NOT NEEDED

REPORT

OF THE

STATE BOARD OF GEOLOGICAL SURVEY

OF MICHIGAN

FOR THE YEAR 1907

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STATE GEOLOGIST

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BOARD OF GEOLOGICAL SURVEY

1907

EX OFFICIO:

THE GOVERNOR OF THE STATE,

HON. F. M. WARNER, *President.*

THE PRESIDENT OF THE STATE BOARD OF EDUCATION,

HON. D. M. FERRY, JR., *Vice-President.*

THE SUPERINTENDENT OF PUBLIC INSTRUCTION,

HON. L. L. WRIGHT, *Secretary.*

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LANSING

ALFRED C. LANE, State Geologist.

W. F. COOPER, Assistant.

HARRY R. WIGHT, Clerk.

HOUGHTON

A. H. MEUCHE, Engineer in Charge.

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Papers Included.

NINTH ANNUAL REPORT

OF THE

STATE GEOLOGIST,

ALFRED C. LANE

TO THE

BOARD OF GEOLOGICAL SURVEY

FOR THE YEAR 1907.

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THE PRESIDENT OF THE STATE BOARD OF EDUCATION,
HON. D. M. FERRY, JUNIOR.

SCIENTIFIC ADVISERS.

Geologists.—Dr. L. L. Hubbard, Houghton; Prof. W. H. Hobbs, Ann Arbor.
Botanists.—Prof. W. J. Beal, Agricultural College; Prof. F. C. Newcombe, Ann Arbor.
Zoologists.—Prof. W. B. Barrows, Agricultural College; Prof. J. Reighard, Ann Arbor.

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ANNUAL REPORT, 1907.

To the Honorable the Board of Geological Survey of the State of Michigan:

Gov. Fred M. Warner, President.
Hon. D. M. Ferry, Jr., Vice-President.
Hon. L. L. Wright, Secretary.

Gentlemen:—I beg to present herewith this my ninth report for the fiscal year from July 1, 1906, to June 30, 1907, inclusive, and for the field season of 1907.

FINANCES.

The following is the usual statement of expenditures from the annual appropriation:

	Salary.	Field.	Office.	Total.
July	$589.03	$155.96	$19.49	$764.48
August	601.00	163.31	33.55	797.86
September	503.00	124.08	121.57	748.65
October	397.63	62.82	36.03	496.48
November	424.00	103.11	56.37	583.48
December	427.19	12.61	31.37	471.17
January	392.20	92.18	50.68	535.06
February	400.60	54.16	65.51	520.27
March	392.20	2.82	15.85	410.87
April	477.46	188.02	30.21	695.69
May	430.40	47.99	128.67	607.06
June	873.12	183.26	268.62	1,325.00
Total	$5,907.83	$1,190.32	$857.92	$7,956.07

In addition to this we had:

For the year 1906–7, to be used in the topographic survey through the U. S. Geological Survey, $3,000.

Of this there was expended in completing the survey of the Rochester and Pontiac quadrangles, $2,991.09.

The legislature of 1907 have granted an additional $3,000.00 for 1907–8, which is being expended on the Milford and Howell quadrangles, and $500 on a survey of Calumet, a work of especial importance to the College of Mines in their gravity determinations. This as well as the appropriation for biological survey is provided by Act 245, Session 1907.

PUBLICATIONS.

On the new system practically the sole publication of the Board is its annual report. The report for 1906 which should be out in November, 1907, will therefore be a book of 601 pages, with very numerous maps and plates. Besides my personal report it contains a report of the late Prof. Russell's survey of a portion of Menominee, Iron, and Dickinson Counties. This is mainly on the surface geology, and contains an especial description of the drumlins so characteristic of this region.

From Prof. C. A. Davis comes a report on peat, which I believe to be of value to science and the State.

A section across the Copper Range at the west end of the State, from Bessemer north, by W. C. Gordon and myself, will prove of service when commercial exploration strikes this hitherto neglected part of the State.

A paper by Prof. C. S. Sargent on the Crataegus—hawthorn or thornapple—was heartily recommended by the Botanists on the Board of Scientific Advisers, and is a detailed account of the species of this genus in which Michigan is so wonderfully rich that the discrimination has been very hard for our local collectors. It is hoped that it will add to our knowledge of the origin of the plant species as well as aid our local teachers and botanists.

Papers have also appeared in "Economic Geology," the "Michigan Miner," Transactions of the Lake Superior Mining Institute, Proceedings Michigan Academy of Science, Bulletin Geological Society of America, and Journal of Geology.*

WORK READY FOR PUBLICATION.

In the report of the Board for 1907 should be included, besides my report, at least the following:

1. A report by Prof. H. Ries on molding sands and on some tests of fire resistance, for engineers.
2. A report of T. L. Hankinson and others on the plants and animals of Walnut Lake, with especial reference to occurrence of whitefish therein, for zoologists, botanists and teachers.
3. A description of the geology of the copper bearing rocks; for people generally, and for teachers, by myself.
4. A description of the deeper mine waters which are strong brines, by Dr. Fernekes and myself; for mining men, chemists and geologists.
5. Four sheets out of a map of the surface geology of the State to be covered by nine sheets, these four covering the surface geology of the Lower Peninsula; not only for geologists, but for all those interested in the agriculture, the soil, the clays, sands, etc., of the State.

It is quite likely also, if the date of transmission to the printer is delayed that we can include a number of other reports.

Among these are Davis' on Tuscola county, Gregory's on Arenac county, Meuche's on the Development of Mining Machinery and the Geological Factors Therein, and further contributions by myself to a knowledge of the copper bearing rocks and the distribution of the lodes therein, including several detailed cross sections and maps. With this Dr. Wright's report on Mt. Bohemia could profitably be included.

*"Salt Water in Lake Mines" and "Geology of Keweenaw Point," Lake Superior Mining Institute, Vol. XII, 1907, pp. 81–104, 154–163.
"Prospects for Oil and Gas," Michigan Miner, March and April, 1907.
"Dr. Carl Ludwig Rominger," Michigan Miner, June, 1907.
"The Formation of Lake Superior Copper," Science, April 12, 1907, page 589.
"The Early Surroundings of Life," Science, August 2, 1907, p. 129.
"Chemical Evolution of the Ocean," Bulletin Geological Society of America, Volume XVII, p. 691.
Discussion of Howe's piping and segregation of steel ingots, Trans. A. I. M. E., 1907, pp. 765–768.
Notes on the geological section of Michigan, Part I, the Pre-Ordovican, by A. C. Lane and A. E. Seaman, Jour. of Geology, 1907, pp. 680–695.
Contribution to symposium on water supplies, 8th report Michigan Academy of Science, p. 127.
Michigan Topographic Surveys, by W. F. Cooper, Michigan Engineer, 1907, p. 113.
Geology and Physical Geography of Michigan, by W. F. Cooper, Michigan Academy of Science, ninth annual report, 136.
Some interesting glacial phenomena in the Marquette region, Chas. A. Davis, Michigan Academy of Science, ninth report, p. 132.

I should like also in the near future to give a really popular account of the geology of the State, for teachers and those with no special knowledge of geology, saying also something about the prospects for oil and gas.

CO-OPERATION.

We have continued our policy of general co-operation with all agencies or individuals who are studying the resources of the State.

It seems to be worth while to list some of these that those interested may look up the matter.

The U. S. Department of Agriculture, under Milton Whitney of the soil division have now made soil survey of Allegan† (1901), Owosso (1904), Pontiac (1904), Alma (1904), Saginaw (1904), Munising (1905), Oxford (1905), and Cass (1906). Moreover, they have, at my requests, sent us maps marked with locations for gravel pits and notes on road materials. I append the letter on the area issued since last year.

Bellefonte, Pa., Sept. 23, 1907.

PROF. MILTON WHITNEY,
Chief of Bureau,
Washington, D. C.

Dear Sir:—Your letter of the 19th inst. regarding the location of gravel in the Cass county, Michigan, area, has been received. I have gone over the soil map and have indicated with a red cross the areas which I recall where gravel beds containing suitable road building material can be found. Gravel pits have not been opened in all these areas, but the surface features, the presence of a high percentage of gravel in both soil and subsoil, and the fact that a gravel bed is encountered at a depth of three feet in most of the places, indicates that gravel deposits exist.

All of the soils of the Cass county area contain varying amounts of gravel, and beds have been found in every type except muck, clyde and meadow. The soil mapped as Miami gravelly sandy loam contains a higher percentage of gravel than any other type, and the greater proportion of the gravel beds are found in this soil. Miami loam, sandy loam, and sand also contain a few gravel pits where material suitable for road building may be obtained. These gravel deposits usually occur as low hills or knolls and the gravel is encountered at from 3 to 5 feet below the surface.

Very respectfully,
(Signed) W. J. GEIB.

With the State Highway Department, whose headquarters are located just across the hall from us, relations have been more informal, but very pleasant.

The U. S. Geological Survey, topographic division, has in co-operation finished the field work of the Howell sheet and begun in the Milford and Calumet Special. The work was in charge of Mr. A. M. Walker.

Professor W. H. Hobbs, assisted by C. W. Hunt, were employed about Green Bay in making accurate lines of levels of some of the old shore lines. Prof. W. M. Gregory did similar work from East Tawas north. This work was undertaken by request, to further an elaborate report of the U. S. Geological Survey by Messrs. Frank Leverett and F. B. Taylor upon the geo-

†Field operations of the Bureau of Soils of the year given in parentheses.

logical history of Michigan during the time of the retreat of that ice sheet which once covered all this part of North America, and was the main factor in the present soil distribution. It is in continuation especially of Goldthwait's work in Wisconsin. The old shore lines appear, rise and fan out to the north. In producing this effect three factors were perhaps concerned —the *direct attraction* of the ice, the compressing effect of the ice on the rocks beneath, and a tendency to sink the solid crust down into a more or less fluid layer beneath as a boat would be loaded. How far these factors really entered into the result is a question of great interest to the geologist. Whether the relative uplift of the land is still going on or not, and whether it is a tilting or bending or a blockwise uplift has some practical importance.

From the U. S. Survey we have also obtained the assistance of Dr. Geo. H. Girty, who is to work over the Carboniferous fauna, and Mr. A. J. Hazelwood of the U. S. Geological Survey, assisted by your Mr. W. F. Cooper, have examined some coal mines as suggested by me, with the object of seeing how much fuel value is now wasted.

The new Director of the U. S. Geological Survey, Dr. G. O. Smith, invited the officers in charge of the various State Geological Surveys to meet him in Washington with a view to more harmonious work. There was a good attendance, and such meetings will in all probability tend to remove any friction or occasional waste of money that may have occurred in the past. In connection therewith there was a meeting of the State Geologists of the Mississippi Valley.

Assistance has also been obtained from the College of Mines and the Agricultural College. The chemical assistance of Dr. Fernekes, Mr. Wilson and Prof. Kedzie in the study of brines has been especially appreciated.

It will be noted that our special assistants are well scattered through our various State Institutions. It is the policy which has seemed wisest that your Board should along the lines of research which the legislature has put in its charge be a uniting bond among those interested.

WORK OF THE YEAR.

The State Geologist besides his multifarious executive, editorial and consultive duties (for almost every mail brings questions to answer and samples to examine), has spent most of his time on the copper bearing rocks and the occurrence of brines therein,* and in the southern part of the State.

Mr. Harry R. Wight has had charge of the correspondence, the sale and distribution of reports, and has assisted in blue printing and in many other ways.

During the calendar year of 1907 Mr. W. F. Cooper has been largely engaged in editorial work on the annual report for 1906. In the field he did some work for the State Highway Commission on the limestone formations near Jackson, and during a leave of absence without pay, studied shale and limestone near Saginaw Bay. He also assisted Prof. Sherzer in Wayne county and on the salt shaft, and Mr. A. J. Hazelwood of the U. S. Geological Survey who came to study coal waste. Some time has been spent in running levels and compiled data for a topographic map of Saginaw county. He has also articles in a report of the Michigan Academy of Science and Michigan Engineering Society.

Mr. A. H. Meuche has had charge of the Houghton office, and besides his report on the Development of Machinery in its geological relations, has done much work on copper country maps and has had charge of the party surveying and compiling a map of the Ontonagon copper mining district.

*See list above.

Of those employed for a time or on contract, the following report may be made:

Prof. W. H. Sherzer has kept track of the developments at the salt shaft and has also been at work on his Wayne county report.

Prof. C. A. Davis has edited the peat report and reviewed all and contributed certain parts to the Walnut Lake report. He has been interrupted by peat work for the U. S. Government, but is now finishing his Tuscola county report.

Dr. C. H. Kauffmann has continued his studies of the mushrooms in an unusually favorable season.

Prof. Mark S. W. Jefferson made some studies of stream erosion, coming to the tentative conclusion that they tend to cut their south banks more as the land tilting is still going on.

Dr. F. E. Wright spent a couple of months in the Houghton office finishing his Mt. Bohemia report.

Prof. A. W. Grabau has continued his work on the Traverse group and also assisted in correlating the beds of the Oakwood salt shaft.

Prof. W. M. Gregory has continued his work on his Arenac county report.

LEGISLATIVE MATTERS.

With your consent I asked the legislature for the following sums:

BUILDING.

Cases (250)	$250 00
Cement walks	60 00
Wiring (25x2)	100 00
Veneer (550–1050)	700 00
Furnace (360)	300 00
Addition to lot	750 00

ADDITION TO BUILDING.

60x34x22 ½x10	4,500 00
Stacks, 3 stories @ $1,700	5,100 00
	$11,850 00

BIOLOGICAL SURVEY.

Fish Work—	
Biologist	$1,200 00
Assistant	200 00
Fisherman	500 00
Chemist	600 00
Equipment and Expenses	500 00
Educational report, on one area	500 00
Algae report	500 00
Bradford, Bay county	100 00
	$4,100 00

TOPOGRAPHIC SURVEY.

($1500-$2500 each) x (4-6 sheets) $10,000 00

The committee on Geological survey who visited the building we now occupy in Houghton and saw the situation concluded that the old building was a disgrace to the State (in which they are not without some justification) struck out the provision for repairs and addition, and instead inserted one for a new building. Then in the last days of the session the Ways and Means committee who had not, so far as I know, been near the Houghton or Lansing office of the Survey, cut out the provision for the new building, and very naturally in the rush, didn't reinstate any of the items for repair and enlargement of the present building, which naturally in two years will look worse than ever. It would seem as though the State could afford a sidewalk in front of its property.

RECOMMENDATIONS.

However, there is this consolation. As near as I can find out a suitable new and fire proof building would cost much more than was suggested. There is no doubt that our work is more and more hindered, more cramped, and less effective than it might be and should be owing to limited quarters for collections. Not only that, but is going to be more and more so in the future. Investigation and mining tends to show a greater permanence of copper enrichment at certain horizons, and calls for a sharper and closer determination of beds from year to year.

To this end samples of the various borings and beds should be preserved. The diamond drill core sections are being made at a cost of from $3.00 to $5.00 a foot bored, and the cost per foot of core saved it is safe to put near $5.00 a foot. There are many thousand feet now preserved in our office, and tens of thousands of feet one might almost say without exaggeration are scattered along the range in buildings not fire proof, and in many cases mere shacks, in wooden, mouldering boxes. This material is of value not only for the local goelogist and miner, but for the solution of many broad scientific problems.

We could have it,—at least a great deal of it, were we in a position to give it proper fire proof storage.

It would be a graceful and gracious monument of foresight and far sight if some one so placed as to appreciate the value of these records, should erect a dignified building for their keeping—a stone library for a library of stone. But I think the State itself, which derives a revenue from every successful exploration, whose wealth is curtailed by every unwisely directed, fruitless or bootless exploration, can afford a plain but substantial building for them, to the end that money spent in exploration may be put to the best possible advantage, and the great fabric of organized Science which has added so much to the welfare of mankind derive the benefit of this expensive work. I may say that without the study of such drill cores I should probably never have arrived at my theory of the dependence of the grain of igneous rocks upon the distance from the margin, which has proved of distinct economic as well as scientific value.

I believe there can be wisely expended on such a building at Houghton, $20,000.00.

TOPOGRAPHIC SURVEY.

I hesitate to urge you to ask for farther appropriations for joint topographic survey until such time as the legislature feels that the State can afford to grant sums large enough to work with economy, to make the necessary supervision not burdensome, out of proportion, and be comparable with those granted by other States of like rank. Ohio has been granting $20,000.00 per annum, and Illinois $10,000.00 per annum.

If Michigan, which, as the late Senator McMillan said, more than almost any other State needs just such maps, with all her water power resources, lands to drain, electric roads to run and other engineering projects which would be aided or suggested by such maps, beside the use of them geologically and by teachers, can not expend at least $10,000.00 within a biennial period, which with an equal amount put in by the gen ral government would make $20,000.00, it would be well—I believe I am in agreement with the authorities of the U. S. Geological Survey in saying—not to put in anything at all.

The demands from the several states for co-operation from the general government are so numerous that I have known of refusal of co-operation when the legislature had already made the necessary appropriation.

The endorsements of these maps by the Academy of Science, Engineering Societies and others I need not repeat.

The Biological Survey could in my judgment expend with profit $2,500.00 per year.

I have received much assistance by letter from time to time from the various gentlemen composing the Board of Scientifie Advisers. At their fall meeting, held Nov. 14, the following resolutions were passed:

Paleontologic material should be returned to the Board of Geological Survey as soon as the report is published, unless permission for further detention is given by the State Geologist.

It is recommended that so far as the expenditure of the funds of the Biological Survey is concerned that the balance, not otherwise appropriated, be referred to Prof. Reighard and Mr. Lane.

Realizing the importance of reforestration to the interests of this State, we recommend that the State Geologist or Board of Geological Survey consult with the Forestry Commission and the Professors of Forestry at the University and Agricultural College with the object of furnishing all assistance that the Geological Survey might properly give in the work of reforestration.

We recommend that the Board see what can be done in connection with the Forestry Commission toward publishing a book of a popular nature on the condition and prospects of Michigan forests, using the maps already prepared by Prof. Davis.

Voted that the matter of Bradford and Brown report be referred to Prof. Newcombe.

CONSTITUTIONAL CHANGES.

May I be permitted with all deference at this time to urge upon the Board certain constitutional changes.

In connection with the work of this board it has been impossible not to note the devastation of the forests, and the impoverishment thereby of the country, especially in connection with fires. Studies under this Board have shown that there is a slow improvement of the forest soil and that as under the shade of the forest leaves and humus accumulates, jackpine may be replaced by white pine and that in turn by hardwood. Once a forest is devastated and fire gets in not only the trees but the soil itself, the accumulation of a geological cycle, is burned away and the surface may at times revert to shifting dune sand. Rapid erosion, heavy loads to the rivers, upgrading of their beds, sharp and disastrous floods in the spring, severe droughts and very low run off and feeble water power in the summer, all then may in some way be connected with the reckless stripping of the once supposed "inexhaustible supplies" of timber. These, then, are geological consequences of the first order. So it does not seem out of your or my province to urge that from the constitution should be eliminated any clauses that might interfere with stumpage taxes or other means of relieving private forest culture of present unfair burdens. Nor should there be anything to prevent the State itself from going into forest culture or such other plans of internal improvement and development as may become and be deemed wise by succeeding legislatures. For as the commonwealth becomes more and more closely settled the regulation of our rivers, the inflow of sewage into them and the outflow of drains from lowlands, and their floods, must become more and more a matter of State concern in order to conserve our State resources and secure the greatest good to the greatest number.

It is my belief too, that Prof. Roth is entirely right in saying that every acre of its land is worth at least $5.00 an acre to the State of Michigan.

But if the State is to remain owner in any large degree of its lands, it should be able to lease them to cut timber and to explore for mineral wealth.

In fact as regards the whole matter of exploring for oil and gas in my judgment it could be very much better controlled, with less waste of money and less danger of falling into the hands of the monopolies too powerful to control if, as I have elsewhere suggested, the following policy were adopted.

Let the State exercise its right of eminent domain as to petroleum, as it has according to the fundamental law in gold and silver, and arrange terms by which the development of the same in suitable areas and under suitable restrictions, and with such provisions for the protection of the public as the people of the State, through their legislatures, might seem wise, should be given to those who choose to run the risk so that they may reap the rewards, if any. For instance, provision might be made that any company having actual capital paid in and available as an exploration fund enough under ordinary circumstances to put down say a dozen wells to some horizon known to yield some oil or gas, should have exclusive right to the oil or gas in a given county or district for a term of years or so long as they continue exploration or production, subject (1st) to the usual royalties to be paid to the county authorities, which, if they exceed the county tax should be divided pro rata among the land owners; (2nd) to the usual provisions of oil leases as to making good surface damages, and (3rd) specific tax, and in case two equally responsible companies were bidding for the same county that offering the largest specific tax might be preferred; (4th) in case a monopoly detrimental to the public welfare were threatened, the State might step in and buy out the company at a fair price.

I do not say that this plan should be introduced into the constitution, although I am convinced that this would be a far better plan than the present. But ought not the constitution to leave opportunity for the legislature to provide for this or some similar plan? Can anything be much worse than the waste and scrabble, stock jobbing and loss of about half of the material of the Spindletop furore? And on the other hand, is control by a monopoly of the type of the Standard Oil in all ways acceptable?

In accordance with my custom heretofore I will append gleanings from our work for the year of matters not large enough for a separate report but of some immediate interest.

PEAT.

To the elaborate report on peat of last year we have a few words to add. Prof. C. A. Davis, author of that report, has been extending his researches over the United States, under the auspices of the U. S. Government, and in connection with the Jamestown Exposition had quite an exhibit. There was in October at that exposition quite a congress of those interested in the exploration of peat.

Just at present, however, other uses for peat than for fuel are interesting. The more fibrous peats make good paper, and the Pilgrim Paper Co., at Capac, making paper for cartons, boxes for tacks, etc., is understood to have its output entirely engaged.

This is one of the built up bogs, due perhaps to the successive elevation of beaver dams, and for such use too great decomposition is not desirable.

A paving block has been made in New Jersey by the Pompton Peat Fuel Co. of the more decomposed, ground up and compressed peat. It should not be forgotten that once dried, peat becomes insoluble.

But the most interesting use is as fertilizer filler—as an absorbent of stock yard and slaughter-house waste. This use bids fair to have a wide application. Not only does the great absorbent and antiseptic power of the peat enable the fertilizer to be put on the market from four to six weeks sooner than otherwise (a sample with 83 per cent may appear dry), but its own composition adds material of value, humus, and carbon and nitrogen. Just how much this is worth to the farmer, and in particular just how far the nitrogen, which may run up to 3 per cent in a dry feeling peat holding 83 per cent water, is in a form that is worth paying for is a point upon which the Agricultural College experimenters are at work. It is difficult to distinguish by analysis the nitrogen from cottonseed meal, hoof meal, tankage, etc., from that of peat. No doubt they will also try if some bacterial fermentation to make it more available can not be devised. Freezing and thawing is said to make the nitrogen more available. In time, no doubt, with the approaching exhaustion of our timber resources, the manufacture of peat, coke and fuel gas will be commercially realized here as abroad. It would esem also that concerns using marl for cement could well consider utilizing the peat which so often overlies it in one of the several ways mentioned.

COAL.

Prof. S. W. Parr, inventor of the most useful calorimeter, has been working up the heating power of Illinois coals‡ and discussing the classification of coals.** About the only other tests he used were those of the St. Louis testing plants, those of Lord and Haas, and those made for us by H. J. Williams, who has recently prepared specifications for coal for the city of Boston. From total carbon Parr subtracts "fc" the "fixed carbon" left in the coal and finds the ratio of this "vc" to the total carbon

$$\frac{c - fc}{c} = 1 - \frac{fc}{c}.$$

In my work in Volume VIII, I classed the seams by the ratio of fixed carbon to the total combustible, or fixed carbon and volatile combustible of a proximate analysis. The total carbon is relatively easy to obtain with the Parr calorimeter, being absorbed as CO_2 by the sodium peroxide, and so he proposes as a basis of grading replacing the total combustible of the

‡Bulletin No. 3, Illinois State Geological Society.

**Campbell, E. R., and Fraser, Prof., have written also in Trans. and Bulletins in Am. Inst. M. E., 1906, 36, on the grading of coal. See also Grout, F. F., Economic Geology, II, p. 225.

proximate analysis by the total carbon. This has the very great advantage of getting rid of the troublesome question how the line is to be drawn between moisture, combined water, and volatile combustible. It is, however, probable that in making perfect combustion and in making fuel gas, the water can not be so simply eliminated, and its heat of combination with the sodium peroxide must also be accounted for.

It seems worth while, nevertheless, to reproduce his results on Michigan coal, adding to the samples he worked up, one analyzed by Dr. Koenig, given in the Annual for 1905, and an analysis of a coal by Prof. Kedzie which Mr. Cooper thinks represents the Upper Rider above the Upper Verne, a seam not hitherto analyzed. This sample, No. 14, was of churn drillings from a hole put down by T. Archambeau on the farm of P. Brissette, 497 feet N. of S. line fence, N. E. ¼ of N. W. ¼ of Section 14, Kawkawlin Twp. 15 N., R. 4 E. The record was as follows:

Sandy Clay	66'		66'		
Gray Shale	9'		75'		
Gray Sand Rock	17'		92'		
Dark Sand Rock	2'		94'		
Gray Sand Rock	5'		99'		
Gray Shale	5'	6"	104'	6"	
Black Slate		11"	105'	8"	
Coal—Upper Rider	3'	6"	108'	11"	478 A. T.
Black Chip Slate		7"	109'	6"	
Gray Shale		6"	110'		

This being a new seam it seemed worth while to have it analyzed. The result of Prof. Kedzie is as follows:

"Coal Sample 'P. Brissette—40 acres—test hole No. 14.' All results on thoroughly dried sample.

Proximate analysis—

Volatile Matter	45.02%	
Fixed Carbon	45.50	
Ash	9.48	B. T. U. 13,838 (Parr)

Total Sulphur, 4.19%

Ultimate analysis—

Carbon	69.02%
Hydrogen	7.53
Nitrogen	1.36
Sulphur (Volatile)	4.12
Ash	9.48
Oxygen (by diff.)	8.57

The ash I find contains—

Fe_2O_3	3.17%	Calculated to the original coal.
S	.068	

(Signed) FRANK S. KEDZIE."

We give Prof. Parr's proposed classification of coals below. The Saginaw seam belongs sharply to class B, of the bituminous coals, while the upper seams, the Verne coals and Upper Rider belong to class D, toward the lignitic end. They have perhaps never been buried very deep, and are distinctly nearer the wood end of the series.

TABLE A—PARR'S OUTLINE FOR CLASSIFICATION OF COALS.

Coals	Anthracite	Anthracites Proper		Ratio $\frac{vc}{c}$ below 4.
		Semi-Anthracite.		Ratio $\frac{vc}{c}$ between 4 per cent and 8 per cent.
		Semi-Bituminous		Ratio $\frac{vc}{c}$ from 10 per cent to 15 per cent.
	Bituminous	Bituminous Proper	A	Ratio $\frac{vc}{c}$ from 20 per cent to 32 per cent. Inert volatile from 5 per cent to 10 per cent.
			B	Ratio $\frac{vc}{c}$ from 20 per cent to 27 per cent. Inert volatile from 10 per cent to 16 per cent.
			C	Ratio $\frac{vc}{c}$ from 32 per cent to 44 per cent. Inert volatile from 5 per cent to 10 per cent.
			D	Ratio $\frac{vc}{c}$ from 27 per cent to 44 per cent. Inert volatile from 10 per cent to 16 per cent.
		Black Lignites		Ratio $\frac{vc}{c}$ from 27 per cent up. Inert volatile from 16 per cent to 20 per cent.
		Brown Lignites		Ratio $\frac{vc}{c}$ from 27 per cent up. Inert volatile from 20 per cent to 30 per cent.

TABLE B—ANALYSES BY H. T. WILLIAMS AND OTHERS.

Description.	Proximate Analysis.				Additional Factors.			Deduced Values.			Hydrogen Values.	
	Moisture.	Volatile Matter.	Fixed Carbon.	Ash.	Sulphur	Total Carbon.	Volatile Carbon.	Hydrogen from curve.	Ratio vc / c	Inert volatile pure coal basis.	H. from ultimate analysis.	H. from indicated calories.
1. P. M. No. 1, Saginaw Seam......	10.15	33.14	53.95	2.76	1.10	71.11	17.16	3.91	24.13	12.60	3.64	3.74
2. Standard, Saginaw Seam..........	10.67	33.59	53.80	1.94	1.04	71.67	17.87	3.91	24.93	12.36	3.84	3.67
3. Somers, St. Charles Seam..........	7.79	34.74	52.58	4.89	1.01	71.37	18.79	3.87	26.33	12.67	3.33	3.88
4. Owosso Seam?....................	7.58	35.70	52.69	3.76	1.50	72.88	19.92	3.94	27.33	11.66	3.81	3.80
5. New Hope, Jackson Verne Seams, One of........................	5.58	46 73	45.28	2.41	2.83	73.55	28.27	4.38	38.43	12.22	4.72	4.45
6. New Hope, Jackson Verne Seams, One of........................	5.93	46.59	44.64	2.84	3.07	72.42	27.78	4.33	38.36	12.56	4.67	4.59
7. Wenona, Bay Co., Lower Verne.....	8.71	38 45	41 16	'11 68	2.72	65.87	24.71	4.25	37.51	8.50	4.24	4.01
8. Albee Township, Saginaw County....	5.82	39.79	45.15	9.24	3.83	68.33	23.18	4.22	33.92	10.19	4.17	4.46
9. Sebewaing, Verne Seams, One of....	6.09	39.54	46.06	8.26	5.72	68.07	22.01	4.14	32.34	9.40	4.62	4.17
10. Michigan, Bay County............	5.01	39.62	41.67	13.70	6.66	62.29	20.62	3.79	33.10	10.51	3.77	4.32
11. Central, Bay Co., Lower Verne......	4.52	40.57	42.16	12.75	6.92	63.57	21.41	3.90	33.68	10.08	3.99	4.15
12. Wenona, Bay Co., Upper Verne.....	3.78	41.18	49.34	5.70	2.50	73.09	23.75	4.44	32.49	11.58	3.90	4.51
13. Wenona, Bay Co., G. A. K. Verne..	1.09	42.11	50.89	5.91	1.95	72.74	21.85	5.40	39.00	14.60	3.74	....
14. Bressette, F. S. K., Upper Rider....	Dried Drillings	45.02	45.50	9.48	4.12	69.02	23.52	3.88	34.10	15.10	6.51	14.70

For further information regarding analysis 1 to 13, see Vol. VIII, Part II, pp. 89, Et seq.

The following note refers to specimens at a depth of about 175 feet from the present surface from room 23, entry 4, west, of the south part of Wolverine Coal Mine shaft No. 3. This I take to be the top of the Verne seams. The roof was a beautiful display of bark and fern and rush leaves. The foot is mainly a smooth looking hard white shale. There are in a sense four seams of the coal in 80 inches, but the lower two are very close together. There comes between them a sulphurous seam, three inches to two feet thick, with many pieces that look like wood chip pebbles, with impressions of Lepidodendron bark in pyrite.

Washington, D. C., Nov. 30, 1907.

DR. A. C. LANE,
State Geologist,
Lansing, Michigan.

Dear Doctor Lane:—The specimens of shale sent by Mr. Thompson from the Wolverine Mine No. 3, at Bay City, Michigan, contain excellent impressions of a very early form of *Lepidodendron aculeatum*, this is, in some respects, intermediate to *Lepidodendron obovatum;* several cones, included in the rather ill-defined species *Lepidostrobus variabilis;* a considerable number of fern fragments which, in spite of their differences in aspect, evidently belong to a single plant. This fern is very interesting since it almost certainly represents a new form, if not an entirely new species, belonging to the peculiar group typified by *Neuropteris desorii.* The plant should be duly described and figured.

The associated forms mentioned above have no other effect on our correlations of the Michigan coals than to confirm a reference of this bed as probably near the top of the Pottsville. None of the material sent by yourself or your colleagues, from the Michigan coal fields appears to furnish any evidence for an age earlier than the Upper Pottsville.

The University Museum at Ann Arbor contains a number of typical examples of the Upper Pottsville phase of *Lepidodendron clypeatum,* from Jackson, Michigan. I presume it older than the coal at Bay City. * * * I remain,

Very truly yours,
(Signed) DAVID WHITE.

The general trend of core drilling and development this year has been west from Bay county into Midland around Edenville and Gladwin, and east into Tuscola, where a mine has been opened up near Unionville. I suspect considerable faulting and disturbance will be found in this latter region. The exploration for coal near the corner of Missaukee, Wexford and Osceola counties has not reached bed rock or coal but has been in surface deposits still at 400 feet. The map of the State printed in U. S. Water Supply Papers Nos. 182 and 183 and issued herewith would indicate over 600 feet of drift in this region. Coal has been found so frequently and in such large pebbles in the drift of the southern part of Roscommon county, that it is probable that a coal seam outcrops under a heavy covering of surface drift near the south line of this county. Coal has also been struck in wells for water a little north of Lansing. A coal washery at Saginaw shows progress in economy, but I hope Hazlewood's work may lead further in that direction and especially to the use of the black shale or bone coal, with ash over 20 per cent, but a large amount of volatile hydrocarbon. Of this there is a good deal, which would not bear much transportation but might be utilized for fuel or gas at the plant. It will often have half the heating value of coal, but can not of course be mined at the same rate.

LIMESTONE.

Descriptions of the limestone resources of the State have been given in the annual for 1901, especially pages 139 to 210; for 1902, pages 17 to 19; for 1903, pages 171 to 174; for 1904, pages 122 to 124; and for 1905, pages 563 to 567.

During the past year our attention has been especially called to the Niagara limestones and those around Detroit. Professor Sherzer and Grabau will make a report on the latter in connection with the Wayne county report. But a few notes on the development of limestone in the Niagara may not be out of place, especially as it has been generally understood that the Niagara limestone is dolomitic or magnesian, and might more properly be called dolomite.

The caves which I visited in 1901, on sections 15, 16, 21, and 22, T. 44, R. 7, were revisited in the spring of 1907, and have been opened out into extensive quarries at Chase Osborn. An unusually good chance is offered to study glacial striations in part of the quarry, other parts under a less impervious cover. The striations run to N. 28° W. from S. 28° E., or to N. 40° W. The N. 30° W. and another N. 10° E. are still older. There are chatter marks, minutely faulted, curving convex to the northwest. The striation is somewhat more north of west than the heavy grooving, and the motion was from the southeast.

At one end of the quarry the surface is very heavily corroded, as exposed gypsum beds often are, and this is in patches only, grooved and striated so that the last ice motion from the south only cut a little into a deeply corroded surface. The indications are that the very last motion of the ice in this region was from the Lake Michigan lobe of the Wisconsin ice sheet, spreading from a center in Labrador, and that the direction of ice motion became more northerly toward the end. A peculiar set of slanting joints at right angles occur. Others are more nearly vertical and run with the striæ.

The section of the quarry is as follows:

3 feet—Limestone, with Orthoceras, a loose Favositid, a small gastropod, but most abundant fragments of heads of stromatoporoids.

1 foot—Greenish sandy looking limestone, with greenish tubes running into each other (anastomosing), with corals and stromatoporoids, which latter show well on the green surface.

6 feet—Very massive.

4 feet—Mottled brown and light with Stromatopora heads.[1]

9 feet—Finely banded mud rock (calcilutite) with quite persistent bands of holes, empty gastropod cavities half way down. These have calcite crystals lining them. A Leperditia and stylolitic sutures occur and this lower part has a more porcêlanic, less sugary appearance than the upper part containing the coral and stromatoporoid heads. A notable thing is the absence of Pentamerus.

The shape of the exposure may best be illustrated by a sketch.

The shipment of the limestone which (runs up to 98 per cent $CaCO_3$) runs up to 19 to 30 cars a day, two-thirds of it say goes to the Duluth furnaces for flux. But some is used by the Munising Paper Co. in the sulphite fibre process, some to make acetate of lime at Marquette, and some goes to Sault Ste. Marie, for flux, or for paper or carbide manufacture. However the calcium carbide is more produced by another quarry.

A price quoted is: 45c a ton for limestone; 45c a car for screenings.

[1]Prof. W. A. Parks of the University of Toronto kindly identifies the stromatoporoid as Clathrodictyon vesiculosum, which he has not found high in the Niagara, but commonly in the lower beds and Clinton. Letter Jan. 8, 1908.

Besides the quarry the caves I explored in 1901 show that there is considerable extension of this high grade limestone which seems to be more soluble than the dolomite.

The elevation of the quarry is about 820 A. T. The local dip appears to be a few degrees (5° to 7°) to the east. But really, as we know from deep wells at St. Ignace and Manistique the general dip of the formation is to the south at about 50 feet to the mile.

The carbide works are, however, supplied by another quarry on Section 6, T. 44 N., R. 8 W. This is farther north but it is also nearer the top of a hill, which extends over into Section 31, T. 45 N., R. 8 W., and to an elevation of about 900 feet A. T., and then breaks off suddenly with a northward facing escarpment of limestone above an old sea cliff. About 80 to 100 feet below there is a big spring starting a regular stream, of the kind typical of limestone countries. Again in the N. E. ¼ of the S. W. ¼ of Section 25, T. 45 N., R. 9 E. is another of the streams making a small pond. There is a strong smell of hydrogen sulphide, and a heavy coating of sulphur, and the water has a peculiar greenish tinge and a temperature of about 45. 2° F. This has an elevation of only 777 A. T. Similar streams may be expected, as well as artesian wells, on the north side of the limestone ridge and may be a useful guide.

But to return to the quarry. The section is about as follows:

18 feet—Solid limestones which may be subdivided into

A.—6 feet—With fossil corals, Zaphrentid and favositid forms and gastropods, banded especially at the bottom.

B.—6 feet—Compact, brownish, splintery, etc., also a cystiphylloid coral.

C.—Also massive.

The calcite crystals in the cavities show a prism or long + R with — ½ R termination. Below these 18 feet in which is the main quarry, a large part of which is said to run 98 per cent $CaCO_3$, (not less than 93 per cent being desired for carbide), come layers not so uniformly high, as follows, exposed in a smaller central pit:

D. 2 feet—Thin bedded with green partings.

6 feet—Lime mud rock, calcilutite, with very distinct, nearly horizontal bedding, dip 1 foot in 40 to W.

1 foot—Brownish banded with holes.

2 feet—Pink, massive, faulty, banded.

A greenish stratum forms the bottom layer.

The general character of the two quarries is much the same. The general strike of the formation is toward Drummond Island where at the northeast quarter, in a 100-foot section, below dolomite beds full of Pentamerus, siliceous and with chert, Rominger found layers running 93 per cent to 95 per cent calcium carbonate (Vol. I, Part 3, pp. 35–36) and of similar physical character. This gives a strike of 1 S. to 8 E., or S. 82½ E. Allowing for this and the 80 feet difference in elevation, the quarries would be at the same horizon at a dip of about 40 ft and 50 ft to the mile. A dip of about 50 feet to the mile is quite widely indicated for the Niagara.

CEMENT AND LIME.

In the Portland cement industry the tendency to use limestone and the dry process rather than bog lime and the wet process continues.

Dr. F. E. Wright, formerly of this Survey, has with other friends shown that there is no such thing as tricalcium silicate, and what has been so called is a mixture of oxide and dicalcium silicate,†† (the latter 35 per cent SiO_2, 65 per cent CaO).

The statements regarding tricalcium silicate in our report on marl‡‡ must be modified. How far cements with lime above this ratio need seasoning remains to be tested. The earlier work by the Newberrys was very different in its conclus'ons, but most cements run not over 60 per cent CaO. Professors E. D. Campbell and A. H. White, of the University, have been making some elaborate tests on this point and on the ill effects of free magnesia, and we quote the following results of their investigation, of use both to users and manufacturers of cement and also add an interesting paper by F. J. Beal, one of the recent graduates of the Agricultural College, showing the exact changes that go on in burning cement.

SOME CONDITIONS INFLUENCING CONSTANCY OF VOLUME IN PORTLAND CEMENTS

From the article by E. D. Campbell and A. H. White in the Journal of the American Chemical Society, Volume XXVIII, No. 10, October, 1906.

Free lime in Portland cement will not only not be slaked during the mixing and setting of the cement but will not become completely hydrated even when the cement is immersed in water, until about fourteen days have elapsed. The result of this gradual slaking is to produce abnormal expansion of the cement. Any evil effects due to the presence of free lime in cements kept under water will be manifested within two months. In case free lime is present in cement used in structures above ground or where it is usually dry, the expansion due to hydration of the cement will be more gradual but several times greater in volume than when the material is under water. The expansion due to free lime slaking in the air may become so great after a few months as to cause complete disintegration.

The deleterious effects of free lime may be completely removed by aging the ground cement or storing the clinker to weather until the pat will stand a perfect boiling test. Weathering the clinker for three months is usually sufficient. It is difficult to state the length of time necessary to properly age ground cement to eliminate the free lime. It will not ordinarily be less than one month and may be longer according to the conditions under which it is stored.

Cement which passes a perfect boiling test may be safely assumed to contain no free lime. The expansion of a bar of neat cement containing no free lime when kept in cold water for seven days is usually under 0.040 per cent., but occasionally may go as high as 0.060 per cent. A cement with 2.8 per cent free lime showed an expansion of 0.220 per cent in the same period.

The effect of magnesia like that of lime depends less upon its total amount than upon the form in which it exists. Combined magnesia like combined lime has no injurious effect in Portland cement. Magnesia combined with silica and alumina forms a hydraulic cement which is safe but as compared with Portland cement is too weak to be of any commercial value. Free magnesia has no appreciable effect in cement used above ground where it is continuously dry. If the cement is wet for a part or a whole of the time, the free magnesia will very slowly hydrate and cause expansion. Even where the cement is continuously immersed in water the expansion due to free magnesia is not appreciable until after two months and only becomes distinctly evident after a year. The hydration seems to be only well under headway at the time of the first year and expansion continues at an increasingly rapid rate for at least five years, and probably longer. Aging

††Am. Jour Sc., Oct. 1906, p. 284.
‡‡Volume VIII, Part 3, page 172.

does not seem to diminish the deleterious effect of free magnesia in cement. This is to be expected, since the rate of hydration of hard-burned magnesia in air is almost imperceptibly slow.

The boiling test for twenty-four hours does not detect free magnesia as it does free lime. Cement containing as high as 4 per cent of free magnesia has passed a perfect boiling test, yet the last measurement of this cement at the end of five years in cold water showed a total expansion of over 1 per cent, nearly half of which occurred during the fifth year after making.

The slow hydration of free magnesia with its accompanying expansion seems to be the probable cause of the expansion, frequently accompanied by more or less complete disintegration, so often noticed in sidewalks, occurring several years after the walk has been laid.

One per cent or less of free magnesia in cements kept under water causes little noticeable expansion even in neat cement; probably simply filling up the voids. Increased percentages of free magnesia cause cumulatively greater expansion until with 3 per cent of *free* magnesia the expansion is too great to be at all safe.

In the manufacture of cement from raw materials containing magnesium carbonate, some portions of the magnesia will remain in the free state. The amount will increase in coarseness of raw materials, increasing percentage of lime and increasing percentage of magnesia. If the total of magnesia does not exceed 3 per cent it is not likely that well made cement will carry enough of this magnesia in the free form to cause injurious expansion in large monolithic structures kept continuously or frequently wet. In structures where suitable provision can be made for expansion joints, a higher percentage of total magnesia is permissible than in monolithic structures. Magnesia should not exceed 5 per cent total when used even under these circumstances.

An increasingly large amount of cement is being used in the structure of buildings where it will never be exposed to the action of water. There is no ground for believing that magnesia even in free form would cause trouble under such circumstances. Free lime, however, is more dangerous in these structures than where the concrete is to be kept damp, because the expanding lime increases its volume much more in air than in water. Concrete made from sound cement will normally contract in the air, and this contraction continues according to our measurements for at least five years and amounts with neat cement to about four-tenths per cent. Whether this contraction will be sufficient to seriously weaken structures such as floors deserves investigation.

Any cement worked up fresh will change its volume more than if properly aged. It will show a noticeable drop in the curve representing change of volume after about three months, a period which corresponds to that in which briquettes show a falling off in tensile strength. Cement should always be aged for work where constancy of volume is of the highest importance. The only disadvantage of aging lies in the tendency for a cement to become very quick setting. If it is aged long enough it reverts again to a slow setting cement.

CALCINATION OF LIME AND CLAY MIXTURES TO MAKE PORTLAND CEMENT.

By F. J. Beal, Engineering Chemist with the Wyandotte Portland Cement Co., of Wyandotte, and the Huron Portland Cement Co., of Alpena.

As is generally known, Portland cement is manufactured from an intimate mixture of lime and clay. The lime may be in the form of marl, limestone or industrial lime, and the clay may be in the form of clay or shale. Besides these, some mills make cement from what is known as cement rock, which contains both the clay and lime in about the correct proportions. If the cement rock does not contain enough lime or clay, the required amount is added as limestone or shale. These two substances are mixed in proportions dependent upon the exact chemical composition of each and subsequently burned or heated to a state of incipient fusion. This fused substance or clinker has changed the mixture of lime or clay to a chemical compound which when ground to an impalpable powder is Portland cement.

The first step in the manufacture of Portland cement is the proportioning of the raw materials. As stated above, this depends upon the composition of the materials themselves and will be governed to some extent upon the thoroughness with which the subsequent operations, such as grinding and burning, can be done in any particular mill. The finer the raw materials can be ground the easier and more completely they may be fused, thus allowing a greater per cent of the lime in the raw mixture without leaving any lime in a free or uncombined state after the process of fusing. An ideal Portland Cement is one in which there are no uncombined elements. There is a loss in the quality of a cement by having too little lime as well as having too much. The limitations of variation in the mixture of raw materials is generally one per cent in their lime content.

After the process of mixing and grinding, comes the burning process or the one in which the mixture of the two substances containing no cementing qualities and capable of crystalizing into rocklike hardness. I shall try to explain the changes that take place during the process by giving the composition of our raw materials and a description of their treatment up to the time they enter the rotary kiln, together with the results of several experiments that I have personally conducted along this line.

This explanation will deal entirely with the so-called wet process. Our clay is a yellow clay containing from 10 per cent to 25 per cent of moisture varying with the condition of the weather. The following is an average analysis of the dry clay. Loss on ignition 7.05 per cent; silica (SiO_2), 65.38 per cent; iron (Fe_2O_3), 2.63 per cent; alumina (Al_2O_3), 21.37 per cent; lime (Ca), 1.66 per cent; magnesia (MgO), 1.05 per cent; carbon dioxide (CO_2), 2.47 per cent. Our lime is a precipitated carbonate of lime received by us in the form of mud containing about 37 per cent of moisture and fine enough to entirely pass a 200 mesh sieve, and having the following composition after drying: Silica (SiO_2), .40 per cent; iron and alumina (Fe_2O_3), .60 per cent; lime (CaO), 55.10 per cent; magnesia (MgO), .30 per cent; carbon dioxide (CO_2), 43.30 per cent.

Our clay is first passed through a rotary drier 50 feet long by 6 feet in diameter. From this it is conveyed to a drypan where it passes under large iron rollers that grind it to a granular form about the size of coarse sand and fine gravel. From here it is elevated to bins in the mixing room ready to be weighed out and mixed with lime. This lime is received at the mill in side dump cable cars carrying approximately 5,000 pounds of lime mud. These cars stop directly over a large hopper into which the lime mud is dumped and through which it passes directly to a large pug mill. Adjacent to this large hopper and resting on scales is a smaller hopper into which the required amount of clay for one car of lime mud is weighed and at the moment the lime mud is dumped into the pug mill the clay is allowed to run in with it and the two are pugged in this mill until thoroughly mixed.

At this point enough water is added to make the mixture or slurry contain from 40 per cent to 45 per cent of water. This is added simply to facilitate the mixing, grinding and pumping of the slurry. From the pug mill the slurry passes through a tube mill. This mill grinds the slurry fine enough so that 98 per cent will pass through a 200 mesh sieve. From this mill it is pumped to large storage tanks from which it is fed into the rotary kilns to be burned.

These rotary kilns are 100 feet long by 7 feet in diameter and lined with fire brick. These kilns are placed on a slant and rotate causing the slurry to gradually work its way from the upper or feed end of the kiln to the lower or discharge end of the kiln. The heating is accomplished by the burning of a mixture of pulverized coal and air which is blown into the front end of the kiln. A heat of from 2500° to 3000° Fahr. is required to burn cement. The following 35 analyses of cement mixture taken every three feet apart from the interior of one of these kilns together with the explanation will show the changes that take place and the effect that they have on the finished product.

ANALYSIS OF CONTENT MIXTURE TAKEN FROM THE ROTARY CEMENT KILN 100 FEET LONG AND 7 FEET IN DIAMETER, SHOWING THE CHANGES THAT TAKE PLACE DURING THE PROCESS OF BURNING.

Sample No.	Distance in feet feed end of kiln.	SiO_2	Al_2O_3	Fe_2O	CaO	MgO	CO_2	Moisture.
1.............	0	15.76	5.93	1.69	42.74	1.70	31.47	33.96
2.............	2	14.68	6.52	1.48	43.17	2.26	31.29	44.33
3.............	5	15.96	7.36	1.48	42.95	1.06	30.92	33.53
4.............	8	15.88	5.28	1.06	42.64	1.13	33.76	23.29
5.............	11	15.60	5.78	1.06	43.27	1.50	31.98	14.08
6.............	14	14.84	5.72	1.48	43.38	1.42	32.69	12.34
7.............	17	16.14	8.14	1.48	43.27	1.95	28.31	5.97
8.............	20	15.96	7.05	1.27	42.95	1.87	30.21	1.20
9.............	23	15.70	6.81	.85	43.06	1.94	30.19	10.12
10.............	26	14.56	7.07	1.27	43.70	2.56	30.17	.38
11.............	29	14.20	6.71	.63	43.16	2.51	32.19	4.06
12.............	32	16.16	9.57	.85	41.69	1.91	29.32	1.78
13.............	35	15.90	7.27	1.27	43.70	2.17	29.14	2.23
14.............	38	15.90	7.61	.85	43.16	2.18	29.84	2.12
15.............	41	14.74	5.74	1.48	43.38	1.95	32.08	2.48
16.............	44	15.92	7.71	1.69	43.80	1.91	28.42	1.56
17.............	47	16.24	6.08	1.06	43.70	1.93	30.38	1.43
18.............	50	14.90	6.13	1.69	43.38	1.97	30.59	1.36
19.............	53	17.02	7.13	.63	44.43	2.03	27.38	.31
20.............	56	16.66	6.96	1.48	44.12	1.75	28.12	.07
21.............	59	17.70	6.52	1.06	44.54	2.16	27.30	
22.............	62	21.69	8.59	1.27	44.85	2.35	19.04	
23.............	65	18.62	7.16	1.48	45.49	2.48	24.17	
24.............	68	16.14	7.80	1.48	45.80	1.76	26.50	
25.............	71	18.14	7.17	2.11	50.76	1.64	19.89	
26.............	74	20.00	8.45	1.69	48.97	1.76	19.00	
27.............	77	21.44	9.59	1.27	55.83	2.18	9.12	
28.............	80	23.26	11.33	1.99	58.68	2.37	2.00	
29.............	83	23.00	8.88	2.32	60.37	2.56	1.48	
30.............	86	22.66	9.74	1.90	62.48	2.70	.26	
31.............	89	21.20	8.52	2.32	65.12	2.75		
32.............	92	22.20	11.41	1.97	61.13	2.43		
33.............	95	21.42	10.82	1.58	63.54	2.59		
34.............	98	21.30	10.11	1.37	64.06	2.66		
35.............	100	21.84	9.93	1.37	63.96	2.45		

Analysis by (Signed) F. J. Beal, Chemist, 1907.

The table gives the chemical composition of the cement mixtures and their respective locations in the kiln. The mixture of the raw materials is controlled by the per cent of lime it contains. It will be noticed in the table that the amount of lime in the mixture from the time it enters the kiln till it passes through the first half of the kiln or 50 feet, has been practically constant, and any variations that are shown in the composition of the mixture up to this point, excepting the moisture are due to the slight variations in the compositions of the raw materials themselves and not due to any change effected by the process. On the other hand, the use of this half of the kiln is to drive off the moisture from the mixture. This is entirely accomplished while the mixture is passing through the first 56 feet of the kiln. That column of the table giving the per cents of moisture in the mixture at various points in the kiln will require some explanation. Sample No. 2 shows that this sample, which is 2 feet from the feed end of the kiln, contains 44.33 per cent of moisture and represents the amount that the mixture contained at the time it entered the kiln, since the feed pipe extends into the kiln this distance. Sample No. 1 is taken from the extreme feed end of the kiln and is of the moisture or slurry which has backed up in the kiln to this point and partly dried. From this point through the first 17 feet of the process the moisture is gradually and rapidly driven off. Samples No. 8 and 10 respectively are very low, while Sample No. 9, which is between these is much higher. This is explained as follows: Samples 8 and 10 are each taken from mud rings which have formed at these particular places, composed of the slurry which has been partly dried or baked, building up and forming rings about a foot thick entirely around the inside of the kiln. Sample No. 9 is of the slurry which is held in more or less of a quantity between these rings and protected by them from being dried out so rapidly. From Sample No. 10 on the change is carried on till the moisture is entirely driven off by the time the mixture has passed through the first fifty-six feet of the kiln, but not as rapidly as in the first part of the operation.

Up to this point the change has been only a physical one, merely the drying out of the mixture. Next comes the chemical change which really starts while the last traces of moisture are being driven out. This chemical change is first the driving off of the carbon dioxide and takes place while passing through 36 feet of the kiln between the points 53 feet and 89 feet. This operation is gradual and effects a change in the lime, changing it from a combined lime to an uncombined lime. The next change is to cause the free or uncombined lime to unite with the silica, iron and alumina to form a chemical compound. This is accomplished at the time the last traces of carbon dioxide is driven off and immediately thereafter. This chemical union between the lime, iron, alumina and silica causes the material to form into clinker or fused particles about half an inch in diameter or smaller. This clinker when cooled and ground is Portland cement.

The changes that take place in the process of burning are not only shown by the change in chemical composition but also by the change in color. The first eight samples are of a creamy color which is the color of the original slurry or mixture. At Sample No. 9 the color changes to a very light gray or slate color which remains till it got to No. 20, where the carbon dioxide starts to be driven off and the color changes to a very delicate pink. The pink color remains until we reach Sample No. 27, at which point about two-thirds of the carbon dioxide is entirely expelled which point is reached in Sample No. 31, the color changes to a black having a very slight tinge of sage green. This last color is the characteristic color of Portland cement clinker, but when ground to a fine powder becomes much lighter.

The great change in the operation has been the converting of a mechanical mixture of two substances, lime and clay, either of which alone or together have no cementing or hardening properties other than simply drying out into a chemical compound having cementing properties and power to crystalize or harden into rocklike hardness. This chemical change is not entirely accomplished until it has reached Sample No. 32 as is shown by the table of chemical analyses and also the chart of physical tests which follow.

Physical tests were made of samples No. 29, 30, 31, 32, 33, 34, and 35 with the results:—

Sample No.	Per cent. Fineness. 100 Mesh.	200 Mesh.	Setting Time. Initial.	Final.	Boiling Test.	Cold Water Test.	Specific Gravity.
29..........	98	82	30 min.	60 min.	Bad	Bad	2.94
30..........	99	84	45 "	90 "	Bad	Good	2.95
31..........	95	77	15 "	30 "	Good	OK	3.07
32..........	92	75	150 "	300 "	OK	OK	3.11
33..........	97	98.5	120 "	240 "	OK	OK	3.12
34..........	97	78	75 "	150 "	OK	OK	3.12
35..........	97.5	79	180 "	360 "	OK	OK	3.12

Tensile strength in pounds per square inch. Sand briquettes made of a mixture of one part of cement and three parts of standard sand. All the briquettes were kept moist in air during the first 24 hours and the rest of the time under water.

Sample No.	48 hrs. Neat	7 Days Neat	7 Days Sand	28 Days Neat	28 Days Sand	3 Months Neat	3 Months Sand	6 Months Neat	6 Months Sand
29......................	115	120	0	205	0	240	0	155	0
30......................	125	185	25	290	170	405	165	325	50
31......................	130	365	105	455	175	420	180	435	225
32......................	460	510	120	795	185	925	225	965	315
33......................	540	690	360	800	500	810	525	880	565
34......................	515	670	310	725	470	745	480	785	500
35......................	525	685	360	805	495	830	530	865	560

Tested by (Signed) F. J. Beal, Chemist.

Even as far back as sample No. 29, the cement mixture, though not entirely chemically combined, shows some cementing properties, but the amount of uncombined lime and other elements are enough to overcome in a short time and cause it to disintegrate and fall to pieces. When Sample No. 32 is reached the tests show that the chemical action is complete and that there is no uncombined lime, etc., in proportions large enough to cause the cement to disintegrate or crumble, and the result is a cement that will crystalize in a rocklike hardness and will retain this condition for all time.

(Signed) F. J. Beal, Engineering Chemist.

In conclusion I would express my thanks to my fellow employees, and the gentlemen who compose the Board of Scientific Advisers, and my appreciation of the support which the Board has through these years given to my efforts.

Dr. Rominger, the only one of my predecessors of longer term of service, passed away this year at the ripe age of 93, a fine specimen of that sturdy, intellectual and honest German stock which has contributed so much of value to the commonwealth.

Very respectfully,

ALFRED C. LANE.

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