OOLITE AND OOLITIC STONE FOR PORTLAND CEMENT MANUFACTURE.

By W. S. Blatchley.

As mentioned on a preceding page, the carbonate of lime used in making Portland cement can be either a marl or a limestone. There are in Indiana vast beds of limestone which possess the chemical purity and physical conditions necessary for making such cement. Practical tests in which they have been used as the carbonate of lime ingredient show the resulting cement to be superior to that in which marl was the source of the lime.

The process of manufacture where limestone is used is in general similar to that already described with the exception that the limestone has to be crushed and ground very fine before it is mixed with the clay. The Indiana limestones are soft and easily crushed and ground when first quarried, but harden on exposure. The necessary labor and expense of grinding is therefore much less when the stone is immediately used.

Oolite.—In Crawford and Harrison counties, notably near Milltown and Marengo, are extensive deposits of the purest limestone in Indiana. It is a true oolite, consisting of minute concretionary spherical masses which resemble closely the petrified eggs of fish. These are cemented together in a firm white mass, forming the stratum of stone. In Eichol's quarry at Milltown the stratum as exposed is 13 feet thick and more than 1,500 feet in length when it disappears in the bluffs of Blue River. The complete section at the quarry is as follows, No. 16 being the oolite in question:

Section at Eichol's Quarry on Northeast Side of Blue River, Opposite Milltown.

		Ft.	*In.*
1.	Slope mostly hidden by sandstone debris, probably all sandstone	24	..
2.	Semi-crystalline, semi-oolitic gray limestone, with fossils	4	..
3.	Light gray oolitic limestone, with pentremite bed at top	..	15
4.	Hard buff sub-crystalline limestone	3	..
5.	Hidden	4	..

		Ft.	In.
6.	Crystalline brownish-gray limestone	1	..
7.	Covered	8	..
8.	Lithographic limestone	3	..
9.	Light gray crystalline limestone	20	..
10.	Covered (limestone?)	25	..
11.	Bluish-gray lithographic limestone, buff in spots	7	..
12.	Bluish calcareous shale	..	15
13.	Sub-lithographic light drab limestone, with fine quartz sand, mustard-seed size. Some cross bedding toward top	12	..
14.	Light grayish-buff colored limestone	9	..
15.	Buff, rather soft magnesian (?) limestone	5	..
16.	Oolite, white to gray, oolitic structure imperfect locally	13	..
17.	Hard bluish gray, sub-crystalline to sub-oolitic	6	8
18.	Bluish green shale	..	2
19.	Light gray granular limestone, with a crowfoot near the middle and with occasional green blotches	5	..
20.	Shale parting	..	1
21.	Light gray sub-crystalline—sub-oolitic limestone	3	9
22.	Shale and lithographic limestone intercalated	..	24
23.	Drab colored lithographic limestone, with irregular calcite band near the middle	3	..
24.	Gray crystalline limestone	2	6
25.	Lithographic limestone with flint bands and flint concretions	7	..

Floor of quarry about 10 feet above low water in Blue River.

An analysis by Dr. Noyes of an average sample of the oolite shows its percentage composition to be as follows:

Calcium carbonate ($CaCO_3$)	98.91
Magnesium carbonate ($MgCO_3$)	0.63
Ferric oxide and alumina ($Fe_2O_3+Al_2O_3$)	0.15
Insoluble in hydrochloric acid	0.48
Total	100.17

The analysis shows the oolite to run from one to three per cent. higher in carbonate of lime than the better grades of Indiana oolitic limestone from Lawrence and Monroe counties. It is softer and therefore more easily reduced to a fine powder. At both Milltown and Marengo switches from the St. Louis Division of the Southern Railway are already in place. At Milltown Blue River can be easily dammed and cheap and permanent water-power thereby be obtained. The river at that point is about 225 feet wide, and between there and its mouth at the Ohio River, the fall is 89 feet, or about seven and a half feet to the mile.

In my report for 1899 I called attention to this deposit of oolite at Milltown, and its value as a Portland cement ingredient. A number of capitalists were afterward, by letter and in person, given full information concerning it. Finally some gentlemen from Cleveland and Detroit, who had called upon me for information relative to marl deposits, were induced to investigate it and were so pleased with both the quality and quantity of the material that they at once organized a company and secured possession of the more available portion. The same company—The Indiana Portland Cement Company—also secured the marl in and about Dewart and Milford lakes, Kosciusko County, and are now engaged in raising the capital to construct large plants at both places. The one at Milltown—utilizing the oolite—will be the sooner completed, the chances being that it will be well under way by the close of the year 1901. The company has had an analysis made showing the average composition of six limestones from the face of the Milltown quarry, one of which was the oolite. The result of this analysis was as follows:

Calcium carbonate ($CaCO_3$)	96.87
Magnesium carbonate ($MgCO_3$)	1.19
Silica (SiO_2)	.51
Alumina (Al_2O_3)	.37
Total	98.94

This analysis proves that the greater portion of the face of the cliff is well suited for the making of cement, the carbonate of lime being from three to four per cent. higher than in the better grades of marl. The only difficulty arises in the proper grinding of the hard crystalline limestones, but the company has assurance that this can be readily and cheaply done.

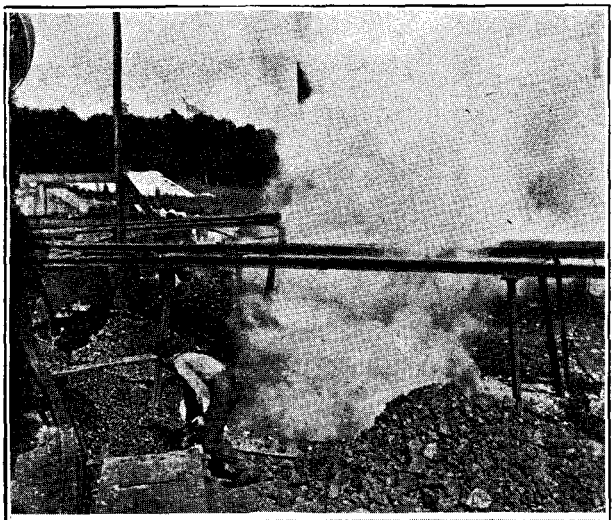
A section of the quarry face at Marengo is as follows:

SECTION OF QUARRY AT MARENGO, IND.

		Ft.	*In.*
1.	Surface clay	1 to 5	..
2.	Hard gray sub-oolitic limestone	4	6
3.	Hard light bluish-gray sub-oolitic limestone	5	..
4.	Gray sub-lithographic to sub-oolitic limestone in 6 to 36-in. strata	6	..
5.	Buff limestone, hard to rather soft	4	6
6.	Coarse crystalline gray limestone, oolitic in places	6	..
7.	Dark gray lithographic limestone	3 to 5	..
8.	Pure white to light gray oolitic limestone	2 to 4	..
9.	Buff limestone, very hard to rather soft	5	6
10.	Dark bluish-gray lithographic limestone, irregular in layers and texture	6	6

PLATE 13.

a



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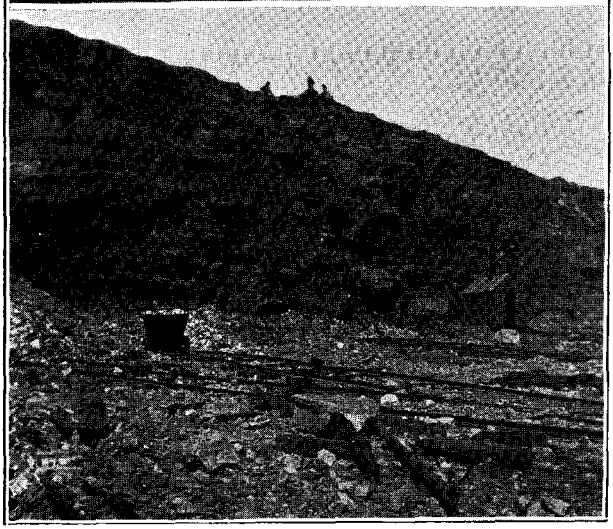

ILLUSTRATING QUARRYING INDUSTRY AT MILLTOWN, INDIANA.

These deposits of oolite, lying as they do in proximity to the coal fields of Dubois, Warrick and Pike counties, and also close to extensive beds of clay and shale, offer most excellent investments to capitalists in search of good sites for Portland cement manufacture.

OOLITIC LIMESTONE.—Chemical analyses and numerous practical tests show that the Indiana oolitic limestone is in every way suitable for the making of a superior grade of Portland cement. This stone is found in a strip of territory from two to fourteen miles in width which extends from Greencastle, Putnam County, to the Ohio River. It occurs in a stratum varying from a few feet to nearly one hundred feet in thickness. The principal quarries are located near Romona, Owen County; Stinesville, Ellettsville, Bloomington and Sanders, Monroe County; Oolitic, Dark Hollow and Bedford, Lawrence County; Salem, Washington County, and Corydon, Harrison County.

Few limestones are more accessible than the Indiana oolitic limestone. Occurring as it does in an almost horizontal position, it outcrops over a comparatively large area, with either no covering at all or one so light that it can easily be removed. The map of the area prepared for the Twenty-first Report of this Department shows the total length of the outcrop in Owen, Monroe and Lawrence counties to be not less than 1,600 miles. The C., I. & L. (Monon) Railway traverses the area from north to south over all the productive part, and there are also three east-west railroads and a short line known as the "Belt," which serves to connect many quarries around Bedford with the other roads. There are also short branch roads, making switch connections with one or more of these roads, running into each of the quarries.

The oolitic stone is a granular limestone, or calcareous sand rock in which both grains and cementing principle are carbonate of lime. In the common sandstones of the State the grains are hard and nearly angular. In the oolitic stone they are always soft and either round or rounded, and the cement is harder than the grains. In color the stone is either buff or blue. Its specific gravity is about 2.47, and its weight about 152 pounds per cubic foot.

Chemical analyses show the Indiana oolitic stone to be a lime carbonate of remarkable uniformity and purity. No other stone in the United States shows such a uniformity of composition over so large an area. The following analyses made in the past, mostly by the chemists of this Department, show accurately its percentage composition:

CHEMICAL ANALYSES OF INDIANA OOLITIC LIMESTONE.

Number.	LOCALITY.	Quarry.	Date.	Lime Carbonate, $CaCO_3$.	Magnesium Carbonate, $MgCO_3$.	Insoluble.	Iron Oxide, Fe_2O_3.	Alumina, Al_2O_3.	Alkalies, K_2O and Na_2O.	Water, H_2O.	Total.	Authority.
1	Bedford	Bedford, Indiana Stone Co.	1896	98.27	.84	.64	.15	.....	.....	.....	99.90	W. A. Noyes, Rose Polytechnic Inst.
2	Hunter Valley	Hunter Bro.'s Quarry	1896	98.11	.92	.86	.16	.....	.....	.....	100.05	W. A. Noyes, Rose Polytechnic Inst.
3	Romona	Romona Oolitic Stone Co	1896	97.90	.65	1.26	.18	.....	.....	.....	99.99	W. A. Noyes, Rose Polytechnic Inst.
4	Twin Creek	Twin Creek Stone & Land Co.	1896	98.16	.97	.76	.15	.....	.....	.....	100.04	W. A. Noyes, Rose Polytechnic Inst.
5	Big Creek	Indiana Steam Stone Works	.....	95.80	4.01	.15	.64	.....	.....	1.09	100.00	L. H. Streaker, State University.
6	Big Creek	Indiana Steam Stone Works	.....	95.07	4.22	.50	.71	.....	.....	1.19	100.00	L. H. Streaker, State University.
7	Bedford	Chicago and Bed. Stone Co.	1878	96.60	.27	.50	.98	.....	.40	.61	100.00	Indiana Geological Rep., 1878, p. 95.
8	Bedford	Hoosier Quarry, buff	.....	98.20	.39	.63	.39	.....	.....	.....	99.61	Bedford Quarries Co.'s Circular.
9	Bedford	Hoosier Quarry, blue	.....	97.26	.37	1.69	.49	.....	.....	.....	99.81	Bedford Quarries Co.'s Circular.
10	Four miles E. of Spencer	Simpson & Archer	1878	96.79	.23	.70	.91	.....	.32	.41	99.90	Indiana Geological Rep., 1878, p. 91.
11	Bloomington	Dunn & Dunn Quarry, white	1881	95.62	.89	1.74	.23	.06	.....	.59	99.45	Indiana Geological Rep., 1881, p. 32.
12	Bloomington	Dunn & Dunn Quarry, blue.	1881	95.55	.93	1.60	.09	.09	.....	.42	99.37	
13	Bloomington	Dunn & Co.	1878	95.54	.40	.65	1.00	.....	.55	.25	.....	Indiana Geological Rep., 1878, p. 95.
14	Stinesville	Monroe Marble Co.	1862	95.00	.22	.90	3.00	.....	.83	.05	100.00	Ind. Geol. Rep, 1862, Owens, p. 137.
15	Salem	.....	1886	96.04	.72	1.13	1.06	.....	.15	.10	.....	Indiana Geological Rep., 1886, p. 144.
16	Harrison Co	Stockslager's Quarry	1878	98.09	.....	.31	.18	.14	.40	.12	.....	Indiana Geological Rep., 1878, p. 96.
	Average	.....		96.50	1.00	.88	.75	.....	.17	.29	.....	

From the table it will be seen that the percentage of carbonate of lime varies between 95 per cent. and 98.27 per cent., a variation of but little more than three per cent. in 16 different samples from widely separated localities, varying from Romona on the north to near the Ohio River on the south.

The percentage of magnesium carbonate is less than one per cent. in all the specimens except two from Big Creek, and there is a possibility in that case that the greater quantity may be due to error in analysis.

The insoluble residue which includes the silica, insoluble silicates, and organic matter, averages less than one per cent., never as high as two per cent., and only four running over one per cent. The iron and alumina combined average less than one per cent. The alkalies form a mere trifle. The last column, headed "water," in the two analyses, where it shows more than half of one per cent., includes water and loss on ignition. Probably the greater part in each is due to the unavoidable errors of analysis. Thus, from the standpoint of purity, the stone is all that could be desired, only the purest marbles and oolite giving a higher percentage of lime carbonate.

It seems strange that Indiana capital has not hitherto been invested in the manufacture of Portland cement from oolitic limestone. Dr. J. Gardner of Bedford, and others, had tests made three years and more ago which proved the fitness of the stone for such purpose. Samples of stone from the vicinity of Bedford, with copies of their analyses, were later sent by this Department to Aman Moore, then in charge of the South Bend cement factory. Under date of July 7, 1898, Mr. Moore wrote: "I have carefully examined the oolitic stone with regard to its physical properties, etc. Since the analyses show that it contains 97+ per cent. of carbonate of lime it can certainly be utilized in the manufacture of Portland cement, providing a suitable clay can be had at a reasonable price. The limestone is exceptionally good, and with a good and cheap clay, cheap fuel and good freight rates, by constructing a modern plant, equipped with the best machinery for the business, a large and paying industry could be built up in the region from whence the stone was obtained. Twenty-five thousand dollars would construct a plant that would turn out a capacity of 150 barrels per day at a cost of from 50 to 60 cents per barrel, and which, at the present price of Portland cement, would net $1.85 at the factory."

The statement that the oolitic limestone would make excellent cement was given wide circulation, both in the newspapers and in the reports of this Department, yet none of our local capitalists cared

to interest themselves in the matter. They acted in this as they have in regard to most of the other great resources of Indiana. These are being developed at the rate of nearly twenty millions of dollars yearly, yet much of the capital which is bringing about this development is owned by parties outside of the State. They reap the benefits; they pocket the profits. The people of Indiana, with hundreds of thousands of dollars of capital lying idle, are, for the most part, reluctant to invest in the resources of their State. They stand by and see our thickest coal veins, our greatest clay factories, our largest stone quarries, the majority of our oil wells, and the greater part of our natural gas property owned and operated by foreign capital.

A few millions of dollars are invested in developing these resources and pay taxes into our treasuries, but the profits, aggregating far greater sums, go into the coffers of non-resident owners. Were Indiana capital invested, both capital and profits would remain in the State, and the wealth upon which taxes are based would increase in much greater proportion.

In 1900 the Bedford Portland Cement Co. was organized by gentlemen from Minnesota and Michigan, to whom information concerning the fitness of the oolitic stone for cement purposes had been furnished by the writer. They purchased a large tract of land near Bedford upon which occurs oolitic stone, common clay and kaolin in quantity. Samples of these materials were sent to Dr. A. W. Smith, chemist at the Case School of Applied Science at Cleveland, Ohio, for analyses, which resulted as follows:

ANALYSIS OF OOLITIC LIMESTONE FROM LAND OF BEDFORD PORTLAND CEMENT CO.

Calcium carbonate ($CaCO_3$)	97.48
Magnesia (MgO)	0.61
Iron oxide (Fe_2O_3)	0.13
Alumina (Al_2O_3)	1.27
Water (H_2O)	0.15
Total	99.64

ANALYSIS OF COMMON CLAY.

Silica (SiO_2)	74.29
Alumina (Al_2O_3)	12.06
Iron oxide (Fe_2O_3)	4.92
Lime (CaO)	0.41
Magnesia (MgO)	0.68
Potash (K_2O)	0.76
Soda (Na_2O)	1.80
Total	94.92

ANALYSIS OF KAOLIN.

Silica (SiO_2)	43.55
Alumina (Al_2O_3)	36.25
Iron oxide (Fe_2O_3)	2.65
Total	82.45

Quantities of the materials were also sent to S. B. Newberry, Superintendent of the Sandusky Portland Cement Co., Sandusky, Ohio, in order that he could determine by practical experiments their fitness for cement making. In due time he made his report as follows:*

SANDUSKY PORTLAND CEMENT CO., GENERAL OFFICE AND WORKS.
SANDUSKY, OHIO, May 28, 1900.

C. A. Nimocks, Esq., Minneapolis, Minn.:

Dear Sir—As instructed by you I have made practical tests of the limestone and clay sent me at your request by Dr. J. Gardner, of Bedford, Ind., from the land of the Bedford Portland Cement Company, and respectfully submit the following report on the suitability of these materials for the manufacture of Portland cement:

The samples received consisted of a soft gray limestone, a red clay and specimens of impure kaolin.

I have examined the analyses made by Dr. A. W. Smith, of these materials, and I have not considered it necessary to repeat his analyses, but have confined my work to practical tests of the material, and tests and analysis of the resulting cement.

The limestone and clay were crushed to such fineness as to pass a No. 20 sieve, and the mixture ground with 40 per cent. of water, until the mixture, on washing through a sieve of 200 meshes to the linear inch, left scarcely any residue. The mixture was then dried and burned and a well sintered clinker resulted, which on grinding gave a cement of a light gray color, slow setting, sound in both cold and hot tests and of *extraordinary tensile strength.* The following are the results obtained in testing this cement:

Cold pat test, 7 days, sound; 28 days, sound.
Hot test, 5 hours in steam, 19 hours in boiling water, sound.
Tensile strength, neat 7 days, 713-740; 28 days, 870-935.
Tensile strength with three parts standard sand, 7 days, 415-490; 28 days, 536-585.

These tests show the cement to be of the highest quality and at least equal to any Portland cement manufactured in this country or in Europe.

*Prospectus of the Bedford Portland Cement Co., of Bedford, Ind., p. 4.

An analysis of this cement gave the following results:

Silica (SiO_2)	21.88
Alumina (Al_2O_3)	5.46
Iron oxide (Fe_2O_3)	3.02
Lime (CaO)	64.52
Magnesia (MgO)	0.84
Loss on ignition	3.12
Total	98.84

This analysis shows the cement to have a very satisfactory composition. The alumina is a little lower than in most commercial cements, but will be all the better in respect of hardening qualities and durability on this account.

Yours very truly,

S. B. NEWBERRY.

There are thousands of acres in Monroe and Lawrence counties which contain materials as good as those furnished Mr. Newberry for the experimental tests above reported upon. Millions of tons of spalls and refuse pieces of the oolitic stone, unfit for building purposes but in every way suited for cement manufacture, are thrown aside yearly from the leading quarries. The stone, when first quarried, is soft, and much more easily ground than is generally supposed. Lying, as it does, adjacent to fuel, the shales and other clays of the coal-bearing counties to the westward, there is no good reason why this oolitic stone region should not become the center of the Portland cement industry in Indiana.