the Woods report, 29 cc. 30, 63. Rainy Lake report, 126, 127, 128, 130.

See also: W. O. Crosby, American Geologist, Vol. XXV, May 1900,p. 301; L. V. Pirrson, Am. Jour. Sci., 157, pp. 271 to 280. It will be noticed that they both, Crosby and Pierson are trying to explain a porphyritic texture at the center, which also occurs in granites, for instance that of Carvel hill which I have described with Crosby, while in these Laurentian cases, the porphyritic texture is marginal, and the porphyritic feldspare is coarser than any farther in. In this it differs from the fine grained porphyritic texture at the margins of diabase dikes.

As may be seen I am inclined to attribute the variations in porphyritic character to differences in the relations of the initial condition of the intruding rock, the conditions of consolidation and the conditions of the intruded country rock, the latter being nearer the conditions of crystallization when the country rock is coarser.

I shall not enter into controversy regarding the theories. To determine the relative value of various explanations we must have more numerous careful examinations of series of rock specimens at known distances from the margin. My explanation is certainly capable of being a true cause. How often it is the efficient cause remains to be seen.

[3] It is quite possible that early in geological time the rocks would be hotter than these temperatures which correspond to an increase in temperature of only 3° C. in 100 meters or 1° F. for 60 feet.

[4] Geol. and Nat. Hist. Survey of Minnesota, Volume IV, p. 1002; American Geologist, XX, 293 to 299.

[5] Preliminary report on the Rainy Lake gold region. Minn. Geol. and Nat. Hist. Survey, 23rd annual report, pt. 3, 55, 221.

[6] Rainy Lake report, p. 126 F.

"It contains many darker masses sometimes a foot or more in diameter," which (as Winchell and Grant suggest as one possibility) are according to Dr. Adams most probably inclusions of the country rock the contact with which, as we shall see, was not far off, and these may have affected the chemical composition of the whole rock giving it its relatively basic nature. "Below the falls the rock becomes porphyritic with crystals of feldspar which are often an inch in length. The crystals stand out all over the weathered surfaces of the rock. Two islands about three-fourths of a mile below the falls contain excellent exposures of this rock; the upper of these islands is composed of syenite alone, while the lower also shows a fine micaceous schist which in places is seen in sharp contact with the syenite, and in other places there is apparently a transition from the syenite to the mica schist within the distance of a few feet." "Two exposures of the syenite occur on the Minnesota side," "the second is near the N. ½ of the N. W. ¼ Sec. 25, T. 71—24. At the latter outcrop the rock is porphyritic with feldspar crystals."

In Volume V of the Minnesota Reports it is classed as a hornblende biotite granite, but while there is some micropegmatitic primary quartz, I do not think it would ordinarily be classed as a granite. Orthoclase, biotite, and andesine oligoclase are said to be common, microcline and quartz, perhaps in part secondary, hornblende in part after augite epidote, apatite (secondary?), and kaolin occur. Zoisite is reported (but I suspect may be epidote) calcite, muscovite, and pyrite are doubtful or rare. Titanite and tourmaline are accessories.

So far the observations are of others which my own confirm.

At the falls the river turns and flows across the formation, i. e. across the prominent jointing and at right angles to the general trend of the formation and gneissoid banding of the syenite.

At the foot of the falls it turns again at right angles and flows with the formation S. 71° W., with shelving ledges of the syenite plunging into the water almost continuously on the south side and no exposures on the north side until the islands referred to. At Fort Frances where there is a large amount of fresh material thrown out from the abandoned lock, the syenite is not noticeably porphyritic. The feldspar dimensions are not over 10 mm, usually 3 to 4 mm the mica about the same and across the falls on the American side the grain is about the same, though there are a few larger laths (15 x 2 mm to 10 x 1 mm being measured). At the foot of the falls where the turn comes however the porphyritic texture is plainer, the larger feldspars (but apparently not a separate generation) being 17 x 4 mm. Following down river 176 feet we find them about the same 17 x 5 mm, 264 feet farther a little coarser 21 x 6 mm, 77 feet farther a dike, 209 feet farther another 6 feet wide striking north of the east and dipping south, 60 feet farther another only 3 feet wide, 165 feet farther another 4 feet wide the dip still south, the porphyritic feldspar of about the same size 17 x 4 mm, 60 feet farther on a dike striking S. E. and dipping at a pretty flat angle to the south, 165 feet farther a dike running along shore and dipping pretty steeply to the south, 100 feet farther on it remains about the same text and the feldspar 21 mm or so in length. The grain continues about the same down opposite to the islands above mentioned, where the contact was said to be. The nearly uniform size of the feldspar crystals on the river going along the course S 71° W. suggests that the river here is running parallel to the contact line, parallel to which is the pronounced jointing already mentioned. And this is also indicated by the tendency of the dikes noted to dip off the south. But if so, thought I, why should not the rock be equally porphyritic following the line of strike across the falls of the Canadian side? My first observations were made August 10th, and on August 20th I had a chance to revisit the falls for a few hours and found the explanation in a well marked fault which runs through the Canadian lock, and the syenite which is somewhat porphyritic south of it is not at all so to the north. This fault plane dips 60° to south and strikes more nearly west than the general strike of the irregular intrusive contact probably. The bit of Couchiching at the mouth of the river which we examined appeared to be a bit of the contact rock of this granite in which dikes, probably originally ordinary augite trap dikes were turned to hornblende schist and the original sandstones and shales to hornfels and mica schist.

About three miles east (Sec. 28, T. 71 N., R. 23 E.) are a couple of small islands which we visited where the same general contact is exposed, but the gradual development of the porphyritic appearance is even plainer, as the contact is approached. The northwest corner of the farthest island is farther from the contact. The mica is there coarsest 2 mm, the feldspar 2 to 4 mm, the quartz 1 to 2 mm. There are numerous mica enclosures or secretions. At the south end of this island it is distinctly porphyritic, the larger feldspars, which have irregular contact with, and enclosures of, the others minerals being 15 x 7 mm in size. The mica is about 1 mm, the quartz 2 to 4 mm. An aplitic dike is coarsest at margin. To the immediate contact the porphyritic appearance persists, and there are fragments of the schists in the granite and they are intruded and altered by the gneiss. Other instances have been described by Lawson, and I know no other writer who more clearly recognizes the grain as a function of the slowness of cooling or more exactly described the phenomena. All that I add is a reduction of the matter to a numerical basis, and the inference that while the intruded strata were nearly or quite fused and softened the intruding rocks were considerably superfused, and were therefore not the immediately subjacent strata, but (as Lawson says) in all respects analogous to plutonics generally.

The granite intrusive in the greenstone schists back of Virginia is also porphyritic with red feldspar near the margin.

The Canadians made considerable concession to the point of view of Van Hise, Leith, Seaman and myself in regard to the limitation of the term Huronian and the division of the iron-bearing rocks and it seemed courteous to assent to their views in regard to the use of the term Laurentian, as this was a term of Canadian origin. Historically the Laurentian has been used with an idea of time to include everything thought to be earlier deposited than the Huronian rocks. This usage has been prevalent for a half century in this country and in Europe, and in the leading geologies of various tongues.[2]

Moreover, it seems to me clear that Logan's original and the Canadian usage had consistently recognized stratigraphic divisions in the Laurentian and an Upper and Lower Laurentian and included therein what I take to be probable sediments. But the true correlation of the Upper Laurentian or Hastings-Grenville series with the rocks of the Lake Superior region has yet to be made out. It may be that Logan's Upper Laurentian,

2 See for instance so late a book as Kemp's Ore Deposits, 1903, not to mention Credner, Lapparent, Geikie, Dana.

which contains so much limestone will prove to be equivalent to the Kona dolomite and rocks of the Lower Marquette series, here included in the Huronian. But should they prove to be coeval with the Keewatin series, it would then seem to me decidedly advisable to include the Keewatin-Hastings-Grenville all in the Upper Laurentian. The use of Huronian and Laurentian recommended in the general report of the committee will be nearly accordant with the use of those terms by Brooks and Pumpelly, my predecessors on the Survey. The fact is, as above shown, that Logan included in his original Huronian area, one small area of greenstone schist which is stratigraphically as old a formation as I know of. Moreover he and others had included large areas of similarly granite cut greenstone schists in the Huronian. This same group has also been called Keewatin by Lawson and it would have upset the Canadian ideas and mapping entirely to have counted them as Laurentian, while they can very well be called Keewatin until detailed study shows just what the typical Laurentian should include.

It is a euphonious term, geographic in origin, analogous to the Huronian and Cambrian, well fitted to take its place at the base of the geological column.

The term Archean has had an unfortunate history. Introduced by Dana possibly with some personal feeling to replace Azoic, it was avowedly to avoid the implication of lack of life and to include the earlier fossiliferous strata, and was always used by its eminent sponsor to include both the Huronian and Laurentian, as practically a synonym for pre-Cambrian.[1] It was, however, redefined by Van Hise acting for the U. S. Geological Survey, as pre-Cambrian non-clastic, and though he has since essentially modified his definition and included the Vermilion Iron Range and Keewatin, he would still exclude from it the Huronian and practically any fossiliferous character. It does not seem to me that clear thinking and mutual understanding will be promoted by adding a third sense to the two senses in which Archean has been already used. Moreover the term is not in origin and mode of formation analogous to Huronian. It will not be necessary for me often to use Archean in a sense different from that of the U. S. Geological Survey. I can simply avoid the term. As far as the usage of the Michigan Survey is concerned, the general connection of the rocks of the iron bearing ranges with Canadian Huronian has been recognized by Brooks, Winchell, Rominger and Wright, and as in Canada Brooks applied the term Laurentian to rocks supposed to be subjacent. But there has been much uncertainty as to the relations of the greenstone schists. Rominger included all the pre-Keweenawan rocks in the Huronian. In this I should have had to follow him, had the Canadians insisted that the Keewatin, Marinescan and all like greenstone schists be included in the Huronian, as some of them have been inclined to do.

I may say that, for reasons given above, I do not believe the rocks called Laurentian are a fused, immediately underlying formation and it seems to me that the system agreed upon can only be logically held as a stratigraphic one by those who believe in the subcrustal fusion of Lawson's theory. I do not. But as a temporary modus vivendi until we know more about the correlation of the Huronian and Laurentian it has advantages. The difficulty is that the original Huronian and original and typical Laurentian are in different areas and, as usually happens in all parts of the geological column, while the main points of the various systems are easily assigned there are difficulties in drawing

[1]See Geological Survey of Minnesota, Vol. VIII.

the exact line in all places, and there is a certain overlapping of concepts.

For the present the term Laurentian will be a convenient one under which to group certain large old batholites of plutonic rock.

GRAIN OF LOGAN SILLS, ETC.

I also had a chance to make observations on the grain of the basic intrusives in the iron bearing series, the trap dikes and the Logan sills and may sum up by saying that they generally appear to be in main features like the Keweenawan diabases which I have already described, the grain of the augite being indefinitely fine near the margin, increasing rapidly then more slowly and being almost or practically constant near the center and roughly proportional to the thickness of the intrusive. For instance: In a sill south of Loon lake near Port Arthur we have the following observations:

Augite at 2 feet (609 mm) is in granules 0.1 to 0.2 mm in diameter.

Olivine at 4 feet (1,218 mm) is 0.25 mm in diameter.

Feldspar at contact is sharply idiomorphic, up to 0.35 mm x 0.05 mm, with a second generation, a fine felt, 0.02 mm x .002 mm or smaller; at 609 mm there are sheaves of feldspar of variable size the two generations not so distinct 0.3 to 0.5 mm long; at 1,218 mm it is similar, on the whole distinctly coarser than at 609 mm, but the maximum not so very different, 0.4 to 0.5 mm.

Magnetite at contact is dust; at 609 mm is in triangular skeletal ochahedra about .2 mm; at 1,218 is coarser.

Augite at contact varies from one side of the large section to the other, is not over .02 mm; at 609 mm it is just beginning to be ophitic; at 1,218 it tends to cluster, .6 mm.

The rock appears to be as coarse at 4 feet as at the center of the sheet which was 15 or 20 feet thick. A section collected from near the top of Mount McKay, and from the crowning cap sheet shows a coarseness somewhat proportional, for according to Lawson it must be somewhere near 260 feet from the lower contact. The upper contact is eroded away but I suspect is not so far off, but unfortunately I could not locate either exactly. The lower was covered with debris. The augite patches of luster mottlings are plainly visible to the naked eye. I estimated them as 4 to 5 mm, but measurements on the section show that they are really about 6 mm in diameter. The thin section shows that when they began to grow there were labradorite feldspar laths, small, (.25 x .05 mm) but very sharp, which they enclose freely, while in their growth they pushed the granules of magnetite (.07 mm) and olivine before them. The feldspar continued to grow, and that enclosed near the margin of the ophitic patches is larger than that at the center. Finally in the interstices between the growing augite there was accumulated a probably hydrous solution of alkaline alumo-silicates and chlorides, etc., which reacting formed brown hornblende out of, or rather than, augite, biotite out of the iron oxides and magnetite, and a pegmatitic (granophyric) fringe of quartz and orthoclase (0.3 mm) upon the feldspar laths, and apatite, the most soluble residue presumably either remaining as a ("bergschweitz"), rock moisture in the interstices, as an aqueous solution chiefly perhaps of calcium magnesium and sodium chlorides, or passing entirely out of a given part of the rock to be collected in especial cavities or veins or driven forth. But such interstices are not visible, and may be supposed to amount to but a fraction of a per cent. as in the Light House point dike. The ophitic texture is thus not confined to effusive rocks entirely, though it is apparently not so conspicuous in the corresponding trap dikes and sills as in the effusives because the grain of the feldspar is usually much coarser in the former. It is however possible that the ophitic texture should be combined with the acid interstices which I have described as an acid intrusive texture. It is worth noting that these acid interstices resemble those ophitic "redrocks" which I have slightly touched on in connection with Mount Bohemia,[1] and have been described by Irving,[2] and the Minnesota geologists, Winchell and Grant.[3] While I can hardly go so far as to say with Winchell that the "gabbro and the redrock were simultaneously in a state of mobility," I have no doubt that they were consanguineous and that the redrock was intruded before the black rock, the gabbro, was cool. At Duluth I had a chance to examine once more in the quarry, four blocks west of the Spalding House, exposures of the Duluth gabbro and the red rock. The gabbro is full of large labradorite feldspar rhyocrystals, arranged in flow lines, up to 3 cm long. Near the bottom of the quarry is an intrusion of red rock. That it was injected soon after the gabbro is shown by the following facts: (1) the contact is closely welded; (2) it does not follow straight joints but runs irregularly; (3) near the center of the quarry it seems to saturate the gabbro, which appears redder and almost as though remelted; (4) the red rock has a decided grain at the margin even in 3 and 4 inch seams sometimes even coarser than at the center but in general is uniform in grain, showing that the country rock (the gabbro) was near the conditions of consolidation. Two possible hypotheses not altogether incompatible occur to me; first, that the acid interstices are the deposit of the last remnant of a hydrous magma, and secondly, since a hot rock cooling and crystallizing becomes denser, so much of this process as had taken place after it had hardened enough to fix the general form, which would produce a sugary granular texture unless new matter was sucked in, had done so and that this matter had which crystallized in the form of these red rocks. N. H. Winchell (p. 98) speaks of "the penetration of the acid element into the basic along contacting"(contracting) "zones through the agency of mineralizers during the period of cooling." To this phenomenon he attributes the micropegmatite structure, and uralitic augite with chlorite and a reddened state of much of the feldspar, and is practically the second suggestion above.

If it can be shown that there is a certain eutectic ratio of silica to alkali, and that in the process of crystallization of a basic magma there is no tendency for the silica to increase above that ratio, which I have suggested may be 12:1, and that the red rock contained silica in excess of the ratio we could not consider it a remnant. The following analyses are from Mount Bohemia and No. 12 represents the red rock there, and in this case the alkalies are in excess of one-twelfth the silica. But similar analyses in some respects of a similar rock is given in volume V of the Minnesota reports, p. 89, and in that the silica is in excess.

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[1] Volume VI, part 2; Annual report for 1903, p. 236.
[2] Copper bearing rocks of Lake Superior. p. 119.
[3] Vol. V, p. 59, 87 to 102, 978, 981.

MOUNT BOHEMIA ANALYSES.

April 16, 1904.

	No. 9.		No. 12.		No. 21.		No. 37.	
SiO_2	46.01	.767	62.28	1.036	44.91	.742	47.01	.783
Al_2O_3	16.95	.166	17.54	.172	18.01	.176	17.80	.175
TiO_2	2.48	....	.98	....	2.54	....	2.19	....
Fe_2O_3	5.14	.032	1.55	.010	4.50	.028	5.32	.033
FeO	9.83	.137	5.64	.078	7.64	.106	6.59	.092
CaO	6.71	.120	3.44	.061	7.49	.134	5.31	.095
MgO	6.20	.154	1.51	.038	7.67	.192	8.75	.219
K_2O	1.71	.018	2.97	.032	1.33	.014	1.58	.017
Na_2O	2.22	.035	4.26	.069	1.75	.028	2.00	.032
	97.25	1.429	100.57	1.496	95.84	1.420	96.55	1.446
Alkalies	....	.053	....	.101	....	.052	....	.049
Alkalies: SiO_2	....	.69	....	.97	....	.70	....	.625

L. KIRSCHBRAUM, Analyst.

Of these analyses No. 9 is the unaltered ophite, No. 12 is the red rock dike in the gabbro, while numbers 21 and 37 are from the ophite altered and recrystallized by the gabbro, showing hornblende zones around the augite. The figures on the right are molecular proportions.

GENERAL REMARKS ON THE IRON RANGES.

I have handled together for convenience the notes of my trip which refer to grain observations and those bearing on geological problems. We will now return to some other observations.

This trip gave me a chance also to see something of the vast supplies of ore on the Mesabi range, and the systematic way in which that range has been tested by holes each 300 feet apart.

In one tract of 200 acres there are said to be 120,000,000 tons of ore. It is fortunate for Michigan that the large owners there are also large owners on the Michigan ranges, and that there is a real economy of ore in mixing them. If it were left to cut-throat competition it would seem as though some of the Mesabi mines might, by wasting part of their ore and sacrificing much of their profits, put all other mines temporarily out of business. It cannot be doubted, however, that the present policy is the best in the long run.

Another feature that I noticed was that in points huge piles of waste stripping had to be rehandled again to make room for more extensive exploration. Down near Ishpeming, on Sec. 21, T 47, R 27, a great bluff of lean ore is being mined which when I was over it a few years ago was not considered worth mining. So on the Gogebic range the tendency now is to have foot wall shafts. The moral is that on planning work, dumps, shafts, etc., provision should be made for the future and the geology considered so as to make everything as permanent as may be, and generally speaking everything conveniently placed on the footwall side. It may also be worth while to stock pile for future use rather than stow underground rock too lean to work at present, down to say 35% iron.

Passing from the Marquette range we went to the Gogebic range where we found the section to be given in connection with our Black river work, which may be briefly summarized here:

Neo-Huronian. Greywackes and black slates—Tyler slate.
800. Iron bearing formation, cherty carbonates and slates ferruginous chert characteristic—Ironwood formation.

An apparently slight unconformity.
400. Quartzite and then red and green slate of the Palms formation, with a few narrow bands of basic tuffs. The base is a conglomerate with pebbles of dolomite, red jaspilite, granite, etc., on the granite—Palms formation.

Large unconformity from Ironwood to Bessemer.
Granite cut by various trap dikes altered to hornblende schists, and itself intruding, for instance near the Ironwood water tower, some very curious amphibolites—Mareniscan-Laurentian.

At Wakefield and Sunday lake there is a fault or possibly a very sharp fold by which this old greenstone schist series with veins of red granite or syenite is well exposed south of the lake, Sec. 16, T 47, R 45, while farther south is the iron series. But the iron series also appears on the north side of the lake close under and in close contact with the labradorite porphyrite which forms the base of the Keweenawan, and being devoid of cap hard ore jasper occurs.

There have been frequent rumors of late of an iron range south of Bessemer. None has been reported by any previous geologist, the country being supposed to be all Laurentian granite. Yet it is not impossible, and it might be worth while to continue the work of the Black river party of this summer by making a section from Bessemer to Wakefield southward.

Around Tower the greenstone schist series and especially the spheroidal greenstone were well developed and folded in or at times included either by shearing, or some process of filtration were bands of iron bearing jaspilite. But these things have been so fully set forth in the U. S. Geological Survey Monographs that I need not repeat them here. I will only make one comment. About six hundred paces south of Tower the greenstone schist series is cut by a porphyry which contains porphyritic oligoclase feldspar (of 2-4 mm.) Leith says it was as a field name called, and very fitly, the white-eye porphyry. It also occurs on the islands of Vermilion Lake and is there extremely hard to distinguish from a conglomerate or arkose composed of its debris. Now this feldspar matches exactly the oligoclase of a granite which is frequent in boulders of which these porphyries are but apophyses. Here again as usual the granite is intrusive in the oldest sedimentary series, the greenstone schist series, and I have never found it otherwise.

LAKE SUPERIOR GOLD MINING.

This excursion also gave me an opportunity to get a view of the Lake of the Woods, Rainy Lake and Seine River Gold Mining regions, and a glimpse of the mines. The general geological conditions are quite similar to those north of Ishpeming, the Ropes and Lake Superior Mines, a gold region where gold mining is now suspended. Mining is also at a low ebb in the Canada regions, only the Sultana being fully at work as a going and apparently well-paying mine. And yet the geological conditions appear to me to be not unfavorable for an established industry and worthy of careful investigation. In both regions the gold mines are located in a series of old, generally green, rocks, which underlie all the principal iron ranges but the Vermilion, and are apparently of about the same age as that. They are the greenstone schist,—Keewatin,—Mareniscan. In both they occur in solid quartz veins, most of the rusty upper part having been removed. In both fine specimens of free gold occur, but the bulk of the ore is of low grade. In both the subsequent disturbance of these old rocks makes it hard to follow the chutes of ore.

These old rocks have in Minnesota and Canada been called the Keewatin. Around Rainy Lake City an abandoned stamp mill and a couple of log houses of the American mine are signs of the former boom, while two or three houses serve as rendezvous for fishermen and homesteaders, who take the tug for International Falls and Fort Francis here. On the north side of Shoal Lake, in the Seine river district, the rather extensive equipment of the Foley Mine is idle, and the village of Mine Center has every symptom of a burst boom, though I believe a little work is yet being done on claims not far off. The town is practically on an island, composed of conglomerate which fringes the north shore of the lake and overlaps unconformably a granite, the Bad Vermilion granite, which, together with a gabbro, is said to cut the Keewatin schists, and these two igneous rocks seem to have had something to do with the concentration of the gold. At the Lake of the Woods things are a little better. The country rock is still mainly the same greenstone schist series of crushed felsitic or basic rocks, making light-colored or green schists and pieced by a variety of igneous rocks. Mainly the explorations are in the basic rocks. I believe, though, at Gagneau's island there is an abandoned shaft 80 feet deep in an altered porphyry impregnated with pyrite.

The Sultana Mine is, however, working and appears prosperous. It is exploiting three or four veins, which lie near the contact of a diorite (which is accordingly quite porphyritic), with a volcanic agglomerate of the greenstone schist series. I understand that ore worth less than $7 to $8 a ton in gold can hardly be worked, and that much of the material raised from the Sultana will run from $14 to $15 a ton.

There is a custom stamp mill at Rat Portage, belonging to the Dominion Company, idle at the time of our visit, with Frue vanners, etc. This is only a few yards from the magnificent water power of Hebe Falls, and one would think could be very economically run by the same. As a whole, this district of greenstone schists along the international boundary has yielded perhaps a million and a half of dollars.

Now the gold region of Michigan is located in exactly similar conditions. Running west from Marquette and passing but a mile or two north of Ishpeming and Negaunee and bounded and overlain unconformably by the basement conglomerates of the regular iron bearing series of Negaunee and Ishpeming on the south and cut into by the granites on the north, and by a great many other igneous rocks, including some important masses of peridotite, is a series of green, largely volcanic, rocks, which correspond in composition and geological position to the Keewatin of Canada and the Lake of the Woods. They are known as the Kitchi and Mona Schists by the U. S. Geological Survey, the two terms indicating merely different degrees of alteration. In this series the gold product of Michigan, amounting to over half a million of dollars, has been found. The first discovery of gold in Michigan was made by State Geologist Douglass Houghton near the very region where gold has later been mined. In his biography by Bradish (p. 107), S. W. Hill is reported to have said:

"He was sent up with a party of men to where Negaunee now stands, and they pitched their tents a hundred rods northeast of the city, where the doctor was operating at the mouth of the Chocolate river. One day the doctor visited their camp to see how they were progressing at that end of the survey. He arrived at the camp in the afternoon, and, after resting and refreshing himself, he took a pick and went out among the hills. Returning just before darkness set in, he said; 'Mr. Hill, are you aware we are in a gold region?' Mr. Hill replied that he was not. 'But,' said the doctor, 'we are;' and he took some specimens of rock from his haversack which were quite richly charged with gold. Mr. Hill asked the doctor if there was much of it. Dr. Houghton answered that he had not examined the ground very closely, and also said that he did not wish anything said about it just then, as they had already had some trouble with the men, and if these should become aware that they were in a gold region they might desert them to hunt it for themselves.

Unfortunately, that fall Dr. Houghton was capsized in a squall at Eagle river and drowned, and all his notes were lost with him. Mr. Hill says the doctor came from a northeast course—not from the northwest, as I have been previously informed—and that he could not have been over a mile or so away, which would be about on the range with the Ropes vein."

This would indicate that the gold was found in the Kitche and Mona Schists, northeast of Teal Lake, almost in the line of strike of the Ropes Mine.

The second chapter is due to Mr. Julius Ropes, of Ishpeming, who opened in 1881 the Ropes Gold and Silver Mining Company on the south half of the northwest quarter of Sec. 29, T. 48, R. 27. Here hornblendic rocks of the "greenstone schist" series, often known as diorite, are cut by peridotite,[1] and near the contact much talc and many gash veins of quartz are found. The gold is not confined to the veins, but impregnates the country rock more or less. The peridotite has been altered, yielding serpentine, talc, ferro-dolomite, etc. The mine published full and instructive reports, which are embodied in the reports of the Commissioner of Mineral Statistics, but was hampered by a lack of capital and experience. The owners could not stand and did not declare heavy initial assessments, and it was never possible to open up far ahead or do as much selection as would probably have been wise. In 1886 from 6,959 tons of rock, with a tailing loss of 95 cents to $2.50 a ton averaging $1.90 a ton, the mine produced $43,499.93, or $6.20 per ton net, or $8.10 per ton gross. In 1888, however, 10,216 tons only yielded $34,930.66, while the loss in tailings is said to have been from 90 cents to $1.50 a ton. In 1891, 31,578 tons of rock yielded $65,240.67 net. The mine continued in operation until 1897, having been a considerable help to the city of Ishpeming in a season of dull times, and having produced $647,902.37 out of the $666,485.73 with which the Ishpeming field is credited. It had sunk about (15 levels) 850 feet and drifted 400 to 500 feet. Some very rich rock has, however, been found on other locations, and I am inclined to believe that the above total for the district does not include many thousands of dollars worth of gold carried off as specimens or stolen. Some of the other places which have been developed for gold are:

N. E. ¼ of N. W. ¼ Sec. 35, T. 48, R. 28, 275 feet west of the east line (Gold Lake and Superior). Specimens of this vein showed much free gold and assayed as high as $40,000 a ton.

The same vein runs east and west through the next property: N. W. ¼ of N. E. ¼ of Sec. 35, T. 48, R. 8, just east (Michigan Gold Mining Co.), and was wonderfully rich in gold near the surface, yielding $17,699.36 in a few months.

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1 Wadsworth, 1891 report p. 143.

Sec. 36, T. 48, R. 28, has also yielded gold.

On Sec. 26, T. 48, R. 28, were the Peninsula and Grayling Companies.

On Sec. 21, T. 47, R. 27, was the B. & M. and the Fire Center Gold Mining Company was also near Dead River.

The Ropes Gold and Silver Mining Co. closed down in 1897, was bought at the auction sale of the receiver in 1900 by Corrigan, McKinney & Co. for about $12,000. They are said to have recovered from the amalgam plates with the gold contained alone more than the total purchase price. They removed the machinery and thus ended the second chapter in the history of gold mining in Michigan.

But I believe there are yet chapters to be written. Such competent and impartial judges as Newett and Lawton have expressed the opinion that the Ropes could be a paying mine. If it had had, as many of the copper mines have had, a half a million to start with, it might have paid dividends, worked continuously and opened up ahead. Our field has hardly been tested. We have seen that these rocks in which the gold occurs are extremely old. It is also probable that the disturbances which led to the concentration of the gold are very old, certainly before the last ice age, which has probably removed the most friable and easily crushed and richest part of many of the lodes, probably before the formation of the Lake Superior sandstones, and quite possibly earlier yet.

It is therefore not beyond the bounds of probability that the gold of the eroded part of the veins may have collected in rewashed glacial gravels, or at the base of the Lake Superior or Potsdam sandstone, as quarried in Carp River, or even in yet older conglomerates.

I am informed that up in the Lake of the Woods region and in other places in Canada the glacial gravels yield almost enough to pay to work, and it is liable to be so here.

Moreover, there are other areas of serpentine and large areas of greenstone schists which have hardly been touched. Gold has also been reported by Prof. C. D. Lawton from the Menominee river, south of Quinnesse and in connection with some of the iron ores.

BLACK RIVER WORK.

The resignation of Dr. F. E. Wright early in the spring to accept an urgent call of the U. S. Geological Survey was disconcerting, especially as it was desirable that he personally should finish some of the work which he had begun. This in fact in leaving he still hoped to do. It seemed to me that it would aid him in his task of unravelling the relatively complicated structure of the Porcupines to have a careful geological section of the copper bearing or Keweenawan rocks to the west, where they ran more regularly, as well as to the east. This would bring out the persistent horizons, and would also be worth doing in itself, and was suggested by Mr. L. L. Wright of the Board. I therefore made a trip to the Gogebic range early in the spring and with the aid of L. L. Wright of the Board examined the country north. The region is traversed by three rivers which starting from the granitic area (Laurentian) that occurs along the Wisconsin line flows across the Iron range and the copper bearing rocks. Of these the Montreal and Presque Isle had been the more carefully examined by Irving and others in his examinations for the Wisconsin survey and in his well known and admirable Monographs for the U. S. Geological Survey on the Copper Bearing Rocks of Lake Superior[1]

[1] Monograph V.

and the rocks of the Penokee Gogebic range. A hasty examination of the Montreal made it seem to me unlikely that new facts of so much interest would be gathered there as on the Black river. For his knowledge of this latter Mr. Irving depended on second hand information, not of trained geologists, and by some error, probably clerical, the work of the Chippewa Mining Co. on Sec. 32, T. 49 N. R. 46 E., was considered to be Sec. 22. The building by the State of the Black river road made the section by the river quite accessible, and my visit early in the spring and information of a former member of the Survey corps, County Surveyor George Rupp, indicated so many outcrops as to make it likely that a close geological survey would be rewarding. I accordingly instructed Mr. W. C. Gordon, whom Dr. Wright had recommended to succeed him, having been his assistant in 1903, to take charge of a field party to survey a strip of country four miles wide including the river from the lake to Bessemer.

His report and map I hoped to append to this report. I joined him during part of September and October. I have asked him to work my field notes with his. The results were even more rewarding than I expected.[1] For the first time in Michigan we found a westward extension into Michigan of the gabbros so widespread in Minnesota that were known to extend to Bad River, Wisconsin. I consider the evidence clear that it is a deep seated intrusive in the Lower Keweenawan. The feldspar tablets are often 2 to 3 decimeters in diameter, and the magnetite 5 to 8 mm across, so that its age is probably not earlier than middle Keweenawan. We found the upper intrusive contact well exposed. We found a felsitic horizon near North Bessemer which is, I think quite likely, that of Mt. Houghton and the Bohemia conglomerate No. 3. We found the great belt of ophites (lustre mottled melaphyres—see Plate XVII,) some quite coarse, which are the central part of the Keweenawan formation. The Chippewa Bluff felsite and associated beds appear to be near the horizon of the Ash bed series (Hancock West No. 17) and various beds above, the Nonesuch shale, outer conglomerate, lake shore trap, etc., were identified substantially as by Irving. Gordon was then able to obtain a fairly continuous section of the Keweenawan rocks from near Bessemer to the lake, and it appears, contrary to my expectation, that in this geological column of about 40,000 feet there is no important repetition by faulting to be proved. Irving's estimates of the thickness of the Keweenawan are thus confirmed. It does not necessarily follow, however, that all the 40,000 feet ever formed in a continuous vertical pile. Many evidences of unconformity within the series such as exist between the Keweenawan and underlying series also exist. In fact just here there are more evidences of unconformity between Upper and Lower Keweenawan than between Lower Keweenawan and Animikie, for the upper conglomerates have a much gentler dip and contain pebbles not only of jasper, but also of agatized amygdaloids and various other rocks of the Lower Keweenawan including various of the "red rocks" already described which were probably deep seated intrusives in the Lower Keweenawan and could have been yielded as pebbles to the upper beds only by considerable erosion of the lower. But though the south range does not appear due to be a mere repetition by faulting, but petrographically independent, there is faulting in plenty. Even in the spring it had been suggested to my mind that there was faulting. Conversation with Mr. J. R. Thompson, agent of the Newport mine, who thinks that most of the gaps in the copper

[1] Southeast part of Sec. 4, T. 47 N. R. 46 W.

range mark faults, when I visited the iron ranges with the international commission confirmed this impression, and careful study shows that he is probably quite right and gave undisputable evidence of extensive faulting across the formations. The Black river valley follows a fault most of the length as Gordon will describe more in detail, and within the four mile belt of his survey there are four or five similar faults. But while these faults in the Keweenawan have very considerable throws, back in the Iron range the amount of the throws are much less, though Mr. Thompson has found evidences of much faulting of similar nature. I made a little examination of the granite a little farther south, especially on Palms and Colby Hills and while there was evidence of jointing and veining and throws of a few millimeters parallel to the faults of the Keweenawan the amount was very minute. It is as though the whole country had been subject to the same type of stress, but the strain was possibly greater and the yielding thereto certainly greater as one goes progressively northward.

The most natural way in which one can easily conceive mechanically of a fault like that of the Bessemer fault with a horizontal throw Gordon computes of about a thousand feet and next to nothing at the granite but a mile or two away, is to suppose that there are also strike faults and that there has been slipping up and down on these faults but much greater in some places than in others. Of such strike faults Mr. Thompson has indeed found evidence, but curiously enough the throw in them appears almost strictly horizontal as though the gabbro in intruding from the west had tended to shove the strata westward ahead of it, while the granite acted as a resistent medium. But if it also crowded up or kept from collapse the block of strata west of the Bessemer fault it could produce the apparent displacement of the Bessemer fault. This faulting however displaces the Keweenawan dikes, the quartz diabases. It is worth noting that most of these latter dikes appear to have preceded the faulting. Many of them strike toward the Porcupine mountains as though that were an old focus of eruption or of stress.

The map prepared by Gordon is typical of the country west of the Presque Isle river and a section north through Ironwood should show essentially the belts and the same kind of faults. I see no reason why the Black river valley should not be a copper producing center, as well as that of the Ontonagon or Portage lake. We have the same variety of rocks, about as great topographic differences, and as much faulting.

The river has dead water for a half mile above its mouth. Dr. Wright in his report last year called attention to the fact that the water level of Lake Superior has been rising, drowning the mouths of the rivers.[1] Thus though a bar has formed across its mouth dredging would make a tolerable small harbor.[2] The river which is quite largely spring fed, shows a minimum horsepower of something like 125 H. P. for each ten feet of fall. It may be too far ahead to look to the time when there shall be a nice little port at the mouth of Black river, with a sawmill, lights and electric line to Bessemer and to mines back up the river, run by waterpower electrically transferred, which shall ship hemlock bark, lumber and copper concentrates, and receive supplies for copper and iron mines, but there is nothing geologically impossible in the vision. It is probably only a question of the willingness and ability of those who would profit by it to do the necessary development.

The dead water ends in falls. Thence above the river to the falls (on Sec. 32, T. 49 N, R. 46 W.) opposite Chippewa Bluffs, there is a rise of 380 feet

[1] Annual Report for 1903, p. 38; this report p. 104.
[2] The U. S. Engineers have reported on this project.

250 232 202 172

APPROXIMATE DISTANCE FROM MARGIN, IN FEET:

4 13 28 43

LUSTER-MOTTLING IN DRILL-CORES OF OPHITES.

and up to Sec. 30, T. 48 N., R. 46 W., as Gordon's map shows, there is over a hundred feet of additional fall available along the Black river road, mainly in rapids, with clay or rock foundations for water power.

Observations on the river[1] show that much of the way it cuts through

Date.	Gage readings.	
1904.	A. M.	P. M.
Sept. 26	8.6	9
Sept. 27	8.5	8.5
Sept. 28	8.5	8.5
Sept. 29	1.2	1.3
Sept. 30	1.5	1.5
Oct. 1	1.4	1.4 (1.38)
Oct. 2	1.3	1.3
Oct. 3	1.25	1.2
Oct. 4	1.15	1.1
Oct. 5	1.1	1.1
Oct. 6	1.15	1.15
Oct. 7	1.15	1.15
Oct. 8	1.15	1.2
Oct. 9	1.3	
Oct. 10	2.1	2.22
Oct. 11	2.3	
Oct. 17		(1.5) at 2.30
Oct. 24	[2.8]	
Oct. 29	[3.4]	
Oct. 30	[3.3]	

The gage readings were taken twice a day usually about 7 in the morning and 5 in the evening, but not with strict regularity. Observer generally J. G. Côté. Observations in parenthesis A. C. Lane, in brackets J. W. Vogtlin. Low water is not much below 8.5 I think.

sand into clay and its floodplain is lined by a swampy strip next the bluff fed by frequent springs. So that we should expect its runoff to be quite constant.

A section was also taken at the gage and 25 feet above as follows, beginning at a point opposite gage:

At gage. Feet.	Depth.		25 feet above gage. Depth.
32	0	waters edge	0
37	.40		.30
42	.65		.67
47	.66		1.01
52	.70		.98
57	1.00		1.11
62	1.20		.91
67	1.37		.92
72	1.44		.82
77	1.60		1.00
82	1.96		1.07
87	1.82		1.05
92	1.86		1.16
97	1.74		1.55
102	1.58		1.79
107	1.59		2.32
112	1.70		2.68
117	1.39		2.33
122	1.33		1.90
127	1.28		1.32
132	.89		.62
134	.85		bank.
135	.00		bank.

[1] A gage was set on Sec. 17, T. 48 N., R. 46 W,. at the Narrows as shown. The gage was braced against an overhanging cedar in which a notch was cut and a nail driven at 4.5 of the gage, which is about the level of the flood plain.

Bank being cut vertically about 5 feet high into heavily wooded flood plain.

The cross-sections at this point seem to be in the one case 130.46 square feet and upstream 124.07 or say 125 square feet as an average for a gage height of .8. Observations of maximum velocity with floats check remarkably well in discharge curves, considering how rough they are.

At 0.86 on the gage the maximum velocity was 25 feet in 23 seconds.

At 1.38 on the gage the maximum velocity was 25 feet in 13 seconds.

At 2.2 on the gage the maximum velocity was 25 feet in 7 or 8 seconds.

These correspond to 1.1, 1.9 and 3.1 feet per second. For every foot increase in gage height I estimated the increased area by a formula [103+12 (a–.86)] (a–8.6) where a is the gage reading. The minimum discharge is not far from 110 cubic feet per second. The area above the gaging station I have not yet accurately computed; using Chas. Cumming's estimate in the Michigan Engineer for 1904, and subtracting 30 for the part of the basin below the station from 250 square miles gives 220 square miles or a low water runoff of .50 cubic feet per second per square mile. Comparing this with the records in Water Supply paper No. 83, pp. 246–262 of Upper Peninsula streams, we note that October is a month of low water, and that the runoff per square mile is comparable with the Dead River near the Hoist and the Carp.

DRILL CORE PRESERVATION.

I have also spent some time in studying the records of explorations and diamond drill holes by the Arcadian, Atlantic, St. Mary's, Wyandotte and Winona companies, but a report on the results of the same is not yet ready. The bulk of the material examined is, however, in that belt of ophites, which may be taken to be the center of the Keweenawan formation and is overlain by the ashbed group of melaphyre porphyrites and conglomerate 16 and underlain by conglomerate 3 and a group which contains many coarse Labradorite porphyrites.

I am invited to look over much more material. There are thousands of feet which would be sent us for examination if I had the place to bestow it. But we are crowded. In the meantime records of great interest to the geologist, and of practical value as well, which could be preserved to science for the mere cost of storage but have cost from $3.00 to $6.00 a foot to private parties who would generously put the information in the hands of the Survey after they have made their immediate use of it, lie mouldering in sheds, much exposed to fire and accidents which in displacing them will make their story forever illegible. It must be remembered that drill holes are rarely sunk but for one or two objects, for signs of copper, ore bodies, coal, salt, etc., and are scanned at the time with that object alone in view. The information they may incidentally afford in other directions can never be foreseen and is not obtained by those who examine them. This is not said in any spirit of criticism of the mining engineers for a similar remark might be made of my own work. One can never tell when some peculiarity that one supposed to be trifling may not prove of great importance. Even if I as well as others have examined the records it is well that they should be preserved. And whereas surface outcrops can generally be revisited, diamond drill cores can only be duplicated at a cost of thousands of dollars.

I would suggest therefore that a library of these stone records should be created, at some central point, preferably at the College of Mines, into which all the drill cores could be collected. It should be absolutely fireproof, of concrete and steel. Wherever, and so long as desirable, the location of drill holes could be kept secret, being deposited in sealed tin boxes.

OPHITE.

There is one point, however, concerning which I have had inquiries, namely the term ophite, a term not original with me but which I first introduced into use in Lake Superior literature. Ophite is a shorter name for the kind of rock which Pumpelly called lustre-mottled melaphyre, and is used, whether the lustre betrays mottling or not and no matter what the coarseness of texture may be, for those flows which are composed very largely of feldspar tablets enclosed in crystalline patches of augite. The interstices of the augite have not the same hardness as the augite and are more easily decomposed. So that there is a lumpiness or a weathered surface, which I have illustrated in Pl. VII, Part 1, Vol. VI., as well as a mottling of luster, and on a ground surface like that of a pebble or drill core a mottled pattern is also brought out, which becomes coarser the coarser the augite grains are and the farther from the margin. This is shown in Pl. XVII. The rate at which this coarsening takes place is not absolutely uniform, depending on the composition of the flow, its temperature when it began to cool, and that of the rock over which it flowed and other factors. Yet an examination of the Isle Royale drill cores led me to the conclusion that for the majority of the Keweenawan ophites the following formula was true: $16\ (y \pm 1) = x + 20$ in which y represents the linear diameter through the larger patches in millimeters (305 mm = 1 foot) and x = the distance from the margin in feet.[1] The plus or minus term represents the range of error in getting the coarseness of the grain and all other sources of error. A still rougher formula is that the mottling is in proportion to 1 inch diameter for 400 feet distance.

I have reproduced as Pl. XVII for this report drill cores at the depths noted in St. Mary's Mineral Land Co. drill hole No. 5 a vertical hole. I take it that the dip of the strata is 59° and that the bottom of this ophite being at 257 feet in the drill hole they are really respectively 4, 13, 28 and 43 feet from it. According to this by the rough formula the diameter of the mottles should be .25, .82, 1.78, 2.73 mm respectively and by the closer formula 1.5 mm, 2.05 mm, 3 mm, and 3.93 mm respectively with a latitude of a millimeter. In a first quick estimate as I walked over the core boxes I put the grain of the sample at 245 feet at 1 mm, that at 228,2 mm, at 202,3 mm and 172,3 mm. I will leave it to the reader to say what the size of the mottling appears really to be.

I have had no thin sections made yet and it was upon measurements of these that the formula was based. I think it is plain, however, that with the naked eye one can tell somewhat nearly what the grain is and whether it is becoming coarser or finer and have some idea how far off the next amygdaloid is by comparing with the cores shown in the plate.

WELLS AND BORINGS.

Our notes on wells may be divided into two classes. First we have those which are of comparatively moderate depth and put down for water, like those at Battle Creek, Holly, etc.

All our notes on this subject are going into the hands of Mr. Frank Lever-

[1] This is a correction of the misprinted formula on p. 129 of the Isle Royale report, which as is obvious does not agree with the figure opposite.

ett, who is preparing a water supply paper for the U. S. Geological Survey on this subject to replace my papers 30 and 31 which are out of print.

Mr. Leverett and I have been conducting a series of observations on the temperatures of relatively shallow wells, 10 to 200 feet deep, with the object of finding out what indication the temperature is of the depth of the source and how it is affected at different times.

In regard to deep wells, we shall hope to take this matter up for more careful treatment in the report for next year. The following letter from Mr. Ellinger is, however, of current interest[1] and we will also include a few wells of some especial interest.

LETTER REGARDING OIL NEAR ALLEGAN.

Fremont Station, Seattle, Wash., March 20, 1904.

Alfred C. Lane, Lansing, Michigan.

Dear Sir—Your letter of the 7th just reached me. You will see from the above that I am far away from home. Now in regard to the borings in Allegan, will say that four more wells were drilled since I sent you samples.

I forgot whether I reported to you or not that we shot No. 2 well. Now if my memory serves me right I think not, so I will give you a history of it. The well produced some oil; say two to three barrels per day of 24 hours. Not being satisfied with this after pumping it for several weeks, I suggested having it shot and ordered 20 quarts of glycerine; realizing that would hardly be enough to clean itself and also afraid to use more, on account of the shallowness of the sand. If we had used two shells instead of one it would have shot into the blue shale and filled up our well. So we thought we would try one shell of twenty quarts. The result was, after the shot went off it failed to clean itself. By this I mean there was not power enough behind to throw up all the rubbish onto the surface and leave a clean hole. As soon as the report was over I run the sand pump down and found it was bridged over, so I run the measuring line down to find out where the bridge was; we located it in the blue shale.[2] I then ordered the drill sent down to clean it out (which was a little dangerous of getting fast on account of the caving in). Being very careful we broke the bridge and got an opening to the oil. We then cleaned it all out with the sand pump and brought up oil. We then put down the tubing and commenced to pump oil and salt water—more water than oil. After pumping several days I noticed gas escaping at the mouth of the well; so adjusted a 1″ pipe to the side of the drive pipe and piped the gas to the fire box under the boiler, which almost made fuel enough to pump the well. We pumped the well steady for over two weeks day and night into a 100 barrel tank and measured the amount of oil it would produce, which was a little over three barrels per day of 24 hours. We then shut down about four hours, then the salt water accumulated so fast it shut off our gas. We again pumped the well for four weeks, but could not notice any increase, so we shut down again for a few days. After pumping off the head and getting below the gas vein I detached the 1″ pipe from fire box and turned it up perpendicular and lit the gas to demonstrate to the public that we had gas as well as oil; it burned a blaze about five feet high and would continue so as long as we pumped the well and kept salt water down. We believe we made a good test of this well but found that there was not oil enough in it

[1] Grand Rapids Herald, 1: 30: 1903. M. Egan of Washington, Pa. was hoping to try again.
[2] See Plate IV of Vol. V. Lane.

in paying quantities so we abandoned it. In less than four weeks after oil came within two feet of the mouth of the well and never lowered. A year ago a firm from Ohio took all the casing and drive pipe out of the wells in town.

Our No. 3 well on the hill was similar to No. 2 as far as shales and limestone was concerned. We struck sand at 1,328 feet and drilled down to 1,411 feet—no show of gas or oil; but the sand when first struck was the best showing for oil I have found in Michigan. I mailed a sample of it to experts in Ohio who pronounced it fine oil sand. A party from Pennsylvania drilled a well about one mile due west of our No. 3. I watched this well every day while drilling and was there when oil was struck which amounted to about a 10 quart pail full. Oil was struck after 1 o'clock at night so drilling was shut down until morning. I was there at 6 o'clock when they commenced to steam up and let the sand pump down which brought up nothing but salt water. This well was at once abandoned. Two years later the Bangor, Mich., people hired me to oversee the boring of a deep well. The contract was let for a deep well 2,500 feet unless gas or oil was found sooner in paying quantities. At 1,180 I think (I have mislaid the record of it) salt water was struck which amounted to several barrels a day. This was a very difficult well to drill owing to the hardness of the rock at that depth. The contractor threw up the job and after weeks of waiting another party took the contract to finish the hole. The deeper he went the harder the rock and the more salt water which soon filled up the hole to about 600 feet, and at about 1,205 feet he pulled out his tools and threw up the job. I saved samples of this well and ordered them sent to the State Geologist by a party in Bangor.[1] I was called away and could not attend to it.

A little over a year ago two more wells were drilled in Allegan by Pennsylvania people; a little oil was found but not paying. Over five thousand acres were leased. The party died and the leases were returned. Last summer another party wanted to lease and drill a test well but people around Allegan would not lease so he went back East.

This I think ends the Allegan oil business. I became discouraged and moved to this state. I truly believe oil will never be found in paying quantities around Allegan—you might find small pockets but that is all.

Now Mr. Lane if there is anything more you wish to know and I can answer it will be pleased to do so. I surely would be pleased to receive your annual report for 1901 if you think I am entitled to it. Hoping I have answered all satisfactory, I am,

Yours respectfully,

(Signed) J. G. ELLINGER.

Personally I believe the time is near at hand when wells that run two barrels a day will not be sneezed at. The formation struck in these wells is the Dundee or Corniferous of Canada and Port Huron, where none of the wells are great producers but they tend to be durable.

UPPER PENINSULA.

In regard to the Upper Peninsula, and in connection with Prof. Russell's paper the record from Manistique in the annual report for 1903 (p. 140) should be consulted. Another well just outside the state in Marinette is of interest as confirming my theory that that part of the state is underlain by

[1] These have never been received. I have vainly tried to locate them. Information thankfully received. Lane.

the Huronian iron bearing rocks at no great depth. This well is only 8 feet from the one reported on in 1903 (p. 130) and struck it about 860 ft. so that hereafter the water discharged through the old hole. On the old tools the new deflected and went down to 978 feet. Mr. H. B. Simcox who kept a careful set of samples is inclined to believe that the oil comes from vugs in the limestone as at Rapid River, rather than works up from below. He says that at 435 feet the two wells were in the same bed and it appears from a geological map that they started in nearly equivalent horizons.

In consequence of comparisons of samples it seems possible that there is a hundred feet error in the facts given in 1903 (p. 123) as regards Oakwood.

MARINETTE WELL.[1]

Surface sand and gravel	69	69
Galena dolomite	121	190
Trenton dolomites, brown and blue shaly (at 260 to 275 sandy)	135	325
St. Peters sandstone	75	400
Calciferous (Lower Magnesian)	180	580
Potsdam	215	795
PreCambrian.		
Cherty or jaspilitic arkose quartzite	183	978

I think it probable that the bulk of Menominee county is underlain by the iron bearing formation at no great depth. I do not think it wise for wells to go far[2] into this formation until the surface distribution has been better made out by wells less than 1,000 feet deep which will probably encounter often good artesian water, softer in the Potsdam or Lake Superior sandstone than above, and *may* encounter in the dolomites pockets of gas or oil of small commercial value, especially if an oil bearing stratum should be found covered by a heavy coat of clay till. However, the Rapid River well is said to be booked for 2,000 feet and will perhaps show that I am wrong.[3] I should think, however, that better chances for oil or gas would be in going to the area covered by Lorraine, Utica or Niagara, and trying to see if the Galena-Trenton did not have oil somewhere when covered by the Utica black shales. Interesting in this connection are reports[4] of oil in Manitoulin Island, Canada, at a depth of about 400 feet.

LOWER PENINSULA.

Wells at Muskegon, White Pigeon, Bridgman, Milan and around Fowlerville have received brief treatment in last year's report. A well is now going down at Ypsilanti which expects to go further than any previous ones. I take it that it went through the Traverse between 291 and 520 feet. We have taken some temperature observations, and a fuller record we hope to make when complete.

We are investigating the Swan well 2,370 feet deep at Grosse Isle. This was supposed to be to blame for the drying up of certain wells near Carleton but from the known strike and dip of the strata I thought it unlikely, and

[1] Letter W. C. Alden, Nov. 6: 1904, agrees with these correlations.
[2] Menominee 4: 15: 1904. Gladstone Delta, 7: 23: 1904.
[3] Gladstone Delta, 7-23-1904.
[4] Detroit Journal, Sept. 24, 1904. Toronto Globe Sept. 24, 1904, on Indian Reserve, near east end.

Mr. M. L. Fuller of the U. S. Geological Survey to whom I referred the question and who has presented the report previously given agrees with me.[1]

It seems to me that more attention should be paid to minor flows of gas and oil, which may be worth saving even if they cannot make millionaires—such flows I mean as those struck: at Adrian, at Bailey Park at 136 feet, probably from a gravel bed at the base of the drift,[2] at Bear Lake, 419 feet deep, flowing both gas and water.[3]

I have also had occasion at request to prepare sections of what would probably be encountered at various depths, at various points.[4] I do not pretend to know just how much gas, oil or water is going to occur at various depths, but I can estimate at what depths they are most liable to occur, and this is often of use to drillers in planning their casings, the diameter of their holes, etc.

Sometimes I am nearer right than other times. Mr. J. H. Killmaster was kind enough to write regarding the Harrisville well that[5] "your estimate of the depths of the rock was practically correct and that we encountered the formations that you said we would."

The record of the well as actually developed was:[6]

HARRISVILLE, Alcona County Court House, 640 A. T.

Post glacial and outwash.		
Yellow loamy soil	12½	12½
Quicksand	14	26½
Red clay	6½	33
Gravel	6	39
Glacial.		
Wisconsin. Last till *sheet* (sand of mixed character, boulders, etc.)	60	99
Interglacial.		
(Quicksand, solidified to a blue hard pan at base.)		
Sand, signs of oil	30	129
Earlier till sheet.		
Red hard pan	59	188
(Weathered till sheet.)		
Red clay	4	192
Blue hard pan and pebbles	38	230
Berea Grit.		
White *fine* grained sandstone	30	260
Antrim.		
Light gray shale Bedford or weathered black shale	149	409
Brown and black shale	97	506

The Manistee (East Lake) well, put down by T. Percy in about five months, finished August 1, 1904, striking 20 feet of salt at 2,025 feet.[7] It reached

[1] Detroit Free Press, Aug. 31, 1904.
[2] Bay City Tribune, Aug. 26, 1904.
[3] Jackson Press, Oct. 26, 1904.
[4] Harrisville: Alcona Review, July 28, 1904. Sherwood: Coldwater Reporter, April 30, 1904.
[5] July 21, 1904.
[6] As compiled by me from the samples, with assistance of F. Leverett and W. F. Cooper. See also Alcona Review, July 28, 1904.
[7] Traverse City Eagle, Aug. 3, 1904. Ludington Chronicle, Aug. 31, 1904. Michigan Investor, March 26, 1904. Detroit News, Aug. 1, 1904.

1,300 feet about March 26th and the shaft was then almost full of water. It was mainly limestone below. The salt was as deep as in the Peters well showing no upward bend, and no oil or gas worth mentioning was struck.

In closing this report, my last to the present Board, may I express my pleasure at the pleasant personal relations which have subsisted, and my hope and belief that the fact that its president and secretary are about to retire will not mean the severance of the same, nor imply a lessening of their interest in the development of our knowledge of the natural history of a state whose almost matchless variety of resources makes her geology an inexhaustible field of research.

Very respectfully,

(Signed) ALFRED C. LANE.

December 1, 1904.

INDEX.

INDEX

H.

I.

J.

M.

T.