ANNUAL REPORT

OF THE

GEOLOGICAL SURVEY OF MICHIGAN.

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State Geologist.

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Geological Survey of Michigan.

Lansing, Mich., Dec. 31, 1902.

To the Honorable Board of Geological Survey, A. T. Bliss, President, Patrick H. Kelley, Delos Fall, Secretary:

Gentlemen—Herewith I beg to submit my report for the fiscal year from July 1st, 1901 to June 30th, 1902, and for the calendar year from Dec. 31st, 1901, to Dec. 31st, 1902. These annual reports are not in the series of the scientific reports, now extending to Vol. VIII, in which the main scientific work of the survey finds its place, but last year my report, which you ordered printed, was extra large. I have in view of these facts and the fact that in this, the winter of the legislative session the state printer will be extra busy, condensed my report so far as possible.

FINANCES.

	Salary.	Field.	Office.	Total.
July	$ 383 50	$ 88 62	$ 20 52	$ 492 64
August	393 18	482 10	59 00	934 28
September	264 67	341 24	19 66	625 57
Supplementary	100 00	85 23	13 00	193 23
October	408 50	391 57	53 53	853 60
November	293 43	95 65	16 15	405 23
December	587 42	260 83	41 78	890 03
January	364 62	130 62	116 71	611 95
February	316 43	3 46	46 15	365 98
March	331 85	19 31	16 86	368 02
April	497 67	43 90	39 17	580 74
May	317 51	145 30	70 15	532 96
June	368 80	269 69	31 97	670 46
Supplementary	....	456 16	14 15	470 71
Total	$4627 58	$2813 62	$ 558 80	$8000 00

The above is the financial statement of the expenditure of the annual appropriation. This includes the money spent in conjunction with the United States geological survey in the topographic survey of the Ann Arbor sheet ($2,000), which is included under field expenses. Salaries and office expenses are less than usual. This does not include the expenses for printing which are given below. We have used up the appropriation of Act 73, Session of 1899, for printing, and start on that of Act 203, Session of 1901. The completion and binding of Volume VIII, which is now in press and the printing of this report, if you so order, will use most of that.

Printing of Parts I and II of Vol. VIII and the Annual Report for 1901.

	Vol. VIII-I	Vol. VIII-II	Annual 1901
Paper	$ 21 63	$189 30*	$136 57
Printing and presswork	77 19	50 55	314 22
Corrections	8 05		
Illustrations	82 65	143 15	284 16
Binding	9 32	198 21*	200 00
	$198 87	$581 21	$928 95

Vol. VIII-I	$ 198 87
Vol VIII-I	581 21
Annual (1901)	928 95
Total	$1709 03

*Items cover a portion of the cost of paper and binding of Vol. VIII-I.

Publications.

There have been published by the Survey this year Part II of Vol. VIII, Coal in Michigan—its Mode of Occurrence and Quality, 232 and viii pages with 9 plates, and the Annual Report for 1901, 304 and viii pages, with 15 plates.

Part III of Vol. VIII, upon marl and the Portland cement industry, which will contain over 400 pages and over 20 plates, will be practically finished this year and with it the volume closes, being about 700 pages. It will be noted that the whole volume in its three parts—clay, coal and marl—pertains to the raw materials of Portland cement. A fourth part upon limestones should have been added were it not already too large, but a lot of matter about them is included in the annual report for 1901 and enough more can be said to take a volume to itself.

Beside the official publications, a number of extracts from them and other articles have appeared in the Michigan Miner. The Alcona County report has been reprinted by Killmaster and Clappeile. Mr. Livingston will reprint his paper on the Plant Societies of Kent County in a botanical magazine. The geological map which appeared in the annual received many compliments, which mainly belong to Messrs. Silas Farmer & Co., and was reprinted, with some other matter regarding the raw materials of the state, in the Lansing souvenir published for the meeting of the National Grange, Nov. 12th to 19th, 1901.

I also furnished the article on the Northern Interior Coalfield for the twenty-second annual report of the U. S. Geological Survey, pp. 305 to 331 of Part III., and we furnished some material to Prof. I. C. Russell for his article on Portland cement in the same report (pp. 629 to 686).

I will also call your attention (not assuming the credit of it) to the work of Prof. C. R. Van Hise and his assistants in the Iron Country, Mr. Leverett and F. B. Taylor, on the surface geology of the Upper Peninsula, and Mr. Robert E. Horton on the water powers, all of this work having been done under the United States Geological Survey, but upon the geology of the State, and with more or less assistance from me. Mr. Frank Leverett has recently published a monograph*, which gives the surface geology of the Lower Peninsula as far north as the end of the Thumb, and will soon take up one covering the whole of the Lower Peninsula.

*XLI. of the United States Geological Survey "Glacial Formations and Drainage Features of the Erie and Ohio Basins."

Work in Hand.

C. A. Davis has continued the preparation of the reports on Tuscola County at odd times; W. F. Cooper that of Bay County (and done much other incidental work); W. M. Gregory that of Arenac County.

These reports, which are upon adjacent counties of the coal basins, and my report on Saginaw County should make up Volume IX.

W. H. Sherzer has a report on Wayne County nearly ready.

G. P. Grimsley, who has done a good deal of work on gypsum in other States, has contracted to prepare a report on the gypsum of our State. Though a leading State in the plaster industries, the increase of product has not kept pace with other States of late years. He has turned in a preliminary report given below:

A PRELIMINARY REPORT ON THE GYPSUM DEPOSITS OF MICHIGAN BY G. P. GRIMSLEY.

Historical Sketch.

In 1827 an Indian trapper brought to the Slater Mission, which had been established two years before near the present site of the City of Grand Rapids, a specimen of gypsum, which he had found on Plaster Creek, to the south, but the soft rock seems to have attracted little interest until 1838, when Dr. Douglass Houghton called public attention to the deposits in his first State report and wrote that the gypsum in Kent County "cannot fail to prove a subject of much value to the agricultural interests of this and adjoining parts of the State," a prediction which became a reality nearly 35 years later. With regard to the lack of interest in the subject of gypsum development in this district, Dr. Houghton two years later wrote: "This should not be, for the time has now arrived when it is required for use and no contingency should be allowed to arise that will cause it any longer to lie dormant." The next year, 1841, Granger and Ball erected the first gypsum mill, which was located on Plaster Creek, near the Grandville road. The mill was equipped with one run of mill stones, operated by water power and the plaster was calcined in a two-barrel cauldron kettle. The manufacture of plaster of Paris was a small feature of the work, as the mill was started for the making of land plaster, of which the greater portion was shipped by water to Detroit. Ten years later the home market was so well developed that 60 tons of plaster a day were hauled south of Grand Rapids by the farmers of that section, who paid $4.50 a ton for the material at the mill.

This mill was later moved across the Grandville road and enlarged. The control passed through various hands until today it is owned and operated by the Alabastine Company of Grand Rapids.

In 1860 Mr. Freeman Godfrey entered the plaster business near the mouth of Plaster Creek, and to his enterprise and skill is due a great part of the advancement of the plaster industry.

The first plaster mill north of the river was built in 1849 by Mr. R. E. Butterworth. This property was sold in 1856 to Hovey & Company, who erected a new mill, and in 1860 this company was incorporated as the Grand Rapids Plaster Company, which now owns this original Eagle mill and the Emmet mill, which has been built in 1869 by Taylor & McReynolds, a short distance beyond the Hovey mill. The Gypsum Products Co. built a mill of one kettle capacity within the city on the bank of the river in 1898.

In 1900 the English mill was built to the west of the Grand Rapids Plaster Co., and is now the property of the United States Gypsum Company.

At Grandville the White and Red mills were erected about 1872, and were sold in 1896 to Mr. Dummer, of Chicago. The Red mill has been abandoned for 15 years, and the white mill has not been in operation for four years, though it is well equipped and the machinery is kept in good condition. The Durr mill at Grandville was started in 1875 by Taylor & Day and sold to Durr in 1886. It is now the property of the United States Gypsum Company.

The Alabaster quarry and mill were opened in 1862 by George B. Smith, and then operated under the name of Smith, Bullard & Co. The company was reorganized in 1891 as the Western Plaster Works, and in 1898 was changed to the Alabaster Company. It is now owned by the United States Gypsum Company. The mills so far mentioned are the only ones in the State.

Location and Topography.

Gypsum in deposits of economic importance is found in two portions of the State, with a possible third area as yet undeveloped. The two important sections are Grand Rapids and vicinity on the western border of the Lower Peninsula, and Alabaster on the eastern border on Saginaw Bay. The third locality, where very little is known concerning the value of the deposits, is near St. Ignace, on the Upper Peninsula, (and perhaps some of the northern islands of the Beaver Island group, where it would have to be mined.)

At the present time six mills and one mixing plant are in operation near Grand Rapids and one mill at Alabaster. These mills are owned by four companies two by the Grand Rapids Plaster Company, one mill and the mixing plant for the manufacture of Alabastine wall finish, by the Alabastine Company of Grand Rapids, one mill by the Gypsum Products Co., and three mills by the United States Gypsum Company of Chicago. In addition three idle mills are found in the Grand Rapids area.

The mills on the western border of the State are located in the valley of the Grand River, just below the rapids. This river, rising in the southern part of the State, near Jackson, flows in a winding channel with a general northwest direction past Lansing to Ionia, where it turns west and with a horseshoe bend near Grand Rapids flows south through that city, bending to the southwest to Grandville, and then takes its northwest direction to Lake Michigan.

Near Grand Rapids the river varies in width from 600 to 900 feet and has a fall of a half foot in a mile in the northern part of the city, and near the rapids it falls 12 feet in less than a mile (4,620 feet), and from the city to the lake a distance of 34 miles in air line or 40 by the river the fall is less than six feet (5.8.)

The valley is about one and one-half miles wide below Grand Rapids, rising in a steep bluff at the northwest 120 to 150 feet above the valley and at the south rising into rounded gravel ridges 60 to 100 feet high. One of these ridges extends through the city from Coldbrook avenue to Fulton street, and another through the southern part of the city.

The gypsum south of the river is found near Plaster Creek, and its outcrops in this creek have been traced for a distance of a mile from the Grandville road, north to the river. The bottom of the rock is about 10 feet above the river. North of the river the mines enter the hill at the level of the river plain, but on a downward incline from the level of the ground at the mills, and these mines are locally spoken of as the caves. The old workings, dark and damp, have been converted into a mushroom farm. In the city and north beyond the city limits gypsum is found in the deep wells at varying depths, but it appears to be absent in the wells to the east of the gravel ridges which pass through the town. Gypsum is also found in the deep wells to the west of the city.

The valley of the Grand River widens to the south near Grandville and the drainage of the south is through Buck Creek. The quarries are located about one mile south of the river and not far above its level, so that water is very troublesome and requires pumping. The Alabaster quarry is located about three-quarters of a mile from Saginaw Bay and the bottom of the quarry is 15 or 20 feet above the water level. The gravel beach extends back a few hundred yards and then the land is almost level for a long distance inland and is more or less marshy. The gypsum is found at a number of places to the south of Alabaster along the bay and can be seen out from the shore under the water.

Geology.

The interior coal basin of Michigan is almost entirely surrounded by a border of lower carboniferous rocks known as the Grand Rapids formation, which in age probably corresponds to the St. Louis-Chester, and Augusta formations of the Mississippi Valley. This formation is divided into the Upper Grand Rapids, or as it is called in the older writings the carboniferous limestone, equivalent to the Maxville limestone of Ohio and the Bayport limestone of Eastern Michigan, and to the St. Louis-Chester of the Mississippi Valley, and into the Lower Grand Rapids, called by Winchell the Michigan salt group, but as it is without salt it has been called by Lane simply the Michigan group and is thought to be equivalent to the Augusta of the west. The gypsum deposits of Grand Rapids and Alabaster are found in the Lower Grand Rapids series. The thickness of this group is stated by Rominger to be 184 feet, and it is underlain by the Napoleon group of shales and sandstones 123 feet thick, which in turn rest on the sandstones of the Lower Marshall group.

The deposits near St. Ignace are in the Salina or Monroe group of the Silurian. Gypsum is found in many of the deep wells of the State, but these have not been studied in detail at this writing.

MINES AND MILLS.

Alabastine Mine and Mill.

The old quarry of George H. White & Co. was located just north of the Grandville road, two miles south of Grand Rapids, but, as the gypsum showed signs of exhaustion about 1876, a new quarry was opened three-quarters of a mile northwest. The old quarry is now filled with water and the new quarry is in active operation. The gypsum is found in two strata, the upper is six feet and separated by a foot or less of shale from the lower 12 foot ledge. The whole is covered by 12 to 15 feet of shale. The gravel cover is of shallow depth.

The upper six-foot ledge is very irregular in its distribution and runs out to the east and west in this quarry. On the north side of the quarry both layers of gypsum have disappeared over an area 100 feet wide and extending to the north. The gypsum at the side of this space shows the solution effects of water in its irregular surface. The main working is on the 12-foot ledge, which is capped in places by fibrous gypsum, and the lower 2½ feet is a red gypsum rock with red cone-in-cone gypsum, called by the quarry men, pencil rock. The bottom rock is a hard, blue limestone, called the flint rock. The lower portion regarded as impure rock was formerly ground for land plaster and the upper nine feet were used for the calcined plaster. At the present the red rock is used with the white and analysis shows that it is nearly as pure as the white. The rock is blasted and broken by sledge and wedge into blocks which can be readily handled and loaded into mine cars which are hauled up an incline track 320 feet long and dumped near the mill. For the manufacture of alabastine finish the whiter rock is selected and hauled in wagons to large storage sheds.

The overlying shale was formerly burned into brick by the company, but as the quarry was worked farther and farther away the hauling of this clay became more expensive and the brick work was abandoned. The Portland cement mill at Newaygo found this shale was especially adapted for the manufacture of their cement and made arrangements with the gypsum company to secure this shale which is hauled 35 miles north on the Pere Marquette.

The mill of the Alabastine company, located about 700 feet north of the quarry, is built in three sections, the middle one is built of brick made from the quarry shale and is 215 feet long by 55 feet in width. It contains the grinding machinery and the calcining kettles, and in the west part is the hard plaster (plasticon) mixing room. On the west is a frame wing devoted to land plaster and for storage. On the east is another frame building used for sacking the plasters and for storage. The total length of these buildings is nearly 400 feet. The engine and boiler house, built of brick, is to the south of the center of this building and separate from it. The grinding room is equipped with two Butterworth and Lowe nippers with the two crackers below them. North of the crushers are four runs of four-foot buhr stones and one large vertical emery mill. Above on the second floor are the elevators and the storage bins for the ground plaster.

The calcining room is east of the grinding department and is three stories high. The kettles extend from the first floor up into the second, and the storage bins are on the third floor. There are four 10-foot kettles which hold 10 tons each of gypsum flour and are calcined in about three hours. The finished plaster is dumped from the kettles into fire-brick bins below and fed into screw conveyors which carry it to the sacking and mixing rooms.

The Alabastine mixing plant is located near the Grandville road, three-quarters of a mile from the calcining plant and is the original Geo. H. White & Co. gypsum mill enlarged and remodelled for the manufacture of this ornamental wall finish. This mill is equipped with eight runs of small buhrs for regrinding the plaster, and with the mixing vats.

GRAND RAPIDS PLASTER CO.—MINES AND MILLS.

The mines of this company are on the double entry system entering the bluffs on the north side of the river. The gypsum is worked out in rooms 40 feet square, and at the present time the workings of mines No. 1 and No. 2 are connected and contain about 45 acres of rooms. The gypsum is worked on the drift and bench system with no under cutting and the roof gypsum is heavily timbered. A geological section at the mine shows practically the same series of gypsum and shales as south of the river but the upper six-foot ledge is more constant and is left for the roof of the mine. The rock is hauled in cars by cable up an incline into the upper portion of the mill. The gypsum of this mine is nearly of the same chemical composition as in the other mines of this section and is a very pure rock as shown by the following analysis made of the crushed rock as it runs into the buhrs:

Water	.01903
Silica	.01245
Iron and alumina	.00495
Sulphuric acid	.45404
Lime oxide	.33115
	.99289

This analysis propably represents the following compounds in the rock calculated on the basis of the sulphuric acid:

	Per cent.
Water	19.03
Silica	1.245
Iron and alumina	.495
Sulphate of lime	77.186
Carbonate of lime	2.380
	100.336

The Eagle mill. No. 1, of this company is a central brick building for the three 10-foot kettles with the two-story frame buildings to the east and west, used for the grinding, mixing, and for storage. The rock is crushed in a nipper and cracker and ground in four runs of buhrs. The Eagle mill, No. 2, is equipped with three 10-foot kettles and the crushing is done in a Godfrey double nipper and cracker, while the fine grinding is done in three runs of vertical emery mills. For the finest grades of work the plaster is reground in two runs of small buhrs. The special brands of plaster of this company are the Hercules wall plaster, the Eagle and Acorn finish plasters.

The English Mill and Mine.

The English mill of the United States Gypsum company is located to the west of the mills last described. It is a three-story frame building 40x50 feet with a mixing and regrinding room to the east 60x40 feet. The rock is brought in mine cars from the shaft down a slight grade to the second floor of the mill where the nipper and cracker are located. The broken rock is then elevated to bins above the two runs of buhrs and one vertical emery mill in which it is ground to flour and carried by a screw conveyor and elevator to the third floor above the two ten-foot kettles. The mill has also three sets of regrinding buhr stones for the finer plasters. This mill was erected in 1900 and has a daily capacity of 150 tons.

The gypsum rock is obtained from under the same hill that is worked to the east by the Grand Rapids Plaster company, but is reached by a vertical shaft 62 feet in depth which starts on the hill. The twelve-foot ledge is the one worked and the six-foot layer is left for the roof.

The Gypsum Products Company Mill and Mine.

The Powers mill and mine are located on the west bank of the Grand river at the water's edge within the city at the end of the G. R. & I. railroad bridge and a block below the Pearl street bridge. The rock is hoisted through an eighty foot shaft and it is crushed in a nipper and cracker of the usual pattern and ground in two runs of buhr stones. The calcining is carried on in a ten-foot kettle patented by Mr. Powers and differing from the other kettles in the plan of the flues. The company is known under the name of the Gypsum Products company. The shaft was put down in 1896 and the plaster manufacture was commenced in 1898. The company make a specialty of a sanded plaster known as Granite Wall Plaster. For this purpose the sand is dried in a revolving cylinder sand dryer. This is the only gypsum mill in the state using wood for fuel and run by water power.

The Durr Mill and Mine.

At Grandville only one mill is now in operation and is known as the Durr mill of the United States Gypsum Co. The quarry is located about a half mile east of the mill and the rock is hauled in cars to the storage sheds near the mill. At the present time a shaft near the mill is being completed which reaches the gypsum at a depth of 32 feet. The quarry shows twenty feet of gravel resting on a dark shale a foot in thickness just above the eleven-foot layer of gypsum which is worked. A hard shaly lime rock forms the floor of the quarry and is four feet thick and below this is a fourteen foot vein of gypsum not worked. A large acreage of this upper gypsum has been worked out, and on the completion of the shaft this quarry will probably be abandoned.

The gypsum rock is hauled from the storage sheds by cable to the ground floor of the mill, where it is crushed in a nipper and cracker and is hoisted by elevators to bins above the two eight-foot kettles and one ten-foot kettle. The finished plaster is elevated and carried by a long screw conveyor to the opposite end of the mill 350 feet, where it is mixed with sand to form the Adamant wall plaster, or it is taken out in the storage room and sacked as plaster of Paris. The storage room is 350 by 50 feet with 900 tons capacity and connects the grinding building with the Adamant building. The mixing department is equipped with three Perfect sand dryers and two Broughton mixers. The capacity of the entire plant is about 200 tons a day.

The Alabaster Mill and Mine.

The Alabaster mill is the only one in the eastern part of the state, and is located at the town of Alabaster which was built by the company for the accommodation of the workmen. The original mill of Smith & Company was destroyed by fire in 1891 and was rebuilt in 1892. The main building is 40 by 52 feet and 50 feet high. It contains the grinding and calcining machinery. To this has been added a packing and storage room nearly as large as the main part. Several other buildings have been erected for the carpenter and cooper shop, store room, and a rock shed with a storage capacity of 3,500 tons. The grinding is done in a Stedman disintegrator and in three runs of buhr stones. For calcining three ten-foot kettles are used, giving a capacity of 240 tons in twenty-four hours.

The mill makes a special feature of very fine plaster reground in two runs of buhr stones, which is used for plate glass grinding. This fine groundplaster free from grit stands in high favor among the plate glass works of the country, and most of the material for this purpose comes from the Alabaster mills.

The quarry is located one-fourth of a mile back of the mill and shows a half mile face of exposed rock. This is the largest gypsum quarry in the state and probably in the United States. The gypsum face is 16 to 22 feet high covered by five to 16 feet of tough boulder clay which is removed by a steam shovel. The rock is hauled in cars by two small locomotives. The rock is used at the mill, and is hauled to the wharf where it is loaded in vessels to be hauled to the Alabaster mill at South Chicago, and to the various mills in other places where it is used for a variety of purposes. It is also hauled by rail, so that nearly 100,000 tons of rock are shipped from the quarry each year. The Alabaster rock is readily mined and is of exceptional purity. An analysis of the rock as it runs into the buhrs shows the following composition:

Water	.2028
Silica	.00555
Iron and alumina	trace
Sulphuric acid	.45745
Lime oxide	.33155
	.99735

This analysis probably represents the following compounds in the rock:

Water	20.28 per cent
Silica	0.555 per cent
Iron and alumina	trace.
Sulphate of lime (gypsum)	77.766 per cent
Carbonate of lime	1.86 per cent
	100.461 per cent

Selected rock shows gypsum of almost the theoretical composition.

Technology of Gypsum.

The process of manufacture of gypsum products is practically the same in all the Michigan plants. The crushing is effected by means of a nipper or crusher. This machine has face plates or jaws of chilled iron, which have a backward and forward motion, and it is operated usually by steam power and weighs about 6,000 pounds. It will crush from seven to 11 tons in an hour. Blocks averaging 50 pounds weight are thrown into this machine and crushed into pieces about the size of a man's hand. These small masses drop from the crusher into the cracker, which is set in the floor under the nipper. This machine, with its interior revolving shaft, acts somewhat like a coffee mill and further crushes the gypsum into fragments of the size of small gravel, which falls into the buckets of a chain elevator, whereby it is raised to a bin on the second floor. Three sizes of crackers are made, with capacity of three to 12 tons per hour and the average sized machine weighs 3,500 pounds. From the bin the gypsum particles pass through a spout into an ordinary buhr mill, where it is ground into flour. In some of the mills the Sturdevant vertical emery stone mills are used and have a greater capacity than the mill stones. From the buhrs the gypsum flour passes into a screw conveyor and into another chain elevator and is carried to the top of the second or third story into the storage bins located just over the calcining kettles. It is then run slowly into the calcining kettle, taking about one hour to fill it. The average kettles in this State are 10 feet in diameter and about the same in depth and will hold nine or 10 tons of material. The kettle is surrounded by a wall of brick nearly three feet thick, with the bottom seven feet above the grate, which is about four and one-half by three feet in size.

During the process of calcination where the water is driven off, the whole mass is stirred by a revolving stirrer making 15 revolutions per minute. The kettle is heated to about 240 degrees F. before filling with the raw material, and this temperature is gradually increased to about 360 degrees as the evaporation progresses. At this temperature the material stops the boiling and settles down solid and the steam ceases to rise. In a short time the material comes up again and boils vigorously and at a certain temperature not far from 400 degress the whole mass is rapidly withdrawn through a gate near the kettle bottom, and the blaster runs into a fire proof bin on the ground. The kettle is refilled, so that three kettles are usually burned in a day, and these require about 1,500 pounds of coal for the 10 hours.

After the hot plaster passes from the kettle to the ground it remains for a time to cool and then is raised to the second floor and passes over a horizontal cylindrical reel forty inches in diameter and 10 feet long, slanting downward. This reel is made of wire cloth about 40 by 40 meshes to the inch. The tailings, about 1 per cent, are carried back to the buhr mill and reground. The fine plaster is then run into 100-pound sacks or into 265-pound barrels and is ready for shipment as plaster of paris or as it is usually called in this State, stucco. For hard wall plaster a retarder is mixed with the plaster in mixing machines to hold the set back for a couple of hours or less. The retarders used are patent mixtures of organic composition. The Adamant and Granite wall plasters are mixtures of retarded plaster and kiln dried sand ready to be mixed with water and placed on the walls.

The advantages of wall plaster made from gypsum, are outlined in the circulars of the various companies as follows: Being a good non-conductor of heat it is valuable for the protection of iron joist, elevator shafts and stairs; it sets and the walls dry out much more rapidly than in lime work, so that the carpenters can follow the plasterers almost immediately, as also the painters and paperhangers; any color can be mixed with the material in its preparation for mortar to produce any tint desired, and it does not affect coloring material as lime will; ceilings and walls thoroughly soaked from leaking and unprotected roofs have not been in the least injured; it attains a high polish and is now largely used for wainscoting as a substitute for marble; this plaster makes walls fireproof, and they are not affected by changes of temperature; it makes a dense and hard wall which is vermin proof.

Uses of Gypsum.

The gypsum in its ground uncalcined state is used as land plaster for a fertilizer. Many theories have been advanced to explain its value in this work. The theory most generally accepted at the present time is that gypsum decomposes the double silicates in the earth ,setting free potash as a soluble sulphate. In this way the potash can be taken by the plants. Soils with abundant soluble potash would not be benefited by gypsum, and soils with no potash compounds would not respond to the gypsum treatment. This material was manufactured on an enormous scale in the early days of the plaster industry of Michigan, but at the present time it is a minor feature in the industry of the State.

The greater part of the gypsum is calcined into plaster of paris or by mixing with retarder used as hard wall plaster. Gypsum is used in the manufacture of fine papers as a filler. In the form of finely ground plaster of paris, much of it is used by the plate glass factories to form a bed on which the glass is placed before polishing. It fits all the inequalities of the glass and so removes strain on the different parts of the plate. About 40,000 tons of plaster of paris are used annually in this country for this purpose. It is also used in making whiting, and also in small quantities in making Portland cement.

Ground uncalcined gypsum is used as an adulterant in some flours, white lead, etc.

In connection with the work on Bay County, Mr. F. D. Owen, a student at the Agricultural College, made a series of tests of characteristic mineral waters; these were suggested by me and were a continuation of the studies of Prof. Davis and myself in Huron County.

It is worth noting that the water from the deeper drift may be a poorer boiler water than that from certain sandstones in the rock. The character of the rock water is, however, not uniform.

Mr. Owen's paper is as follows:

Some Field and Laboratory Tests of Bay County Waters.

(By Floyd D. Owen.)

During my senior year at the Michigan Agricultural college, it was my privilege, through the kindness of Dr. A. C. Lane and Prof. F. S. Kedzie, to make a somewhat general study of the waters of Bay County. In undertaking the work the following objects were kept in view.

I. The practicability of field analysis, and a comparison of field and laboratory results.

II. The mode of geological occurrence and the chemical character of the waters, their relations and interdependency.

III. Applicability of certain waters for boiler use.

IV. The distribution of carbon dioxide.

V. The sanitary and hygienic character of the waters.

Methods.

Until recently water analysis has been restricted to the laboratory although it is known that for several reasons such results are not as satisfactory as those that might be obtained in the field. For instance the geological occurrence of valuable bicarbonates may be indicated by the amount of carbon dioxide in the freshly taken water, and for other reasons the determination of CO2 is very important. This gas is lost so rapidly, however, that when tested in the laboratory the results can never be relied upon, and even in the field, a portion of it may be lost. Beside the loss of certain elements, the transportation of waters necessary to laboratory work is frequently inconvenient and always affords many chances of error, and so there is much in favor of field analysis if for nothing more than a preliminary examination.

The field work was done in July, 1901, the outfit consisting of a bicycle with a triangular luggage-carrier fitted in the frame, and in which were carried the following standardized reagents and apparatus.

(N H 4) C2 O4 for Ca.

Ag NO3 for Cl.

Ba Cl2 for SO3.

Soap solution Oc neutralizes 0.000714 gr. Ca Cl3) for total hardness.

Na2 CO3 (1:200 normal) for CO 2 free.

One burette for Na2 CO3.

One 50 cc graduated cylinder for soap sol.

Phenolpthalein-indicator for CO 2 test.

One 200 cc glass-stoppered bottle.

Six test tubes; swab; extra corks, etc.

The chemicals were carried in rectangular glass bottles holding one pint each and were protected by cases of heavy corrugated paper. The bottles rested on excelsior, were fitted very snugly into the carrier and, although they made a very considerable weight, were easily carried and withstood the roughest roads without break.

In testing for Ca, and SO3 a test tube of a specimen of water was used and the reagent slowly added until no further precipitat formed, the amount then being recorded as "trace," "low," "medium" or "strong"*.

In testing hardness 100 cc of a sample was placed in the glass-stoppered bottle—a 100 cc mark being etched on the side—and the soap solution measured from the graduated cylinder. Free CO 2 was determined with Na2 CO3 from a burette which was readily mounted to a clamp attached just back of the saddle. A rubber cork for the upper opening permitted a daily supply of the reagent to remain in the burette, which, when not in use was carried horizontally in the top of the carrier. Phenolthalein was used for indicator in this test, 100 cc of a fresh sample being titrated in the bottle above mentioned. Aside from these tests, and observations for deposits of Fe 2 O 3 in the case of wells the location, (township and range), age, name of owner, amount and force of flow if flowing (for many wells in this county are artesian) character of sub-surface, whether drift or stratified rock, etc., were all noted and as many peculiarities of a well and its waters as could be relied upon were recorded. After this preliminary work, I drove over the county and collected samples of those waters which from the field analysis seemed sufficiently important and

(*See report on Huron County, Vol. VII, Part II of the Reports Michigan Geological Survey, p. 138.)

characteristic of a certain territory to warrant a more extensive quantitative analysis in the laboratory. These samples were collected in carefully sealed, two quart, mineral-water bottles and shipped in cases to the chemical department of the Michigan Agricultural college.

Laboratory. In the laboratory work, the following gravimetric method was pursued.

500 cc (200 cc of a water rich in mineral matter) of water evaporated in platinum dish to dryness and the residue weighed as "Total solids." This was then ignited to a red heat, moistened with distilled water charged with CO_2 and again evaporated to dryness, this loss of weight being organic matter. The total inorganic matter thus obtained was dissolved in HCl and distilled water, the insoluble matter filtered and weighed as SiO_2, and the Al_2O_3 and Fe_2O_3 precipitated with NH_4OH at boiling temperature. $(NH_4)_2C_2O_4$ next brought down the Ca, heat being also used, and to this last filtrate Na_2HPO_4 was added and the Mg weighed as $Mg_2P_2O_7$. Boiling 200cc of a water, acidifying with HCl and adding $BaCl_2$ precipitated $BaSO_4$. These precipitates were all deposited on "ashless" filter paper and reduced in platinum crucibles—a large precipitate in the case of Ca always being weighed as a sulphate. Cl was titrated with $\frac{N}{10}$ $AgNO_3$ (17 gr. per litre) and when very abundant only 50cc of the water was used. Potassium chromate served as indicator. Spectroscopic an-analysis was also made, a very accurate instrument being used. 100cc of each sample was evaporated to 1-2cc, but of the alkalies only Na was found present.

Especial care was exercised in the laboratory work and every precaution taken to obtain accurate results, and the laboratory results of the 10 samples analyzed are appended in tabulated form.

RESULTS.

Field. The method and equipment used in the field analysis proved very satisfactory. A wheel was found to permit much more rapid work than would a horse, the chemicals were easily carried and the results were quite readily obtained. Of course in collecting samples a wheel is of little use. Forty-five complete field analyses were made.

Laboratory. The laboratory work will be found to give the most accurate and comprehensive ideas of the waters of Bay county. The samples analyzed are very characteristic and indicate first, an abundance of lime—especially in deep wells.

With reference to their applicability for boiler use, we note that the presence of calcium and magnesium carbonate and sulphate, oxides of iron and alumina and silica constitute the incrusting solids and that the presence of $NaCl$ or brine in the water makes it very injurious to metal fittings as bolts, rivets, etc. Samples No. 1, 10, 9, 7 and 4, would probably give considerable trouble while 5 would give almost none.

According to the results, Na_2SO_4 and $CaSO_4$ or gypsum may be said to occur most frequently in deep rock wells. Ca and CO_2 appear to be closely associated and to be most abundant in shallow wells and less abundant in the deeper and rock wells. In the laboratory the waters often contained considerable deposits of various salts and of Fe which had been carbonates, showing that a quality of CO_2 had been present but had been lost while being kept in the laboratory. Laboratory tests for CO_2 to determine the amount lost were not thought to be of much consequence and so were not attempted.

The hardness of the water as indicated by the field tests show it to be the greatest in drift and least in deep, rock wells, although in some cases, the deep wells possess considerable hardness.

Ordinarily the presence of $NaCl$ in potable water is indicative of sewage contamination, but where present over quite an area, no such inference can be drawn, and in Bay county waters, salt is a natural ingredient. In regard to their effect, the people regularly using them state that a slightly salty water has a very beneficial effect. Strangers, however, usually experience considerable trouble. The strongly salted waters are only used for stock, but are said to be excellent for this purpose as the animals soon become fond of such water, and require no salting.

1. S. Rowden, 113 feet. Pumped, clay, sand, rock.

2. Chas. White, 16 feet. Clay. Dug.

3. Endline, 100 feet. Clay, sand, gravel, rock. Flow.

4. Meyer, 67 feet. Slate rock or coal. Gravel-rock. Flow.

5. Cherry, 180 feet. Red rock. Flow. (Very heavy flow and used a great deal in the surrounding country as a mineral or medicinal water.

	(1)		(2)		(3)		(4)		(5)	
	Found 200cc	Computed parts per 1000	Found cc	Computed parts per 1000	Found 200cc......	Computed parts per 1000	Found 500cc........	Computed parts per 1000	Found 500cc.......	per 1000 ....
Total solids	2.3800	11.9000	.2534	1.2670	.1805	.9025	2.8660	5.7320	.375	.750
Total organic	.1965	.9825	.1914	.5070	.0100	.0500	.570	1.140	.135	.310
Total inorgania	2.1835	11.0175	.1520	.7600	.1705	.8525	2.2960	4.5920	.220	.440
Ca O........	.0673	....	.0454	....	.01154	. ....	.01826	....	.00226	....
Ca CO3	....	.42900	....	.37254	....	.01383	....	....	....	....
Ca SO4	....	.20625	....	.04454	....	.10706	....	.08868	....	.01096
Al2 O3 and Fe2 O3............	.00806	.04030	.00376	....	.00176	.00880	.01286	.02572	.00086	.00172
Mg O	.01394	....	.02263	....	.00386	......	.0005	Mg SO4 .00300	.00053	Mg SO 4 .00318
Mg CO3	....	.14635	....	.23767	....	.04053	....	....	....	....
Si O2	.01106	.05530	.00706	.0353	.00326	.0083	.01386	.02772	.00906	.01812
Na Cl	2.00304	10.01152	.05148	.2574	.09009	.45045	2.19375	4.3875	.17555	.35110
SO3	.02200	....	.00524	....	.01142	. ....	.0508	Na2SO4 .08418	.01399	Na2SO4 .03446

(6) Kawkawlin River, Surface water.

(7) Bay Mine, 150 ft. below. From coal. Not used.

(8) Wolverine Mine, slate and coal.*

(9) Emmet or Lutz. Clay 93.5 ft. 2 in. flow.

(10) M. Tebo 55 ft. Clay and sand. Drive well flow.

*No. 8 is used for drinking by both men and mules and has its source 140 feet below the surface from which it is conveyed in pipe 30 ft. further down to bottom of mine.

	6		7		8		9		10	
	500 cc		500 cc		500 cc		500 cc		500 cc	
Total Solids	.147	.2834	7.2300	14.4600	.7020	1.4040	4.505	9.010	.6935	1.3870
Total organic	.0400	.0800	4.195	8.390	.0980	.1960	1.872	3.744	.1440	.2880
Total Inorganic Solids	.1017	.2034	3.035	6.070	.6040	1.2080	2.633	5.266	.5495	1.0990
Ca O	.03443	......	.07718	......	.02768	......	.07595	......	.10785	......
Ca CO 3	......	.12296	......	.26960	..	.04170	......	.12954	......	.17258
Ca SO 4	......	......	......	.00822	......	.07772	......	.19258	......	.28903
Al2 O3 and Fe2 O3	.00266	.00532	.00306	.00612	.00526	.01052	.00076	.00152	.00546	.01092
Mg O	.01031	......	.02847	......	.00702	......	.00234	......	.03472	......
Mg CO 3	......	.04330	......	.11956	......	.02948	......	.00822	......	.14502
Si O2	.00586	.01172	.01736	.03472	.00426	.00852	.01156	.02312	.00566	.01132
Na Cl	.00731	.01462	2.9425	5.88510	.49725	.99450	2.56815	5.13630	.16380	.32760
SO 3	No trace	......	.00242	......	.02286	......	.05658	......	.08501	......

I have given some slight assistance to Dr. Burton E. Livingston, of Chicago University, who has recently been appointed Field Assistant by the U. S. Department of Agriculture, in continuing over the area covered by the Forest Reserve of the State, the same studies of the distribution of the plant societies, which he began for us in Kent County last year. He has, at my request, paid special attention to the peat question, and hoped that his report may be received in time to be incorporated with this.

A feature of my last annual which attracted attention was the computation by Dr. C. H. Gordon of the rate of wasting away of the shore at a selected point north of Port Huron. From 1823 to 1901 it averaged 5.7 feet a year. This rate agrees with observations recorded in my Huron County report.* This wastage is of clay bluffs and the question arises, what becomes of the material?

A good part, as I believe, reappears in St. Clair Flats, for after a big northerly storm the St. Clair River is very muddy.

The growth of this delta of the St. Clair River from the time of the Bayfield Survey in 1817 to that of Prof. J. B. Davis, just completed, I have arranged with Mr. Leon J. Cole, then of Ann Arbor, now at Harvard, to study.

I would earnestly beg all engineers into whose hands this report may come, to report to me any cases where a resurvey shows waste or accretion since earlier survey. In cases where the matter promises to throw enough light on the rate of geological change, it may be worth while to make additional surveys at the expense of the Board. Mr. W. B. Sears has, for instance, sent us a re-survey of the line between Sec. 22 and 23, T 19 N, R 13 E, (at Point Aux Barques), which shows that the low water mark on June 28, 1897, was 54 feet farther north than the meander post set Monday, Nov. 30, 1835, but that the lake bank was 219 feet farther south. The lake level was probably a foot lower on the latter date than on the earlier, so that for the same lake level, there was practically no readvance, and moreover, the lake bank had on the whole retreated, probably to the high water of 1885, for on Nov. 30, 1835, pines of good size were found only 52.8 feet away toward S. 16 E. and 23.76 feet to S. 48 E., whereas the bank now overgrown with trees, supposing its course to have been N. 58 E., would be 146.3 feet away in the directions S. 16 E. and S. 48 E.; or if we take its course to have been N. 75 E., then it would be 159.5 respectively 187.5 feet.

In other words, in 1835 the lake was rising toward the high water of 1838 and the lake bluff was within 25 feet of meander post. In June 28, 1897, the water had been low for a number of years, but in the interval, the bluff had receded so as to be 140 feet away. The probabilities are, therefore, that the bluff had been wasting away at the rate of some two feet a year. Mr. Sears shows another marked bluff from 2,546 to 2,691 feet south of the bank at the Lake Algonquin level. The present shore is just here about 2,900 feet in from the six-foot line of the coast charts. Over this broad flat, the bottom is largely solid rock. In the next 1,000 feet it drops to over 30 feet deep with a sand or clay bottom. We may accordingly infer that the notch and beach cut at and near the present lake level is 2,900 plus 219, say 3,100 feet deep, perhaps more, and may have taken 1,700 years, though the rate of erosion should have been greater near the edge of the beach, so that if the upper or Algonquin notch was started as far out, its greater depth indicates a greater time (5,800 feet in 3,100 years.) It is sure to have been more than 2,856 feet, and the time since the beginning of the Algoqnin can hardly be less than 3,300 years. For cutting the notch which Gordon described last year, where the normal slope of the plain back of the bluffs, estimated for the contour map is some 25 feet per mile and the height of the bluffs about 25 feet so that the notch cut has a depth of perhaps a mile, the time required at the rate of erosion of the last 80 years (5.7 feet per annum) would only be 925 years. But the place was chosen as a point of extra rapid erosion and before the trees were gone it was some four feet a year, which would imply if continued as in the past, some 1,300 years for the completion of the present notch.

I rather think that transportation by ice in the spring has an important part to play in cutting such beaches.

My own work has been of a varied nature. Beside seeing the various publications above mentioned through the press, a task which was far more than mere proof reading, even when I was not the author, there have been many letters to write, samples to examine and office consultations on oil, coal, peat, water and numerous other questions.

Many times an inquiry would require quite a little research to answer properly. As an instance selected, because I found little about it in print, I will give the results of investigation into Moulder's Sand.

* I have recently received further notes from W. B. Sears, mentioned below.

Moulder's Sand.

Moulder's sand (used for making iron castings) is of more than one grade. The essential qualities are that it must pack enough to take the impression of the wooden or iron mould sharply, and must hold the facing, that is praphite or some other lubricant, used to make a smooth casting. If too sharp, that is to say with too much grit, it will make a rough casting, but on the other hand it must not shrink or crack like a genuine clay, nor "cut" —that is, let the iron eat into it. Both varieties contain some iron, roots and organic matter and are practically river silts.

At E. Bement's Sons they use two grades: one, the light, has a yellow color, is finer grained, mealy, and is obtained from Zanesville, Ohio, or Newport, Kentucky. Under the microscope we see that it is very largely quartz sand, but the grains that are over 5-64 mm in diameter and are rounded, are very rare, while the much smaller, down to indefinitely fine fragments of quartz, are abundant. There are occasional accessories, such as hornblende and tourmaline, which indicates the character of the material as a rock flour from which the real kaolitic, clayey matter has been largely removed. The coarser variety is brownish red and is found in Lansing and Diamondale. More frequent are the larger quartz grains 10 to 20 64ths mm in diameter.

Moulder's sand is then derived in all probability from rock flour or glacial till, by a washing in the river, which has removed much of the genuine clay. The washing has not been so severe as to round the grains or remove the fine quartz material.

River silt from regions of glacial clays will be most likely to yield the right kind of material, I should think.

Peat.

Judging from inquiries the following notes on peat may not be out of place.*

Peat is simply common swamp muck which has not too much matter that will not burn. It is composed of more or less compressed vegetable matter, which has partly decomposed and matted together under water. Although the famous peat bogs of Ireland are largely made up of the peat moss or sphagnum, peat may be found without and in fact, in Michigan peat, moss is not conspicuous.

The famous celery and peppermint soils of Michigan are peaty soils but they are not as free from earthy matter as is considered desirable when the peat is to be used for fuel.

For instance, experiment station bulletin No. 99 of the Michigan Agricultural College gives the following analysis of the Kalamazoo celery soil No. 1, and analyses of those at Grand Haven and Newberry do not vary much.

An analysis of genuine peat No. 2, comes from the 1865 report of the Michigan Agricultural College, p. 208 and No. 3 is the average of eight analyses of Michigan peat by Prof. W. H. Allen and No. 4 of 10 analyses which I owe to Prof. Delos Fall.

* See Kohler "Die Torf Industrie" Vienna, 1897, for a full account of the German industry; the various pamphlets issued by the "Peat Industries Limited," a corporation of Brantford, Canada, for the Canadian industry; also a paper on peat by Arthur G. Ardagh, read before the Engineering Society of the School for Practical Science, Toronto, 1901, p. 59; peat by Heinrich Ries, Mineral Resources of the U. S. for the calendar year 1901.

	No. I (Kedzie)		No. II (Kedzie)
Organic matter ..	63.76		
Water	6.51		97.78
	70.27		
Sand and silicates.	19.16		4.03
Alumina	1.40		
Oxide of iron	3.94		.536
Magnesia	.81		.144
Oxide of lime	6.09	Car.	.835
Soda	.38		.065
Sulphuric acid ...	1.31		.051
Potash	.34		.131
Carbonic acid	1.95		.051
Phosphoric acid..	.88		.053
Total ash	36.26		2.238
	106.53		100.018

	No. III (W. H. Allen)	No. IV (Deloss Fall)
Moisture &		64.935
Volatile C.	59.192	28.843
Fixed carbon	31.006	
	90.198	93.788
	9.802	9.222
	100.000	100.000

The vegetable covering so often found in connection with marl deposits is peat.* Tamarack swamps and cranberry bogs almost invariably contain peat. Very many lakes are surrounded by a margin of peat, especially marl lakes. Sometimes lakes are entirely filled up by it, a dense tough fibrous mat forming beneath the surface and beneath a more fluid ooze. A grade over the top may last a while and then give way.

There has been a great wealth of peat in the state but it has in places been destroyed by fire and by drainage. When fire gets into one of the peat bogs it will, as is well known, linger for a long time. Many of the peat deposits occupy the beds of filled or practically filled lakes. If one takes a map of the state and notices where lakes are abundant, one will also outline the areas most rich in peat. Channels of old ice drainage like the Chandler swamp, Pine lake and Old Maid swamps near Lansing, and others near Charlotte and Chelsea, frequently contain large deposits of peat, but it may also occur behind ridges of sand or gravel at the head of bays cut off from the lake. Not only is this true for the present shore line, especially south of the line from Port Huron to Frankfort, but also peat deposits are found back of ridges which were formed when the lakes stood at a higher level.

Originally peat was merely cut into blocks with a spade and laid out to dry in the sun, before being carted away to be burned, but the interest in peat at present is with a view of compressing it and drying it, so as to make an article of fuel much superior to the uncompressed peat or even to go further and by distillation produce coke or gas with the usual bi-products, sulphates of ammonia, acetates of lime, wood alcohol and tar. Peat has also been used for packing nursery stock and paper can be made from the fibrous kinds.

Peat has been mixed with the molasses which is a by-product of the beet sugar factories, and fed to stock. It is said to keep the molasses from fermenting.

It has also been proposed as a fuel for cement factories and as it very commonly occurs in connection with marl, it would seem a natural thing to do. Mr. W. H. Hess has made the following report to the Egyptian Portland Cement Co.

"I have been investigating the "Peat Question,' and submit for your information the following table:"

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*See Vol. VIII, Part III.

	Carbon	Hydrogen	Oxygen	Colorific or Heat Unit Values	Capacity of High Heat or Intensity
Wood	50.13	6.08	43.74	42.12	2389
Peat	61.35	5.64	32.82	56.54	2547
Lignite coal	67.86	5.75	23 39	65.69	2628
Bituminous coal	79.38	5.34	13.01	75.44	2694
Charcoal	90.44	2.91	6.63	80.03	2760
Anthracite	91.86	3.33	3.02	83.37	2779
Coke	97.34	0.49	....	80.09	2761

In examining this table, note the column designated "Calorific Intensity" and notice you can get as high heat with peat as you can with bituminous coal, lacking 150 degrees centigrade, and the conclusion is therefore warranted that you can burn Portland cement with dried peat as rotary fuel. It would not cost over 20 cents per ton to prepare peat for rotary work, using waste heat as a drier. The grinding would be very easy."

Yours truly,
(Signed) W. H. HESS,
Chemist.

In compressing peat some plants proceed at once to take the wet peat as it comes from the bog and put it into the machine, while others air dry and then compress. The peat as lifted from the bog may contain from 75 per cent to 90 percent of moisture, whereas air drying will reduce 160 lbs. down to 70 pounds or even less than 40 lbs., so the moisture will be reduced down to 40 per cent. on 50 per cent. or even less. Thus the amount of raw material entering the factory will be lessened and its capacity very greatly increased and this appears on the whole to be the weak spot in the business at present. I found on a recent trip to Canada that the Dobson plant at Beaverton produced only 64 tons a week and the Stratford plant about 15 tons a day.

The prospecti do not figure more than 200 tons products per area and one foot in depth. An acre of water a foot deep, weighs 1261 tons. As the peat is drier it becomes also lighter than water, crude peat weighing about 22 lbs. per cubic feet.

Areas of peat to be worth considering for factory purposes should, according to circulars, be equivalent to not less than 200 acres, six feet thick. This we see would mean at 200 tons per acre per foot, only 240,000 tons, which at only 10 tons a day output, would mean but a seven year life for the plant.

The following is the schedule of questions asked by the Peat Development syndicate of Toronto, Canada.

1. Describe location of marsh lands, noting means of transportation available, and distance from railway or water transportation.

2. How many acres of peat or swamp muck?

3. What is the nature of the growth on the surface of the bog?

4. If timbered, what is now growing on the land? If cleared, what was grown?

5. About how much of it is cleared now?

6. Do you know or have heard, about what the depth of the peat is?

7. What information have you as to the deepest part of the bog? Does the depth vary much?

8. Is there a good fall from the land so as to readily admit of draining?

9. Peat covered by a heavy growth of moss is generally of good quality. If moss covers surface of land, what is your information as to its depth before the peat is reached?

One ton of peat is said to be equal to one cord of four-foot dry maple wood. The price at which it is retailed at the factory varies from $3.50 to $4.50 a ton.

Peat factories have been planned for location near Capac and at Chelsea. The former is, I believe, nearly finished.

The compressed peat comes in cylinders about 2½ inches in diameter and from one to three inches high. It needs somewhat different treatment from other fuels. The following directions are given:

It should be burned in a small area, with less draught, and renewed somewhat more frequently.

The fuel in burning should be disturbed as little as possible and the fine ashes retained in, rather than forced out of the fire pot. Do not touch or poke the peat briquettes, but instead, when a quick fire is required, a small passage opened through the ashes will serve to admit air and revive the fire.

For ranges and cooking stoves the fire-boxes should be small, as it requires a much less quantity of peat than of coal to make a fire, though it must be renewed somewhat oftener. Peat ignited and covered with ashes will keep fire equal to the Yule Log, can be easily kept alive over night, even in cook stoves, and by merely re-opening the dampers a surprisingly active fire is quickly rekindled.

Where coal grates are used it is best to partially stop up the spaces between the bars by covering the whole grate surface with fine wire meshing, or where this is not available, the openings may be lessened by filling in with coal clinkers, or even by sufficiently covering with pieces of tin.

When a quick fire is wanted, use about the same amount of light wood as for soft coal. Experience will teach when to close the draughts. If the stove is apt to smoke, the draughts must not be closed too soon, or else the fumes, which are given off at first, will escape into the room. However, these gases are not only harmless, but are positively wholesome. On the other hand, do not let the fire gain too much headway unless great heat is required. When the fuel becomes red hot, or before that time, according to circumstances a steady fire may be maintained for hours by closing off all the draughts. Peat can be burned in almost any kind of a stove, but gives the best satisfaction in surface heaters, whether coal or wood. Self-feeders, as at present built, are not suitable. Peat does not require much draught and will burn in the open air when started. Always store peat for fuel in a dry place.

Limestone.

Beside this I supervised and assisted in the studies of limestone by visits to the quarries of Huron County, to those around Petoskey and Charlevoix, including the quarry of the Petoskey Mackinaw stone quarry (4 miles south of Mackinaw City on the M. C. R. R.) and the Beaver Island Group, and to Manistique and Gladstone. Much of the material collected will come in Dr. Grabau's report.

The following items are of enough interest to deserve mention.

The Petoskey Mackinaw Limestone Quarry is on an old French Concession. The exposures are close to the track of the M. C. R. R. and the water along Mill Creek. Magnesian limestones of the Monroe Group, sometimes gashed, extend from the lake shore to south of the railroad track and up to the highway. South of this the beds appeared to be purer limestones of the Dundee formation for some 700 feet south of the road. Analysis by the chemist, Mr. Stebbins, confirmed this.

The northern part of the Beaver Island Group:—Squaw, Whiskey, the north part at least of Garden Island, etc., belongs to the Monroe dolomite, i. e. Salina Formation. The rock is mainly a fine grained dolomite, sometimes gashed. On Whiskey Island, blue and clayey beds are exposed. I think that borings would strike gypsum at but little depth. We find no exposures south of the northeast corner of Beaver where there are extensive deposits of the Dundee limestone. It is cherty and fossiliferous, and appeared to be typical corniferous but a specimen taken by Mr. H. P. Parmelee from a cellar northeast of the light house, where the rock was plainly in place gave Dr. George A. Koenig.

Calcium carbonate	48.50
Magnesium carbonate	37.68
Clay and insoluble matter	13.22
Difference (iron carbonates)	.60
Total	100.00

This is practically a dolomite which is decidedly unusual in the Dundee limestone. However, in the new well put down at Ludington by the J. S. Stearns Lumber Co. dolomite comes below the shale at the base of the Traverse (Hamilton) Group, the Bell Shale.

I take it that the hard limestones of the Monroe and Dundee form a ridge in the rock surface and that south of them the rock surface drops off into a valley corresponding to this shale and then rises again in the ridge which is exposed from Norwood and Charlevoix clear around to Alpena. In other words, the upper part of the Traverse Group determines a ridge of the rock surface. The limestones of the ridge are at times over 90 per cent. calcium carbonate and so in demand for various chemical purposes, being suitable for the manufacture of acetate of lime, Portland cement and, to a certain extent, for beet sugar. The following are analyses by Prof. F. S. Kedzie, from the Petoskey Lime Stone Co. Loc. 44, of Grabau's map in the Annual for 1901.

	I.	II.	III.	IV.
Moisture	.08	.04	.06	.09
Insoluble silica	.36	.52	2.86	2.66
Oxide of iron and Alumina	.76	.88	.66	.49
Calcium oxide	53.96	53.86	47.65	50.17
Magnesium oxide	.46	.60	4.89	2.72
Carbon dioxide	40.38	41.50	38.94	38.90
Difference, mainly organic matter	3.94	2.60	4.94	4.97
	100.00	100.00	100.00	100.00
Pure calcium carbonate	96.40	96.20	85.09	89.52

Nos. 1 and 3 will do for sugar.
Nos. 3 and 4 will do for lime.

The Alma Sugar Co. found the following results:

	Top	Mid.	Bot.
Insoluble iron and alumina	3.00	4.50	5.40
Calcium carbonate	85.38	81.11	88.32
Magnesium carbonate	11.60	13.97	5.22
Undetermined	.02	.42	1.06
	100.00	100.00	100.00

The Antrim Iron Company found some stone of the Jarman Quarry (see last year's report, Loc. 43) Analysis No. 1 following

	I.	II.	III.
Silica	.54	.26	1.192
Alumina and iron oxide	.48	.40	.26
Calcium carbonate	96.55	97.30	94.54
Magnesium carbonate	2.17	1.40	3.602
Difference	.26	.64	.456
	100.00	100.00	100.000

Nos. 2 and 3 are also analysis of Petoskey limestones as well as the following set (except No. 5 which is from Trenton, Mich,) by W. F. Brady.

	I 8-ft.	II 3-ft.	III 4-ft.	IV ?	Trenton
Silica	1.04	1.000	2.90	2.06	.96
Iron and alumina	.62	.46	1.16	2.04	.66
Calcium carbonate	95.23	95.23	82.46	90.60	96.35
Magnesium carbonate	3.12	3.58	13.60	6.31	.88
Sulphur	.044	.033	.030	.074	.038
Phosphorus	.004	.003	.007	.007	.003
Difference	.058	.306	.157	1.091	1.109
	100.000	100.000	100.000	100.000	100.000

While these are all limestones rather than dolomites, the amount of magnesia varies from nearly 14 per cent to nearly nothing.

It would be of great practical importance to be able to separate rapidly at the quarry the higher grade limestone from those not so low in magnesia.

Tests with acid which will distinguish between dolomite and limestone have proved of no avail here. I took six specimens from the quarry near locality 44 and had them tested for magnesia.

The results were as follows:

Nos.	I	II	III	IV	V	VI
Mg O	1.2	0.75	8.2	3.9	0.85	1.65

Of these No. 2 is largely coralline, and its low percentage of magnesia goes to confirm Grabau's rule, that the coarse reefs are the purest limestone but I have found no physical character to distinguish 3, 4, 5, in which the magnesia varies so greatly.*

A test which would determine rapidly and in the field from 90 per cent. calcium carbonate up, is then something to be sought for, and I should be very glad to co-operate with any chemist in search for it. At present we can only say, that it will be very unsafe to guarantee any percentage of calcium carbonate above 90 per cent. on the strength of single samples, and that the coralline parts will probably be the best.

The following notes as to the corresponding beds at Alpena was received from Dr. Grabau too late for insertion in his report last year.

"Since the preceding pages were in type, the following additional analyses have been received from Mr. S. H. Ludlow, chemist of the Alpena Portland Cement Co.:

I. Alpena limestone, cement quarry. Limestone sent to Alma Sugar Factory.

Sample.	A.	B.
Silica	00.34	00.17
Alumina	00.28	.....
Iron Oxide	00.21	00.48
Calcium carbonate	98.20	98.38
Megnesium carbonate	1.05	00.94
	100.08	99.97

The following according to Mr. Ludlow is about the average required by the sugar factories. Here is an analysis of a random carload.

Sample.	C.
Si O2	00.42
Al2 O3 and Fe2 O3	00.35
Ca CO3	96.58
Mg CO3	2.57
	99.92

II Lower Traverse beds.

The following analysis are of calcareous beds in the clay pit of the Alpena Portland Cement Co., locality 31, p. 189. The first in the hard bed just below the clay, the second six feet lower:

	D.	E.
Si O2	39.39	20.04
Al2 O3	8.43	2.27
Fe2 O3	1.13	1.42(Fe only)
Ca CO3	41.92	69.62
Mg CO3	5.94	4.47
S O3	2.15	2.04
Asphaltum undetermined.		
	98.96	99.96

The iron in the beds is undoubtedly in the form of pyrite.

The following is the analysis of the compact lithographic stone from the sink holes. (Locality 19, p. 190 of the annual report for 1901):

	F.
Si O2	00.55
Al2 O3 and Fe2 O3	00.62
Ca CO3	97.75
Mg CO3	1.04
So3	trace
	99.96 plus

ROAD METAL.

Some of the islands of the Beaver Island group, especially Garden island, would yield quantities of stone for road metal very cheaply. It would of course have the usual qualities of such road metal, yielding fine white dust freely, and wearing rapidly but cementing well.

I was also asked for advice regarding road metal to be used in the Saginaw county stone roads and in consequence visited Huron county once more. The question was primarily between the quarries of the Bay Port Stone Co. and that of the Saginaw Stone Co., a newly developed quarry on the sw quarter of the nw quarter of section 14, T 14 N, R 9 E, to the east of the Pere Marquette track. This, it will be noticed, is not far from the Shebeon exposures mentioned on pages 111-112 of the Huron county report (Vol. VII, Part II), where also the Bay Port quarries are described (pp. 112 and 214).

I examined a number of nearby exposures beside the Saginaw Stone Co.

* Just for experiment I tried small polished surfaces with Bertrand's total reflectometer. The line for the index for refraction of the ordinary ray was well defined at scale 63-1.664. There was another band somewhere near 47, for which n-1.573, which may represent the average for extraordinary rays.

quarry and the stone taken from it. In all cases the surface stone was a sandy limestone. The grains of sand were easily visible on the weathered surface and there was a large coarse fossil Allorisma, characteristic of sandy limestone. There was no chert nor Lithostrotion.

The following tests were made by Prof. F. S. Kedzie. No. 1 is from a corded pile taken from the quarry. No. 2 from the east side of the quarry near the top. No. 5 is from an exposure in section 11, just north of the bridge.

The physical tests have been figured by me from data furnished by him.

	(1)	(2)	(5)
Insoluble matter	42.60	.....	42.61
Oxide of iron and alumina	.91	.....	.94
Calcium oxide	31.22	.....	31.08
Magnesium oxide	.56	.....	.09
Carbon dioxide	23.70	.....	25.85
	98.99	.....	100.57
Weight in ounces per cubic foot, wet	2.633	2.572	2.660
Weight dry	2.610	2.524	2.630
Per cent. of pore space by volume	2.35	4.75	2.2

While part of the insoluble matter was chert a very large part was sand. It will be noticed that the percentage of pore space is higher than in the lower bed or at Bayport. I should certainly consider this a relatively inferior grade of limestone for road metal or lime for it is a lot of sand in a softer cement. For concrete or construction, it might be perfectly satisfactory.

In a well put down near the quarry, lower and much better beds are exposed, the section being roughly:

	Thickness.	Total.
Sand	5	5
Sand limestone with Allorisima	2.½	7.½
First rate limestone (test 9A)	2.½	10
Sandy limestone	1.½	11.½
First rate limestone (1A)	1	12.½ plus

The analyses and tests of 9A and 1A are as follows:

	9A	1A
Insoluble	2.08	1.90
Iron and alumina oxides	.68	.21
Calcium oxide	52.91	53.49
Magnesium oxide	.72	.76
Carbon dioxide	43.80	44.00
	100.19	100.36
Weight wet	2.712	2,702
Weight dry	2,708	2,699
Per cent of pore space	0.31	0.26

The weights are in ounces per cubic foot (kilograms per cubic meter) and it will be remembered that there are 1,000 ounces of water to a cubic foot so that they give the density as well.

The lower limestones are well cemented, break with a clean conchoidal fracture and I should expect them to make as good road metal as any limestone. It is obvious, however, that it will be very difficult to avoid mixing in inferior rock.

I had similar tests made on the parosity and weight of the Bayport stone, as follows: (No. 8 being from a top sandy layer there which occurs in the southwest part of the quarry and is said to be excluded from the road metal; No. 9 being from a trainload of crushed stone for concrete, and No. 10 being from the main layer, which lies below the Lithostrotion horizon and has frequent balls of chert).

	8	9	10
Insoluble matter		11.13	
Oxide of iron and alumina		.67	
Calcium oxide		48.65	
Magnesium oxide		.56	
Carbon dioxide		39.00	
		100.01	
Weight dry	2,640	2,678	2,688
Weight wet	2,624	2,669	2,680
Per cent of pore space	1.66	.089	.082

The Bay Port dark stone gave H. & W. Heim of Saginaw 86.21 per cent calcium carbonate, the Bay Port light, 73.4 per cent. The Saginaw dark gave 81.66 per cent and the light, 55.02 per cent. This last corresponds to 1 and 5, the Saginaw dark to 9A, 1A, 2A etc., the Bay Port light and dark to 9.

Mr. H. H. Eymer made some further tests recorded in a report to the County Road Commissioners.

The best road metals in the Lower Peninsula, however, are crushed cobble stones or boulders and the gravel that occurs with glacial deposits, especially of the Kame and Esker nature. It is only the parts near the lake where the coating is clay.

Most of the limestone quarries of the state, however situated, furnish some road metal, and the waste of brick yards and coal mines is also used.

In the Upper Peninsula there is no dearth of road metal and that of the very best quality worth exporting. In particular the traps of the copper range should be mentioned. The waste trap rock of the copper mine, when it is not too soft and decomposed makes excellent road metal, * and the amygdaloid especially has good cementing properties. This cementing power it shares in common with the limestones, but in addition it is much harder.

* TEST OF TRAP ROCK FROM FRANKLIN MINE.

	Sample Marked...	Widths Ins......	Breadth Ins......	Height Ins........	Breaking Load lbs. Area Sq. In........	Ultimate Strength Per Sq. In........
A	1 7/8	1 7/8	1 1/2	3.516	87,000	24,750
B	1 7/8	2 1/8	1 3/4	3.984	83.300	20,910
C	1 1/2	2 1/2	1 1/3	3.75	95,800	25,550
Average strength						23.770

Mar. 31, '94 Sig.

EDGAR KIDWELL.

The Calumet conglomerate stamp sand cemented by asphalt has been very successfully used in blocks. By itself it has not quite the same cementing powers as the trap and amygdaloid sand, but it is much harder.

Besides the waste dumps of the mines there are a number of places where it seems to me crushers might be installed and road metal obtained under very favorable conditions.

Various parts where the Minong trap on Isle Royal comes near the water, as at McCargoe Cove and Stockly Bay, seem to be well adapted, and places on Tobin Harbor also, but I should like to call particular attention to a place studied by us for a week or two last summer, to wit: The south side of Mt. Bohemia. Here we have a very interesting phenomenon, scientificially; it is the only case of which I know where plutonic, that is, coarse grained and granite rock, is intrusive in the copper bearing series. It has indurated the traps into which it has intruded and baked them and also shattered them, so that they stand up in cliffs of hard and tough and yet at the same time in broken and shattered rock, at the foot of which are huge slopes of talus blocks containing millions of tons. The base of these slopes is over 100 feet above the lake and a crusher could be so placed that the material could be transferred almost entirely by gravity to the hold of a boat loading in Lac LaBelle.

Mr. F. E. Wright, who was with me in the study and will continue it I hope, writes as follows:

"I shall enclose several small sketch maps I have made from the notes we took. The contour lines of 2 and 3 were made as well as possible from the barometer readings we took at the different points. Of course they are not very exact, still they give a very fair idea of the topography. Shall have many corrections to make when I visit Mt. Bohemia again as I hope to the end of October or November.

"The main facts we observed in our work were the following: The gabbro (or whatever we decide to call it, after careful microsopical and chemical investigation) is intrusive into the melaphyre and forms a contact zone in the same. How far reaching its effect on the melaphyre is we did not attempt to ascertain. Shall do that after the leaves have fallen. The gabbro sends small stringers (remarkably small for so large an intrusive mass) into the melaphyre and these stringers then resemble the red rock found as a large mass enclosed within the gabbro. The exact relation of the gabbro to the red rock we did not settle definitely as I wish to make a microscopical investigation of the contact between the two before forming an opinion."

It will be remembered in my last annual report, (p. 229) I referred to the asphaltic oil found near Rapid river. I visited the region this summer. I believe that the oil comes mainly from the Trenton limestones which is the first bed-rock encountered and is often exposed. Cavities in this often contain a dark thick oil or gum of the character described. There are places where the Traverse and Dundee limestones are similarly charged with bituminous matter. It might be worth while to try several of these for paving as rock asphalt.

Iron Bearing Rocks.

The Rapid River Well, 200 paces W. and S. of the N. E. corner of Sec. 34, T 42 N., R. 21 W. below the Trenton which was some 300 feet thick, struck a strong flow of water (temperature 47 degrees F.) Below that somewhere was found some very fine samples of clean white glass sand like that in the Neebish Well from 222 to 384 feet down (page 227 of the Annual Report for 1901). Below that comes a more impure red sandstone and the well ended at about 800 feet in a decomposed schist that came up in large fragments with quartz veins and appears to belong to one of the iron bearing formations of the Archean. Another well about 900 feet deep on Sec. 8. T. 39 N., R. 21 W., struck at 900 feet what appears to be a quartzite also of the Archean, iron-bearing formations. It may of course be a boulder in a conglomerate. These facts are of some interest, for if I have made no mistake they indicate that the mantle of the post Archean formations is not very thick over the iron bearing rocks.

It might be possible by means of lines of the greatest magnetic deviation to decipher the structure of these rocks and prolong it out from the Menominee range with such accuracy that explorations for iron ore would not be altogether at random.

We received a request from *Prof. C. R. Van Hise in charge of the Section of the Precambrian and metamorphic geology to have the use of our material in finishing up their work on the iron ranges.

Some years ago under State Geologists Wright and Wadsworth, a large amount of work was done and material collected, but only a partial summary was printed at the time in 1891-2, and the U. S. Survey having taken up the matter in the mean time with ampler means, it seemed to me that it would be truer economy, not to have two parties doing the same kind of work at the same time. We have accordingly done practically no work in the iron country of late years, and the work already done (although there were thousands of typewritten descriptions by myself) was not so complete that I thought it deserved publication, yet the public is entitled to whatever of value can be extracted. I therefore, with your approval, wrote him offering the use of our material with restrictions, and also suggesting that he employ Prof. A. E. Seaman (now of the College of Mines, who was in charge of most of our field work in the iron country, and under whom I served) to assist in their use and the work which remained to be done. Prof. Van Hise seemed very much pleased, and made arrangements with Prof. Seaman as suggested. I am inclined to think that as a result the differences between the Surveys as to the facts of the case regarding the iron bearing rocks will be reduced to a minimum, though I have not been able to accept their use of the term Algonkian and Archean. It will probably be agreed that there are three iron series south as well as north of Lake Superior. There will still be much work left to do when they finish, and especially does the question of the distribution of gold deserve attention.

The following are assays from the Saux Head Mining Company Limited, whose deposit is located on Sec. 6, T 49 N., R. 26 W. The work is an amphibolite (diorite) charged with pyrite.

Analyst—Collection.	Ozs. Gold	Ozs. Silver	Copper
C. J. Thorpe, gold	6	3½	
Silver			
C. J. Thorpe	$9.60		
Silver	$1.00	2.	
F. D. Tower	.08		1.6
No. 22			
No. 365	.208		2.01
No. 410	.3065	5.16	1.18
No. 530	5.61	3.16	2.18
No. 600	1.35	trace	trace
W. N. Brainard, gold	¼		
W. N. Brainard, gold	9½		

Madison, Wis., April 28, 1902.

My dear Lane—I am very much gratified at your letter of the 25th inst. All of the suggestions you make as to the manner in which the material is to be used are entirely reasonable. The supplementary detailed work in reference to our final monograph is to be done by Dr. C. K. Leith, and to him I turn over your letter, with the request that he meet you at Houghton when he begins his field season, the latter part of June or the first of July.

I shall be very glad to make arrangements if we can to have the services of Mr. Seaman in the matter. Of his field work, I have, as you know, a very high opinion. However I cannot say anything definitely as to what arrangement can be made until my allotment has been received for the next fiscal year, and this I am not likely to know until about the middle of June.

Thanking you for your help in this matter, which I am sure will be of great importance in making our work fairly satisfactory, I remain,

Very sincerely yours,

Sig: C. R. VAN HISE.

Topographic Survey.

The topographic sheet around Ann Arbor has been completed by the U. S. Geological Survey, with the contribution of $2,000 from your Board. They have expended about twice as much on the field work alone.

The sheet covers a number of different types of topography, some of them

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*See letters April 16, 17, 25, 28, May 10th.

very complex, and will I trust be of material assistance to the scientific departments of the University who have asked for it. Photographs of the completed map ready for publication, are promised about Feb. 1st, 1903.

The work is of a high order. Mr. C. A. Davis of Ann Arbor writes: "Both he (Mr. Bebb) and Mr. Muldrow seem to be thoroughly conscientious in their work and to have that professional pride in a nice piece of work that insures a good piece of work".......... "if the rest of the work has been done as carefully the maps are as accurate and as good as could be expected on the scale used."

Our contribution has undoubtedly induced its completion at this time, and I should recommend continuance of similar co-operation upon the very liberal terms offered by the U. S. Geological Survey to cover the areas, where such maps are most needed.

Water Power.

The transmission of water power by electricity and its conversion into light, heat and power elsewhere, has become so important that the powers of this State have become of more value and interest than ever. The investigation of the hydrography of the State for which our act provides can, it seems to me, be most effectually done in co-operation with the U. S. Geological Survey. I have been in frequent communication with Messrs. Newell, Horton and Pressey and Messrs. Savicki and Gregory have been given leave of absence to attend certain gagings.

In the future the relations will be even closer in accordance with your vote.*

"That this Board express its sense of the importance and economic value of the work which the U. S. Geological Survey is doing through its Hydrographic Division in estimating the available water power and river discharges of the State, a resource in which the State is rich, which has been but partially developed; and that it hereby requests them to continue the work, and tenders the services of the State Geologist in the supervision of the same, so that records may be available in his office."

I am still gathering facts as to the increase of temperature with depth and have a large number from relatively shallow wells. The J. S. Stearns well at Ludington, which had a strong flow of water at 53 degrees F. from between 204 feet of 10 inch casing, and 576 feet of 8 inch casing to bed rock, gave a temperature of 80.8 degrees at 1,945 feet, a rate of increase of 1 degree in nearly 60 feet, about the normal rate for wells that are largely shale.*

*See report for 1902.

* Resolution passed Nov. 13, 1902.

Much more interesting, however, are a set of observations in the Champion Iron Mine, kindly made for me by the engineer, Mr. D. C. Peacock and given herewith:

"Letter Aug. 20, 1903.

Rock temperatures at Champion Mine.

Corresponding to a surface temperature of 41.6 degrees F., and an increase of 1 degree each 111 feet vertical.

Place.	Temp.	Vert. Depth.
9th level drift 250 feet west of No. 7 shaft	45.8	465 feet
24th level west drift 140 feet from No. 7 shaft	52*	1,355 feet
End of 26th level C. C. 100 feet from No. 7 shaft	55!	1,500 feet
End of 28th level east drift 750 feet from No. 5 shaft	56.5!!	1,650 feet

REMARKS.

No. 7 shaft drift has no connection, hence no air circulation.

*Strong current of air (cold) close to hole used which was only 4 feet deep. Result probably too low.

!Cross cut has just been driven in; no connection.

!!Drift has no connection and no ventilation except the air from the machine.

The rate of increase is fully as low as in the copper mines. In the Phoenix Copper Mine, I found the temperature of a little slow water seepage at a depth of 355 feet, 46 degrees, while at 615 feet depth it was 48.5 degrees.

My statement that the nearness of mines to Lake Superior has nothing to do with their coolness is confirmed by the results of a deep well at Freda, which from a surface soil temperature of 43 degrees to 45 degrees (the latter that of a spring near by) rises to 51 degrees at 480 feet; 51.5 degrees at 550 to 636 feet, and 55 degrees at 950 feet, which shows an increase of 1 degree in 79 feet. The rock is all sandstone, but basic and somewhat indurated.

It will be seen that no essential modification of the conclusions reached in my report last year is required.

Wells and Deep Borings.

Like all times of prosperity this has been one of marked activity in deep borings. A number have been or are

* Annual report for 1901, p. 251.

being put down and more or less complete records collected for discussion later.*

Two or three matters are worthy of mention now. One, concerning which there have been several inquiries, is the thickness of the salt bearing formation and the depth beyond the first salt to which it is worth while to sink. I give, therefore, a list showing the depth to the first salt bed and to the last salt bed and the difference, in case I think the well is through all the salt. I have added a plus sign (unless the well has gone so far beyond that there is a reasonable certainty that no more is to be found) when I am not sure that this is all. When I think that it probably or certainly is not all, I have not given the difference.

It appears from the list that north of Alpena and Manistee, there are probably only a few feet of salt if any at all, and that down the Lake Michigan shore there is but one main bed of salt, which runs out north of a line running from Muskegon to Monroe. Milan and Trenton are on the edge, but going northeast, it soon thickens and several beds probably aggregating much over 100 feet occur within a thickness of perhaps 900 feet, so that along the Detroit and St. Clair Rivers, while all the salt may occur within 700 feet of the first salt, it is more likely to be spread over 900 feet. In detail, the succession of beds is quite likely to be very irregular, even in wells close by.

Salt Beds at—

Ludington, between 2,296 feet and 2,304 feet, give 8 feet plus.

Ludington, between 2,195 feet and 2,213 feet give 18 feet plus.

Buttersville between 2,242 feet and 2,260 feet, give 18 feet plus.

Manistee, 1830 to 1,978 feet and 2,027 feet, give 42 nearly.

St. Ignace, 350-?, 355-? feet, give 5.

Cheboygan (near 1,400 is the horizon) 0.

Alpena, at 1,164 or 1,267 feet, 20 feet or more.

Goderich, Canada, between 916 feet and 1,517 feet, give 601.

Clinton, Canada, between 1,180 feet.

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* Next year I hope to make a full report of progress in oil and gas developement.

The following is a fairly complete list of wells over 500 feet deep or planned for such, concerning which, facts have been or are being collected.

St. Johns, Mich., Alkali Co., Ecorse; Solvay Process Co.; Reed City, Freda, Rapid River, Gladstone, Manistique, Ludington (J. S. Stearns No. 3) Manistee, Milan (continuation) St. Clair No. 4, Port Huron, Allegan, Assyria, Grape, Niles, West Bloomfield, Fowlerville.

Carmen well (Petrolea), 1,210 feet and 2,105 feet give 895.

Cleveland (Sarnia), 1,529 feet 8 inches, and 1,781 feet 8 inches.

Wells, Port Huron, 1,555 feet, 1,750 feet.

Port Huron Salt Co., 1,498 feet.

St. Clair, between 1,600 feet to 1,610 feet and 2,168 feet.

Courtwright, 1,620 feet.

Marine City, between 1,520 feet to 1,570 feet, and 1,815 feet.

Port Lambton (no salt, salty shale), 1,710-? feet.

Algonac, 1,550 feet, 1,614 feet.

Wallaceburg (no salt, represented by anhydrites) from 1,700 feet to 1,380 feet.

New Baltimore, 1,600 feet, 1,715 feet.

Royal Oak, 1,543 feet, 2,475 feet, 932 feet.

Detroit River—

Stroh's Brewery, 1,150 and 1,815 feet, 745.

Solvay No. 6, 873 feet, 1,607 feet, 634 feet plus.

Solvay No. 10, 891 feet, 1,596 feet, 705 feet.

Windsor C. P. No. 11, 640 gypsum, 1,127 feet, 1,167 feet.

Tecumseh Salt Co., 828 feet.

Detroit Salt Co., between 906 feet and 1,692 feet, gives 786 feet.

Penn. Salt Co. (Ecorse River), 830 feet, 1,050 feet.

Saliote & Ferguson, 855 feet.

Rouge River Salt Co., A. W. Palmer, 871 feet, 1,660 feet, 789 feet.

Brownlee, 875 feet.

River Rouge Improvement Co., between 815 feet and 1,533 feet?, 725.

J. B. Ford, between 876 feet and 1,323 feet?, 447 feet plus.

Wyandotte (Eureka) between 730 and 1,235 feet, gives 505 feet.

Trenton*, Church & Co. No. 1, in Nos. 2 and 5 absent, 1,185 feet to 1,215 feet, 30 feet.

Milan, 1,540 feet, 1,545 feet, 5.

Britton, Monroe, Dundee absent.

Work Ahead.

For the future we have before us as desirable to undertake or as already undertaken and to be finished:

First—A report upon the limestones of the State, especially in their economic relations, but also with a view to their paleontology. Upon this Mr. Grabau is at work.

Second—A report upon the peat of this State. I have given a few facts upon peat above, but judging from the inquiries, this resource will be of more importance as the years roll on and the supply of hard woods grows scarcer. I expect peat to compete not with soft coal as a steam producer, but with

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* Upper salts replaced by anhydrite; lower also perhaps.

hard wood and gas as a range and domestic fuel.

Third—The report on plaster and gypsum, which is in preparation by Prof. Grimsley.

Fourth—Water Supply Paper No. 30, prepared by myself for the U. S. Geological Survey is now entirely out of print, sooner than many of the more recent numbers. This seems to indicate that it was of use and it might be well for the State to take up the matter therein contained, with the necessary revision and enlargement, and at the same time incorporate a study of the water supplies from a chemical standpoint, and also of the water powers. I have already referred to the work begun by Mr. Horton.

Fifth—We need a general, fairly popular and practical summary and revision of the exhaustive work of the U. S. Geological Survey in the iron country, which might well be in somewhat more portable shape. This should at the same time be not a mere compilation but a thorough revision from our point of view.

Sixth—A continuation of the work began by Dr. Hubbard upon the Copper range and the correlation of the Copper bearing lodes through the Porcupines clear to the Wisconsin boundary would be of especial value and I think develope some important scientific information.

Seventh—An examination of the available supplies of material for good roads.

This by no means exhausts the list of work assigned us to do by the Act or that I could find to be done without going out of my way to do it.

Beside, this, there is the areal work in hand, to-wit: Tuscola, Bay, Saginaw and Arenac counties, reports on which will make up Vol. IX of our standard set; the report on Wayne County which Prof. Sherzer has in hand; Co-operation with the U. S. Geological Survey in extending their topographic map down to cover Detroit; a report on Washtenaw county, which the completion of their may of the county, the studies of Frank Leverett and the deep wells at Ann Arbor and Milan, make timely; a report on Kent county, which will be of large use to schools of that county, and will be no great task after the work done by Nellist, Livingston, Leverett and Grimsley. I will not go on to enumerate other things to be done as I have laid out more than enough to keep us busy for two years, when one considers the ordinary routine of giving and acquiring information wherever it may be obtained, but I hope as I find time to continue my studies on the grain of the rocks and the inferences that may be drawn therefrom.

Once more I renew my plea that the statistics of production of raw materials be gathered or at any rate published through the Bureau of Labor and Industrial Statistics for inquiries now frequently come to my office which are not merely hard to answer, but hard even to know where to refer for answers; coal does not differ from copper nor cement from salt so much that the facts concerning them should be differently published.

Tests.

A few words as regards chemical work and other tests.

In accordance with the usual policy of the Board I have always been ready to receive inorganic samples and give a rough estimate of their nature and value and whether they are worth further chemical test without any elaborate chemical examination. The Geological Department of the College of Mines will do the same thing. Samples of animal life will usually be determined at the Agricultural College if addressed to Prof. W. Barrows, and of vegetable life if addressed to Prof. W. J. Beal. To the latter I am indebted for examining various samples of wood brought up in well drilling.

Inasmuch as the state supports several chemical laboratories I have not thought it economy to equip another, but rather to get the work done where it can be best done. I am indebted to Prof. F. S. Kedzie for numerous favors in this line. I also sent a circular to the various chemical laboratories and others who had furnished us analysis to obtain a summary of facilities in that line, the results of which are given below.

If it is deemed wise for your Board to undertake the business of making more thorough examinations, charging a fee therefor, as the Bureau of Mines does in Canada, advantageous arrangements could be made with the University of Michigan.

STATE LABORATORIES NOT SOLICITING OUTSIDE WORK.

Name, Director, Address, Equipment and Spesialties:

University of Michigan—

Technical—A. B. Prescott, Ann Arbor, general, some private work by advanced students.

General—S. L. Bigelow, (in charge), Ann Arbor, general, some private work done by advanced students.

Engineering—E. D. Campbell, Ann Arbor, Portland cement materials, etc.

Hygiene—V. D. Vaughan, Ann Arbor, sanitary analysis, public water supplies.

Agricultural College—F. S. Kedzie, Lansing, general, calorimeter; fuel and fertilizer values, sugar and cement materials, water analysis.

College of Mines—G. A. Koenig, Houghton, general, assaying, etc.

State Analyst—R. E. Doolittle, Lansing, organic mainly; adulterations.

LABORATORIES CONVENIENT FOR PRIVATE ANALYSES.

Name. Director, Address, Equipment and Spesialties:

McMillan Chemical Laboratory—Delos Fall, Albion, general; marl, clay, peat, lead, silver and copper. Sanitary water analyses.

Dearborn Laboratories—W. A. Converse, Chicago. General; Water, coal, clay, marl and general commercial, circular price list, $5 to $10 up.

Detroit Board of Health—W. J. Tibbals, Detroit. General; price on application.

Midland Chemical Co.—H. H. Dow, Midland. Brines, bromine, limestone.

Kennicott Softener Co.—Chicago. Boiler waters.

Detroit College of Pharmacy.—W. H. Allen, Detroit. Organic and peat.

PROFILES, MINE MAPS.

The Michigan Engineering society have turned over to us through Mr. C. W. Rubbell a collection of railway profiles, largely made by Mr. W. B. Sears, which will be of use, which reminds me to renew my recommendation that from time to time copies of profiles of railroads and maps of mines should be filed in some bureau. I should think our fire proof vault in Houghton would be a good place. It is of advantage to the companies themselves in case of loss of the originals, and in case of abandoned mines, may be of vital importance in opening mines on adjacent properties.