IOWA

# GEOLOGICAL SURVEY

BULLETIN NO. 3.

## Supplementary Report on Portland Cement Materials in Iowa

FRANK A. WILDER, PH. D., STATE GEOLOGIST,
T. E. SAVAGE, ASSISTANT STATE GEOLOGIST.

DES MOINES
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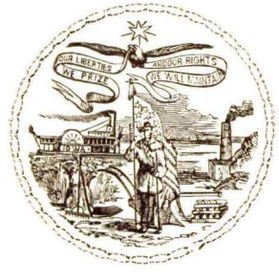


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# Supplementary Report on Portland Cement Materials in Iowa.

BY

S. W. BEYER.

## CONTENTS.

## LETTER OF TRANSMITTAL.

IOWA GEOLOGICAL SURVEY.

Des Moines, Iowa, April 1, 1906.

To Governor Albert B. Cummins, and
Members of the Geological Board:
Gentlemen:

I have the honor to transmit, herewith, a preliminary bulletin by Professor S. W. Beyer, which describes certain localities within our state which seem to be favorably located with reference to the manufacture of Portland cement.

A more complete report on Portland cement materials in Iowa, prepared by Professor Beyer, will be published as an annual report in the year 1907. On account of the urgent demand for a brief statement in regard to some of the more important cement localities, it has seemed desirable to present at this time the information that is contained in this bulletin.

Very respectfully,
Frank A. Wilder,
Director of the Iowa
Geological Survey.

# SUPPLEMENTARY REPORT ON PORTLAND CEMENT MATERIALS IN IOWA.

BY S. W. BEYER.

## INTRODUCTION.

The manufacture of Portland cement in the United States shows a remarkable growth during the last ten years. According to the U. S. Geological Survey the production for 1894 was 798,757 barrels while the output for 1904 reaches a total of 26,505,881 barrels. Figure 1 shows graphically the growth of the industry and also the production of natural cement, slag cement or pozzuolana, and Portland cement imported during the period. It will be noted that the production of natural cement shows but slight variation save those fluctuations which can be explained by the industrial fluctuations of the time. The same is true when imported cement is considered. The production of domestic Portland cement appears to be as yet almost independent of trade conditions, which may be interpreted to mean that the supply does not yet more than keep pace with the rapidly increasing demand. While the production shows a continuous increase the price was more responsive to industrial conditions in general and has changed from year to year. The average net factory prices for Portland cement during the last five years were as follows:

| | |
|---|---|
| 1899 average price per barrel | $ 1.43 |
| 1900 average price per barrel | 1.09 |
| 1901 average price per barrel | .99 |
| 1902 average price per barrel | 1.21 |
| 1903 average price per barrel | 1.24 |
| 1904 average price per barrel | .88 |

Reliable data are not at hand for the year 1905, but enough is known to assert with some degree of positiveness that the domestic production is still on the increase, but the average price has been materially reduced owing to the opening of large plants in the gas belt of Kansas. The cheap natural fuel of Kan-

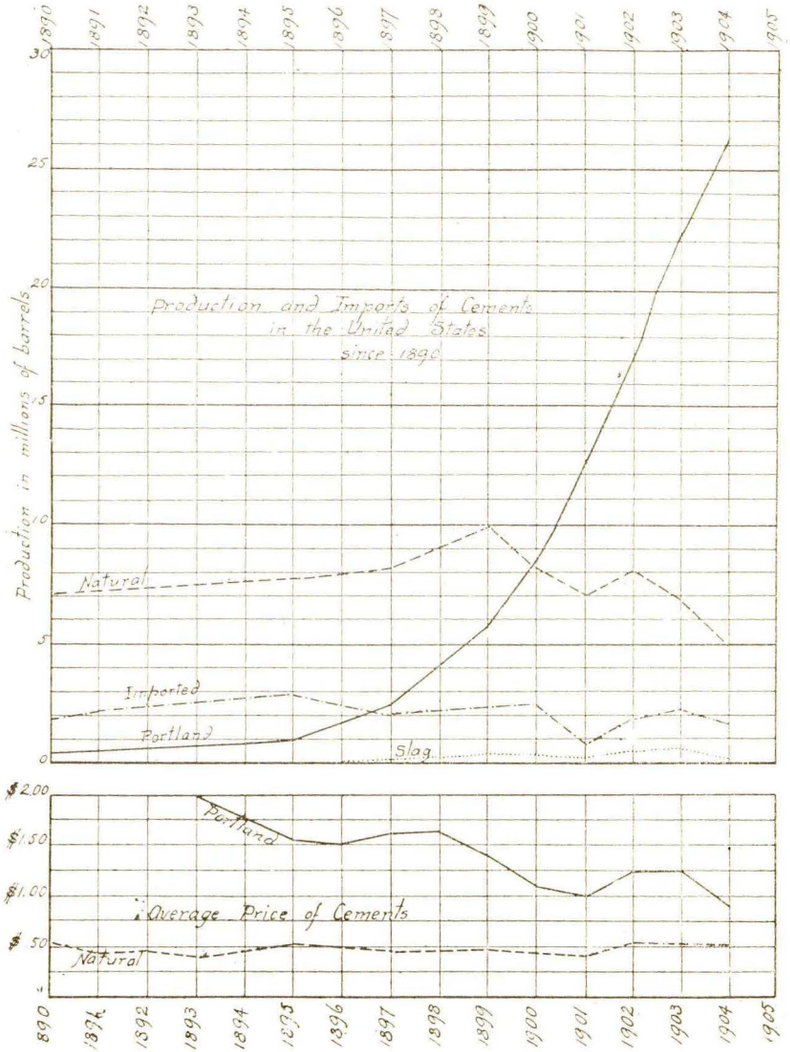



Fig 1. Table showing production and imports of cements in the United States for the years 1890-1905 inclusive.



sas has greatly reduced the cost of manufacture and to some extent has lessened the price of the finished product to the consumer.

Notwithstanding the enormous growth of the industry and the further fact that Portland cement is rapidly becoming almost a necessity to the prairie states, Iowa has not, as yet, contributed a single barrel to swell the total production.

Soon after the organization of the present Geological Survey, the Director, Professor Samuel Calvin, realized the importance of the then youthful industry and his first paper was entitled "Cretaceous Deposits of Woodbury and Plymouth Counties, with Observations on Their Economic Uses," and appears in Volume I of the annual report bearing the date of 1892. In this paper the Niobrara chalks and associated clay-shales are described and their suitability for the manufacture of cement pointed out. Professor Calvin's paper was later supplemented by himself in Volume III, and greatly elaborated by Bain in his Woodbury and Plymouth county reports to be found in Volumes V and VIII respectively. While this information has been available for some years and the district has been visited by numerous interested parties, nothing has been done toward the utilization of the chalks of Iowa. Within the past few years it has come to be generally recognized that chalks and marls are not necessary in the manufacture of Portland cement; that limestones, be they hard or soft, providing they are correct otherwise, are suitable for cement manufacture. The recognition of this fact has led to a renewed search for locations favorable for cement plants within the confines of the state and never has the search been so strenuous as during the past year. The Survey has been importuned for information on the subject and samples from numerous points in the state have been sent in for analysis. One factor appears to be uppermost in the minds of those seeking information and that is, "that given the raw materials which will make cement" a cemen plant is assured. They do not fully realize that suitable raw materials in commercial quantity is but one of the most important factors in the location of an industry of this kind. Suitable transportation facilities, and cheap fuel suitable for burning the cement are equally important factors and must be taken into account. In fact some authorities are inclined to doubt the wisdom of placing suitable raw materials first in the list of controlling factors. However the factors may be rated, the

raw materials are usually the first factors in the problem of cement plant location to receive attention by the average investigator.

As has been intimated before, the eyes of the promoter and of the cement manufacturing world are at the present time focussed on Iowa. A number of causes contribute to bring this about. Iowa is at the present time one of the greatest cement users, and the increasingly high price of lumber and other structural materials, and the new and varied uses to which cement is being put will increase her consumption many fold; and her position geographically (Minnesota has little in the way of suitable materials or cheap fuel to commend her for consideration in this connection) gives her a commanding position strategically. A cement plant in Iowa ought to command the markets of the "Twin Cities of the North" in addition to her own domestic trade. Her nearest competitors are located in Illinois; Hannibal, Missouri; Iola, Independence, and Neodosha, Kansas; and Yankton, South Dakota. A factory located in north-central Iowa would be protected by a freight rate of from 12 to 14 cents per hundred pounds, a sum sufficient to cover a considerable portion of the cost of production in the cement mills of today.

About two years ago the director of the Iowa Geological Survey assigned the writer "Iowa Quarry Products" for investigation and report. The work has been carried on jointly by the Survey and Iowa State College and on account of the increasing importance of cement, and in order that the public may have results without undue delay the publication of this preliminary report on that special phase of the subject is believed to be warranted.

It is generally known that most of the so-called limestones in Iowa are dolomitic, or at least contain a percentage of magnesia prohibitory to their use in the manufacture of Portland cement. While this is true, there is in the state sufficient limestone low in magnesia, to supply all the cement plants of the country. They range in age from the Ordovician, exposed at Spechts Ferry, Waukon, Decorah and numerous points in northeastern Iowa, to the Niobrara chalks and limestones exposed in Plymouth and Woodbury counties. The investigations upon which the present report is based were confined largely to the calcareous and argillaceous deposits of the north, central and northeastern portions of the state. Special efforts were made



to secure average samples for the various beds. Most of the chemical work was done by Professor L. G. Michael, Survey chemist.

## ORDOVICIAN.

### GALENA-TRENTON AND MAQUOKETA STAGES.

The Galena-Trenton *stage of the Ordovician was investigated at Spechts Ferry, and points in Wisconsin on the opposite side of the river, Zollicoffer Lake north of Dubuque, Waupeton, Decorah and Clermont. At Spechts Ferry the section exposed is about as follows:

SPECHTS FERRY SECTION, IOWA.

7. Limestone, impure, weathered.....
6. Limestone..... 10 feet
5. Shale with bands of limestone..... 9 feet
4. Limestone, massive..... 20 feet
3. Limestone, less massive..... 5 feet
2. Limestone, compact, fine grained, in thin layers..... 10 feet

A sample representative of each of the above beds was analyzed and the results are given below. The samples are numbered as in the section, save that 5a in the table is for the limestone bands selected from number 5 in the section, and 5 in the table is an analysis of number 5 in the section minus the limestone bands.

| | 2. | 3. | 4. | 5. | 5a. | 6. |
|---|---|---|---|---|---|---|
| Silica | 7.50 | 7.94 | 10.71 | 49.32 | 11.24 | 5.74 |
| Alumina and iron | 6.17 | 12.05 | 6.69 | 20.16<br>8.30 | 6.31 | 6.69 |
| Calcium carbonate | 79.50 | 73.38 | 78.67 | 9 52 | 78 51 | 83.56 |
| Magnesium carbonate | 3.97 | 3.52 | 0.28 | 3.21 | 0.24 | 0.25 |
| Alkalies as $K_2O$ | ..... | ..... | ..... | 4.68 | | |
| Sulphur trioxide | 1.48 | 1.69 | 1.51 | Trace | 1.58 | 1.77 |
| Combined water | 1.60 | 1.40 | 1.70 | 4.82 | 1.85 | 1.50 |
| Moisture | 0.15 | 0.10 | 0.15 | 0 72 | 0 10 | 0.10 |

L. G. Michael, analyst.

*Samples from Spechts Ferry, Waupeton, Potosi, McCartney and Zollicoffer Lake were collected by Mr. E. F. Burchard of the U. S. Geological Survey.

About one mile north of Waupeton, Iowa, the following beds may be viewed:

GALENA-TRENTON EXPOSED NEAR WAUPETON, IOWA.

| | | Feet | Inches |
|---|---|---|---|
| 5. | Limestone, sub-crystalline, with oilrock partings | 12 | |
| 4. | Shale parting | | 4 |
| 3. | Limestone, similar to the above | 1 | 5 |
| 2. | Shale, blue with thin limestone partings | 5 | 7 |
| 1. | Limestone, heavy bedded | 5 | |

No. 2 was carefully sampled and analyzed and the result is given below.

| | |
|---|---|
| Silica | 50.69 |
| Alumina | 15.63 |
| Iron oxide | 4.83 |
| Calcium carbonate | 11.15 |
| Magnesium carbonate | 8.43 |
| Alkalies as $K_2O$ | 1.46 |
| Sulphur trioxide | 2.65 |
| Combined water | 4.64 |
| Moisture | 0.49 |

L. G. Michael, analyst.

The shale member appears to be rather unimportant on both sides of the river. Samples were selected from two points on the Wisconsin side of the river, near McCartney and Potosi. The section at the former place is about as follows:

SECTION EXPOSED AT McCARTNEY, WISCONSIN.

| | | Feet |
|---|---|---|
| 10. | Limestone, subcrystalline, with oil-rock partings | 12 |
| 9. | Limestone, crystalline, with calcareous shale parting below | 1 |
| 8. | Limestone, hard, subcrystalline, chocolate colored | ½ |
| 7. | Shale, blue | 2 |
| 6. | Talus slope | 5 |
| 5. | Limestone, bluish, crystalline, thinly bedded | 5 |
| 4. | Talus slope | 10 |
| 3. | Limestone, compact, fine-grained, thinly bedded | 7 |
| 2. | Talus slope | 13 |
| 1. | Limestone, buff to blue, heavy bedded, appears to be sandy on weathered surface | 6 |

The above section is very similar to the Spechts Ferry section. An average sample of the shale from the above section and also a sample from Potosi, Wisconsin, which exhibits an almost



identical assemblage of beds to those exposed at Spechts Ferry, were selected for analysis. The results are as follows:

| | McCartney. | Potosi. |
|---|---|---|
| Silica | 49.10 | 48.88 |
| Alumina | 17.15 | 14.54 |
| Iron oxide | 8.46 | 12.00 |
| Calcium carbonate | 11.04 | 8.58 |
| Magnesium carbonate | 2.85 | 3.15 |
| Sulphur trioxide | 1.69 | 1.26 |
| Alkalies as $K_2O$ | 3.62 | 6.43 |
| Combined water | 5.36 | 4.48 |
| Moisture | 0.91 | 1.30 |

L. G. Michael, analyst.

South of Spechts Ferry the Platteville limestone is well exposed at Zollicoffer Lake. The section is given below:

SECTION IN GULLY NEAR ZOLLICOFFER LAKE, NORTH OF DUBUQUE IOWA.

| | | Feet | Inches |
|---|---|---|---|
| 10. | Magnesian limestone in beds 8-10 inches; top undefined | | |
| 9. | Upper calcareous shale (Galena limestone) | 1 | |
| 8. | Magnesian limestone or dolomite beds in 7-10 inch layers | 4 | |
| 7. | Thinner, coarser-grained, fossiliferous beds, containing calcite crystals, runs 1-4 inch beds | 2 | 6 |
| 6. | Thin-bedded fossiliferous limestone, somewhat coarsely crystalline at top, becoming more "glass-rock"-like lower down; beds 1-5 inches, wavy bedded, with thin scales of "oil rock" in partings | 5 | |
| 5. | Beds more like "glass rock", finer grained but otherwise similar to No. 6 | 5 | 10 |
| 4. | Heavy bed of medium grained limestone with calcite crystals | 1 | 4 |
| 3. | Shale, blue, clayey with numerous argillaceous limestone partings | 8 | 1 |
| 2. | Hard, rather coarse grained beds running from 3-5 inches thick, appear to be slightly magnesian, but may be because badly stained and weathered | 6 | |
| 1. | Hard, finer-grained, wavy bedded limestone in beds 3-6 inches thick. Upper 5 feet is gradation from (2) but lower down it becomes very fine grained, almost a "glass rock" at bottom of exposure | 12+ | |

All of the members in the above section below number 8, the dolomitic beds, were carefully sampled and analyzed. The analyses are given in the table below. The samples are numbered in the table the same as in the section.

| | 1. | 2. | 3. | 4. | 5. | 6. | 7. |
|---|---|---|---|---|---|---|---|
| Silica | 8.02 | 6.79 | 50.22 | 3.85 | 4.54 | 3.26 | 8.28 |
| Alumina and iron | 5.78 | 4 61 | 12.45<br>9.08 | 6.03 | 2.54 | 0.83 | 4.67 |
| Calcium carbonate | 77.93 | 78 24 | 13 83 | 84.16 | 86 33 | 90.20 | 80.14 |
| Magnesium carbonate | 4 43 | 5.12 | 2.96 | 1.93 | 3 54 | 2.65 | 2 37 |
| Alkalies as $K_2O$ | ..... | ..... | 5.23 | | | | |
| Combined water | 3.18 | 3.28 | 3 81 | 4.23 | 2.62 | 1 84 | 2.17 |
| Sulphur trioxide | 0 22 | 1.74 | 1.16 | 0.64 | 0.22 | 1 64 | 2.60 |
| Moisture | 0 16 | 0.04 | 1.71 | 0.03 | 0.08 | 0.05 | 0 13 |

L. G. Michael, analyst.

All of the beds carry some magnesia but not in prohibitory amounts. Number 2 carries the most, approximating two and a half percent of magnesium oxide. The entire section is above the tracks of the Chicago, Milwaukee & Saint Paul railway.

The pure limestones and shales in all of the sections given thus far are well above the railways of the vicinity and numerous exposures are directly on the railways, and near the Mississippi, so that cheap transportation would be assured in case the Platteville is developed commercially. The dolomitic portion of the Galena-Trenton overlies the shales and limestones in the bluffs, but considerable areas are available where the overburden has been removed or at least has been reduced to an almost negligible thickness. At any of the above sections both the limestone and the shale could be mined easily by drifting directly into the bluffs. The scarcity of the shale is something of a drawback, but by no means as serious as might at first thought be supposed. Maquoketa shales of considerable thickness outcrop at no great distance inland. Good sections are exposed at Kidder and Graf, along the Chicago Great Western, and at Peosta along the Illinois Central railway. Thesection exposed near Graf is given below.

| | | Feet | Inches |
|---|---|---|---|
| 5. | Shale, drab and black, unfossiliferous | 2 | |
| 4. | Shale, brownish, hard, granular, non-fissile and fossiliferous | 1 | 2 |
| 3. | Shale, drab, fissile, non-fossiliferous | 1 | 4 |
| 2. | Shale, variable in color, texture and fissility, with fossiliferous bands | 11 | |
| 1. | Shale, brown or black, non-fissile, fossils rare | 6 | |

An analysis of the shales developed near Kidder gave the following results:



| | |
|---|---|
| Silica | 42.53 |
| Alumina | 16.83 |
| Iron oxide | 5.66 |
| Lime | 5.66 |
| Magnesia | 4.82 |
| Potash | 3.70 |
| Soda | 4.10 |
| Combined water* | 15.76 |

J. B. Weems, analyst.

*Combined water and carbon dioxide.

The limestone and magnesia are believed to be confined argely to the hard fossiliferous layers, and on that account the magnesia percentage could be easily reduced by wasting the ndurated bands.

In the vicinity of Decorah, in Winneshiek county, the Galena-Trenton is well developed and is non-dolomitic. At the ice house in the west part of town, the section exposed on the south bank of the Oneota river is as follows:

| | | Feet. |
|---|---|---|
| 4. | Limestone, massive when first exposed; weathered into thin bands displaying either a cuboidal or a decidedly concretionary facies; 25 feet exposed but thickens greatly toward the upland | 25 + |
| 3. | Limestone, argillaceous, with numerous shaly partings; mixed zone | 10 |
| 2. | Shale, greenish-gray, strongly calcareous and with argillaceous limestone bands | 20 |
| 1. | Limestone, hard, compact, flaggy; exposed at this point | 4 |

The beds dip to the west at a low angle and form an abrupt escarpment on the south bank of the river for some distance west of the above section.

Samples were selected from numbers 2, 3, and 4 of the section and analyzed. The analyses are given below:

| | 2. | 3. | 4. |
|---|---|---|---|
| Silica | 17.45 | 14.53 | 3.86 |
| Alumina and Iron oxide | 9.15<br>5.75 | 6.49 | 2.54 |
| Calcium carbonate | 54.07 | 72.89 | 91.19 |
| Magnesium carbonate | 4.11 | 1.03 | 0.84 |
| Alkalies as $K_2O$ | 2.53 | 0.36 | .00 |
| Sulphur trioxide | 1.67 | 0.48 | .00 |
| Combined water | 5.57 | 3.75 | 2.14 |
| Moisture | 0.25 | 0.15 | 0.05 |

L. G. Michael, analyst.

There is practically no stripping at this point and the two lines of railway which enter the town could easily be extended to favorable outcrops.

In Allamakee county, the Galena-Trenton beds exposed north of Waukon very closely resemble those exposed in the Decorah section. Transportation facilities are not good at the present time and no analyses were made.

It may be noted from the analyses of the shales of the Galena-Trenton that all carry a low percentage of silica and relatively high percentages of alumina, iron and lime. The silica, iron-alumina ratio varies from less than unity in the Decorah shale to less than two and four-tenths in the Zollicoffer Lake shale. The limestones are as a rule of fair quality as far as the presence of magnesia and sulphur are concerned. Practically all of the limestones analyzed carry a considerable percentage of silica, but at the same time they carry a relatively higher percentage of iron and alumina which does not remedy the silica deficiency in the shales.

The Maquoketa shales appear at no great distance from the Platteville limestone throughout the region. Excellent sections aggregating fifty to sixty feet are exposed near Edgewood in Clayton county. The analyses given below may be considered to be fairly representative for the Clayton county Maquoketa.

| | 1 | 2 |
|---|---|---|
| Silica | 52.29 | 44.89 |
| Alumina | 20.64 | 13.72 |
| Iron oxide | 5.16 | 7.80 |
| Lime | 1.89 | 7.88 |
| Magnesia | 1.12 | 6.05 |
| Potash | 2.77 | 1.56 |
| Soda | 8.27 | 5.29 |
| Combined water | 5.17 | 12.18* |
| Moisture, sulphur trioxide and $CO_2$ | 2.76 | |
| Moisture | | 0.89 |

J. B. Weems, analyst.
Sample 1. Sperry Township.
Sample 2. Newberry Park.
* Contains the carbon dioxide in addition to combined water.

The Maquoketa shale, as in the case of the shales in the Galena-Trenton, is low in silica and relatively high in lime, magnesia and the alkalies.



## THE NIAGARA LIMESTONE.

Professor T. E. Savage, in his report on the Geology of Fayette county reports the non-dolomitic character of the Niagara limestone exposed in northern Fayette county. The sections near Auburn Mills were revisited, samples collected and analyses made. The results are tabulated below with a number of analyses of Maquoketa shales exposed in the immediate vicinity and other portions of Fayette county.

| | 1. | 2. | 3. | 4. | 5. | 6. |
|---|---|---|---|---|---|---|
| Silica | 49.60 | 0.68 | 11.95 | 33.82 | 7.55 | 18.31 |
| Alumina | 6.36 | 0.50 | 2.80 | 7.83 | 3.43 | 3.60 |
| Iron oxide | 6.25 | | | 1.92 | | |
| Lime carbonate | ..... | 98.52 | 84.80 | ..... | 78.69 | 73.48 |
| Lime | 22.45 | ..... | ..... | 31.73 | | |
| Magnesium carbonate | ..... | ..... | 0.45 | ..... | 2.40 | 3.10 |
| Magnesia | 0.20 | ..... | ..... | 1.52 | | |
| Soda | 0.35 | ..... | ..... | 1.82 | | |
| Potash | 0.90 | ..... | ..... | 4.25 | | |
| Moisture | ..... | ..... | ..... | ..... | ..... | 0.08 |
| Loss on ignition | 13.56 | ... | ..... | 15.60 | 6.90 | |
| Sulphur trioxide | 0 37 | ..... | ..... | 1.62 | 0.84 | 1.52 |

L. G. Michael, analyst.

1. Maquoketa shale, Auburn Mills. Average samples.
2. Niagara limestones, Auburn Mills. Average samples.
3. Argillaceous limestone, near Clermont.
4. Shale near Clermont.
5. Natural cement rock near Clermont.
6. Shaly limestone near base of Maquoketa at Elgin.

Auburn Mills is an inland town and while both shale and limestone are exposed in unlimited quantities they are not available commercially at the present time.

## THE DEVONIAN.

### FLOYD COUNTY.

The Cedar Valley limestone and the Lime Creek shales and marls are the only portions of the Devonian included in this investigation. Analyses were made from materials selected from sections exposed at Rockford, Lithographic City, Osage, the "Clay Banks" near Portland, and Mason City.

The beds exposed in the pit of the Cream City Brick and Tile Company near Rockford are as follows:

| | | Feet |
|---|---|---|
| 5. | Marl, highly fossiliferous, grayish yellow above to blue-gray below: upper beds distinctly lighter in color than the lower.... | 12 |
| 4. | Clay shale, blue-gray, appears to be slightly more gritty than Nos. 1 and 2, and is also more pervious; the contact between this zone and No. 2 is stained and is apparently a plane of seepage,.... | 12 to 15 |
| 3. | Iron-stained zone with numerous concretions, variable..... | ½ to 2 |
| 2. | Clay shale, similar to No. 1..... | 6 |
| 1. | Shale, gray-blue, slightly gritty, non-fissile | 12 |

Analyses were made of each member in the above section and the results are as follows:

*Analyses of Rockford shales and marl.*

| | Marl No. 5. | No. 4. | No. 3. | No. 2. * | No. 1. * |
|---|---|---|---|---|---|
| Silica | 19.63 | 23.83 | 50.40 | 49.00 | 46.12 |
| Alumina and Iron oxide | 11 33 | 15.10 | 31.22 | 15.28 / 6.24 | 15.32 / 5.62 |
| Calcium carbonate | 59.14 | 46.57 | 7.68 | | |
| Magnesium carbonate | 4.73 | 1.63 | 5.77 | | |
| Sulphur trioxide | Trace | 3.50 | 1.54 | | |
| Alkalies as $K_2O$ | ..... | ..... | 4.96 | | |
| Combined water | 4.41 | 3.68 | 4.51 | | |
| Moisture | 0 27 | 0 22 | 0.41 | | |

L. G. Michael, analyst.
*Analyzed by E. E. Bugbee.

In 1903 an average sample was selected from the lower portion of the pit and analyzed. The analysis is given below.

| | |
|---|---|
| Silica | 58.33 |
| Alumina | 15.54 |
| Iron oxide | 3.84 |
| Lime | 9.42 |
| Magnesia | 3.03 |
| Potash | 1.19 |
| Soda | 1.76 |
| Combined water | 3.47 |
| Sulphur trioxide | 1.10 |
| Moisture | 0.42 |

J. B. Weems, analyst.

The marl and shales are generously distributed in the vicinity of Rockford, south of Lime creek and west of the Shellrock river. Roadways crossing the low bluffs facing Lime creek



expose both members, and the overburden is thin for some distance back from the stream, in some instances for more than a mile. The Chicago, Rock Island & Pacific railway passes within about one-half mile of excellent outcrops. A spur could be easily extended to the shales and marls as the grades are low. Lime creek separates the railway from the nearest exposures, but the creek could be avoided by making a slight detour.

Pure limestone does not occur in quantity at this point above the water level in Lime creek. An abundance of good limestone outcrops along the Shellrock river at Nora Springs a few miles north. Analyses of the limestone have not yet been made. Two trunk lines, the Chicago, Milwaukee & Saint Paul and the Chicago, Rock Island & Pacific afford good railway facilities. The latter road would furnish a direct connection with the shales at Rockford.

The limestone members are also well developed in the vicinity of Charles City. Samples were carefully selected from the quarry at Lithographic City by Mr. C. L. Webster. The section as determined by Mr. Webster is as follows:

| | | Feet. |
|---|---|---|
| 11. | Soil and drift..... | 1 |
| 10. | Limestone, lithographic ..... | 5 |
| 9. | Limestone, yellow-gray, friable, coarsely granular and thin bedded..... | ½ |
| 8. | Limestone, dense, compact; buff to grayish white, thin-bedded..... | 3½ |
| 7. | Limestone, lithographic, shattered and unevenly bedded; brown, variegated | 1 |
| 6. | Clay parting..... | ⅙ |
| 5. | Limestone, compact..... | 1¾ |
| 4. | Clay parting..... | ⅙ |
| 3. | Limestone, buff to pink, lithographic.. | 1½ |
| 2. | Limestone, gray, sub-crystalline..... | ¼ |
| 1. | Limestone, lithographic, dense, exposed | 3 |

An average sample was selected from the above section and analyzed. The analysis is given herewith:

| | |
|---|---|
| Calcium carbonate | 92.85 |
| Magnesium carbonate | 5.31 |
| Iron and alumina | 0.80 |
| Insoluble | 1.60 |

A. O. Anderson, analyst.

The magnesia percentage can undoubtedly be lowered by the elimination of number 9 in the above which appears to be strongly dolomitic.

A short line of railway is about to be extended to the quarries. No shale is known in the near vicinity, at least not nearer

than Rockford in Floyd county, and the "Clay Banks" in Cerro Gordo county.

MITCHELL COUNTY.

Similar beds of limestone extend into Mitchell county. An average sample from the Gable quarry near Osage was analyzed; the results are given below:

| | |
|---|---|
| Calcium carbonate | 90.17 |
| Magnesium carbonate | 1.03 |
| Iron and alumina | 3.82 |
| Insoluble | 2.21 |
| Moisture and organic matter | 2.63 |

A. O. Anderson, analyst.

While the limestone is sufficiently pure for cement here, as in the case of Lithographic City, suitable shales are not available.

CERRO GORDO COUNTY.

The shales and marls exposed in the vicinity of Rockford are believed to be more or less continuous with those exposed at the "Clay Banks" near Portland and at Mason City. Near Lime creek there is very little stripping over the beds, in many cases not sufficient to support a sod. While no outcrops are known directly on the railroads, save at Mason City, numerous outcrops are within easy reach of several trunk lines. At the "Clay Banks" the following section is exposed facing directly on Lime creek, and continuing for a distance of about one mile.

| | | Feet |
|---|---|---|
| 5. | Shale, calcareous or marl; in some places indurated layers appear | 3 |
| 4. | Cap rock, variable in thickness | 1 |
| 3. | Marl, highly fossiliferous; containing occasional hard bands | 20 |
| 2. | Shale, non-fossiliferous, weathered yellow | 10 |
| 1. | Shale, bluish-gray to blue and becoming highly plastic on weathering; non-fossiliferous | 40 |

A hard compact limestone outcrops in the creek and forms the floor upon which the above section rests.

Samples selected from this section were analyzed; the results are given in the table below, the numbers corresponding to the numbers in the section. Three samples were selected from the marl comprising number 3 in the section, of which 3a was taken from the indurated layers.



*Analysis of clay shales and marls from the 'clay banks' near Portland, Cerro Gordo county.*

| | No. 1 | No. 2 | No. 3 | No. 3a | No. 3b | No. 4 | No. 5 |
|---|---|---|---|---|---|---|---|
| Moisture | 1.21 | 1.00 | 0.73 | 0.35 | 0.75 | 0.68 | 0.93 |
| Combined water | 3.29 | 0.76 | 2.72 | 0.17 | 3.67 | 2.44 | 2.04 |
| Silica | 49.93 | 50.15 | 20.26 | 5.36 | 20.82 | 7.59 | 27.26 |
| Alumina | 20.23 | 19.68 | 11.28 | 3.79 | 11.55 | 5.62 | 19.15 |
| Ferric oxide | 4.32 | 4.08 | 2.76 | 1.20 | 2.76 | 1.56 | 4.32 |
| Lime | 6.70 | 9.78 | 31.42 | 48.18 | 30.01 | 44.34 | 16.47 |
| Magnesia | 2.79 | 2.25 | 3.44 | 2.70 | 4.01 | 3.22 | 2.23 |
| Sulphur trioxid | 1.14 | 1.18 | 2.09 | 1.02 | 1.19 | 0.51 | 1.11 |
| Soda | 2.17 | 1.03 | 0.50 | 0.27 | 0.72 | 0.29 | 1.55 |
| Potash | 2.25 | 1.62 | 1.09 | 0.46 | 1.41 | 0.48 | 2.20 |
| Carbon dioxide | 6.05 | 8.54 | 23.56 | 35.73 | 23.05 | 33.39 | 12.59 |

J. B. Weems, analyst.

The stripping is of variable thickness but usually thin. The limestone at the base rises toward Portland, occurring in both banks of Lime creek, and aggregating fifteen to twenty feet in thickness with practically no covering. No analyses were made but the section appears to be identical with the upper portion of the limestone section exposed at Mason City. The "Clay Banks" are about equally distant from the Iowa–Dakota division of the Chicago, Milwaukee & Saint Paul and the Fox Lake division of the Chicago and Northwestern railways.

At Mason City, the shales and marls appear some distance to the south and west of Lime creek while there is an almost continuous section of limestone along Willow, Calamus and Lime creeks. The section at the quarries of the Mason City Lime and Cement Company is as follows:

| | | Feet |
|---|---|---|
| 3. | Limestone, Stromatapora zone, which in weathering presents a concretionary appearance | 10-15 |
| 2. | Limestone, white, compact and brittle, in rather thin beds | 12 |
| 1. | Dolomite or at least dolomitic limestone; sub-crystalline, brown, exposed above low water in Lime creek | 10 |

The several members in the above section disappear a short distance east but reappear at Portland. They form almost an unbroken section to the northwest and can be traced to Fertile, in Worth county, some fifteen miles distant.

The shales and marls are exposed south and west of the city. Immediately west of the Fairgrounds, along a small creek, the following section is exposed:

| | Feet |
|---|---|
| 2. Marl, weathered yellow | 12 |
| 1. Shale clay, blue-gray, becoming very plastic when weathered. Exposed | 20 |

The shales are known to attain a thickness of some forty feet southwest of the city in the pits of the brick companies. Analyses were made of all of the members in the above sections and the results are given below.

| | 1. | 2. | 3. | 4. | 5. | 6. |
|---|---|---|---|---|---|---|
| Silica | 35.23 | 54.56 | 51.95 | 0.72 | 0.63 | 54.64 |
| Alumina | 21.09 | 30.62 | 18.34 | 0.91 | 0.71 | 14.62 |
| Ferric oxide | | | 7.56 | | | 6.45 |
| Calcium carbonate | 32.84 | 4.10 | 4.14† | 94.22 | 97.48 | 9.21 |
| Magnesium carbonate | 3.94 | 2.13 | 3.26† | 1.32 | 0.99 | 6.09 |
| Alkalies as $K_2O$ | | 2.32 | 4.12 | | | 5.89 |
| Sulphur trioxide | 3.11 | 2.30 | 2.76 | 0.98 | | |
| Combined water | 4.26 | 4.19 | 7.49* | 2.46 | | 3.74 |
| Moisture | 0.12 | 0.30 | 0.42 | 0.05 | 0.51 | 0.85 |

* Combined water and carbon dioxide.
† These percentages are of oxides instead of carbonates.

1. Marl from exposure west of Fairgrounds. L. G. Michael, analyst.
2. Shale from exposure west of Fairgrounds. L. G. Michael, analyst.
3. Shale from pit of American Brick and Tile Company. J. B. Weems, analyst.
4. Stromatopora limestone, quarry of Mason City Lime & Cement Company. L. G. Michael, analyst.
5. Mason City White Limestone, quarry of Mason City Lime & Cement Company. A. O. Anderson, analyst.
6. Shale from pit of Mason City Brick and Tile Company. G. E. Patrick, analyst.

The marls and shales are known to extend over a large area and are easily reached, as there is but little cover over them. Both the limestones and the shales are within easy reach of the railways which enter the city.

It will be noted that all of the Devonian limestones analyzed are essentially pure, carrying very small percentages of magnesia and sulphur. All of the shales are calcareous and grade insensibly into marls. They carry from less than two to more than eight per cent of magnesium carbonate, and are comparatively low in sulphur trioxide. Calculating the magnesium as an oxide it reduces to from less than one to about four per cent, not enough when blended with the limestone to be a serious consideration in the manufacture of Portland cement. All of the shales are comparatively low in silica and high in alumina and iron, a much more important consideration than the question of sulphur and magnesia. According to the best authorities the shales used in the manufacture of Portland cement, when used with pure limestones, should carry at least 55 per cent of silica, preferably 60 or 70 per cent, and in any event at least twice the sum of the alumina and ferric oxide. *Eckel states that the composition in terms of silica, alumina and ferric oxide should fall within the following limits.

$$\frac{SiO_2}{Al_2O_3 + Fe_2O_3} > 2 \quad : \quad \frac{SiO_2}{Al_2O_3 + Fe_2O_3} < 3.5$$

Now it is apparent from a casual inspection of the analyses that the silica ratio for the various shales and marls varies from less than 2 to about 2.8 per cent, and in order to secure the best composition the addition of silica may be found desirable.

## THE LOWER CARBONIFEROUS.

Deposits belonging to the Kinderhook, Saint Louis and Coal Measures are included in the present investigation. The Kinderhook was observed at various points in Hardin and Humboldt counties, but samples were collected and analyzed from only the latter county. The Saint Louis was investigated only at Livermore in Humboldt county, while the Coal Measures were studied at a number of points in addition to those already mentioned.

### WEBSTER COUNTY.

Highly siliceous shales are available along the Des Moines river between Fort Dodge and Lehigh in Webster county, and along the Iowa Central railway in Hardin county. An average sample was selected from the pit of Johnston Brothers Clay Works at Kalo, in Webster county. The analysis is given below:

| | |
|---|---|
| Silica | 70.20 |
| Alumina | 16.70 |
| Iron oxide | 4.00 |
| Lime | 0.28 |
| Magnesia | 0.63 |
| Potash | 1.75 |
| Soda | 1.39 |
| Combined water | 3.70 |
| Sulphur trioxide | 0.82 |
| Moisture | 0.53 |

* Cements, Limes and Plasters, page 305, 1905.

The Chicago Great Western railway reaches the shales of the Des Moines river district, though not the pit from which the sample was selected for analysis.

A sample selected from the pit of the Eldora Pipe and Tile Company in Hardin county gave the following results:

| | |
|---|---|
| Silica | 72.09 |
| Alumina | 16.24 |
| Iron oxide | 1.08 |
| Lime | 0.48 |
| Magnesia | 0.48 |
| Potash | 1.08 |
| Soda | 0.77 |
| Sulphur trioxide | 0.14 |
| Combined water | 5.18 |
| Moisture | 2.46 |

The Atlas Cement Company ship a portion of the shales used at their Hannibal, Mo., plant a distance of sixty miles, while a considerable portion is mined on the premises. Siliceous shale can no doubt be found at other points within reach of Mason City, Rockford and Portland.

HARDIN COUNTY.

Beds low in magnesia constitute the lower portion of the Kinderhook section in Iowa Falls and in the quarries of the Ellsworth Stone Company and the Barber Asphalt Company. They are overlain by from ten to thirty feet of sub-crystalline dolomite in addition to a thin veneer of alluvium and surface wash. West of Iowa Falls, from the Ivanhoe quarries to Alden, the dolomitic beds have been removed along the Iowa river and the limestone appears almost continuously in one or both banks of the river, rising from five to twenty feet above low water level. The overburden amounts to but little near the river but thickens greatly in the bluffs. A representative section at Alden on the river front is as follows:

| | | Feet. |
|---|---|---|
| 3. | Alluvium, drift and wash | 3 |
| 2. | Limestone, more or less evenly bedded; similar to No. 1; a marly or shaly band separates Nos. 1 and 2 generally | 12 |
| 1. | Limestone, light-gray, hard sub-crystalline and oolitic texture. The upper surface somewhat undulating while the lower 4 feet shows cross-bedding | 5 |



The beds are much rifted and shattered. Individual layers rarely four or five inches in thickness dip to the southwest. The entire assemblage disappears up the river about the corporate limits of the town. The Iowa Falls branch of the Chicago & Northwestern railway runs near the line of outcrop of these beds. Satisfactory shales are not easily accessible in the near vicinity. At the "Honestone quarries" west of Iowa Falls the Coal Measure shales appear in the north bank of the river. The section is appended herewith:

| | | Feet. |
|---|---|---|
| 5. | Drift | 40–90 |
| 4. | Sandstone, fine grained, slightly argillaceous, forming a projecting ledge | 2–5 |
| 3. | Shale, arenaceous, blue-gray and but slightly indurated. Certain hard layers appear throughout the section | 30 |
| 2. | Shale, blue, fissile; in some places almost black | 15 |
| 1. | Limestone, dolomitic, weathered, exposed above the water level | 1+ |

No analyses have yet been made of either the limestone or the shale. It is believed, however, that the limestone is essentially free from magnesia and sulphur, and that the shale number 2 in the Honestone section is highly siliceous and probably of suitable composition to blend with the limestone in the manufacture of Portland cement. It could be produced, however, only by mining. Further investigation is necessary to demonstrate the merits of both limestone and shale. The shale beds could be reached by extending the switch which now reaches the plant of the Iowa Falls Brick and Tile Company.

HUMBOLDT COUNTY.

The Kinderhook limestone beds outcrop near the Minneapolis and Saint Louis railway in the southern part of the city of Humboldt and present an almost continuous exposure on the river for more than a mile. The same beds outcrop near the Chicago

and Northwestern railway north of the city, and near Rutland about five miles to the northwest. The section exposed below the dam in Humboldt is given below:

| | | Feet |
|---|---|---|
| 4. | Alluvial wash, variable in thickness; on top of terrace about | 3 |
| 3. | Limestone, oolitic, rather coarse grained, gray to white | 10 |
| 2. | Limestone, compact, gray white, a gradation from No. 1 but fewer fossils present and apparently less brecciated | 2 |
| 1. | Limestone, brecciated and filled with casts of fossils, chiefly brachiopods; very compact and brittle in outcrop; bedding planes not apparent. Exposed above low water | 4 |

The section rises toward the town and the oolite probably shows a greater thickness than is indicated in the above section. All of the beds dip perceptibly up stream. An average sample was taken from the above section and analyzed. The result is given below:

| | |
|---|---|
| Insoluble | 0.50 |
| Iron oxide and alumina | 1.12 |
| Calcium carbonate | 97.20 |
| Magnesium carbonate | 2.00 |
| Total | 100.82 |

Analyzed by A. O. Anderson, from sample collected by C. M. Morgan.

To the west, just across the Humboldt county line, near Gilmore, extensive limestone beds, belonging to the Saint Louis, appear near the surface. According to McBride in his Humboldt county report the Gilmore section is as follows:

| | | Feet |
|---|---|---|
| 10. | Alluvium, surface soil, etc | 6 |
| 9. | Coarse sand and gravel | 3 |
| 8. | Bowlder clay, much weathered | 2–4 |
| 7. | Limestone, coarse-grained, crystalline | 20 |
| 6. | Shale, blue, with clay and limestone; fossiliferous | 2 |
| 5. | Limestone, lithographic, inclined to angular fracture | 1½ |
| 4. | Limestone, fine-grained, heavy-bedded and non-fossiliferous | 3 |
| 3. | Limestone, shaly with few fossils | 1 |
| 2. | Limestone, fossiliferous, coarse-grained | 1 |
| 1. | Limestone, lithographic | 2 |



An analysis was made of the principal member in the above section and is given herewith:

| | |
|---|---|
| Silica | 0.32 |
| Alumina and iron | |
| Calcium carbonate | 99.62 |
| Water and undetermined | 0.06 |

J. B. Weems, analyst.

A casual inspection of the analysis shows the limestone to be almost absolutely pure. The quarries are within easy reach of the Des Moines and Ruthven division of the Chicago, Rock Island and Pacific railway.

## THE COAL MEASURES.

Extensive limestone beds are to be found in the upper Coal Measures in southwestern Iowa. In Madison county the Bethany limestone forms an almost continuous escarpment diagonally across the county from Peru by way of Winterset to Earlham.

Near Earlham two quarry companies have operated extensively, and are directly connected with the main line of the Rock Island railway. The sections exposed are as follows:

QUARRY SECTION, EARLHAM LAND COMPANY.

Located about one and one-half miles south of railway station in Earlham

| | | Feet. |
|---|---|---|
| 4. | Loess and drift, of variable thickness | 10 to 14 |
| 3. | Limestone, in regular beds, with shale parting near the middle | 9 |
| 2. | Limestone, less evenly bedded than the above, hard and brittle | 6 |
| 1. | Sandstone, calcareous and shaly, exposed | |

QUARRY SECTION OF S. A. ROBERTSON.

Located about two miles east of railway depot in Earlham.

| | | Feet. |
|---|---|---|
| 7. | Loess and drift, variable | 2 to 8 |
| 6. | Limestone, gray to buff, evenly bedded | 2 |
| 5. | Limestone, irregularly bedded, with some cherts | 3 |
| 4. | Limestone, evenly bedded, becoming shaly near the middle | 4 |
| 3. | Limestone, shattered, unevenly bedded, cherty | 1½ |
| 2. | Limestone, rather evenly bedded above, and unevenly bedded below. Hard and compact but in thin ledges | 6 |
| 1. | Sandstone, calcareous and shaly, exposed | |

A composite sample was selected from the Robertson quarry and analyzed: The result of the analysis is given below:

| | |
|---|---|
| Insoluble | 7.85 |
| Iron oxide and alumina | 1 00 |
| Calcium carbonate | 91.15 |
| Magnesium carbonate | 0.61 |

L. G. Michael, analyst.

Similar limestone deposits are to be found southwest of Des Moines along the Chicago Great Western railway at Peru. According to T. E. Savage, Assistant State Geologist, the beds exposed at this point are as follows:

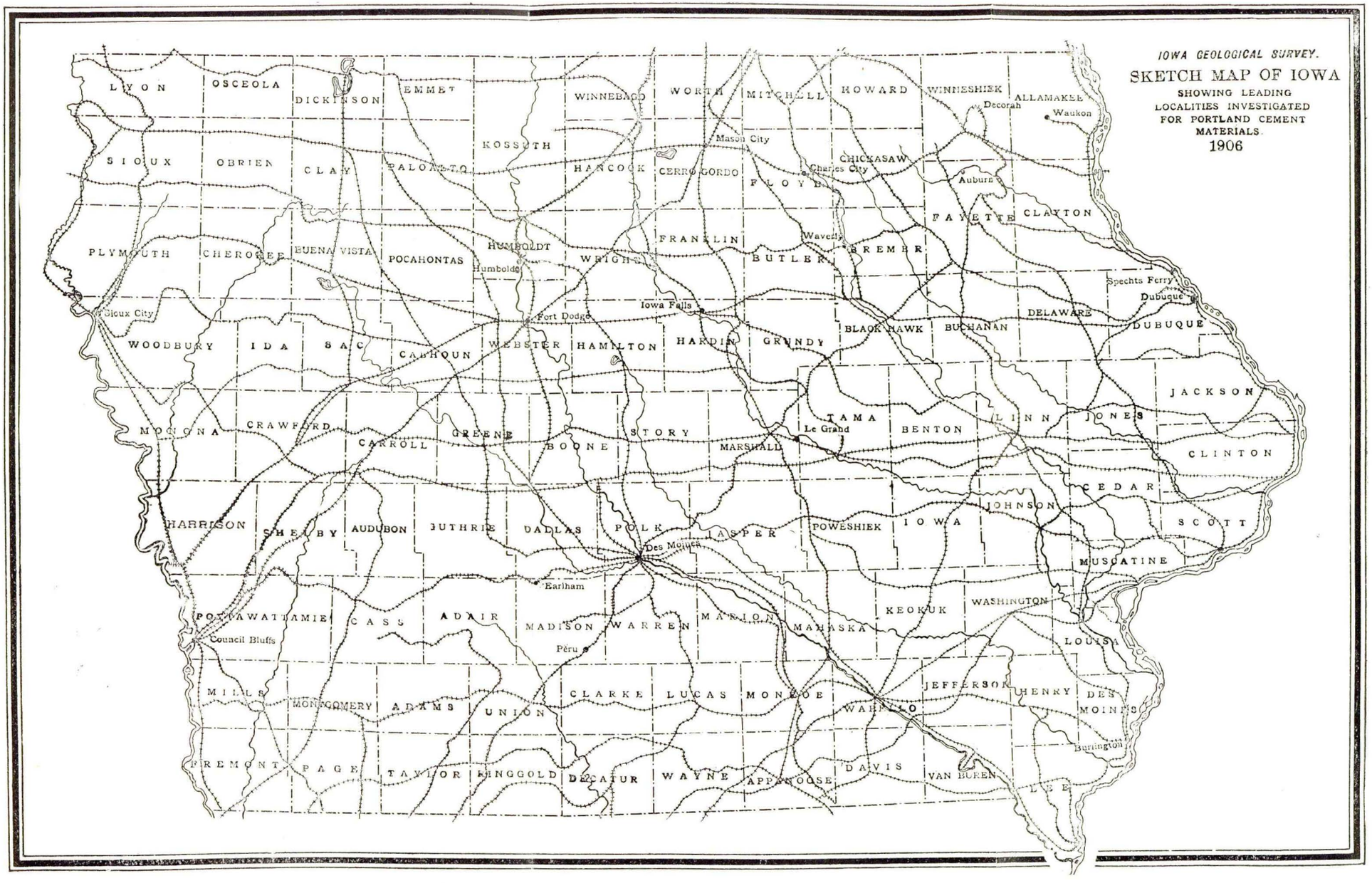
| | | Feet | Inches |
|---|---|---|---|
| 10. | Yellow colored loess | 5 to 8 | |
| 9. | Drift, reddish brown above grading down to gray below; containing numerous bowlders in the lower portion | 9 to 15 | |
| 8. | Gray or yellowish limestone, argillaceous, fine-grained; in three layers respectively 15, 18 and 12 inches in thickness. Much stained in upper part | 3 | 9 |
| 7. | Bluish colored shale, with a band of limestone 1-5 inches in thickness near the middle portion | | 10 |
| 6. | Dense, gray limestone, in layers 16, 24, 6, and 16 inches in thickness | 5 | 4 |
| 5. | Band of gray shale | | 8 |
| 4. | Layer of gray limestone, crinoidal in lower portion | 2 | 6 |
| 3. | Ledge of gray limestone similar to number 4 above, in two layers respectively 12 and 30 inches in thickness | 3 | 6 |
| 2. | Band of grayish-blue shale | | 10 |
| 1. | Talus slope with occasional outcrops of limestone, to level of flood plain | 20 | |

According to Mr. Savage the bluff continues a distance of one-half mile along Clanton creek. A composite sample was selected from the limestone members of the above section and analyzed, and the results of the analysis are given below:

| | |
|---|---|
| Silica | 17.16 |
| Iron oxide and alumina | 2.64 |
| Calcium carbonate | 72.76 |
| Magnesium carbonate | 2.86 |
| Sulphur trioxide | 0.95 |
| Moisture | 0.30 |
| Combined water | 3.12 |

Analyzed by L. G. Michael.

The shales in this neighborhood have not been investigated. None of the exposures are on more than a single line of railway. Winterset and Earlham are on the Chicago, Rock Island and


IOWA GEOLOGICAL SURVEY.
SKETCH MAP OF IOWA
SHOWING LEADING LOCALITIES INVESTIGATED FOR PORTLAND CEMENT MATERIALS.
1906
LYON
OSCEOLA
DICKINSON
EMMET
WINNEBAGO
WORTH
MITCHELL
HOWARD
WINNESHIEK
ALLAMAKEE
Decorah
Waukon
Mason City
KOSSUTH
SIOUX
O'BRIEN
CLAY
PALO ALTO
HANCOCK
CERRO GORDO
CHICKASAW
Charles City
FLOYD
Auburn
FAYETTE
CLAYTON
PLYMOUTH
CHEROKEE
BUENA VISTA
POCAHONTAS
HUMBOLDT
Humboldt
WRIGHT
FRANKLIN
BUTLER
Waverly
BREMER
Specht's Ferry
Dubuque
Sioux City
Fort Dodge
Iowa Falls
DELAWARE
DUBUQUE
BLACK HAWK
BUCHANAN
WOODBURY
IDA
SAC
CALHOUN
WEBSTER
HAMILTON
HARDIN
GRUNDY
JACKSON
TAMA
LINN
JONES
MONONA
CRAWFORD
CARROLL
GREENE
BOONE
STORY
MARSHALL
Le Grand
BENTON
CLINTON
CEDAR
JOHNSON
HARRISON
SHELBY
AUDUBON
GUTHRIE
DALLAS
POLK
JASPER
POWESHIEK
IOWA
SCOTT
Des Moines
MUSCATINE
Earlham
KEOKUK
WASHINGTON
POTTAWATTAMIE
CASS
ADAIR
MADISON
WARREN
MARION
MAHASKA
Council Bluffs
Peru
LOUISA
MILLS
MONTGOMERY
ADAMS
UNION
CLARKE
LUCAS
MONROE
JEFFERSON
HENRY
DES MOINES
WAPELLO
Burlington
FREMONT
PAGE
TAYLOR
RINGGOLD
DECATUR
WAYNE
APPANOOSE
DAVIS
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Pacific, while Peru is on the Kansas City Division of the Chicago Great Western.

Shales of excellent quality outcrop in and about Des Moines, and a cement plant located at this place would have the advantages of unrivaled railway facilities, cheap fuel, and an abundance of shale of suitable quality for the manufacture of Portland cement. A large number of analyses have been made from the shales exposed in the pits of the different brick plants in the city. The pit of the Flint Brick Company may be considered to be fairly representative. The principal beds exposed are about as follows:

| | | Feet |
|---|---|---|
| 5. | Shale, variegated, stained yellow where weathered | 10+ |
| 4. | Shale, red and bluish-gray, laminated | 6 |
| 3. | Shale, brick red in color, clean, unctuous | 4 |
| 2. | Shale, light gray, silicious | 2 |
| 1. | Shale, blue, exposed | 20+ |

In the clay investigation the report of which is published in Volume XIV of the Iowa Survey reports several analyses were made from the above section. One of the most important of these was the analysis of a green brick which doubtless approximates the run of the pit. For comparison an average sample was selected from the middle of the pit section. The results of these analyses are given below:

| | No. 1. | No. 2. |
|---|---|---|
| Silica | 63.75 | 61.36 |
| Alumina | 19.78 | 22.12 |
| Ferric oxide | 5.75 | 6.07 |
| Lime | 1.55 | 1.90 |
| Magnesia | 1.22 | 0.80 |
| Potash | 0.54 | 1.22 |
| Soda | 1.20 | |
| Combined water | 2.92 | 4.52 |
| Moisture, sulphur trioxide and carbon dioxide | 3.88 | 2.01 |

1. Green brick, Flint Brick Company, J. B. Weems, analyst.
2. Middle of pit section, Flint Brick Company, L. G. Michael, analyst.

The shale outcrop continues some distance north of the Flint plant and the removal of almost no overburden is necessary for the development of the section. The interurban railway connects the district with all of the railways entering Des Moines.

The Coal Measure shales outcrop at numerous other points in and about the city, although equally good sections free from stripping within easy reach of a railroad are not known.

### THE CRETACEOUS.

Limestone, chalk and shale are abundant in the Cretaceous beds of northwestern Iowa. No extensive deposits of limestone and chalk, easily obtainable, are known however. As a rule both occur in comparatively thin beds and are deeply buried by the drift and other worthless materials. No samples were collected or analyses made of these materials during the present investigation.



# INDEX.