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INDIANA STATE HOUSE.

THE
Bedford Oölitic Limestone
OF INDIANA.

A JOINT REPORT ON THE OÖLITIC LIMESTONE OF INDIANA AS IT OCCURS
IN LAWRENCE, MONROE AND OWEN COUNTIES, AND PARTIAL
REPORT ON WASHINGTON COUNTY, WITH A CHAPTER
ON THE GENERAL CHARACTER OF OÖLITES.

BY
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AND
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WITH FOUR MAPS BY C. E. SIEBENTHAL.

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W. S. BLATCHLEY, STATE GEOLOGIST.

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LETTER OF TRANSMITTAL.

STATE COLLEGE, PENNSYLVANIA, }
January 1, 1897. }

DEAR SIR—I have the honor to transmit herein my report, along with that of Mr. Siebenthal, on the oölitic limestone of Indiana, prepared under your directions during the past year. It is much to be regretted that time and the means at your command did not permit the investigation and mapping of the entire oölitic area. The accompanying maps will be found, I think, valuable and reliable. They are made with greater accuracy of detail than is commonly given to maps of this character. The locations of the quarries and limits of the outcrop of oölitic stone will be found to be reliable within the limits of the scale of the map.

In accordance with your instructions the work was pursued very largely on economic lines.

Respectfully submitted,

T. C. HOPKINS.

PROF. W. S. BLATCHLEY,
State Geologist.

THE BEDFORD OÖLITIC LIMESTONE.

BY T. C. HOPKINS AND C. E. SIEBENTHAL *

INTRODUCTORY.

The Bedford oölitic limestone is probably the best known building stone in the United States at the present time. It is probably shipped to more different points than any other stone. As shown in the report, it has been used in 23 States, one territory and one foreign country. It has several rather unique features that have placed it and will probably keep it in the list among the best building stones. There is no other building stone as soft and as easily worked that is, at the same time, as durable and strong. This is due largely to the happy combination of the good properties of both sandstone and limestone, being a calcareous free-stone, and also to its great homogeneity both of texture and composition. It is more easily cut and carved than any other well known building stone in this country, and it will retain the carving in good preservation longer than any other stone of equal softness.

Its general usefulness—in plain building, in ornamentation, in monuments—coupled with its lasting properties and its abundance and the ease with which it can be quarried, all combine to keep it in prominence among building stones. Naturally, then, there is a desire among stone dealers, architects, scientists and others to have access to detailed and specific information concerning the stone. To supply this demand the following pages have been prepared.

In view of the brief time and small expense that could be devoted to this subject, all the work was conducted on economic lines, and the more strictly scientific phases of the subject were subordinated or ignored entirely.

On the accompanying maps will be found the location of every quarry that has been opened in the oölitic limestone in Owen, Monroe and Lawrence Counties, showing its relative position to the railroads, the wagon

*Mr. Siebenthal wrote Chapter I, obtained nearly all the statistics at the end of Chapter III, furnished the historical data in Chapter IV, and assisted in Chapter VI. The remainder of the report was written by the senior author. The entire report has had the criticism of both writers. The maps are the work of Mr. Siebenthal alone.

roads, streams, towns and postoffices. There is also shown the area of outcrop of the oölitic stone, where other quarries may be opened, and its relation to the overlying and underlying rocks.

Despite the wonderful development of the stone industry in this region during the past 20 years, it is but reasonable to suppose from the present indications that it will continue to increase for some years to come; because the stone is now better known than ever before and there is a demand for light colored stone and stone adapted to ornamental carving, which demand no other stone meets more satisfactorily than the Bedford oölitic limestone.

Some may criticise the report as partaking too much of the nature of an advertisement. A little contemplation will, however, convince any one that a State has not only a right but a duty to advertise her own natural resources, as the more they are known the more intelligently they will be used to the improvement of the State. The report is intended primarily for persons interested in the use or production of the stone, and to such the so-called advertising features may be not the least valuable.

By advertisement is not meant an extravagant praise of the merits while totally ignoring the defects, but the plain, candid, unprejudiced statement of such facts as will be of interest and use to persons interested in the industry, whether as producers or as consumers. This we have endeavored to do as far as possible, while at the same time endeavoring to say nothing that would compromise or make public the private affairs of any single company.

CHAPTER I.

GENERAL GEOGRAPHICAL AND STRATIGRAPHICAL FEATURES.

C. E. S.

Location. The area mapped and covered by this report includes the Bedford oölitic limestone as it occurs in Owen, Monroe and Lawrence Counties. This limestone, in the region under consideration, is exposed in a labyrinthine outcrop winding in and out the valleys and around the hills over a distance of more than sixty miles, and varying in breadth from outlier to inlier from two to fourteen miles, on the average, perhaps, five miles. It is not to be inferred that this area includes the whole of the Bedford oölitic limestone within the State, nor even all of commercial value. It is simply the ground covered within the limits of time and means at the disposal of the survey, and is inclusive for all the area north of the south boundary of Lawrence County. The quarries at Salem are not included in this area, nor the many other valuable deposits known to occur in Washington, Harrison and Crawford Counties.

The oölitic belt practically begins on the north at Gosport. The limestone is traceable north of there as far as Quincy, but at no place does it occur in commercial quantities. Southwest of Gosport it shows in the bluffs of White River to within about a mile of Spencer. Southeast of Gosport the oölitic crops out in a belt about three miles wide, embracing the quarry districts of Big Creek, Stinesville, Ellettsville and Hunter Valley and extending to Bloomington. Four miles south of Bloomington, in the vicinity of Clear Creek Station, the oölitic belt rapidly widens to six miles, due to the fact that the lower course of Clear Creek makes a broad circle to the west, cutting down through the Mitchell and oölitic limestone, thus adding the oölitic outcrop on each side of the creek to the original outcrop of that limestone.

The great width of the outcrop in Lawrence County is due to similar causes. The lower course of Salt Creek and that part of White River from Tunnelton to the mouth of Salt Creek both lie several miles west of the eastern crop of the oölitic limestone, but have cut their valleys down through both the Mitchell limestone and the oölitic limestone. The various creeks from the east—Little Salt, Pleasant Run, Leatherwood and Guthrie creeks—also cut down through the oölitic, and what would otherwise be a plateau is divided into a number of flat ridges capped with Mitchell limestone, but fringed with a band of outcropping oölitic limestone.

The oölitic belt, after passing out at the southeast corner of Lawrence County, swings eastward to Salem, Washington County, taking in the Salem quarries and Spergen Hill. Thence it swings southward, its westward limit following the lower course of Blue River to the Ohio, and its eastern limit taking in the quarries at Georgetown and Corydon.

Topography.—The dip of the Subcarboniferous rocks over the region herein described is from 50 to 60 feet to the mile in a direction south of west. This dip does not seem to have left any impress on the topography of the region *other than the initial direction of the drainage*. The topographic features of the area owe their existence to the inherent qualities of the different formations. Thus the incoherent, loosely-cemented, easily-eroded knobstone has been cut up into a confused tangle of crooked ridges and deep hollows which trend in all directions. The topography of that part of the Harrodsburg limestone area which borders the knobstone partakes more or less of the character of the knobstone topography, though the ridges are larger as a rule. As for the remainder of the Harrodsburg limestone area, whether or not it is deeply eroded and broken depends on its distance from White River, and the height of its drainage level above the baselevel, which is the level of White River. This may readily be seen in the vicinity of Bloomington, at a point two miles east of that city on the divide between Bean Blossom and Salt Creeks. The distance north to Bean Blossom Creek is five miles, the distance east to Salt Creek four miles, and the distance to Salt Creek by way of Jackson and Clear Creeks is sixteen miles. The result is manifest in the topography. Northward and eastward from the divide the hills are rugged, the hollows crooked and deep. Southward, down Jackson Creek, the surface is but gently rolling.

The oölitic limestone, being the thinnest of the Subcarboniferous formation, has no particular type of topography. It usually occurs as a narrow outcrop from 100 to 400 yards in width fringing the flanks of the hills. Where it forms the surface rock over any extent of territory, as it sometimes does, when it makes the cap rock of a wide ridge, the topography is gently undulating.

The Mitchell limestone, where it has superficial drainage and especially where it has a capping of the Kaskaskia sandstone, forms high, bold hills with wide, well-rounded valleys between. Where the drainage is subterranean, the result, of course, is an irregular undulating plateau.

The valley of White River at Gosport is 570 feet above sea level. The river hills rise 100 to 150 feet above the valley, and the crests gradually rise southward, until in the vicinity of Bloomington along the divide between the two branches of White River, the hills reach 900 to 950 feet in elevation. The highest points in Monroe County range themselves between these elevations. The valley of the east fork of White River, south of Bedford, is 500 feet above sea level. The highlands about Bed-

ford range from 700 to 750 feet in elevation, and those about Mitchell, something near the same. The crest of the ridge, which marks the eastern escarpment of the Kaskaskia group, approximates 800 feet in height.

Nomenclature.—The term Subcarboniferous, as first used by D. D. Owen,* was undoubtedly applied to the whole series of sedimentary rocks which lie beneath the Coal Measures of Indiana. Later, in 1844, he restricted its application in a somewhat indefinite way to the lower calcareous division of the Carboniferous.†

In 1852 the name was definitely applied to the lower division of the Carboniferous rocks and included the Carboniferous limestones of the Mississippi section. In a paper entitled "Researches among the Protozoic and Carboniferous Rocks of Central Kentucky," published in 1847 by D. D. Owen and J. G. Norwood, the Knobstone is referred to the Carboniferous. Finally, in the revised reprint of D. D. Owen's Geological Reconnoissance of Indiana, the Subcarboniferous is specifically designated as "a series of limestones with subordinate fine-grained sandstones and shales" lying between the Coal Measures and the Devonian black slate;‡ and it is as thus limited that the term Subcarboniferous has been since used in the reports of the geological surveys of Indiana, Illinois and Kentucky.

The word has been objected to as having been applied under a misconception and as being a misnomer. As to the first objection, we have seen how that misconception was cleared up and how the term was sanctioned by general use afterward. The second objection arises from a misunderstanding of the meaning of the term in its restricted application. So used, it means not "under the Carboniferous" but "the under-Carboniferous," or, according to J. D. Dana,|| the preposition *sub* is used in the same sense as in the word *substructure*. It was with this meaning that James Hall applied the term independently to certain beds of limestone intercalated in the Knobstone whose fauna he recognized as Carboniferous, yet which he wished to distinguish from the later Carboniferous.§ So it is that in preference to the various synonyms, Lower Carboniferous, Mississippian and Eocarboniferous, which have been proposed, we have retained the Subcarboniferous out of justice and respect to the memory of Indiana's first and greatest geologist.

*D. D. Owen: Report of Geological Reconnoissance of Indiana, made in 1837. 1839 p. 12.

†D. D. Owen: Report of a Geological Exploration of a part of Iowa, Wisconsin and Illinois in 1839. Senate Document, 407, 1844.

‡D. D. Owen: Report of a Geological Reconnoissance of Indiana, made in 1837; reprinted, 1859.

||J. D. Dana: Manual of Geology, 4th edition, p. 634.

§James Hall: Notes explanatory of a Section from Cleveland, Ohio, to the Mississippi river in a southwest direction, with Remarks upon the Identity of the Western Formations with those of New York. Trans. Assoc. Am. Geol. and Nat.; 1840-42, pp. 267-293.

Stratigraphy.—The Subcarboniferous deposits, as generally recognized in Indiana, include the Rockford Goniatic limestone, the Knobstone group, the Harrodsburg limestone, the Bedford Oölitic limestone, the Mitchell limestone and the Chester and Kaskaskia group.

The Rockford Goniatic Limestone was first noticed by Owen and Norwood in their paper on the Protozoic and Carboniferous rocks of central Kentucky, and referred by them to the Devonian. It is a thin bed of limestone and calcareous shale of limited areal extent, coming between the Devonian black shale and the Knobstone and furnishing the famous fossils which led, after much controversy, to its recognition as the base of the Carboniferous.

The Knobstone was originally included by D. D. Owen with the Harrodsburg limestone under the name Calcareo-siliceous or Encrinital limestone series.* The use of the word Knobstone to designate the formation first occurred in 1859 on page 21 of the revised reprint of Owen's report then issued. The name was again used in 1862 by Richard Owen,† and has been retained by the various writers on Indiana geology since that time. It is a series of alternating friable arenaceous shales and sandstones, ranging in the region under consideration from 500 to 600 feet in thickness. The outcrop reaches its maximum development in Hendricks, Morgan, Brown and Jackson Counties, in which region it ranges from 30 to 50 miles in width. The outcrop narrows rapidly both north and south of this area. It is in the main unfossiliferous, but at intervals there are intercalated lenticular beds of limestone and calcareous septaria with rich faunas, and in one place at least the Knobstone itself is fossiliferous. The name is derived from the peculiar topography which it superinduces in regions where fully developed, as in the "knobs" of Floyd and Clark Counties. The use of a topographic term as a designation for a geological formation is rather unfortunate, but in view of its firm establishment and the fact that it is more or less probable that the formation may in the future be subdivided leads us to retain it in this report.

The Harrodsburg Limestone lies above the Knobstone and between that formation and the Bedford oölitic limestone. At first known as the Encrinital limestone, it was afterward correlated with the Burlington and Keokuk limestone of the Mississippi section. These formations have latterly been grouped together in the original locality as the Augusta limestone.‡ Until more detailed palæontologic work has been done in Indiana it would seem better to consider the formation a unit. We have

* Geological Reconnoissance of Indiana, 1837, p. 14.

† R. Owen; Report of Geological Reconnoissance of Indiana made in 1859 and 1860, published in 1862, p. 108.

‡ Keyes: A. J. S., 3d Series, Vol. XXXVIII, 1889, pp. 186, 193. Keyes; Missouri Geological Survey, Vol. IV, p. 58. Keyes; Iowa Geological Survey, Vol. I, p. 59.

designated it the Harrodsburg limestone, taking the name from the village of that name on the L., N. A. & C. Ry., in the southern part of Monroe County, where this limestone is typically developed. The village itself is mainly built upon the oölitic limestone, but near its contact with the Harrodsburg limestone, and descending the hill from the village either north, east or south, one passes over the whole outcrop of the latter from its contact with the oölitic to its contact with the Knobstone.

The following section of the north bluff of Judah's Creek at the crossing of the Bedford-Bloomington road, one mile south of Harrodsburg, is typical of this limestone. The thickness of the different strata are based on barometer readings :

<i>Oölitic Limestone.</i>	Feet.	Inches.
Massive fossiliferous limestone.....	6	0
Gray heavy-bedded limestone.....	16	0
Blue argillaceous shale.....	2	0
Limestone.....	0	4
Chert.....	0	3
Heavy-bedded blue to gray crystalline limestone.....	6	0
Yellow calcareous shale with geodes.....	1	3
Fine, heavy-bedded blue crystalline limestone.....	11	0
Flaggy limestone.....	1	0
Gray argillaceous limestone.....	0	10
Calcareo-argillaceous shale with bands of limestone and some geodes.....	18	0
Heavy limestone, weathering shaly.....	3	0
Calcareous shale in bed of creek.....	?	?
	67	8

The Harrodsburg limestone varies from 60 to 90 feet in thickness. It forms a belt four or five miles in width lying along the eastern outcrop of the oölitic, rising gradually toward the east at the rate of 50 or 60 feet to the mile, and bordered by the broken hills of the Knobstone region.

The "beds of passage" from the Knobstone to the Harrodsburg limestone contain great numbers of geodes, or, as they are more familiarly termed, "mutton heads," ranging from the size of a pea up to 18 or 24 inches in diameter. These geodes are confined to the lower members of the Harrodsburg limestone, though a few are scattered through the Knobstone.

Above the geode layers there is a bright gray or blue highly crystalline and quite fossiliferous limestone with small crystals of pyrites, giving it in places a greenish tint. Many of the bedding planes are marked by "crowfeet" (stylolites), and intercalated lenticular masses of chert are very plentiful. The residual clay is very stiff and of a deep-red color.

Towards the top of the limestone the strata become more massive, and at the top the upper four to eight feet usually have lost the molluscan

character of their fauna and consist almost wholly of comminuted bryozoa. In places these more massive strata are quarried in a small way as marbles. On a polished bedway face the delicate tracery of the bryozoa comes out with a very pretty lace-work effect, but the porosity of the stone prevents its taking a high polish, so that it could not justly be classed as a true marble. The value of some of the more crystalline strata which would take a good polish is lessened by the disseminations of crystals of pyrite, siliceous fossils and nodules of chert.

The contact of the Harrodsburg and oölitic limestones is almost always marked by a bad crowfoot (stylolite), with which are associated masses of silicified oölitic fossils and black siliceous masses.

The Bedford Oölitic Limestone.—The term “oölitic” was first applied in Indiana by D. D. Owen to the whole series of limestones from the Knobstone to the Coal Measures.* The name had been previously applied by G. Troost to limestones in Tennessee, to which those of Indiana were supposed to be analogous. In the revised reprint of Owen’s report † the name is retained, but its application is restricted to a subordinate member of the Subcarboniferous limestone—in reality, to the present quarry bed, the Bedford oölitic limestone—and its age is carefully distinguished from the oölitic of Europe, which is a well-marked group in the Mesozoic.

The name “Bedford rock” first occurs in Richard Owen’s report. ‡ By other writers it has been variously called Bedford stone, Bedford oölitic stone, Indiana oölitic stone, Spergen Hill limestone, White River stone, St. Louis limestone, Warsaw limestone, etc. It is probably best known to the trade as the Bedford stone, but as Bedford itself is situated on an overlying stone, it seems better to include the word oölitic to specify more particularly the bed of quarry limestone. Bedford oölitic limestone is thus a definite geological term and a well-known commercial one.

The economic character of the present report has precluded anything of a paleontologic nature, but the fauna of the Bedford oölitic limestone will be found fully treated by James Hall* and R. P. Whitfield|| in their various papers on the famous Spergen Hill fossils. In favorable localities the oölitic limestone is found crowded with miniature *Brachiopoda*, *Gasteropoda*, *Lamellibranchiata* and pentremites, all in a splendid state of preservation.

The Mitchell Limestone.—Overlying the oölitic limestone is a series of impure limestones, calcareous shales and fossiliferous limestones aggregating from 150 to 250 feet in thickness. We have called this formation

* D. D. Owen, Geological Reconnoissance of Indiana, 1839, pp. 12, 13.

† D. D. Owen, Geological Reconnoissance of Indiana, 1837; reprinted 1859, p. 21.

‡ R. Owen, Report of Geological Reconnoissance of Indiana made in 1859 and 1860; published 1862, p. 137.

|| James Hall, Transactions Albany Institute, Vol. IV, 1856, pp. 4-34. James Hall, Geology and Natural History of Indiana, Twelfth Report, 1882, pp. 319-375. R. P. Whitfield, American Museum of Natural History, Bulletin 3, 1882, pp. 42-94.

the Mitchell limestone, taking the name from the town of that name in Lawrence County at the crossing of the L., N. A. & C. and B. & O. S. W. railways. This limestone is well developed about Mitchell, which is situated upon it, but especially is its peculiar topography typically shown in that locality. The topographic *tendency* of the Mitchell limestone expresses itself in plateaus perforated at short intervals by sink holes. For this reason it has been called the cavernous limestone by early writers, and by others the barren limestone, because of tracts which were largely covered with residual chert fragments which have weathered out of the limestone. The lower members of this formation constitute the so called "bastard limestone" stripping of the quarrymen. They are unfossiliferous and of a dirty yellow or gray color. Above these come shales with interbedded, dark blue, heavy flaggy limestone and gray lithographic beds. Specimens of the lithographic stone have been found which worked almost, if not equally, as well as the Bavarian stone, but as yet no locality has been discovered where they can be obtained in commercial quantities. The stone is usually so intersected at short intervals by calcite seams that no stones of size can be obtained. What search may discover can not, of course, be foretold.

At different horizons in the Mitchell limestone the stone is fossiliferous. In some places it is as truly oölitic as the Bedford stone. Such oölitic limestone may be distinguished from the Bedford oölitic by the fossils, and usually by a peculiar weathering under atmospheric agencies, in which a coating of between one-eighth and one-fourth of an inch scales off or exfoliates with a peeling effect. The following section in Section 13, 7 north, 2 west, is typical of the Mitchell limestone:

Detailed Section of the Mitchell Limestone, R. 7 N., T. 2 W., Sec. 13.

Drab lithographic limestone, <i>L. proliferum</i> , in top layer	20 feet.
Chert breccia, rotten lithographic groundmass.....	8 feet.
Bluish-drab, fine-grained, fetid limestone.....	10 feet.
Lithographic limestone	4 feet.
Drab calcareous clay shale	9 feet.
Drab, rotten, magnesian limestone with chert inclusions.....	29 feet.
Bluish, vermicular, shaly limestone	2 feet.
Drab calcareous shale	4 feet.
Rotten and shaly lithographic limestone.....	5 feet.
Lithographic limestone	2 feet.
Rotten lithographic limestone.....	5 feet.
Drab calcareous shale	7 feet.
Fine-grained, bluish-gray limestone with conchoidal fracture...	5 feet.
Calcareous clay shale	2 feet.
Gray limestone in 8-inch beds.....	5 feet.
Fossiliferous shaly limestone	14 feet.
Concealed	6 feet.
Fossiliferous coarse-grained limestone	2 feet.
Oölitic limestone.....	— feet.

The *Chester* or *Kaskaskia Group*, as recognized by Mr. E. M. Kindle, in Orange and Martin Counties consists of the Upper, Middle and Lower Kaskaskia limestones, separated from each other by the Upper and Lower Kaskaskia sandstones.* Overlying the Kaskaskia is the Mansfield sandstone, the basal member of the Coal Measures.

QUATERNARY. The *Quaternary* deposits of the region under consideration are of three classes: Glacial till and drift, pleistocene lacustral and terrace deposits, and alluvial floodplains.

Drift Limit. The line of the southernmost limit of glacial drift enters Monroe County from the southwest near where the Ellettsville and Spencer road crosses the Monroe-Owen county line. It bends south around the limits of the Flatwood, then angles northeast, crossing Jack's Defeat Creek in the neighborhood of the old Dutch church. Continuing in the same direction it crosses Bean Blossom Creek near the mouth of Cowden Branch. Bending south of the Lost Ridge near the mouth of Indian Creek, it follows the course of that creek to Canada Gap, and on it in the same direction passing one half mile south of Godsey P. O., and crossing into Morgan County three-quarters of a mile east of Godsey. It swings southeastward and reenters Monroe County where Hacker's Creek leaves it, following up that creek to the neighborhood of Hacker school house. From here eastward the drift limit becomes harder to trace. The ice sheet must have been very thin, since the topography shows little, if any, modification. Scattered erratics are found all over the ridge dividing the headwaters of Robert's Creek from the headwaters of Honey and Hacker's Creeks. It seems probable that the foot of the ice rested on this hill, and that the drift found in the headwaters of Honey Creek was carried there by the waters resulting from the melting of the glacier. Many large granitic boulders from one to three feet in diameter are found along the small stream leading north from Hubbard Gap in section 11 (10 N. 1 E.), and along the other tributaries of Robert's Creek. In section 2, same township, heavy deposits of sand, gravel and till lie against the hillsides. In the neighborhood of Hacker school house in section 6 of the same township the smoothing and leveling action of the glacier is plainly seen in the gravel covered plain which rises gently to the north. In the neighborhood of Godsey P. O., section 3 (10 N. 1 W.) the same may be seen. Heavy beds of till and gravel lie against the hills which border their slopes on its south. In Canada Gap, northeast corner section 9 (10 N. 1 W.), the evidences of ice occupation are plain though the quantity of drift material is very limited. The territory between Indian Creek, Bean Blossom Creek and White River displays evidences of ice occupation in many places in modified topography and deposits of till, and sand, and gravel, though on the whole the drift is very light, showing a thin ice sheet.

* Department of Geology and Natural Resources of Indiana. Twentieth Annual Report, 1895, p. 331.

The glacial topography is well illustrated in Section 5 (10 north, 1 west) and in the southeast quarter of Section 21 (10 north, 2 west). The hills north of Mt. Tabor and between there and Gosport are covered with a heavy deposit of sand which seems to have been deposited from high water resulting from a melting ice sheet. The lower hills about Gosport have a similar deposit. North and west of Gosport the drift sheet becomes heavier, ranging from 5 to 20 feet in thickness.

Glacial striae were observed in but one locality, and that was where the limestone had been uncovered by stripping on the west side of Kessler's quarry at Romona. The direction was S. 18° E. A vertical seam or fissure in the rock at this point, 8 or 10 inches in width, was filled with tightly packed red clay up the level of the glaciated rock where it was cut off sharply by the buff sandy till which covered the rocks on either side. The red clay of the seam gave evidence of the great pressure to which it was subjected by shearing cracks and by being slickensided along the sides of the seam. This seam is perhaps a fair average in thickness of the clay seams commonly found in the oölitic. It thus serves to give us an idea through what stretches of time the solvent and erosive agencies have been at work in producing the bothersome seams of the quarries.

Glacial Lake Flatwood.—Occupying the highest land between Ellettsville and Spencer is a level tract two and one-half miles in width by six miles in length, locally known as the Flatwoods. It is drained by McCormack's Creek, to which it gently slopes from all points of the margin except at the extreme west end, a small portion of which drains into Ellison Branch. The Flatwoods is surrounded by a rim of higher land with gaps at Ellison Branch and McCormack's Creek, and at three other points on the north, east and south, where streams head up against the Flatwoods and at the same level with them. This higher border shows evidences of glaciation, especially so on the southern side, where many erratic boulders ranging from six to eight inches in diameter have lodged against the slope. The soil of the Flatwoods is an alternation of black mucks and white clays. A section of a well in the N. W. N. W. Section 31 (10 north, 2 west), which is typical of the district, is here given:

Soil and clay	17 to 18 feet.
Imbedded logs.....	1 foot.
Clay.....	8 feet.
Waterworn gravel	1 foot.
Blue, sticky clay	8 feet.
Limestone.....	

Prof. Collett* gives the following section of a well in the southeast quarter of section 26, 10 north, 3 west:

*Geological Survey of Indiana, Seventh Annual Report, 1875, pp. 333-334.

Black mucky soil	8 feet.
Sand and fine gravel	6 feet.
Blue sticky quicksand with logs, sticks and leaves	8 feet.

Over the area of the Flatwoods several "islands" of the Subcarboniferous raise themselves above the later deposits, demonstrating the undulating character of the preglacial topography.

Prof. Collett suggests that the Flatwoods formed a portion of the preglacial channel of White River, the valleys of McCormack and Raccoon Creeks furnishing the portions connecting with the present valley of that river. A close examination of the region in question, however, shows this to be impossible.

The Pleistocene terraces of Bean Blossom Creek clearly prove the preglacial valley of that creek to have been practically as it is at present. It is impossible to imagine how it could be cut down to its present depth, while White River, into which it emptied, was running at a level approximately 150 feet higher than now, as it is alleged to have done. Moreover, the gorge of McCormack's Creek is clearly postglacial. And further, it empties into White River at least a mile below the upper end of the "narrows," whose existence it was brought forward to explain.

A more reasonable explanation of the Flatwoods is that it is the site of a shallow glacial lake. This area in preglacial times must have been a region of sink holes, with drainage largely, if not wholly, subterranean, similar to the country which surrounds it, and to the region of caves and sink holes west of Bloomington—in short, a region characteristic of the Mitchell limestone. When the glacier pushed down across these sinks, the excess of salt and sand choked up the underground outlets, and on the retreat of the ice sheet, the area was left covered by a thin sheet of water, probably from 20 to 30 feet in depth near the middle. Subsequently the drainage by way of McCormack's Creek was begun, resulting in the cutting of the gorge through which that creek finds its way to the river. The size of the drainage area and a fall of nearly 150 feet distributed over about two miles explain the steepness and narrowness of the gorge.

Pleistocene terraces occur in the valley of Bean Blossom Creek above the crossing of the drift limit. Drift deposits occur below that, but are irregular in height, and have not the level top of the terraces. The terraces range from 40 to 60 feet in height, those further up the creek being the higher. In size the terraces range from mere knolls to benches a mile wide and three or four miles long. The lower portion of these beds consists of sand and erratic gravel with sand and smaller gravel above, and over all sandy clay and loam. These terraces seem to have been deposited by the high waters which must have resulted from the melting of the glacier which covered the headwaters of the creek in Brown County,

and the draining of the glacier which crossed its lower course. The various tributaries of Bean Blossom Creek have similar deposits in a small way, the materials of which are, however, of local origin. The fact that the drift material of foreign origin is confined to the valley of the creek itself, argued that it was derived from the glacier occupying the upper course of the creek.

At favorable points are found stratified deposits of banded sandy clays of variable colors with disseminated spindles and scales of ferruginous claystone and irregular concretions of calcareous claystone. These beds correspond stratigraphically to the terraces and are of the same height. They have been deposited from sluggish water out of the lime of the direct current which bore the erratic materials, and as a result they are free from gravel except some of local origin in their basal portions.

The upper portion of the drainage basin of Salt Creek was also occupied by the glacier, and as a consequence we find well marked terraces along the valley of Salt Creek, though not so extensive or so high as those along Bean Blossom. The further down the creek the lower the terraces become until the last one is reached, which is in the neighborhood of Fairfax P. O., Monroe County.

Like the hills about Gosport, those along the East Fork of White River have deposits of sand, such deposits occurring up to a height of 80 or 100 feet, and always on the side away from the current of the stream; in other words, the deposits were always made in the still water of an eddy. Secondary bottoms also occur which are possibly and probably of Quaternary age, though not of the regularity as regards height and level top of the Quaternary terraces of Bean Blossom Creek.

Alluvial floodplains.—The alluvial bottoms of the West Fork of White River above Gosport range from one to three miles in width. Below Gosport they narrow down to about a mile on the average, and two miles below Romona the foothills on either side approach within less than a quarter of a mile of each other. It was to explain these "narrows" that Prof. Collett projected the hypothetical glacial river up McCormack's Creek through the Flatwoods and down Raccoon Creek, to which reference has been made on a preceding page.

The alluvial plain of Bean Blossom Creek will average a mile in width through Monroe County. Along Salt Creek through Monroe County the alluvial plain will average about a half mile; through Lawrence County it is from three-fourths of a mile to a mile in width.

Leatherwood and Guthrie creeks have bottoms which in their lower courses are about a half mile wide.

The valley of the East Fork of White River through Lawrence County is quite narrow as compared to the West Fork, not exceeding a half mile on the average, perhaps less.

CHAPTER II.

GENERAL STRUCTURAL AND ECONOMIC FEATURES OF THE BEDFORD
OÖLITIC LIMESTONE.

T. C. H.

*[Structural features of the Bedford Oölitic limestone.—*The Bedford limestone occurs in a massive bed varying in thickness in different localities from 25 to nearly 100 feet. The bulk of the stone is free from lamination and shows very few bedding planes. On weathered surfaces on the natural outcrops the lines of sedimentation are brought out more or less conspicuously at many points. Sometimes even a shaly structure may be developed on the top of the bed. In several places lines of cross bedding are brought out quite conspicuously on the weathered surface, noticeably so on the bluffs of Big Creek a mile west of Stinesville, and on the face of the old Terre Haute quarry, half a mile west of Stinesville. (See plate XX.) The same thing is shown less conspicuously in places in a great many quarry openings throughout the region, and known among the quarrymen as cross-grain. There is abundant evidence of this nature both of the false bedding and the true bedding to show the sedimentary character of the stone. Yet, as before stated, the great bulk of the stone is massive, and in all the better class of stone shows little or no evidence of lamination or bedding except at the outcrop.]

In all the outcrops and in many of the quarries there is at least one system of vertical or nearly vertical joint seams, and in most places two systems, one having a general east and west direction, the other north and south. The joint seams are rarely abundant, generally 20 to 40 feet apart. Where there is a solid rock covering over the oölitic stone the seams are generally inconspicuous features, seldom more than regular cracks in the rock mass. In a number of places, in fact in nearly all places where the oölitic stone has no solid rock covering, the weathering agencies have penetrated along the joint planes, forming irregular, cave-like openings sometimes two or three feet across. These cavities are mostly filled with clay and debris from the top (see plates XXI, XXVII), causing a great deal of waste and annoyance in quarrying, as the waste is not limited simply to the cavity, but the irregular walls cause much waste in squaring the blocks, and where the cavities are close together the irregular blocks between them can not always be divided to advantage. There is a further waste where the stone happens to be blue

stone, from the fact that along the joint planes the stone is oxidized irregularly, forming a band of buff of varying width on each side of the cavity. It is hard on the channeling machine to cut across one of these cavities.

Stylolites ("crow-feet," "toe-nails").—While ordinary bedding or lamination planes are exceedingly rare in the interior of the oölitic limestone bed at any considerable distance from the outcrop, there are what might be called extraordinary bedding planes, resembling suture joints, which, unfortunately, occur in many places, appearing on the face of the quarry as jagged dark to black lines. On each side of this line, generally more pronounced on the lower side, are jagged points extending sometimes a fraction of an inch, sometimes several inches into the limestone. The longer points, and sometimes the smaller ones, have an apparent columnar structure, with the sides nearly parallel, and frequently striated. Frequently the shorter points have a more serrated or tooth-like projection. In all cases observed, with one exception, the planes have a nearly horizontal position, as nearly horizontal and about as regular as any other bedding planes, and the teeth or "toe-nails" are generally vertical. While this is true in the oölitic limestone quarries, it is not true in all localities, as in the magnesian limestone quarries in the city of Chicago they follow quite irregular lines, in some places apparently running over little hillocks or sharp prominences. The stylolite seams are of great interest and annoyance to the quarrymen, as they probably cause more waste than any other structural feature of the rock. Because of their economic importance they deserve more than a passing notice.

The stylolites have been variously designated. Among the names which have been proposed are, *suture joints*, *crystallites*, *lignillites* and *epsomites*. The quarrymen designate them as *crow-feet* or *toe-nails* quite frequently with a harsh adjective prefixed. The most commonly accepted term among scientists is stylolite, from the Greek stylus for pen, referring to the fancied resemblance to a pen. The term crystallite, lignillites and epsomites are objectionable, as they imply an origin which is not proven. Suture joint is a very good term. Crow-feet and toe-nails will continue to be used among the quarrymen, and are very expressive and not wholly inappropriate terms.

There is a difference of opinion as to the origin or cause of the stylolites. Both Dana* and Geikie† accept Marsh's explanation that they are caused by "the slipping, through vertical pressure, of a part capped by a fossil shell against an adjoining part not so capped."

Prof. Swallow says‡ that the term lignillites was much used at one time because of its resemblance to wood, and the term crystallites and

* Manual of Geology, 4th Ed., by J. D. Dana, p. 543.

† Text-Book of Geology, 2d Ed., by A. Geikie, p. 290.

‡ Rep. Geol. Surv. of Missouri, 1872, pt. 2, p. 252.

epsomites have been used by those thinking that the markings are due to the crystallization of epsom salts or some other material in this form.

The German writers offer different and (in the opinion of the writer) some more probable explanations. Quenstedt* states that they are due to the filling in of hollow spaces made in the rock while yet soft by the movements of mussel shells.

His later view was that two beds overlying one another, separated by shells and a layer of clay or marl, the two beds having a different hardness, by the pressure of the overlying mass the clay bed would be torn and the underlying and overlying beds pressed into one another, thus causing the stylolites.

Plieninger† thought that the cracks or crevices originating at the surface by the drying mud were the cause, and that the pillar-like or columnar forms could be produced by rain.

Von Cotta and Rossmassler‡ put them in the same class with the "ice needles" produced on the surface of the soil in winter.

Fallati and Quenstedt have likened the stylolites to glacial pyramids, pyramids of ice left on the surface of the glacier, or little pyramids of earth which owe their columnar structure to a small stone or shell protecting the material underneath while that surrounding is washed away by the rain in the case of the earth and by the sun on the ice.

Weiss,|| corroborating the above, states that in his observations in a Bundsandstein formation that a foreign body like a mussel-shell or a piece of clay forms a protective covering to the drying lime particles, whereby the drizzling water has modeled out the stylolite by carrying away the material between the protected parts.

Zelger,§ after detailed work on the stylolites, announces that they are formed by the escape of compressed gases through the soft plastic mass and the later filling in of the passageways.

Gümbel states that the stylolites, particularly those from Rüdersdorf, carry on top a clay cap which without doubt has come from a clay or marl layer which marks the lower limits of the bed of stone bearing the stylolites and which is a part of the under clay layer ascending with the stylolite mass.

Zirkel** says that the stylolites remind one of the phenomenon called creeps by the English miners, in the swelling up and pressing in of the underclay of the coal into the galleries or openings made in the working until the gallery is filled by the underlying clay.

* N. Jahrb. f. Min., 1837, p. 496, and Württemberg, Naturwiss. Jahreshfte, 1853, Vol. IX p. 71, and Epochen der Natur, 1860, p. 200.

† Württemberg, Naturwiss. Jahreshft, 1858, Vol. XIV, p. 292.

‡ Zirkel, Lehrbuch der Petrographie, 2d Ed., Vol. I, p. 535.

|| N. Jahrb. f. Min., 1868, p. 729.

§ N. Jahrb. f. Min., 1870, p. 833.

** Lehrbuch der Petrog., Vol. I, p. 536.

It is quite probable that as the stylolites differ in appearance in different localities that they may not all be produced in the same manner. The writer is convinced from his observations in the field that at least in all places where they occur in the oölitic limestone of Indiana that they mark bedding or stratification planes in the rock. The reasons for so thinking are, (1) That they correspond with the grain or bedding of the rock, occasionally running on the false bedding, but never across the grain; (2) they are in places traceable, with no break or sharp line of division into the common bedding planes, having no evidence of stylolites; (3) there is in nearly every instance a layer of carbonaceous material, sometimes a mere film, sometimes nearly half an inch thick; (4) they are always of considerable, though not unlimited, extent; (5) a view from above shown in a few places on (the Cleveland quarry, near Harrodsburg, is one of the best illustrations) quarry floors shows water action not unlike the common bedding plane; (6) they frequently occur between the oölitic stone and the underlying and overlying beds which are not at all oölitic; (7) the cross bedding always terminates at the stylolite seam: in no instance was it observed to cross it.

The explanation of the stylolitic or tooth-like markings along this seam is not so satisfactory as the evidence of its being a bedding seam. It is quite probable that all are not due to the same cause. Some look as though they were formed by cracks in the drying of the limestone mud, and others look like a rain or spray washed surface. In fact, there is probably about such variety in the markings as one might expect to find on a surface of indurated calcareous mud, some of which dried in the sun, some of which was rain washed or spray washed in the drying; and possibly the escape of gases, as advocated by Zelger, may have acted in some places. The layer of carbonaceous material is probably due to the organisms left to die on the beach, either algæ or animal forms, or both.* It is in some instances associated with considerable iron pyrites. A microscopic examination of this material from two localities shows black bituminous matter, with no organic structure or markings perceptible.

There appears to be little or no evidence in this locality in support of Marsh's theory, as in only one locality was any noticeable proportion of the stylolites capped with fossils, and where such was the case many of the fossils were delicate gastropod shells that would quickly show any pressure, had such been brought to bear. Not only were they not crushed in the least, but 90 per cent. or more of the stylolites have no fossil on either the top or the bottom, while there are shells in abundance both above and below the stylolite seam, with no stylolites near them.

* The explanation given above was worked out by the writer in the field independent of the work of the German writers, with which he was not then familiar, going into the field with no theory but the one given by Marsh, as taught by Dana and Geikie, which was soon found to be unsatisfactory, and the one above given is purely inductive incident to the extended observations in the field.

Furthermore, sometimes the stylolites show just the opposite of compression by forming or occurring in an open seam.

The amount of waste caused by the stylolite or crow-foot seam is frequently more than the width of the seam plus the length of the stylolite points, especially so where they occur in the buff stone, as the carbonaceous material in the seam prevents oxidation and there is an irregular blue band along the seam extending several inches to a foot or more from the seam into the buff stone, and the seams are not always the right distance apart to get either one or more cuts of standard size without considerable waste.

Textural features.—The Bedford limestone is a granular limestone, a calcareous sandrock, in which both the grains and the cement are carbonate of lime. The greater part of it is properly freestone in character, although that term is commonly limited to the siliceous sandstones.

The texture varies in coarseness in different parts of the area, and generally in different parts of the same bed. The finest-grained varieties appear to be the most in demand in the markets and hence are the most sought after and the most valuable. In all of the oölitic limestone throughout the area the grains are made up of fossils, mostly foraminifera and bryozoa, mingled with which are other forms, some of which were not identified. The foraminifera are mostly intact, showing little or no evidence of wear. The other forms appear more or less imperfect in places, but apparently more from a leaching action than from wear. The finer-grained forms differ from the coarse in having smaller shells. The great mass of the stone is made up of these minute, almost microscopic, shells which are generally pretty uniform in size, but in some localities the larger forms predominate, in others the smaller forms prevail, hence coarser and finer-grained stones occur. In some places, as at Romona and Heltonville, bryozoa are very abundant. In other places gasteropods and brachiopods abound, often of considerable size—half an inch to an inch in diameter, in a few instances two or three inches. The large forms are commonly clustered, forming a large part of the rock where they occur, and not scattered indiscriminately throughout the rock, and as all of the coarsely fossiliferous stone goes into the waste or into a low grade stone, none of it being sold for first-class dimension stone, the separation is readily made, and if the bed proves to be wholly or largely of coarse stone it is not worked at all. Hence, from a commercial standpoint, the absence of large fossils is desirable.

The fossils, which are composed of finely crystallized calcite, are imbedded in a cement of calcite. On the relative amount, purity and coarseness of this cement depends the hardness and compactness of the stone. To the happy combination of soft grains in the firm cement in the right proportions depends the value of the oölitic stone for building purposes. With any considerable decrease in the amount of the cement

the stone would be too soft, crumbling and disintegrating too readily, as is the case in several localities. With an increase in the proportion of the cement the stone would become more difficult to work, losing its free-stone character and becoming plucky. There are slight variations in the relative hardness of the stone in different localities, but only in a few places is it too soft to be of any value, and in no place is it too hard to work.

‡ *Colors of the Bedford Oölitic limestone.*—All the stone of the region is classed as “blue,” “buff” or “mixed.” The blue is evidently the original color of at least the greater part of the stone, and is thought to be caused by iron in the protoxide form and organic matter, the buff being largely, if not entirely, derived from the blue by oxidation of the iron to the peroxide, and of the organic matter to some volatile form, or some stable form, in which it unites with mineral matter in colorless stable form. The oxidation is a continuous process, not yet complete, carried on mainly by the oxygen in solution in the meteoric water, the circulation of which is accelerated or retarded by a variety of causes, and hence does not take place along parallel or regular lines, so that there is always considerable stone along the contact of the two colors that can not be obtained in suitable dimensions of either color alone, but contains a combination of the two colors, and is classed as mixed stone. In most of the quarries it goes into the dump pile as waste. Occasionally some of it is sold for bridges or foundations at a greatly reduced price, often less than the cost of quarrying it. The price of the good stone is so low, and the freight rates so high, that none but first-class stone is shipped to any considerable distance.

Some analyses, made with a view of determining the cause of this coloration, gave the following result:

*Partial Analyses of Blue and Buff Oölitic Limestone.**

COLOR.	QUARRY.	Inorganic insoluble matter. Per Cent.	Organic. Per Cent.	Ferrous oxide. FeO. Per Cent.	Ferric oxide, Fe ₂ O ₃ . Per Cent.
Blue	Thornton's	2.16	0.24	0.067	0.196
Buff.	Thornton's ....	.86	.12	.050	.126
Blue.	Hunter's	1.25	.22	.063	.044
Buff.	Hunter's	1.10	.11	.055	.150
Blue.	Perry's	1.14	.21	.055	.089
Buff.	Perry's	1.24	.13	.050	.119

The results are not as satisfactory as might be desired. The samples were taken from three different quarries, in each case from each side of the line of contact at the same place in the quarry, hoping thus to get

*Made for the Survey by W. A. Noyes, Rose Polytechnic, Terre Haute, Ind.

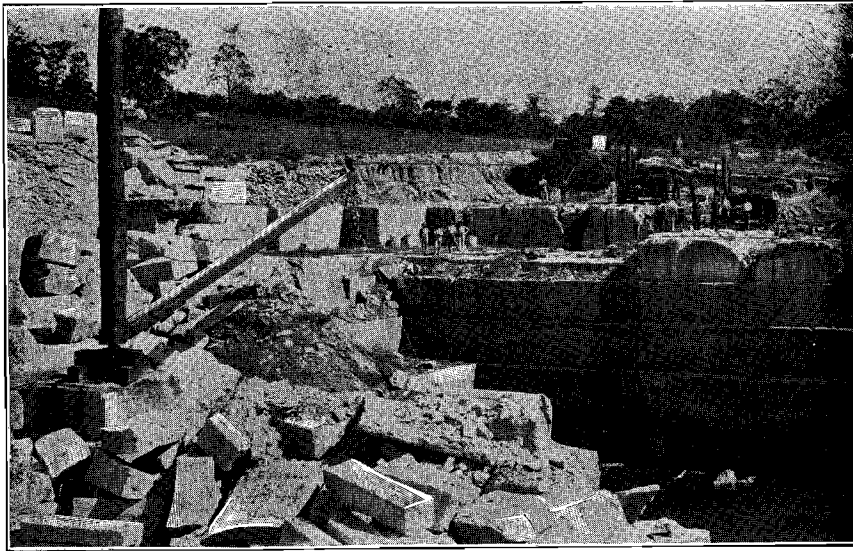
specimens as nearly identical as possible in everything but color. Each sample was then tested for ferrous and ferric iron and organic matter. The organic matter was determined by drying the residue insoluble in boiling dilute hydrochloric acid at 135° to 140° C. and determining the loss of weight on ignition. While the results are only approximate, they ought to be relatively correct. The percentages are so small that it is doubtful whether the differences are due to more than the possible errors incident to manipulation. Yet it is probably more than a coincidence that the organic material in each case is only half as much in the buff as in the blue. It indicates a loss of organic material, as might be expected. It is more marked than the difference in the iron which is indicated only in the second or third decimal place. There is in each instance a slight decrease in the percentage of the ferrous iron in the buff from that in the blue, and in two examples out of the three an increase in the proportion of the peroxide, which is what was expected. Yet the differences are so slight that, considering the possible errors in manipulation, we do not feel like emphasizing the import of them without further evidence.

It should be borne in mind that the difference in color is not great, sometimes scarcely perceptible in a hand specimen, but quite distinct on a large block or quarry face, and is brought out more distinctly by exposure than on a perfectly fresh surface. Thus on the channeled face that has been exposed for a few years the contrast between the buff and the blue is much stronger than it is on a fresh fracture beneath the surface.

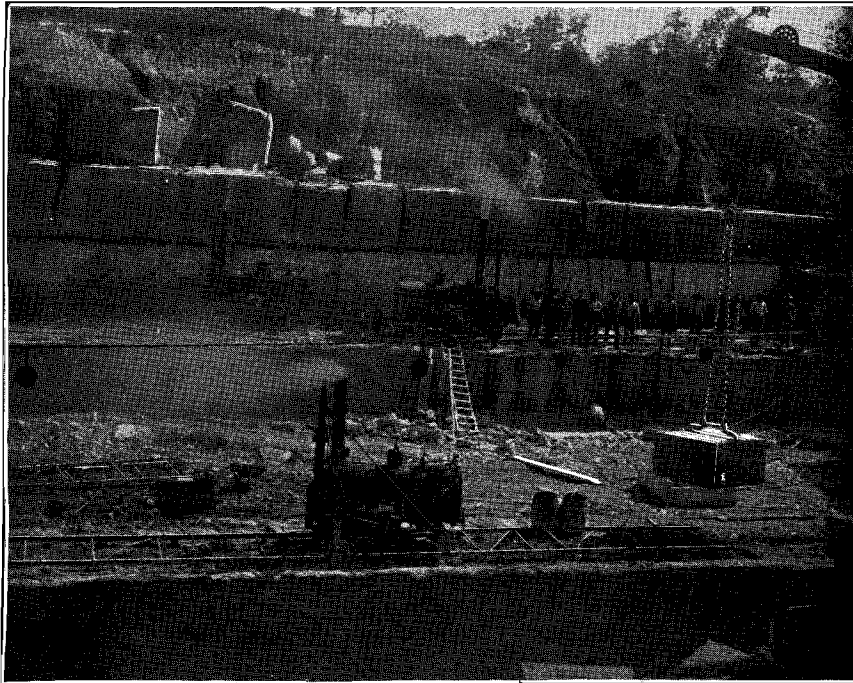
The percentage of bituminous matter is sufficient, in some instances, to discolor the stone to some extent on exposure by the heat of the sun drawing this material to the surface, where it collects the dust and disfigures the stone for a time. Objection has been raised to the stone in some places on this account, but it must be remembered that this occurs with but a small part of the stone, and with that part the disfiguring is only temporary, and in nowise affects the durability of the stone, acting rather as a preservative.

With the exception of the bituminous varieties, the general tendency of the stone is to become lighter colored on exposure. Much of the buff stone has a dull yellow color when first quarried, that becomes much lighter on exposure.

A few years ago the blue stone was the highest priced and most sought after. Now, while there is good demand for both colors, the buff is most sought after and most quarried. The prices are about the same for each.



1. Showing depth of oxidation and line of parting (A) between the buff and the blue stone in old quarry looking north of east.



2. In new quarry, looking south of east, showing method of quarrying, thickness of covering and regularity of the upper surface.

VIEWS IN THE QUARRIES OF THE OOLITIC STONE CO. OF INDIANA, SANDERS, IND.

PHYSICAL TESTS.

Physical tests of various kinds have been tried on the oölitic stone, the results of which are given below. Not only those made directly for the present report, but those made elsewhere, so far as could be obtained, are brought together and classified.

Specific gravity. The specific gravity tests on the accompanying tables were made for the present survey at Rose Polytechnic Institute, except those marked (1), which were made in duplicate at State College, Pennsylvania, to show the different results by different methods. At Rose Polytechnic Institute the stone was weighed in air, and as quickly as possible in water, the specific gravity being the weight in air divided by the difference in weight of the two. At State College it was determined by a specific gravity bottle, weighing first the bottle, second, the bottle filled with water, third, the bottle with the powdered rock, and fourth, the bottle with the powdered rock filled with water. The weight of 3 subtracted from 4, and that result from 2, gives the weight of the water displaced by the stone, and that divided into the weight of the stone, obtained by subtracting 1 from 3, equals the specific gravity. The latter method attempts to give the specific gravity of the particles of the stone independent of the interstitial air, and the former process to give the relative weight of the stone as it is, including the air. As it is impossible to weigh so quickly that some of the water is not absorbed, the actual weight of the stone is less than that shown by the first process. As it is impossible to exhaust all the inclosed air, the absolute weight of the material of the stone, excluding the pores, is a little more than that shown by the second process.

The figures given are for seasoned stone, the green stone being heavier.

The weight per cubic foot, as given in the table, is obtained by multiplying the specific gravity by $62\frac{1}{2}$, the weight in pounds of a cubic foot of water. The quarrymen generally count the weight of the stone in the rough for shipping purposes at from 175 to 180 pounds per cubic foot. C. S. Norton counts his blue stone at 185 pounds. A large block of stone quarried by the Bedford, Ind., Stone Company, said to be the largest block of Indiana limestone ever quarried,* gives the dimensions 11 feet nine inches by 10 feet four inches by eight feet eight inches, and is marked 190,000 pounds (see plate XXXIV), which is equivalent to 180 pounds per foot.

Ratio of absorption.—In the absorption tests made at the Rose Polytechnic Institute the specimens were approximately one-inch cubes, weighed and placed in water, where they were left for 24 hours, and then removed and the faces dried with blotting paper and reweighed. The ratio of absorption is the weight wet minus the weight dry divided

*There are a great many larger blocks than this quarried now, but possibly no larger ones shipped.

by the weight dry. This 1-31 means that 31 pounds of the stone would absorb one pound of water, about five pounds to the cubic foot.

In the recorded tests made by General Gilmore the experiments were made in about the same way.

The stone showing the highest absorption is the most porous, the lightest the softest, and generally, other things being equal, the least able to withstand the weather.

Compression tests.—The compression tests made for the survey at Rose Polytechnic Institute were upon specimens of about two-inch cubes. Each specimen was measured to the nearest 1-100 of a square inch and tested upon a Riehle testing machine having a capacity of 100,000 pounds.

The specimens were tested between two pieces of tarboard $2\frac{1}{4} \times 2\frac{1}{4}$ inches. The rate of application of the load was slow and the same for all.

It will be noticed that most all of the specimens range between 4,000 and 10,000.

The first two tables show the details of the tests made by Professor Howe at Rose Polytechnic Institute.

Table III gives a summary of these, along with tests made by General Gilmore for comparison. It is worthy of note that in four sets of samples the strength on edge is greater than that on the bed, in one instance the first being twice as great. The reason for this is not apparent. One might think that it was due to an imperfect specimen, but the tests on the bed were made on three specimens which averaged nearly the same, and two of them broke with two perfect pyramids. A possible explanation is that the stonecutter marked them wrong.

The samples from Ellettsville are from G. K. Perry's quarry, a half mile north of the Ellettsville Station.

The Twin Creek specimens from a newly opened quarry on the bluff of Twin Creek, about six miles north of west from Salem in Washington County, Nos. 7 to 9, were specimens quarried in November, 1895, about six feet below the surface, in township 8 north, range 1 west, section 20, on land of John B. Crafton.

Nos. 10 to 12, from second and third floors seven to 20 feet deep in the quarry of Hunter Valley Stone Co., Hunter Valley.

Nos. 25 to 27, quarried Nov. 7, 1896, near the top of ledge, township 7 north, range 2 west, section 24, lot 8. No quarry opened.

Nos. 31 to 33, from quarries on Big Creek, North Bedford station, on Gosport branch of I. & V. R. R., part 20 feet and part 30 feet below the surface; quarried Nov. 26, 1896, hence not properly seasoned.

Nos. 34 to 36, broken off near the top of the ledge, Nov. 7, 1896, on lot 15, township 7 north, range 2 west, section 12. Buff and Blue Oolitic Stone Co. Quarries not developed.

I. Compression tests on Bedford Oolitic limestone. Specimens on natural bed.

Number.	COMPANY.	LOCALITY.	Area in Square Inches.	Strength in Pounds Per Square Inch.	REMARKS.
1	G. K. Perry	Ellettsville	4.35	6,700	Faces crowned; top pyramid long.
2	G. K. Perry	Ellettsville	4.22	5,900	Failed on two sides; signs of pyramids.
3	G. K. Perry	Ellettsville	4.33	6,900	Two perfect pyramids.
4	Twin Creek Oolitic Stone & Land Co	Salem	4.08	11,700	Two perfect pyramids.
5	Twin Creek Oolitic Stone & Land Co	Salem	3.92	6,900	One side split off.
6	Twin Creek Oolitic Stone & Land Co	Salem	4.24	11,100	Two pyramids.
7	John B. Crafton	Bloomington	3.82	11,400	Two good pyramids.
8	John B. Crafton	Bloomington	3.72	9,100	Two poor pyramids.
9	John B. Crafton	Bloomington	4.04	8,400	Split off on side; probably tested on edge.
10	Hunter Valley Stone Co.	Bloomington	4.00	3,400	Two fairly good pyramids.
11	Hunter Valley Stone Co.	Bloomington	4.20	4,200	Split off on one side.
12	Hunter Valley Stone Co.	Bloomington	4.08	4,600	Failed on three sides.
13	Romona Oolitic Stone Co.	Romona	4.20	6,800	Two good pyramids.
14	Romona Oolitic Stone Co.	Romona	4.24	6,400	Two good pyramids.
15	Romona Oolitic Stone Co.	Romona	4.20	7,800	Top pyramid good; bottom one-sided.
16	Bedford, Indiana, Stone Co.	Bedford	4.28	6,800	Two fair pyramids.
17	Bedford, Indiana, Stone Co.	Bedford	4.00	3,400	Faces not parallel; failed on one side only.
18	Bedford, Indiana, Stone Co.	Bedford	4.04	6,700	Two fair pyramids.
19	Hunter Bros., Stone Co.	Bloomington	4.14	5,900	Two good pyramids.
20	Hunter Bros., Stone Co.	Bloomington	4.00	6,900	Two good pyramids.
21	Hunter Bros., Stone Co.	Bloomington	4.08	4,400	One side split off.
22	Chicago Bedford Stone Co.	Bedford	4.04	9,600	Two fine pyramids.
23	Chicago Bedford Stone Co.	Bedford	4.12	6,400	Failed on one side; indications that specimen was tested on edge.
24	Chicago Bedford Stone Co.	Bedford	4.12	9,700	Two fair pyramids.
25	John B. Crafton	Bloomington	4.49	6,400	Two poor pyramids.
26	John B. Crafton	Bloomington	4.41	4,700	Split top to bottom around vertical axis of specimen.
27	John B. Crafton	Bloomington	4.54	8,200	Two good pyramids.
28	Crescent Stone Co.	Bloomington	4.10	4,500	One poor pyramid and wedges.
29	Crescent Stone Co.	Bloomington	4.16	7,500	Two fine pyramids.
30	Crescent Stone Co.	Bloomington	4.20	5,000	Two fair pyramids.
*31	Indiana Steam Stone Works	Stinesville	4.08	6,600	Two fair pyramids.
*32	Indiana Steam Stone Works	Stinesville	4.16	4,100	Faces not parallel; failed vertically around axis of specimen.
*33	Indiana Steam Stone Works	Stinesville	4.08	6,200	Faces not parallel; failed vertically around axis of specimen.
34	Bluff and Blue Stone Co.	Bloomington	3.79	6,100	Two very poor pyramids; faces not parallel.
35	Bluff and Blue Stone Co.	Bloomington	4.33	5,800	Top pyramid good; faces not parallel; bottom pyramid wedge-shaped.
36	Bluff and Blue Stone Co.	Bloomington	4.28	6,200	Two good pyramids.
37	Bedford Quarries Co.	Bedford	4.00	3,300	Top pyramid fair; bottom one very poor.
38	Bedford Quarries Co.	Bedford	4.00	4,300	Two fair pyramids.
39	Bedford Quarries Co.	Bedford	4.12	4,800	Failed on two sides; signs of pyramids.

*The natural "bed" of these specimens was not marked.

II. Compression tests on Bedford Oolitic limestone specimens on edge.

Number.	COMPANY.	LOCALITY.	Area in Square Inches.	Strength in Pounds per Square Inch.	REMARKS.
1	G. K. Perry	Ellettsville	4.08	13,500	Failed in two pyramids.
2	Twin Creek Oolitic Stone & Land Co	Salem	4.02	8,900	Failed in two pyramids.
3	Jno. B. Crafton	Bloomington	3.94	8,000	Faces crowning badly cut; failed like specimen tested on natural bed.
4	Hunter Valley Stone Co	Bloomington	3.98	4,200	Split off on sides; for most part parallel to the natural bed.
5	Romona Oolitic Stone Co	Romona	4.20	11,200	Failed in two pyramids; fine specimen.
6	Bedford Ind. Stone Co	Bedford	4.18	4,800	Faces not parallel; one side split off. Signs of pyramids.
7	Hunter Bros. Stone Co	Bloomington	4.12	4,200	Failed in two pyramids like specimens tested on natural bed.
8	Chicago Bedford Stone Co	Bedford	4.02	6,600	Faces badly out of parallel; split off on high sides.
9	Jno. B. Crafton	Bloomington	4.45	3,900	Faces not parallel; split off on one side and corner.
10	Crescent Stone Co	Bloomington	4.04	5,700	Faces not quite parallel; split off on one side.
11	Indiana Steam Stone Works	Stinesville	4.12	2,800	Faces not parallel; one face showed tool marks; split off on one side.
12	Buff and Blue Stone Co	Bloomington	4.10	4,100	Split off on one side.
13	Bedford Quarries Co	Bedford	4.12	4,800	Two fair pyramids.

III. Table showing crushing strength, specific gravity and ratio of absorption of Indiana Oolitic limestone.

Number.	QUARRY.	LOCATION.	Crushing strength per square inch.	No. of specimens tested.	Specific gravity.	Weight per cubic foot.	Ratio of absorption.	WHERE TESTED OR AUTHORITY.
1	G. K. Perry	Ellettsville, Ind.	{ 6,500	{ 3	..	..	1-31	Rose Polytechnic Institute, Terre Haute, 1896.
2	G. K. Perry	Ellettsville, Ind.	{ 13,500 12,625	{ 1	..	152.4	1-41	Gen. Gilmore, Rep. No. 6, Board State House Commissioners, 1879.
3	Matthews Bros	Ellettsville, Ind.	13,500	..	..	142.2	1-28	Gen. Gilmore, Rep. No. 6, Board State House Commissioners, 1879.
4	Indiana Steam Stone Works	Stinesville, Ind.	{ 5,600	{ 3	..	..	1-17	Rose Polytechnic Institute.
5	Simpson & Archer.	4 miles east of Spencer, Ind	{ 2,900 7,500	{ 1	..	142.2	1-30	Gen. Gilmore, Rep. No. 6, Board State House Commissioners.
6	Simpson & Archer.	4 miles east of Spencer, Ind	8,750	..	..	156.9	1-95	Gen. Gilmore, Rep. No. 6, Board State House Commissioners.
7	Hunter Valley Stone Co.	Bloomington, Ind.	{ 4,100	{ 3	..	..	1-14	Rose Polytechnic Institute, 1896.
8	Hunter Bros. Stone Co	Bloomington, Ind.	{ 4,200 5,700 4,200	{ 3	2.46	153.7	1-19	Rose Polytechnic Institute, 1896.
9	Crescent Stone Co	Bloomington, Ind.	{ 5,700	{ 3	..	..	1-15	Rose Polytechnic Institute, 1896.
10	Buff and Blue Stone Co.	Bloomington, Ind.	{ 6,000 4,100	{ 3	..	..	1-22	Rose Polytechnic Institute, 1896.
11	Crafton	Bloomington, Ind.	{ 6,200 3,900	{ 3	..	..	1-16	Rose Polytechnic Institute, 1896.
12	Crafton	Bloomington, Ind.	{ 9,600 8,000	{ 3	..	..	1-3300	Rose Polytechnic Institute, 1886.
13	Dunn & Co	Bloomington, Ind.	13,750	..	..	146.6	1-43	Gen. Gillmore.
14	Romona Oolitic Stone Co	Romona, Ind	{ 7,000 11,200	{ 3	2.48	155.0	1-39	Rose Polytechnic Institute.
15	Bedford, Indiana, Stone Co.	Bedford, Ind.	{ 5,600 4,600	{ 3	2.47	154.4	1-23	Rose Polytechnic Institute.
16	The Chicago & Bedford Stone Co	Bedford, Ind	{ 8,600 6,600 4,100 4,800	{ 3	..	..	1-31	Rose Polytechnic Institute.
17	Bedford Quarries Co	Bedford, Ind	14,000	..	..	..	1-15	Rose Polytechnic Institute.
18	Bedford Quarries Co	Bedford, Ind	11,750	..	..	..	..	Bedford Quarries Co. Circular.
19	Chicago and Bedford Co	Bedford, Ind	6,925	..	..	147.6	1-28	Gen. Gilmore, Indiana Geological Report, 1878.
20	Dark Hollow Stone Co	Bedford, Ind	6,500	..	..	142.9	1-19	Gen. Gilmore, Rep. No. 6, State House Com.
21	Dunn & Co	Bedford, Ind	9,900	..	..	147.0	1-24	Gen. Gilmore, Rep. No. 6, State House Com.
22	Twin Creek Stone Co	Salem, Ind	{ 8,900	{ 3	2.51	156.9	1-31	Rose Polytechnic Institute.
23	E. Zink & Son	Salem, Ind	{ 8,625	{ 1	..	144.3	1-22	Gen. Gilmore, Rep. No. 6, State House Com.
24	S. M. Stockslager	Corydon, Ind	10,250	..	..	149.6	1-27	Gen. Gilmore, Rep. No. 6, State House Com.
25	.. . . . .	Bowling Green, Ky	3,000	..	..	..	..	Min. Res. U. S. 1889-90, p. 396.

One is liable to error in making comparison of the crushing strength of building stones made by different persons, or even by the same person, as the maximum strength of the stone depends upon a number of conditions: 1. On the size of the specimen; a large specimen will give a higher result per square inch than a small one. 2. The shape of the specimen, as shown below. 3. The rate of speed of the machine. 4. The accuracy with which the specimen has been dressed; the more nearly absolutely parallel the higher the results. 5. The method of dressing the specimen. The tests showing difference in transverse strength of tool-dressed and sawed samples made by Mr. Johnson apply as well to crushing tests, as shown experimentally by Gilmore. 6. The seasoning of the specimen. 7. The method of bedding the specimen. 8. The care of the operator in watching all the details of the test; and 9. The accuracy of the machinery. The machines are not all calibrated alike. The above points are not all theoretical, but largely based on experience. Hence comparisons on the basis of crushing strength alone should be made with caution.

The following results by Mr. Hatt will illustrate several of the above points:

The relative crushing strength of Bedford limestone in prisms and cubes.—* From an examination of the results of J. Bauschinger's investigation of the effect which the shape of a specimen of stone has on its crushing strength, a writer in the "Digest of Physical Tests" for July, 1896, has stated that the strength of a stone prism, whose height is one and one-half times its least lateral dimension, is only 92% that of a cube of the same material. If the normal shearing angle for stone is 60° , this conclusion seems reasonable.

There are here communicated tests on a number of specimens of Bedford oölitic limestone, sawn to cubes (4" x 4" x 4") and the prisms (4" x 4" x 6"). They were tested partly directly after being taken from the paper wrappers and rubbed down by hand with emery to a smooth bed, and partly after having been exposed to the air of the laboratory for one month. Part of the series was tested when bedded in a thin layer of plaster of Paris, and part tested directly in contact with the beds of the machine, which was a Riehlé machine of 300,000 pounds' capacity, run at a speed of one-tenth inch per minute. It is to be noted that the specimens were not well seasoned, and so the results are not given as evidencing the full strength of the stone.

* Presented to the Indiana Academy of Science, December, 1896, by W. K. Hatt.

The average crushing strength of the 17 cubic specimens was	4326.7
The average crushing strength of the 14 ¹ / ₂ prisms was	4436.4
Omitting 3 cubical specimens, the strength of the remaining 14 is	4191
Omitting 3 of the prisms, the strength of the remaining 11 is	4305
For those tested with plaster bed the average is	4239
For those tested without plaster bed the average is	4359
For those tested December 17th the average is	4385
For those tested before November 18th the average is	4274
The average of all specimens is	4381.5
The average with six omissions is	4248

In these tests of 31 specimens the six-inch prisms had, under all conditions, a greater strength than the cubes of the same sectional area, and the difference does not amount to three per cent.

The average angle of pyramid of fracture is 64.5 degrees. The results do not sustain the conclusion mentioned above as having been stated in "Digest of Physical Tests."

Fire tests.—There seemed to be some doubt in regard to the heat-enduring properties of the oölitic limestone, and a series of tests were made for the survey at Rose Polytechnic Institute, with the following results: A sufficient number of specimens from different localities were taken, we think, to fairly represent the whole district. The results appear to be about the same in each test, so that it is not necessary to enumerate the different localities under each test.

It will be seen that the results are all that could possibly be desired or expected, since the samples retained their form uninjured up to and beyond the point of calcination.

The specimens were approximately one-inch cubes, all supported in the same manner on wires placed $\frac{3}{4}$ inch apart, and all heated under similar conditions in a furnace composed of an iron box surrounded by an iron jacket, leaving a two-inch space on all sides but the front and bottom.

Specimens were taken from the following quarries: G. K. Perry's, Ellettsville; Hunter Valley Stone Co. and Crescent Co., Hunter Valley, Bloomington; Romona Oölitic Stone Co.'s Quarry, Romona; The Chicago and Bedford Stone Co., Reed's Station; The Bedford Indiana Stone Co., Peerless; The Bedford Quarries Co., in the vicinity of Bedford; The Twin Creek Co., Twin Creek, northwest of Salem; The Buff and Blue Oölitic Stone Co., and two localities on the property of the Crafton Stone Co., south of Bloomington, and the quarry of the Indiana Steam Stone Works, on Big Creek, West of Stinesville.

The specimens were first heated until lead melted on their top surface, about 619° F., and cooled slowly in air—all specimens uninjured. Other specimens heated to the same temperature were sprinkled with water and then quenched in cold water—all uninjured.

The same experiment was tried with melting zinc, temperature about 777° F., with the same result—specimens all uninjured.

The specimens were heated until cupric chloride (CuCl_2) melted, temperature about 928°F ., and some were cooled in air and some sprinkled and quenched in water. The specimens retained their form and were uninjured except a discoloration very slight in some and pronounced in others, due to the oxidation of the iron. Three specimens showed indications of lamination.

They were then heated until aluminum melted on the upper surface, temperature about 1157°F . They were sprinkled and quenched in water. The lower edges crumbled when sprinkled. The upper edges and faces were uninjured.

Some were heated to "cherry red," about 1500°F ., and cooled in air, calcination was pronounced, but the specimens retained their cubical form and sharp edges.

Other specimens were heated to the temperature of melting potassium chloride, KCl , sprinkled and quenched in water. The lower edges went into fine powder (quicklime). The upper edges were uninjured.

These results show pretty conclusively that the oölitic stone is fire-proof up to the point of calcination or turning to quicklime, in which respect it is superior to the average building stone, so far as shown by the published tests. While a few building stones will withstand a temperature above the calcination point of lime uninjured, the greater number will be destroyed at a temperature below that point.

Transverse strength and elasticity.—Mr. Johnson made a series of tests on the transverse strength and elasticity of the oölitic limestone, a few of the results of which are given below,* as the original source is not accessible to all.

He tested specimens having approximately one inch cross-section and 14 inches long, by resting them on supports at the ends and applying the load to them on a knife edge in the center. They were all measured accurately in cross-section, most of them varying from a square inch by a small fraction.

AVERAGE RESULTS FROM EXPERIMENTS ON SAWED AND TOOL-DRESSED SAMPLES OF OÖLITIC LIMESTONE.

	Load causing rupture, in pounds.	MODULUS OF		
		Rupture.	Compression.	Elasticity.
Sawed	130	2,338	12,675	4,889,480
Tool-dressed	81	1,477	7,857	2,679,475
Ratio of tool-dressed to sawed.....	62 per cent.	63 per cent.	62 per cent.	55 per cent.

* Experiments upon the Strength and Elasticity of Building Stones, by Thos. H. Johnson, in the 11th Ann. Rep. Dept. Geol. and Nat. Hist. of Ind., 1881, pp. 34-42.

For the tool dressed specimens the breaking loads varied between 40 and 110 pounds; for the sawed specimens, from 120 to 150. The modulus of rupture for the tool-dressed specimens varied between 950 and 1,928; for the sawed specimens between 2,187 and 2,593. These results show quite conclusively not only the great elasticity of the stone, but the injurious effects of hammering it in tool-dressing. Mr. Johnson also noted that the strongest stones were the most resonant. All the tool-dressed specimens had a dull sound, while the sawed specimens had a clear, ringing sound. It should be noted that the sawed specimens were taken from different quarries from the tool-dressed ones and part of the difference in the results may be due to inherent qualities in the stone.

Chemical composition.—The accompanying table gives a record of all the analyses obtainable of the oölitic limestone from different localities. The similarity is remarkable. Thus 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 alkalis form a mere trifle.

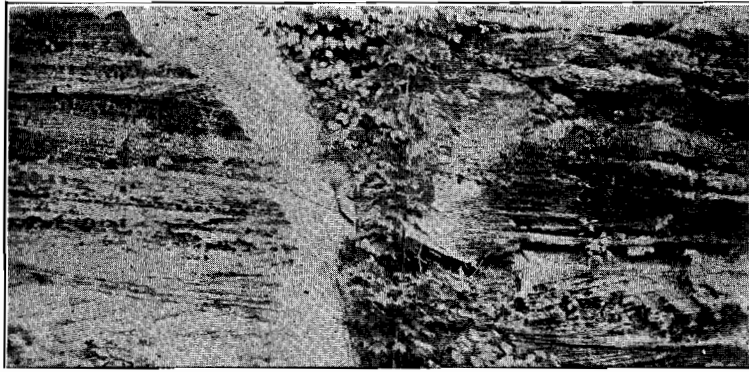
The last column, headed water, in the two analyses, where it shows more than half of one per cent., includes water and loss on ignition. Probably the greater part in each is due to the unavoidable errors of analysis.

The analyses show the stone to be a lime carbonate of remarkable uniformity and purity. Possibly no other stone in the country would show such a remarkable uniformity of composition over such a wide area.

Thus, from the standpoint of purity, the stone is all that could be desired, only the purest marbles giving a higher percentage of lime carbonate.

Chemical Analyses of Bedford Oolitic Limestone.

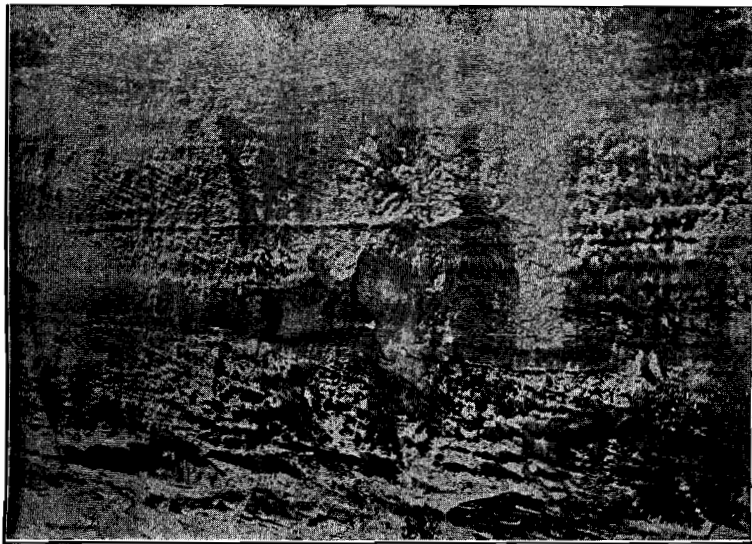
Number.	LOCALITY.	QUARRY.	Date.	Lime carbonate, Ca CO ₃ .	Magnesia carbonate, Mg CO ₃ .	Insoluble.	Iron oxide, Fe ₂ O ₃ .	Alumina, Al ₂ O ₃ .	Alkalies, K ₂ O & Na ₂ O.	Water, H ₂ O.	Total.	AUTHORITY.	
1	Bedford	Bedford, Indiana Stone Co.	1896	98.27	.84	.64	.15	..	..	..	99.90	W. A. Noyes, Rose Polytechnic 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	..	93.80	4.01	.15	.64	..	..	1.09	100.00	L. H. Streaker, State University.
6	Big Creek	Indiana Steam Stone Works	..	93.07	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. Circular.
9	Bedford	Hoosier Quarry, blue	..	97.26	.37	1.69	.49	..	..	..	99.81	Bedford Quarries' Co. 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 Qua'y, 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	..	..	.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	98.69	..	.31	.18	.14	.40	.12	..	Indiana Geological Rep., 1878, p. 96.	
	Average	..	..	96.50	1.00	.88	.75	..	.17	.29	..	..
17	Hardin County, Ill.	Rosiclare Oolitic limestone	1882	90.16	3.18	2.72	1.06	..	..	.15	..	Econ. Geol. of Ill., Vol. I, p. 318.
18	Bowling Green, Ky	..	1889	95.31	1.12	1.42	.39	..	..	1.76	100.00	Min. Resources U. S., 1889-90, p. 395.
19	Portland, Eng.	..	..	95.16	1.20	1.20	.50	..	..	1.94	100.00	Min. Resources U. S., 1889-90, p. 395.



1



2



3

SHOWING STRUCTURAL FEATURES OF THE OOLITIC LIMESTONE.

1. Bluff on Big Creek showing lamination and cross bedding brought out by weathering.
2. Buff and Blue Oolitic Stone Co., Lot No. 20, N. W. N. W. $\frac{1}{4}$ Sec. 13, T. 7 N., R. 2 W., showing manner of weathering in oolitic stone along stream courses.
3. Terre Haute quarry. Part of joint face surface, showing gross regularity and minute irregularity and cross bedding brought out by weathering.

Durability of the oölitic limestone.—The Bedford oölitic limestone ranks among the most durable building stones in the market, the proof of its durability being found in (1) the appearance of the stone in the outcrops; (2) in old buildings and monuments; and (3) the chemical and physical tests.

The outcrops of the oölitic limestone are in some places rounded prominences projecting through the soil, in other places bold cliffs along the watercourses. These cliffs sometimes show a large face of stone, remarkably regular and even, denoting a stone of great uniformity. Plates XXX and XXXVI show two of the largest and finest exposures to be found in the entire area. As the weathering agencies attack the rock always at the weakest spots, if there are any, the outcrop is frequently irregular from the deeper weathering along seams, joints or lines of weakness. See the upper weathered surface of the stone in Nos. 1 and 2 on plate XX, and the views in plate XXI. Where the watercourse has its channel in the oölitic limestone, it frequently cuts a deep, narrow gorge in which it runs, and sometimes undercuts the rock on one side, or the other, forming overhanging bluffs. (See plate XX.) The number and the prominence of the bluffs, the most conspicuous topographic features of the region, indicate its greater durability in comparison with the overlying and underlying rocks.

As the oölitic stone field is a comparatively new one in its larger development, there are not many old structures in which the stone has been exposed for a long period, as is the case with stone in the Eastern States. However, such as have been erected are, without exception, so far as known, in a good state of preservation. The Winthrop Foote vault on the east side of Bedford, constructed in 1840, and the stone chimney on the old homestead of Dr. Foote, built before that date, are the oldest pieces of work in the Bedford stone known to the writer. They are apparently as sound as when first erected, more than fifty years ago. Of the many buildings constructed wholly, or in part, since that time, and of the numerous monuments in the cemeteries, none that are injured in any way, except sometimes by discoloration, have been observed. The same can be said in part of the rock in the old quarry openings south and east of Bedford that were made 40 or 50 years ago. The stone in the dump and on the old quarry face is, as a rule, as sound and firm, and harder than when just quarried. Where the stone lies under the trees, or in well shaded places, it is covered by a vegetable growth, like all other building stones in similar positions; and in a few of the more recent quarry openings the stone is shelly and exfoliating for a few feet above the water that stands in the quarry, caused, presumably, by the freezing of the wet stone, but in nearly every instance of this kind it is a band of very coarse texture, of coarsely fossiliferous stone, that is shelly, while the fine-grained stone, both above and below it, remains firm. It

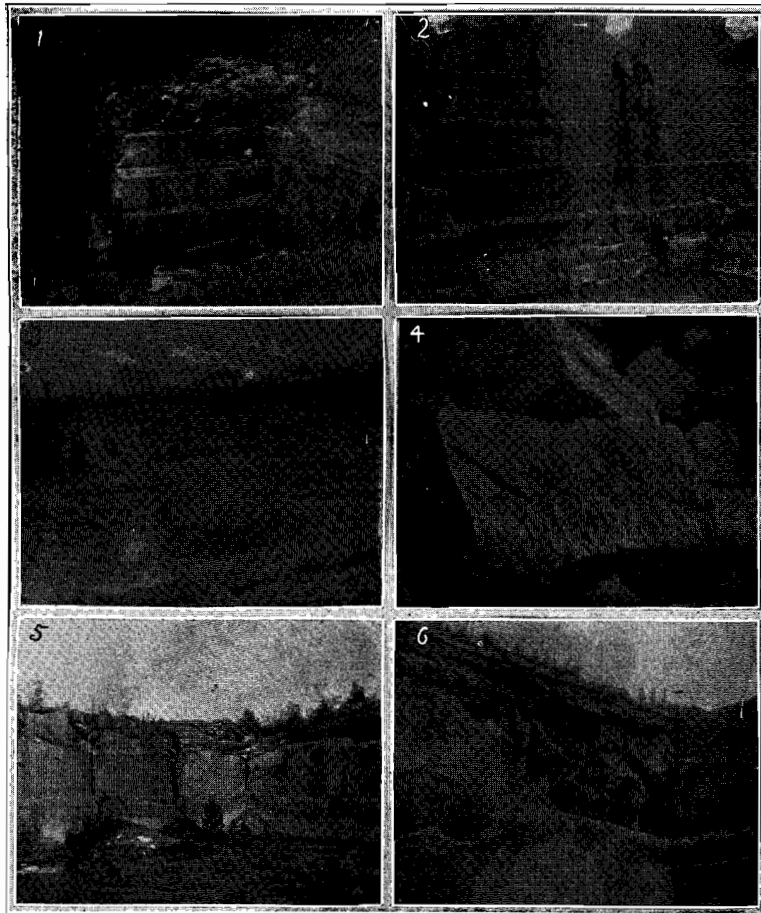
is said that some of the ground courses in bridge abutments have been known to scale and exfoliate. None such have been seen by the writer, but his opportunity for observation in this line has not been extensive.

The chemical analyses show no marked percentage of elements of weakness in the stone any less stable than lime carbonate, the percentage of alumina and alkali being too minute to affect the strength in any way. The stone is practically a carbonate of lime, one of the most durable substances under ordinary conditions. In contact with acids, however, it is one of the least stable, as it is readily dissolved by any of the acids. For this reason it is liable to tarnish in a city atmosphere where there is much sulphurous coal smoke. However, unless it is in the immediate vicinity of a large furnace or factory the injury from this cause is little to be dreaded beyond the roughening and sometimes discoloration of the surface.

The numerous fissures, caves, open seams and corrugated surfaces found in the quarries and outcrops are caused by its solubility in acids, as the rainwater absorbs some acid from the air and more from the soil through which it passes, and, acting continuously for ages, it leaches away great quantities of the stone. This action, which is so marked in the stone in its natural position, ceases almost entirely when the stone is placed in the wall, as the circulation of the sap or interstitial water ceases, its load is deposited and many of the pores are closed. The little water that falls on the surface during a rain storm contains but little acid and that under such slight pressure as not to be very active, and of the little that is dissolved by carbonic and sulphuric acids part is redeposited in the pores, tending to make the surface more impervious. It might readily be inferred, then, that it should not be used where it will be exposed to the action of acids. For that reason it is not suitable for the base of bridge-piers in regions where the water is very acidic, as in coal-mining regions.

The physical tests show the stone to be more porous than the average limestone, but in crushing and transverse strength up to or beyond the average; much more flexible and elastic than the average building stone, by means of which it is able to withstand sudden changes of heat and cold without injury, that would cause less elastic stones to crack or crumble. This is shown by the heat tests described above, in which the stone remains intact, uninjured, under heat up to the point of calcination, even standing sudden cooling in cold water from a nearly red heat, that is, a sudden change of nearly a thousand degrees, which is probably as severe a test as any to which a stone could be subjected.

This happy combination of properties, by means of which this oolitic stone, while so soft as to be so easily cut and carved into desired shape, is at the same time so firm and elastic as to withstand the strains put upon it either by its position in the structure or the strain of rapid changes in temperature, makes the stone so valuable for building purposes. This is



STRUCTURAL FEATURES OF THE OOLITIC LIMESTONE.

1. Hunter Valley quarry, showing corrugations and *irregularity* of the weathered upper surface after removal of the soil.
2. A Big Creek quarry, showing excessive weathering along the joints.
3. Johnson quarry, showing *regularity* of the upper surface after the removal of the soil.
4. A peculiar porous form of weathering.
5. In Perry's quarry, showing cross bedding.
6. In Perry's quarry, showing line of contact of the oolitic limestone with the overlying Mitchell limestone.

due probably to its unique texture as already stated, in which it differs from other sandstones in having the grains cellular and porous in a fine cement. It differs from other limestones in its granular character, consisting of the yielding grains in the finer cement. And furthermore, calcite itself is highly elastic, as shown in the action of many of our marbles.

The Bedford oölitic limestone can unhesitatingly be recommended as one of the most durable building stones in the market, where not exposed to the action of acids. It is fire-proof up to the point of calcination, in which property it can be surpassed by no other limestone and but few other building stones, as very few are absolutely fire-proof.

We cannot refrain at this point from calling attention to the extravagant, boastful and misleading statements made by some previous writers on this subject, statements that are injurious because false. Such statements as the following, by their very extravagance, defeat their object: "This purity insures absolute integrity on exposure to the fumes of coal, while the perfect elasticity and flexibility of the mass render it invulnerable to the forces of cold and heat, air and moisture. Cliffs of this limestone, exposed to our variable climate for unknown centuries, show no sign of disintegration, the finest angles standing out as sharp now as when first the mass was fractured." And from another writer: "At the numerous exposures along the various watercourses, where it has been subjected to the action of the elements for hundreds and thousands of years, it does *not display in a single instance a tendency to disintegrate or break down* under prolonged exposure."

To say nothing about the above statements, one only need to look at the accompanying photographs, or visit any of the outcrops, to see the absurdity of such statements. Again the following awe-inspiring statement has been quoted and requoted with an apparent confidence that seemed to settle all doubts: "When we consider to what awful and prolonged frigidity of temperature this rock was exposed during the Glacial age, without in the least affecting its integrity, we may safely trust it in our buildings. Other limestones were cracked, shivered, crushed under the compressions and expansions of the arctic period, while this massive deposit was scarcely changed in any part of its great body." The "awful and prolonged frigidity" of the Glacial age presumably never reached the main body of the oölitic limestone, at least the glacier itself did not. It stopped near the north end of the oölitic region, probably because of the very opposite condition to frigidity, as the best barrier against ice is heat, and likely the warm climate of this part of Indiana stopped the glacier in the extreme northern part of Monroe County or beyond by melting its southern end. Furthermore, the part of the oölitic belt that the glacier passed over is not the part that contains the best stone, and again the "other limestones" in the glacial areas are

no more "cracked, shivered and crushed under the compressions and expansions of the arctic period" than similar stones are many miles south of the glacial area. The truth in regard to the durability of the oölitic stone is sufficient, and needs no embellishing.

Workability.—The Bedford oölitic limestone probably works as easily and freely as any other building stone in the market, almost rivaling the French Cæn limestone in this respect. While the French stone is a little softer and more easily cut, it is said to be much less durable in a northern climate. Like all freestones, the Bedford stone is much softer when first quarried, hardening on exposure; hence it is more easily sawed or cut to the desired form when fresh than it is after seasoning. Yet while it becomes firm and compact, resonant almost as a metallic substance, calcite in itself being a soft mineral, it never becomes as hard or as difficult to cut as siliceous rocks of equal strength; nor does it become as hard as marble. The lack of grit or siliceous material thus renders the channeling of the stone from the quarry, the sawing of the stone and the cutting and carving of it not only possible, but enables it to be so worked much more economically than almost any other building stone, a saving of both time and wear on the tools when compared with sandstones of equal strength, or granite, or even marble or more compact limestone. Besides being easy to channel, cut or saw, it also splits as readily as almost any other rock, where not locally cross-grained, splitting or breaking readily in any direction, excelling the average building stone in this respect, thus adding to its value for ornamental work. These properties enable it to be removed profitably from a massive bed containing few seams, where a harder stone or one more difficult to work could not be quarried with any profit.

Accessibility.—The Bedford oölitic limestone area is near the center of population of the United States, in the very midst of the Mississippi Valley, which is not only the largest, but destined to be the most productive and populous valley of the world. The area is traversed by one north and south railroad, and three running east and west, besides several branch roads. The topographic features are such that almost every point of the area can be reached by railways at a moderate expense for grading. In evidence of the easy grades, the Monon railway, running north and south on the entire length of the productive area, was built before the great value of the stone was known. The structural position of the stone, lying, as it does, with a gentle dip to the southwest, makes a larger area of the stone accessible than if it were inclined at a high angle or even perfectly horizontal.

A stone may be inaccessible because of its remoteness from markets, such as large cities or populous districts, or its distance from railroads or other means of transportation, or because of its structural and stratigraphical position. Thus an intrinsically good building stone in many

of the Western States would not be accessible to Eastern markets, even though it were on a railway, because of the excessive freight rates. Throughout North Arkansas are valuable beds of marble, but they are inaccessible, because they are many miles from a railroad. A bed of stone, inclined at an angle of 40 to 60 degrees to the horizon, has but a small part accessible, likewise a bed in a horizontal position, overlain by a very durable rock, is liable to be accessible in very limited areas. The Bedford oölitic limestone as noted, is not subject to any of these difficulties.

CHAPTER III.

COMMERCIAL FEATURES OF THE BEDFORD OÖLITIC LIMESTONE. METHODS
OF QUARRYING AND HANDLING THE OÖLITIC LIMESTONE.

T. C. H.

The earliest settlers did not use much of the oölitic limestone, because of the difficulty in quarrying it. After its valuable properties were discovered, it had some local usage, in which the stone was obtained by the liberal use of powder from the loose bowlders and outcropping ledges. It is the almost universal practice among country masons, where the stone is to be quarried by hand, to blast it from the ledges, and if the blocks or bowlders are too large to handle, to break them with another charge of powder. With the invention of the channeling machine and the opening of the large quarries, the use of powder was discontinued, and at the present no powder is used except for removing stripping. The noise of the blast has given way to the clatter of the channeler.

Selecting a site for a quarry.—The primary object desired in all cases is the greatest possible thickness of good stone with the least possible stripping and the least possible amount of waste in the stone quarried. It generally costs as much per yard, sometimes more, to remove the waste stone and stripping as it does the good stone. Hence the less there is of it the less the expense proportionally. The ideal condition where there is no stripping and no waste does not exist in the Indiana limestone belt, nor, in fact, in any other region. The proportion of waste may be less in places, but never wholly absent. Within certain limitations the amount of stripping and the amount of waste in the bed are in inverse proportion to each other. That is, where the stripping is very light, the weathering agencies penetrate deeply along the joint planes, wasting much of the rock, while a thick covering will protect the stone underneath. This relation applies only to the waste due to weathering, and not that due to the stylolite seams or the large fossils, both of which are independent of the weathering or the amount of covering. It applies also to stripping of the same kind of material, as a heavy thickness of soil is not so good a protection from the leaching agents as a much thinner covering of less porous rock that would retard the access of acid-bearing waters. The weathering agencies find ready access through the soil, and the upper surface of the rock is then not only deeply weathered and much corrugated, but the inequalities are all packed full of soil. As a rule, soil covering is more expensive to remove than rock covering.

A ledge in or near the bottom of a valley is more likely to have blue stone than one near the top of the hill. Stone below or close to the drainage level will in most cases be blue, and that above the drainage level will, if not all buff, always have some buff stone, the quantity depending upon the height above the drainage level and the thickness and character of the covering and the texture of the rock itself. The quarries on high ground will then, as a rule, have more buff stone than those on the hillsides or in the bottom of the valley.

The upper surface of the stone is liable to be more corrugated and deeply weathered on a narrow ridge or pointed hill than on a broad flat hill or gentle slope.

Then in selecting an opening, if one desires buff stone in the most favorable locality, let him seek a place where it lies at or near the top of the hill, where at least the greater part of it has a thin rock covering, simply enough to prevent deep corrugation; a heavy rock covering would not only be expensive to remove, but will prevent oxidation and hence have some blue or mixed stone. If the hill is a low one, that is if the valleys are shallow and the slopes gentle, the position is all the more favorable. Many persons seem to think that the desirable condition is to have the stone outcrop at the surface wholly or nearly free from covering, a mistake which many persons have discovered at great loss, after opening a quarry at such a point to find the stone much disintegrated and filled with large, irregular fissures.

A study of all the outcrops in the vicinity and an examination of the nearest quarry openings will often aid greatly in inferring the probable conditions at any locality.

Testing the quarry.—Having made a careful study of the area and selected what appears to be the most desirable location, it is advisable to test the wisdom of the selection in the cheapest manner possible. The points that one wants to know are :

1. The thickness of the bed.
2. How many stylolite (crowfeet) seams.
3. How much blue and how much buff.
4. The texture of the stone, its homeogeneity and coarseness of fossils.
5. How many joint seams and how much the rock has weathered along them.
6. The thickness and character of the overlying material.

Some of these queries can be answered in part by a careful surface examination by one skilled in geology, but a complete answer requires further investigation which may be done by core drilling, or by channeling. It is not wise to go to a great expense such as stripping or channeling over a large area and putting in expensive machinery until an

opening has first been made through the bed, to prove the quality of it, no difference how favorable the surface indications may be.

If the property is in a new locality, the most judicious method would be first to make one or more openings with a core-drill, which may prove the stone worthless from the number of stylolitic (crow-feet) seams, the coarseness of texture or abundance of large fossils, abundance of pyrites or other impurity. If the core shows good stone, the next step would be to channel an opening through the bed. If this shows a sufficient thickness of stone of good quality, with a not too large percentage of waste, a branch railroad may be constructed to the quarry and sufficient machinery put in to run it on the scale desired.

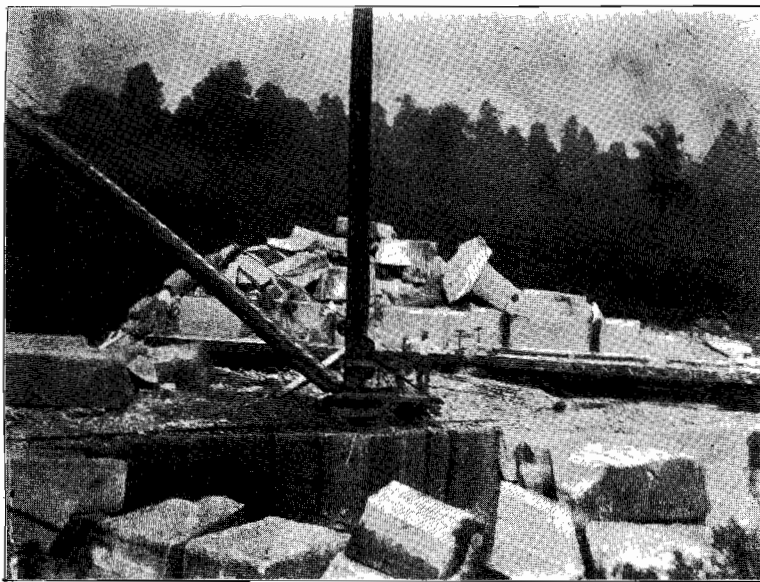
In some instances this procedure has been reversed at a loss to the operators of many thousands of dollars for useless improvements. The preliminary work is of course unnecessary if the quarry is a good one, but experience has demonstrated that a quarry can not be worked profitably at every point in the oölitic limestone, and it is much cheaper to prove the value of a location on a small scale than on a large one.

Method of working the quarry.—Having found an extensive body of good stone and made an opening, it then remains to remove the stone in the most economical manner possible. Practically the same method is employed throughout the district and one description applies to all the quarries with but slight variation of detail. First, channels are cut across the quarry with the channeling machine to a depth varying from six to ten feet, standard sizes being six feet six inches, and ten feet, but the depth may be governed by the size of the blocks desired and sometimes by a seam or change in color. The channels are sometimes cut both ways, that is, two sets at right angles to each other, but frequently if the face is not more than 30 or 40 feet long, the channels are only run in one direction, and a single cut channeled across each end, so that the stone is free on all sides but the bottom. The channels are usually run parallel or at right angles to the open clay seams. The cuts may be at varying distances apart, but are frequently the width of the channeling machine so that two channels may be cut at once. Sometimes the track is moved half its width and another channel cut between, the width depending generally on the sized block wanted to fill the orders. The first block is wedged or broken loose in the best way possible, frequently broken in the process, after the first block is removed the process is simple and rarely any loss. Unless the quarry has one side open, as on the face of a bluff, it is advisable to keep a central opening lower than the main floor so that the dust from the chisels may be washed from channel cuts during the process of channeling by running water.

After the stone is channeled free on all sides, a series of holes a few inches in depth is drilled along the bottom and plugs and feathers or simple wedges are inserted and driven in by the workmen striking them



1. Hoosier quarry. Upper surface of the limestone after removal of the soil, showing also method of channeling on the side hill to get a level floor.



2. Consolidated Stone Co., Quarry No. 1. Scabbling the stone on the car.

CHANNELING AND SCABBLING.

successively until the strain becomes sufficient to crack or split the stone free from the bed. A grappling hook is then attached to the derrick rope and hooked to the top of the loosened block by means of which it is thrown over on its side. If it is a long block, too large to handle, it is then marked off in the size of blocks desired, and along these lines a row of shallow holes is put in with a steam drill, and by driving in wedges the stone is readily split along the desired line. This is a quicker and cheaper process than the cross-channeling. The block is then lifted by the steam-power derrick and placed on the railway car where, if the stone is to be shipped to distant points before working, it is scabbled (that is, has all the bumps and projections trimmed off with the scabbling tool, a heavy sharp-pointed pick) into regular rectangular blocks, mill blocks (see plate XXII), or else the car is run to the mill and the rough blocks sawed to the desired dimensions.

There is practically very little work done by hand in the quarries that can be done by machinery. The loading of the spalls and waste into the dirt boxes and the scabbling is about all that is done by hand in the quarry. The stripping is sometimes done by hand. If the covering consists of soil or dirt, it is removed as far as possible by dirt or road scrapers, but where the upper surface of the stone is much corrugated or weathered unevenly it can only be removed by hand. The most burdensome work that is done by hand is the scabbling or squaring the blocks. It seems strange that pneumatic power should not be used for this. Pneumatic tools for scabbling and carving are used to considerable extent in some localities, and one would think that they could be used to advantage here where there is so much of the work to be done.

The only place that blasting is used is in removing rock stripping, which is generally done in the winter season. It seems a little strange that the Knox blasting has not been used, as the stone could be removed in that way often with less expense. It is fortunate for the credit of the stone that it has not been used, and it is to be hoped that it will not be.

Machinery used.—The machinery in a fully equipped quarry and mill consists of steam channelers, steam drills, derricks, hoists, steam or electric travelers, saw gangs and appliances, planers, jointers or headers, lathes and, perhaps, a rock crusher, with a cost of many thousand dollars. The *channelers* or channeling machines are small locomotives that carry a gang of steel chisels on one side of the engine—single channeler—or a gang of chisels on each side—double channeler—and move back and forth on a movable track of their own, striking with these chisels as they go, thus deepening the channel at each trip. There are two types of channelers, one in which the chisels are attached to the end of the piston and the force of the steam is transmitted directly to the rock. In the other type, which might be called the gravity machine, the drills are attached to a lever which is raised by an eccentric attachment and the blow is given by the

weight of the chisels as they drop on the stone, to be again lifted for another blow. The Ingersoll and Sullivan channelers belong to the first

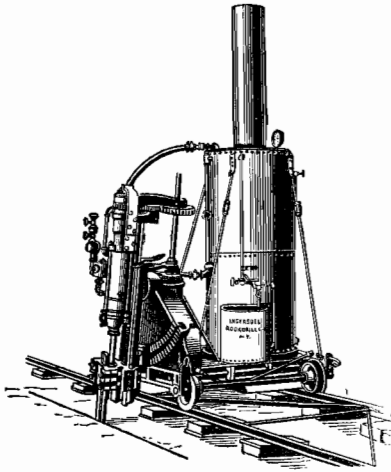


Fig. 5. The direct-acting steam channeler in operation.

or direct-acting class, the Wardwell and the Bryant to the second class. The Wardwell is the oldest machine, the first one having been constructed by George J. Wardwell in 1863. It is simpler, cheaper and more easily managed than the direct-acting machines, which, combined with the fact that it is older and better known, is probably the reason why more of them are used in this locality than of the direct-acting machine, which cuts faster and closer to the wall than the other, but costs more and is not so simple in operation. The Bryan channeler belongs to the Wardwell type of machines, one of the distinctions being that the chisels are at the rear end in the Bryan and the forward end in the Wardwell.

The accompanying figure shows the Ingersoll channeler. The Wardwell and others are shown in several of the illustrations. (See plates XXII, XXXII and XXXIII.)

The steam drill most commonly used throughout the area is the Ingersoll "Baby Drill," see Fig. 6. Although electric and compressed air drills are used in considerable numbers elsewhere, so far as known to the writer none are used in the oölitic region. Compressed air is said to be used for driving the drills and for other purposes at the large limestone quarries of the Casparis Stone Company at Kenneth, in the north part of the State; by A. B. Keepport & Co., Logansport, and in some of the cement quarries in the southern part of the State. It is a power that seems to be growing in favor, and we expect to see it soon introduced into the oölitic stone quarries. Hand drilling is rarely resorted to, except in small local quarries.

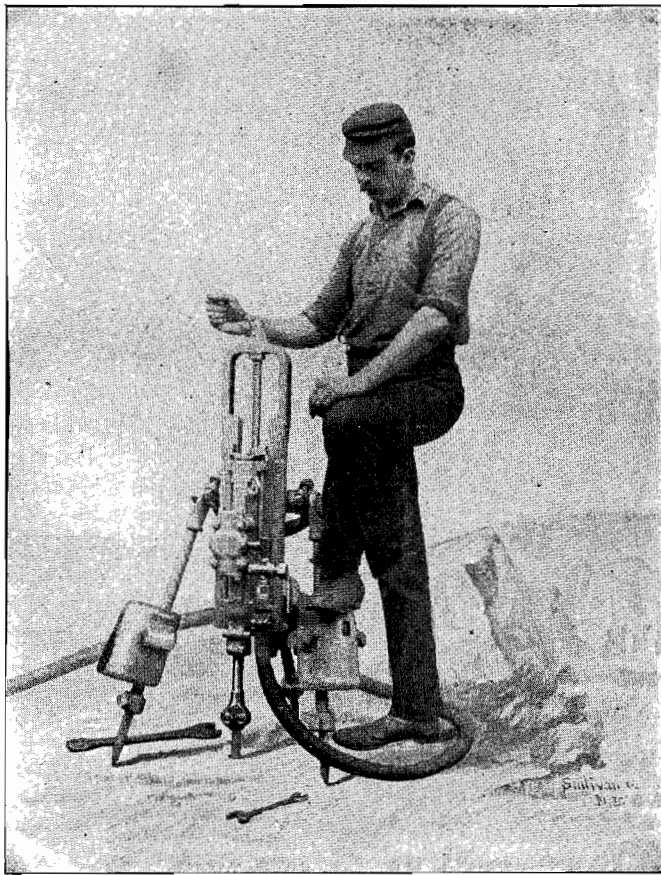


Fig. 6. Steam drill in operation.

Derricks and hoists.—Nearly all the stone is handled by large, heavy capacity, steam-power derricks. The boom-lifting derricks are used almost universally. They are built large and strong, with rarely less than nine guy ropes of galvanized iron cable and 20 to 30 tons capacity. Where properly located they have a reach over a circle 200 feet or more in diameter. Frequently two or three or more derricks are operated by one duplex steam hoist centrally located and operated by one man, which appears to be a saving of both men and power over the plan of having a separate hoist for each derrick. The working parts of a complete derrick are all illustrated in the accompanying figures.

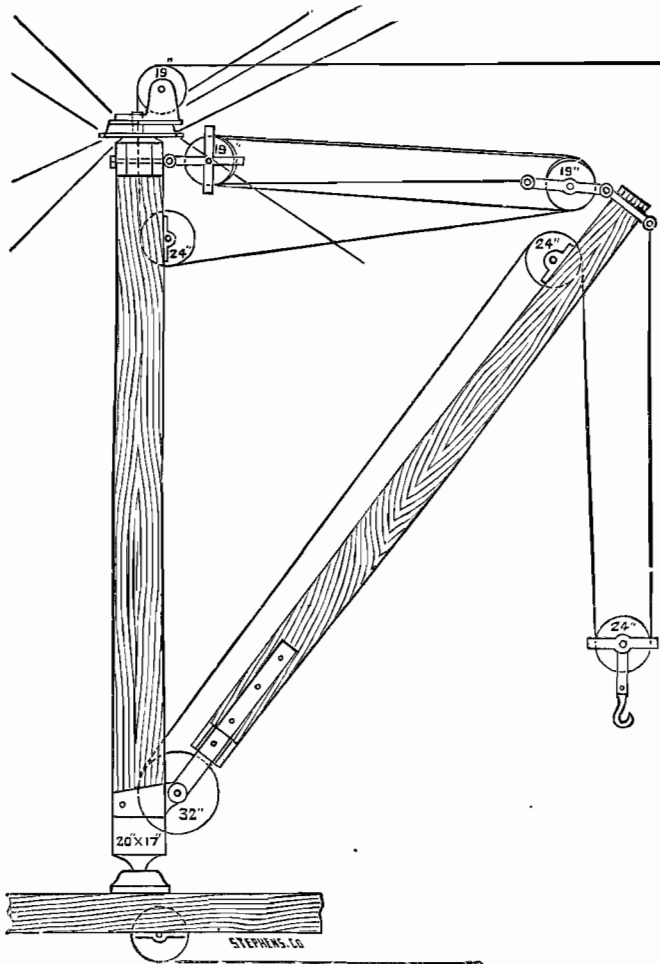


Fig. 7. Sectional view of a boom-lifting derrick, showing the working parts.

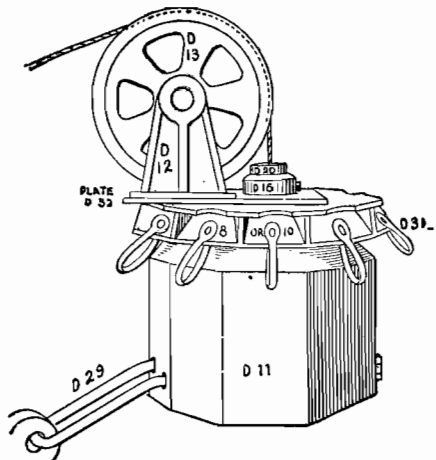


Fig. 8. Top of derrick ready for the guy ropes.

Fig. 7 shows the derrick complete, the rope at the top being the boom rope, or the rope for lifting the boom, that at the bottom the hoisting rope, which lifts the load, independent of the boom. Fig. 8 shows the top of the derrick in detail, ready for the guy ropes. Fig. 9 shows a power hoist of 25 to 30 tons capacity, with all the parts in view. It is arranged with two speeds, both fast and slow. Many of the derricks, especially

in the larger quarries, are fitted with a patent derrick turner, the details of which are shown in Fig. 10. Usually it requires a force of several men to turn the derrick, and where the lift is from a deep hole it necessitates a double crew or a waiting for the men to clamber from

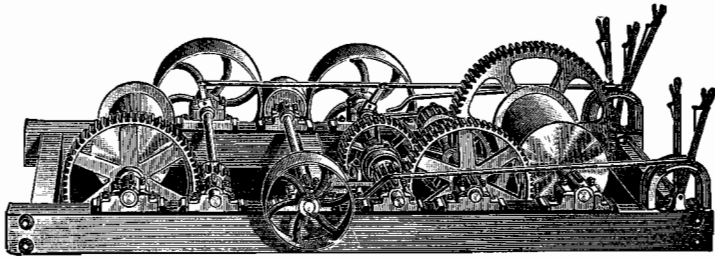


Fig. 9. The New Albany power hoist, with fast and slow speeds.

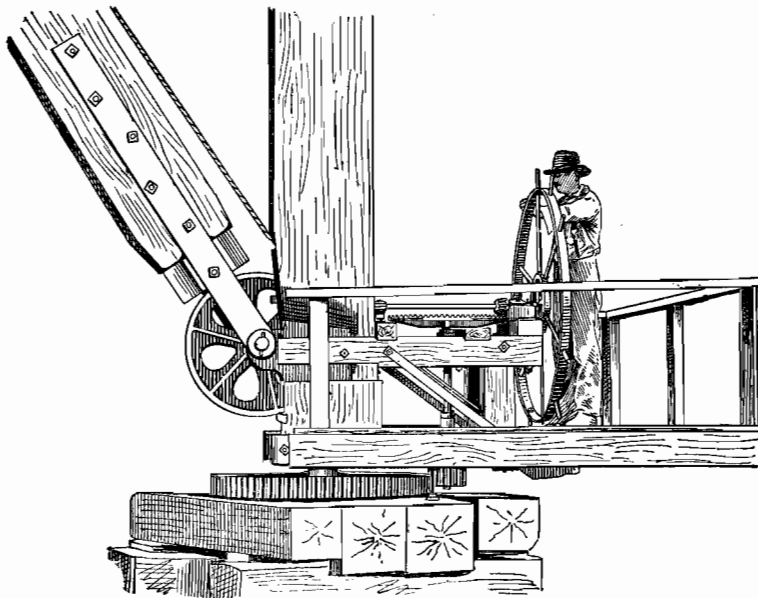


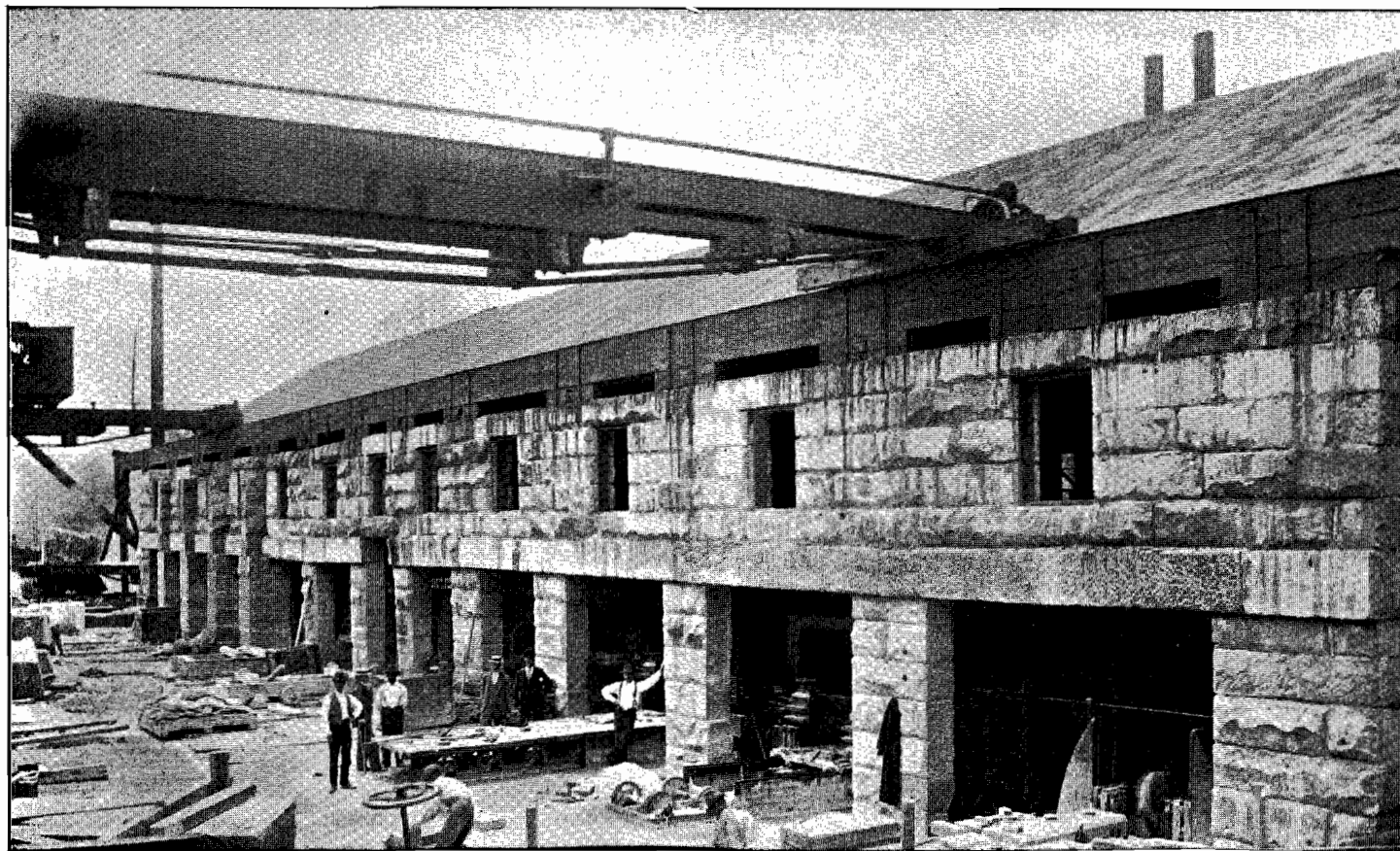
Fig. 10. The New Albany (Lermond) derrick turner, showing method of operation.

the quarry and return. With the patent turner one man shifts the boom to any desired point while the load is being lifted, necessitating no loss of time or extra labor. After seeing one of these turners in operation, one wonders why they are not used on all the derricks.

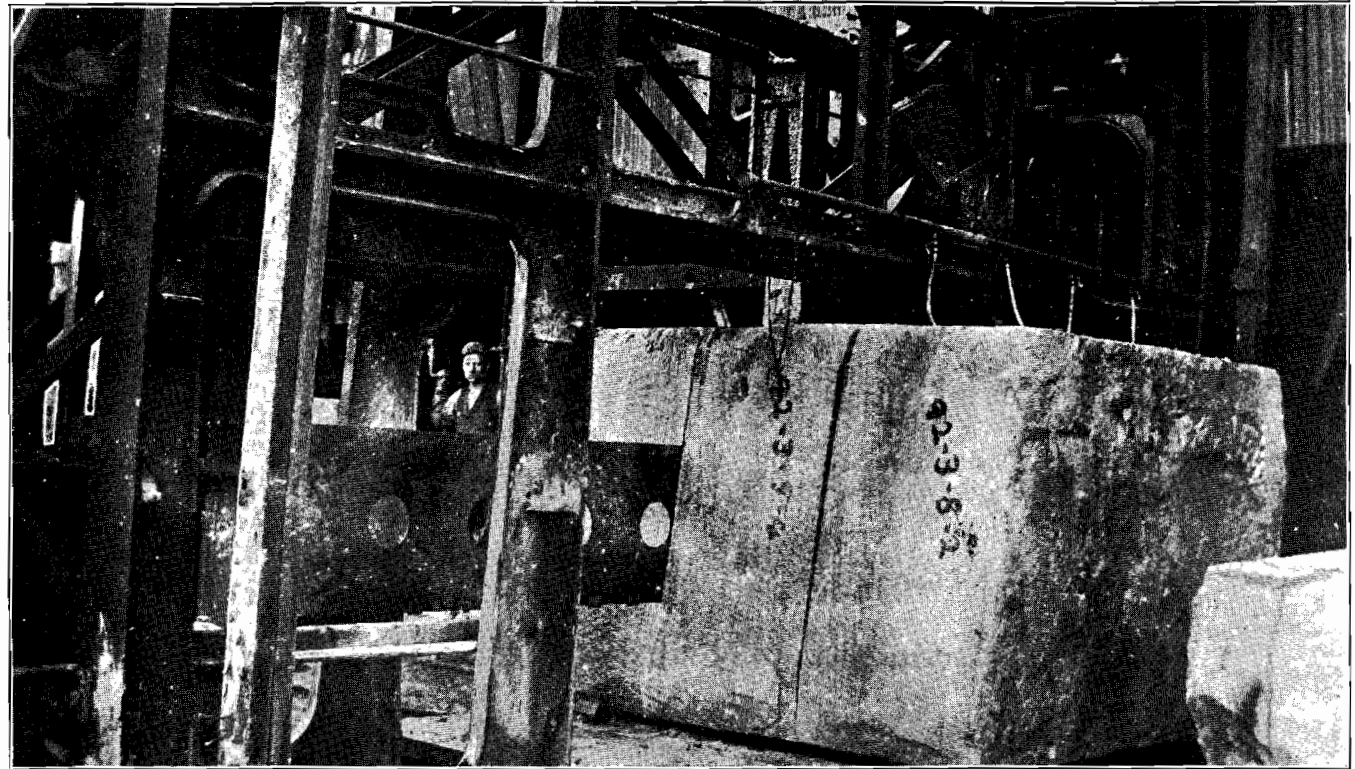
Overhead travelers.—At all the large mills there are overhead travelers running on a high trestlework in front of the mill, having a motion in two directions, parallel to the face of the mill and at right angles to it. These travelers, generally two at each large mill, lift the stone from the railway car and transfer it to the planer or to the saw, and when finished lift it again from the saw to the car or stack it up in the yard. These travelers may be operated by electricity or steam power. The power may be transmitted from the engine in the mill or it may come from a small engine in the car of the traveler.

The overhead wire cableway that is used in the brownstone quarries at Hummelstown, Pa.; at Belleville, N. J., and many other places, and very common in the slate quarries of the east, is not used anywhere in the oölitic region. It is not adapted to use in rectangular or irregular quarries, but might be used with economy in those quarries that have a considerable length of straight face, either along a bluff face or in long, narrow, vertical openings. Their chief advantage over the derrick is where a long, narrow reach, rather than a circular one, is wanted, as in long, deep quarries where the strata dip at high angles and the walls are necessarily sloping, so that a vertical lift is not possible from all parts of the quarry, conditions which do not exist in the oölitic area.

The stone mills are supplied with stone-planers, jointers or headers, turning-lathes and gang-saws, the first two for smoothing the faces by planing off the rough surface and making straight-line moldings; the jointers used for smoothing the surface of the joints in heavy ashlar work; the lathe is the same in principle as the wood or iron lathe used for turning columns. The gang-saw consists of a number of iron blades set in a large frame, generally a tubular iron framework, but sometimes wood, which is given a to-and-fro motion by an eccentric connection with the engines, one power sufficing for 8 or 12 gangs, the framework feeding down automatically. The block of stone to be sawed is placed under the gang of saws, sand and water are supplied on the top of the block, the gang set in motion, and it cuts its way down through the block without any further attention than to keep it supplied with sand and water. This may be done automatically by the sand pump, or the water alone may be allowed to trickle from pipes supplied from a higher reservoir, while the sand is supplied by a workman with a shovel. One man can attend to a number of gangs. So far as observed throughout the region sand is the only abrasive used. Chilled shot, crushed steel and other abrasives frequently used elsewhere are not used here. Chilled shot has been tried several times by different parties, but they claim that even if the stone is well washed with hose, still small particles of the steel will become imbedded in the stone, which, when stacked in the yard, rust and discolor large patches.



STONE SAWING AND PLANING MILL AT HOOSIER QUARRY, SHOWING MILL, PLANERS, TRAVELERS AND YARD.



DIAMOND SAW IN THE MILL OF THE ROMONA OOLITIC STONE COMPANY.

The diamond saw.—The Romona Oölitic Stone Company, in their mill at Romona, Ind., have a large diamond saw, consisting of a heavy steel blade about 12 feet long and 12 inches deep, perforated with a number of holes. The lower edge is set with steel blocks about an inch square and a little thicker than the blade. In the lower edge of the steel blocks are a number of black diamonds that do the cutting. No sand or other abrasive is used with this saw, the cutting being done by the teeth. Water is used as with the gang saw. Plate XXIV gives a view of the diamond saw with the mechanism as far as can be shown on a photograph.

It is a very costly piece of machinery and expensive to keep in operation, owing to wear and loss of the diamonds. It cuts at the rate of about 30 inches per hour, while the ordinary gang saw cuts from three to four inches per hour. It makes a smoother surface than the gang saw, but it is liable to bow and make a curved surface, owing to the diamonds wearing more on one side than on the other. The chief value of the saw is for trimming or squaring large blocks a foot or more in thickness. For slabs ten inches or less the band saw is thought to be as cheap, and for slabs three or four inches thick the band saw is probably cheaper, on account of the greater number of cuts made at one time.

The wire saw or cable channeler.—In the quarry of the Hallowell Stone Co. in Dark Hollow, near Bedford, the wire saw is used for cutting stone from the quarry. This system has been used extensively in Europe, especially in Belgium, it is said, with success, but so far as known to the writer, it has not been used in this country, except in the Vermont marble quarries, where it is said to have been tried and abandoned, and this one in the Dark Hollow quarries. The company refuses to say anything about it, and it is not known whether or not there is any saving over the channeling process. From what could be learned in a visit to the quarry, it did not appear to be a decided improvement, although with a few changes that could easily be made, it might be used economically in the large quarries, along with the channelers, using each in that part of the quarry where it is best adapted.

It consists of an endless three-strand wire about one-quarter inch in diameter, kept in motion by a steam engine and directed by pulleys across the rock where it is desired to make the cut. The cutting is done with sand, as with the band saws, the sand and water being fed on the wire from sand boxes. At either end of the cut the wire rope passes over movable pulleys that feed downward as the wire cuts its way into the rock. The surface cut in this way is generally smoother than the channel face, but it is not always regular, as the cut tends to bow or curve in places where there is any inequality in the stone. The wire runs at a speed of about 1,600 feet per minute, making one revolution in a minute. The wire costs $\frac{7}{8}$ cents per foot, and one wire, 1,600 feet in length, it is

said, will make two cuts 30 feet long and 10 feet deep, before it is worn out. The chief defect appears to be the loss of time from the unexpected breaking of the wires.

The core drill.—A very important piece of machinery in exploring a new area is the core drill, or *diamond* drill, but the two terms will probably soon cease to be synonymous. The diamond core drill, as commonly used, consists of a heavy steel ring, the lower edge of which is set with black diamonds. This is screwed on the end of a piece of iron pipe and revolved rapidly by the drill power, which may be hand, horse, steam, electricity or compressed air. As used in the oölitic stone district, steam power is the most common.

Mr. Harbaugh, of Bloomington, states that he dispenses with the diamond drill bit and simply uses gas pipe alone by putting in some chilled shot at the bottom, which does the cutting. He says it drills as rapidly as the diamond drill and is much less expensive, as in case of accident there is no loss but the gas pipe. A core four inches in diameter is the one commonly made, sometimes a smaller one where it is desired to ship by express. A four-inch core not only shows more of the stone, but gives sufficient material for tests of any kind. The cost is the same for a four-inch core as for a smaller one, the common rate in 1896 being \$1 to \$2.35 per foot, depending upon the amount to be done. The maximum rate of cutting is ten inches per minute or 65 feet per day. The average is about 15 feet per day.

Uses and adaptability of the oölitic limestone.—The bulk of the entire output of all the quarries is used for building stone, for facings, trimmings, ornamentations or foundations. There is a considerable quantity used for monuments, headstones and bases for headstones. One company ships the waste to Chicago for use as flux in the iron furnaces. Another has crushed large quantities of the stone and used it for ballasting the Belt Railroad, now one of the best ballasted roads in the State. The ballast has been carried out a foot or so beyond the end of the ties, and the top layer is of finely ground stone, which has hardened, giving a clean, dustless, solid roadbed. Small quantities of the quarry waste have been used at different places within the last year or two for broken stone for the wagon roads. At several places kilns have been erected for burning lime, but all appear to have fallen into disuse except those at Salem and one at Romona. There is an old abandoned kiln in Bloomington near the old University building, one at Ellettsville, two southwest of Bedford and three south of Bedford along the Monon Railway. The kiln at Romona is said to have burned considerable lime, but was not in operation in July, 1896; later in the fall it was again in operation. The kilns at Salem are the most extensive in the oölitic district, there being five kilns which are said to have been in operation for

many years. Three of the kilns were idle in July, 1896, whether temporarily or not is not known. The company refused to give any information regarding the lime product. Hence no figures are available in regard to the quantity of lime burnt, the prices or the uses. Wood, coal and oil have all been tried for fuel. In the summer of 1896 they were using wood.

To see the great quantity of waste rock on the dump piles about the quarries one wonders why more of it is not burnt into lime, and no satisfaction could be obtained to that query when put to the quarrymen. One said it did not make good lime. Another that the lime was too hot, and some had not thought of it, did not know it had ever been tried, or would make lime at all. One only needs to look at the table of analyses on page 320 to see that it would make a fat or rich lime, but that should not be a serious objection, as for many purposes a rich lime is preferred to any other. The reason that more of it has not been burnt may be due to a number of causes: 1. Freight rates, the cost of bringing in the coal and shipping the lime. 2. A prejudice in the local markets against rich lime. 3. Want of a large market, as they are situated in the midst of the Mississippi Valley, with large deposits of limestone on all sides. 4. The lack of some enterprising person to push the business into prominence, as all the stone dealers are interested in the sale of building stone and not lime. The last is probably the most important reason.

The oölitic limestone is best adapted to building purposes, and the bulk of it will always be used for such. It ranks among the best building stones because of the extensive deposit, the ease with which it can be quarried and worked into shape, combined with its great durability and light color. These combine to adapt it to all classes of building, whether rock face, sawed, or tool-dressed face work, plain trimmings, highly carved work, foundations, bridge piers, the heaviest or the most delicate masonry. There is probably not another stone in the markets so well adapted to carved work and so suitable for ornamental cut stone, where richness of color is not essential. It can never rank with the finer marbles, serpentines, etc., where rich coloring is desirable or for purely ornamental purposes, but for decorative carving on the fronts or exterior of buildings, or in larger monumental work it is peculiarly fitted. Probably the stone which most nearly approaches it in this property is the Caen stone from France, which is a softer stone and can be cut or carved more easily, but it is much lighter, more porous and will not stand the rigors of a cold climate like the Bedford stone.

Some of the accompanying illustrations (Plate XXV, and Figs. 11 and 12*) show its adaptability to carving for monumental purposes. Large

*The cuts for Figs. 11 and 12 were kindly furnished by Mr. John Naugle, Salem, Ind.



Fig. 11.—Carved from a small single piece of Bedford oolitic limestone, showing its adaptability to carved work.

quantities have been used in this way, both locally and throughout the United States. It may be seen in nearly all the stone and marble yards in Pennsylvania, New York and New Jersey, as well as those throughout the Mississippi Valley States. In the cemeteries at Bedford, Salem and Bloomington, Indiana, there are a great many monuments of handsomely carved work, one of the largest and handsomest being the stonecutters' monument in the new cemetery at Bedford.

The stone has also been used for rustic gateways, hitching posts, rustic chairs, lawn settees and stone animals, and for decorative fireplaces.

It is to be hoped that it will have a more extended use on the wagon roads of the region in which it occurs. While it is not an ideal stone for macadam, it is the best in the region where it occurs, because it is most abundant and most accessible. The waste of the quarries is admirably suited to this purpose, and it could easily be distributed along the railroads, and thus made readily accessible to most of the wagon roads. It could be crushed in a large crusher at the quarry and distributed as crushed



EXECUTED IN A SINGLE BLOCK OF BEDFORD OOLITIC LIMESTONE, SHOWING ADAPTABILITY TO CARVING.

stone, or shipped out in the rough blocks as it comes from the quarry, and crushed by a portable crusher moved from place to place.



Fig. 12.—Carved from Bedford oölitic limestone, showing its adaptability to fine carving.

The stone makes an excellent bottom for roads, but not the best top dressing, as it grinds to powder under the wheels too readily, makes a light dust and a blinding glare on a bright, sunny day. One is strongly

impressed with this blinding strain on the eyes in traveling through Monroe or Lawrence Counties by the great feeling of relief experienced by the eyes when he turns from the white stone road to the yellow-brown dirt roads, especially on a hot summer day. There is a partial compensation for this white glare by the greater ease with which the road can be followed at night.

It can be improved by a thin top dressing of gravel where it can be obtained, or of the geodic quartz so abundant through the region, crushed fine. The top dressing should be thin enough to permit some of the underlying limestone material to work up through it where it will act as a cement and will in the course of time form a hard, smooth surface. A thin coating of siliceous gravel will be found to be profitable, even though it should be necessary to ship it from another part of the State.

The oölitic stone in sawed slabs makes good curbing and flagging. It is sufficiently hard to stand the wear of foot traffic and its granular texture prevents its wearing smooth and becoming slippery in wet weather as marble or compact limestone will do. As the stone is easily sawn into regular slabs, it makes a more even, regular pavement than the natural flagstone, and a more comfortable one to walk over.

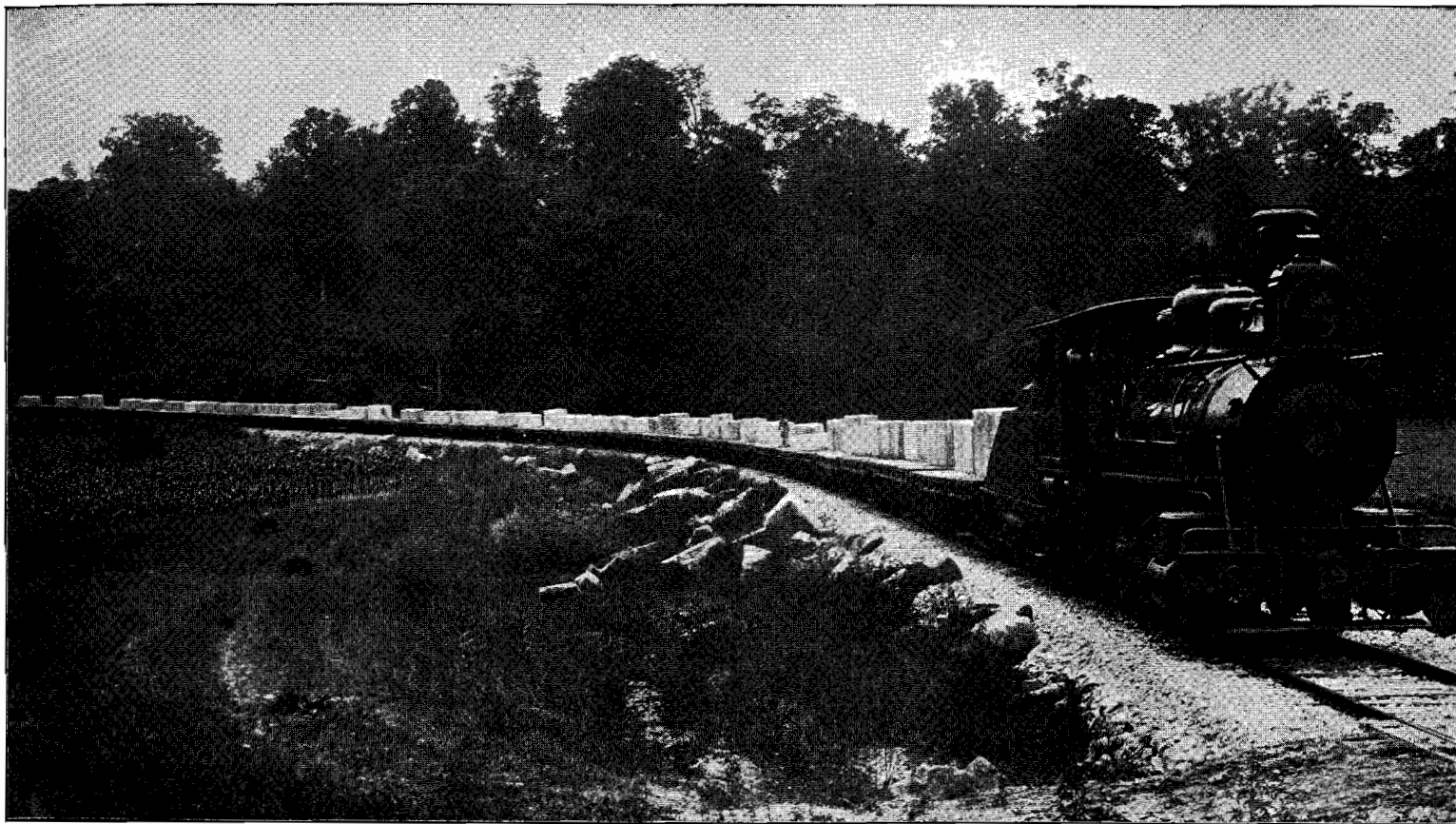
See Appendix B, at the end of this paper, for list of buildings constructed of Bedford oölitic limestone.

*Transportation facilities.**—Closely identified with, and a potent factor in, the development of the oölitic stone industry are the railways. The New Albany & Salem Railroad (now L., N. A. & C. Ry.), was extended to Bedford in 1852, and through Monroe County in 1854. This road, of course, has been the great means of introducing the Bedford oölitic limestone to the trade. Through Washington, Lawrence and Monroe counties, during the construction of the road, many quarries were opened adjacent to the point where the stone was needed. But when the road was extended still farther toward Chicago, the superficial covering of glacial drift was so deep that exposures of stone were few and far between. The company's quarry, located near the water tank, two miles south of Stinesville, furnished stone for the heavy masonry for the northern division of the line. This road, through its branches, reaches all but ten of the active quarries in the belt.

In 1870 the Indianapolis & Vincennes Railway was built through Owen County, opening up several quarries in the Romona district.

In 1876 the Bedford & Bloomfield (narrow gauge) Railroad (now Bloomfield Branch, L., N. A. & C. Ry.), was built. This road opened the productive Dark Hollow, Reed Station and Buff Ridge districts. In 1895 the road was changed to standard gauge, which has still further increased its usefulness.

*The data for the greater part of the remainder of this chapter was furnished by Mr. Siebenthal.



STONE TRAIN ON THE BELT RAILWAY LADEN WITH SCABBLED BLOCKS OF OOLITIC LIMESTONE.
Railway track ballasted with oolitic limestone waste from the quarries.

The Ohio & Mississippi (now B. & O. S. W.) Railway, built a branch from Riverdale on White River to the Tanyard Creek quarries in 1890, which was soon afterward extended to Bedford.

The Bedford Belt Railway was built in 1892-3 by the Bedford Quarry Company. When that company was succeeded by the Bedford Quarries Company, the Belt was organized as a separate property under the title Bedford Belt Railway Company. It has connection with many of the larger quarries and with all the railways entering Bedford, and has contributed in no little degree to the development of the stone interests of Lawrence County.

COST OF TRANSPORTATION.

Freight rates per 100 pounds of Oölitic Limestone from Bedford, Ind., to

Chicago	11 cents.	Detroit.....	12 cents.
St. Louis	10 cents.	Milwaukee	12½ cents.
Kansas City	21 cents.	Pittsburgh.....	18 cents.
Louisville	5 cents.	Philadelphia	26 cents.
Cincinnati.....	6 cents.	New York.....	28 cents.
Cleveland	15 cents.	Boston	30 cents.
New Orleans.....	21 cents.	Buffalo.....	18 cents.
Atlanta	21 cents.	Chattanooga	19 cents.

*Prices of oölitic limestone.**—Before 1877 no channelers were in use in the oölitic belt, and as a consequence the stone coming from the quarries just as it was blasted out was marketed in very rough blocks, unless scabbled to special dimensions. About 1866, James Needham, operating the Salem quarries, sold rough quarry or mill blocks at 25 cents per cubic foot, f. o. b. at quarry. At the same time the Ellettsville quarries were selling at 35 cents per cubic foot for similar blocks and 45 cents per cubic foot for scabbled blocks in small dimensions. Scabbled blocks of large or unusual dimensions ranged up to \$1 per cubic foot. The stone which went into the Illinois State House was billed at \$1.

For sawed ashlar (sawed on two sides) the price was from 60 cents to 80 cents, and for stone sawed on four sides, 90 cents to \$1.10. These prices prevailed up to 1872-3.

In 1873 the Marion County court-house was constructed at 30 cents per cubic foot for mill blocks f. o. b. at quarry, and this price prevailed without much variation up to 1877.

In 1878 the Indiana State Capitol was contracted at 25 cents per cubic foot.

In 1881 the prices were: Mill blocks, 25 cents per cubic foot; scabbled dimension stone, 30 to 35 cents; sawed, two sides, 55 cents; four sides, 75 cents.

*The data concerning prices was furnished by Mr. Siebenthal through the kindness of Maj. Perry, of Bloomington.

By 1891 prices had gradually declined *pari passu* with improved quarry methods and machinery until mill blocks were worth 20 cents, dimension blocks 25 to 30 cents; sawed, two sides, 35 cents; four sides, 50 cents.

These prices by general agreement were maintained until October, 1895, since which time each quarry has fixed its own prices.

Prices to-day are: Mill blocks, 11 to 20 cents; dimension blocks, 20 to 25 cents; sawed, two sides, 28 to 35 cents; four sides, 43 to 50 cents.

The Indiana Oolitic Stone Association was organized March 5, 1895, for the advancement of the mutual interests of the oolitic limestone quarrymen, and, among other things, to establish a uniform scale of prices. The association continued in existence about a year, but in October, 1895, by the withdrawal of several of the larger firms, the established scale of prices was demolished, as noted above.

The Indiana oolitic quarrymen generally have been members of the Ohio Valley Quarrymen's Association, The Chicago Quarryman's and Cut Stone Contractors' Association. The latter association has held prices up in Chicago, and a similar organization in New York city has held prices up there also.

STATISTICS OF THE BEDFORD OOLITIC LIMESTONE PRODUCTION IN INDIANA FOR THE YEARS 1895 AND 1896.

Number.	ITEM.				TOTAL.
		Northern district— Romona, Big Creek, Stinesville, Ellettsville.	Middle district— Bloomington, Hunter Valley, Sanders.	Southern district— Bedford, Dark Hollow, Reed's Station, Oolitic, Peerless, Paradise, Heltonville, Salem.		Mills in Indianapolis.
1	Cubic feet of stone produced in 1895	1,295,000	1,812,716	3,030,591	6,138,307
2	Cubic feet of stone produced in 1896	673,000	1,343,926	3,438,656	5,455,582
3	Value of stone produced in 1895	\$311,875	\$420,487	\$771,468	\$1,523,260
4	Value of stone produced in 1896	\$165,697	\$294,635	\$725,883	\$1,209,632
5	Capital invested in 1896	\$497,700	\$458,400	\$1,337,000	\$2,319,600
6	Number of men employed in 1895	473	424	825	1,784
7	Number of men employed in 1896	315	374	787	1,536
8	Number of quarries in operation recently	12	15	21	48
9	Number of channeling machines in operation	19	39	78 ¹	136
10	Number of channeling machines idle	11	7	11	29
11	Number of steam drills in operation	15	15	44	74
12	Number of steam drills idle	4	3	5	12
13	Number of derricks in operation	24	29	49	103
14	Number of derricks idle	6	3	8	17
15	Number of derrick turners in use	3	10	24	37
16	Number of planers and jointers	6	3	16	29
17	Number of saw gangs in operation	32 ²	32	68	143
18	Number of saw gangs idle	9		9	18
19	Number of steam and electric travelers	4	3	12	20
20	Number of latbes in operation	4		6	10
21	Number of limekilns in recent operation	1		5	6
22	Number of abandoned limekilns	2	2	5	9

¹And one wire saw or cable. ²And one diamond saw.

STATISTICS OF OÖLITIC LIMESTONE QUARRIES.*

LOCATION.	Total wages paid.	Number of men employed.	Number of boys employed.	Highest wages paid skilled labor.	Lowest wages paid skilled labor.	Highest wages paid unskilled labor.	Lowest wages paid unskilled labor.	Average daily wages paid boys.	Number of hours cons. a day's work.
Bedford	\$267,159	846	41	\$2 79	\$1 90	\$1 58	\$1 22	\$0 91	10
Bloomington	41,451	116	4	2 40	1 68	1 38	1 10	1 00	10
Sanders	19,371	103	2	2 25	1 65	1 50	1 25	75	10
Ellettsville	26,164	75		2 75	1 35	1 32	1 00		10
Stinesville	53,425	132	3	2 00	2 00	1 50	1 12	75	10
Romona	35,750	159	3	2 35	2 00	1 53	1 30	75	10
Total	\$443,320	1,431	55	...	...	...	...	...	...

*From Indiana Bureau of Statistics, Bulletin No. 7.

Statements showing location of stone quarries, capital invested, value of stone quarried, men employed :*

Location.	No. of quarries.	No. of acres in quarries.	Value buildings and grounds.	Kind of stone.	Principal use of stone.	Number of cars quarried.	Total value.	Av. No. months in operation.
Bedford	11	1,710	\$1,370,800	Buff. blue, brown oölitic limestone	Buildings	10,513	\$694,012	9.4
Bloomington	5	223	111,000	" "	Building, monuments, etc	2,185	68,700	8.6
Sanders	3	185	220,000	" "	" "	740	37,200	8.3
Ellettsville	2	80	75,000	" "	" "	738	81,568	10
Stinesville	4	357	208,000	" "	" "	1,712	140,410	10.5
Romona	3	122	158,000	" "	" "	1,127	89,060	8.6
Total	28	2,677	\$2,142,800	.....	.....	17,013	\$1,110,950	..

*The Indiana Bureau of Statistics, 1896, Bulletin No. 7.

Machinery in use in the oölitic limestone quarries in 1891 :*

Steam channelers	78
Steam drills	54
Saw gangs	57
Derricks	74
Overhead travelers	12

*Compiled from 17th Annual Report State Geologist of Indiana.

List of the Bedford Oolitic Limestone Quarries, giving the name of the quarry, the location, the date opened, the years operated and the companies operating the same.

ROMONA DISTRICT.

Eagle Quarry	10 N, 3 W, sec. 3, N E	1875	"Eagle Stone Works," Rockwell & Co., Romona, Ind.
Lilly Quarry	10 N, 3 W, sec. 3, S E	1890-1897	Oolite Quarry Co., Indianapolis, Ind.
Kersler Quarry	10 N, 3 W, sec. 3, S E	1874-1885	Gospport Stone and Lime Co., Romona, Ind.
		1885-1897	Romona Oolitic Stone Co., Indianapolis, Ind.
Bienert Quarry	10 N, 3 W, sec. 10, N W	1870-1896	White River Stone and Lime Co., Simpson & Archer, Spencer.
		1896-1897	Keever Stone Co., Columbus, O.
Bladen Quarry	10 N, 3 W, sec. 10, S W	1876 (?)	E. R. Bladen, Romona, Ind.
Railroad Quarry	10 N, 3 W, sec. 10, S W	1870	I. & V. Ry. Co., _____
State House Quarry	10 N, 3 W, sec. 22, N E N W	1878-1879	Kannamaker & Denig, Indianapolis, Ind.

STINESVILLE DISTRICT.

North Bedford Quarry	10 N, 2 W, sec. 17, S E N W	1889-1897	North Bedford Stone Co. (In receiver's hands.)
Big Creek Quarry	10 N, 2 W, sec. 17, N W S W	1854-1868	Biddle, Watts & Co., Pittsburgh, Pa.
		1869-1895	Big Creek Stone Co., Stinesville.
		1895-1897	Indiana Steam Stone Works, Bloomington.
Old Terre Haute Quarry	10 N, 2 W, sec. 17, S W S E	1880-188(?)	Corner & Davis, Stinesville, Ind.
		188(?) -1892	Terre Haute Stone Works, Terre Haute, Ind (Lyne & Chadwick).
		1892-1897	Oolite Quarry Co., Indianapolis, Ind.
Walden Quarry	10 N, 2 W, sec. 17, N W S E	1880	Wickliff Walden, Stinesville, Ind.
John McHenry Quarry	10 N, 2 W, sec. 17, S E S W	1880	John McHenry, Stinesville, Ind.
Griswold Quarry	10 N, 2 W, sec. 20, N W N E	1880-1890	Chas. Eppinghausen, Stinesville, Ind.
		1890-1897	Indiana Oolitic Limestone Co., Chicago, Ill.
Malone & Pickel Quarry	10 N, 2 W, sec. 20, S W N E	1889-1895	Stinesville and Bloomington Stone Co., Stinesville.
		1895-1897	Stinesville Stone Co., Chicago.
Ellettsville Quarry	10 N, 2 W, sec. 20, S W N E	1891-1897	Ellettsville Stone Co., Ellettsville, Ind.
Terre Haute Quarry	10 N, 2 W, sec. 21, N E N W	188(?) -1892	Terre Haute Stone Works, Terre Haute, Ind.
		1892-1897	Oolite Quarry Co., Indianapolis, Ind.
Railroad Quarry	10 N, 2 W, sec. 20, S E S E	1853-1856	New Albany & Salem Railroad.

List of the Bedford Oolitic Limestone Quarries—Continued.

ELLETTSVILLE DISTRICT.

Preacher's Quarry	10 N, 2 W, sec. 28, N W S W	1872-1875	Cornelius, Ellettsville, Ind.
Matthews' Lower Quarry	10 N, 2 W, sec. 28, N W S E	1872-1875	John Matthews & Sons, Ellettsville, Ind.
Kelley's Quarry	10 N, 2 W, sec. 28, S W S E	1872-1875	C. F. Kelly & Perry Bros., Ellettsville, Ind.
Kostenbader's Quarry	9 N, 2 W, sec. 3, N E N W	1864-1875	John Kostenbader & Co., Ellettsville, Ind.
Perry's Old Quarry	9 N, 2 W, sec. 3, S E N W	1866-187(?)	Perry Bros., Bloomington, Ind.
Matthews' Upper Quarry	9 N, 2 W, sec. 3, N E S W	1862-1897	Matthews Bros., Ellettsville, Ind.
Hight Quarry	9 N, 2 W, sec. 3, S E S W	1869-187(?)	Sharp & Hight, Ellettsville, Ind.
		187(?) - 1897	Matthews Bros., Ellettsville, Ind.
Perry's New Quarry	9 N, 2 W, sec. 3, S W S E	187(?) - 1895	G. K. Perry, Bloomington, Ind.
Perry's No. 3 Quarry	9 N, 2 W, sec. 3, S E S E	1896-1897	G. K. Perry, Bloomington, Ind.

HUNTER VALLEY DISTRICT.

Hunter Quarry (Consolidated No. 2)	9 N, 1 W, sec. 30, S W N E & N W S E	1890-1896	Morton C. Hunter Stone Co., Bloomington, Ind.
		1896-1897	Consolidated Stone Co., Chicago.
Johnson Quarry	9 N, 1 W, sec. 30, N E	1892-1897	Chicago & Bloomington Stone Co., Bloomington, Ind.
Norton Quarry (Consolidated No. 1)	9 N, 1 W, sec. 30, N E S E	1892-1895	Norton Stone Co., Bloomington, Ind.
		1895-1897	Consolidated Stone Co., Chicago.
Crescent Quarry	9 N, 1 W, sec. 29, N W S W	1893-1897	Perry, Matthews & Perry, Bloomington, Ind.
Star Quarry	9 N, 1 W, sec. 29, N W N W	1895-1897	Star Stone Co., Bloomington, Ind.
Hunter Bros.' Quarry	9 N, 1 W, sec. 30, N E N E	1895-1897	Hunter Bros.' Stone Co., Bloomington, Ind.
Hunter Valley Quarry	9 N, 1 W, sec. 29, S W N W	1895-1897	Hunter Valley Stone Co., Bloomington, Ind.

BLOOMINGTON DISTRICT.

Bloomington Oolitic Stone Co. Quarry	City of Bloomington	1889-1895	Bloomington Oolitic Stone Co., Bloomington, Ind.
		1895-1897	Henley Stone Co., Bloomington, Ind.
Central Quarry	City of Bloomington	1891-1897	Central Oolitic Stone Co., Bloomington, Ind.

SANDERS DISTRICT.

Reed's Oolitic Quarry	8 N, 1 W, sec. 33, N W S E	1888-1897	Oolitic Stone Co., of Indiana, Bedford, Ind.
Adams' Quarry	8 N, 1 W, sec. 33, N E S W	1889-1897	Monroe County Oolitic Stone Co., Bloomington, Ind.
Reed's Bedford Quarry	8 N, 1 W, sec. 33, N E S E	1891-1897	Bedford Quarry Co., Bedford, Ind.
Empire Quarry	8 N, 1 W, sec. 33, S E N W	1892-1897	Empire Stone Co., Bloomington, Ind.
Tomlinson Quarry	8 N, 1 W, sec. 33, S E S E	1892-1897	John Tomlinson & Son, Chicago.
B. & B. Quarry	8 N, 1 W, sec. 28, S E S W	1893-1896	Bloomington-Bedford Stone Co., Chicago.
		1896-1897	Acme-Bedford Stone Co., Chicago.
Mathers' Quarry	8 N, 1 W, sec. 33, N E N E	1895-1896	Mathers Stone Co., Bloomington, Ind.
		1896-1897	Henry Woollery, Bloomington, Ind.

CLEAR CREEK DISTRICT.

Cleveland Quarry	7 N, 1 W, sec. 20, S E N W	1886-1886	R. F. McKinley, et al., Bedford, Ind.
		1886-1897	Cleveland Stone Co., Cleveland, Ohio.
Buff and Blue Oolitic Stone Co.	Bloomington		Have no quarries in operation, but own much land
Crafton Stone Co.	Bloomington		along Clear Creek valley.

PEERLESS DISTRICT.

Peerless Quarry	6 N, 1 W, sec. 26, S E N W	1890-1897	Peerless Stone Co., Bedford, Ind.
Thornton Quarry	6 N, 1 W, sec. 34, N E N E	1895-1897	Bedford Steam Stone Works, Bedford, Ind.

BUFF RIDGE DISTRICT.

P. M. & B Quarry	6 N, 1 W, sec. 33, S W N E	1889-1897	Perry, Matthews & Buskirk, Bedford, Ind.
Hoosier No. 2 Quarry	6 N, 1 W, sec. 33, S E N E	1885-1892	Hoosier Stone Co., Bedford, Ind.
		1892-1894	Bedford Stone Quarries Co., Bedford, Ind.
		1894-1897	Bedford Quarries Co., Chicago, Ill.
Buff Ridge Quarry	6 N, 1 W, sec. 33, N W S E	1891-1892	Hoosier Stone Co., Bedford, Ind.
		1892-1894	Bedford Stone Quarries Co., Bedford, Ind.
		1894-1897	Bedford Quarries Co., Chicago, Ill.
Oolitic Quarry	6 N, 1 W, sec. 32, S E S E	1885-1892	Bedford Oolitic Stone Co., Bedford, Ind.
		1892-1894	Bedford Stone Quarries Co., Bedford, Ind.
		1894-1897	Bedford Quarries Co., Chicago, Ill.

List of the Bedford Oolitic Limestone Quarries—Continued.

BUFF RIDGE DISTRICT—Continued.

Brickyard Quarry	6 N, 1 W, sec. 33, S W S W	1884(?)—1887(?) 1887—1892 . . . Bedford Oolitic Stone Co., Bedford, Ind. 1892—1894 . . . Bedford Stone Quarries Co., Bedford, Ind. 1894—1897 . . . Bedford Quarries Co., Chicago, Ill.
Hoosier Quarry.	6 N, 1 W, sec. 33, S W	1883—1892 . . . Hoosier Stone Co., Bedford, Ind. 1892—1894 . . . Bedford Stone Quarries Co., Bedford, Ind. 1894—1897 . . . Bedford Quarries Co., Chicago, Ill.
Reed's Quarry	5 N, 1 W, sec. 5, N E	1882—1897 . . . Bedford Quarry Co., Bedford, Ind.
Bedford, Indiana, Quarry	5 N, 1 W, sec. 5, S E N E	1885—1891 . . . Crim, Duncan & Co., Bedford, Ind. 1891—1892 . . . Indiana Stone Co., Bedford, Ind. 1892—1894 . . . Bedford Stone Co., Bedford, Ind. 1894—1897 . . . Bedford Indiana Stone Co., Indianapolis, Ind.

DARK HOLLOW DISTRICT.

Dark Hollow Quarry.	5 N, 1 W, sec. 8, N W N E	1878—1890 . . . Dark Hollow Stone Co., Bedford, Ind. 1890—1894 . . . Dark Hollow Quarry Co., Bedford, Ind. 1894—1897 . . . Consolidated Stone Co., Chicago, Ill.
Consolidated Quarry No. 4.	5 N, 1 W, sec. 5, S W S E	1895—1897 . . . Consolidated Stone Co., Chicago, Ill.
Consolidated Quarry No. 5.	5 N, 1 W, sec. 5, N W S W	1896—1897 . . . Consolidated Stone Co., Chicago, Ill.
Hallowell Quarry	5 N, 1 W, sec. 5, S E S W	1878—1882 . . . Hinsdale-Doyle Granite Co., Chicago, Ill. 1882—1897 . . . Hallowell Stone Co., New York.
Thornton Quarry.	5 N, 1 W, sec. 5, N E S W	1886—1893 . . . Bedford Steam Stone Works, Bedford, Ind.
Baalbec Quarry	5 N, 1 W, sec. 9, S E	1879(?) . . . Wilson, Dunn & Co., Bedford, Ind. 1890—1894 . . . Operated by Acme-Bedford Stone Co., Chicago, Ill.

SPIDER CREEK DISTRICT.

Gowan or Limekiln Quarry	5 N, 1 W, sec. 28, N E N E	1891—1897 . . . Bedford Building Stone Co., Bedford, Ind.
C. S. Norton Quarry	5 N, 1 W, sec. 22, N W N E	1888—1895 . . . Cosner & Norton, Bedford, Ind. 1895—1897 . . . C. S. Norton Blue Stone Co., Bedford, Ind.
West Bedford Quarry	5 N, 1 W, sec. 22, N E N E	1892—1897 . . . West Bedford Stone Co., Bedford, Ind.

BEDFORD AND VICINITY.

Standard Quarry	5 N, 1 W, sec. 11, S W N W	1893-1897 . . .	Standard Stone Co., Bedford, Ind.
Salem-Bedford Quarry	5 N, 1 W, sec. 12, S W N W	1892-1897 . . .	Salem-Bedford Stone Co., Louisville, Ky.
Brown Quarry	5 N, 1 W, sec. 12, N E S W	1890-1897 . . .	Podenschatz-Bedford Stone Co., Chicago.
Blue Hole Quarry	5 N, 1 W, sec. 13, S E S W	185(?) - 1878 . . .	Nathan Hall & Davis Harrison, Bedford, Ind.
		1878-188(?) . . .	Hinsdale Doyle Granite Co.
		188(?) - 1897 . . .	Chicago & Bedford Stone Co., Bedford, Ind.
Benzels Quarry	5 N, 1 W, sec. 24, N E N W	1890-1897 . . .	Bedford Blue Stone Co., Chicago.
Glover's Quarry	5 N, 1 W, sec. 23, S E S W	185(?) - . . .	John Glover, Bedford, Ind.
Johnson Quarry	5 N, 1 W, sec. 23, N E S W . . . . .	. . . - 187(?) . . .	D. Johnson, Bedford, Ind.
Coats Quarry	5 N, 1 W, sec. 23, S W S W . . . . .	. . . - 187(?) . . .	
Heltonville Quarry	6 N, 1 E, sec. 25, S E of N W	1890-1897 . . .	Heltonville Oolitic Stone Co., Evansville, Ind.
Mitchell Hollow Quarry	5 N, 1 E, sec. 30, S W S W	1890-1892 . . .	Tanyard Stone Co., Bedford, Ind.
		1892-1893 . . .	Bedford Stone Co., Bedford, Ind.
Tanyard Quarry	5 N, 1 E, sec. 31, S W	1890-1892 . . .	Tanyard Creek Stone Co., Chicago.
		1892-1895 . . .	White River Stone Co., Chicago.
		1895-1897 . . .	Bedford Sterling Stone Co., Chicago.

ROCK LICK DISTRICT.

Big Four Quarry	4 N, 1 E, sec. 30, S E N W	1889-1889 . . .	Big Four Stone Co., Mitchell, Ind.
Leeds, Chanler & Storrs Quarry	4 N, 1 E, sec. 30, S W N E	1890-1890 . . .	Leeds, Chanler & Storrs, Chicago.

SALEM.

Salem Quarry			Salem-Bedford Stone Co., Louisville, Ky.
Twin Creek Quarry			Twin Creek Stone and Land Co.

INDIANAPOLIS.

The following have mills only:

J. C. Schmid & Sons, 329 Bates Street. Uses stone from the Peerless, the P., M. & B. and G. K. Perry's quarries.
 G. Illenbach & Co., 150 Harrison Street.
 Klink & Matthews, Kentucky Avenue and White River. Stone from the P., M. & B. quarry.

The records show that many other companies were incorporated in the years 1890 and 1891, which exist only in name, which have no holdings of real estate, yet which have kept up their organization. Some of these were *bona fide* companies intending to do a quarry business, but headed off by the business depression; others were for speculative purposes pure and simple; still others were organized to take advantage of a lax law governing the incorporation of companies, and to preempt, or copyright, as it were, certain felicitous combinations of the words "Bedford" and "Oölitic" limestone.

Among these were the *Bedford Limestone Co.*, *Auditorium Bedford Stone Co.*, *United States Stone Co.*, *Bedford Stone Co.*, *Central Bedford Stone Co.*, *Indiana Limestone Co.*, *Bedford Stone Mill Co.*, and *Union Stone Co.* Of these the *United States Stone Co.* owns lands lying three-quarters of a mile northeast of the Bodenschatz and Salem-Bedford quarries, and expects to open a quarry next season. The *Bedford Stone Mill Co.* above must not be confounded with the *Bedford Stone Mill Co.* which was organized in 1895, and which operates the fine new mill near the crossing of the L., N. A. & C. Ry. and E. & R. Ry.

CHAPTER III.

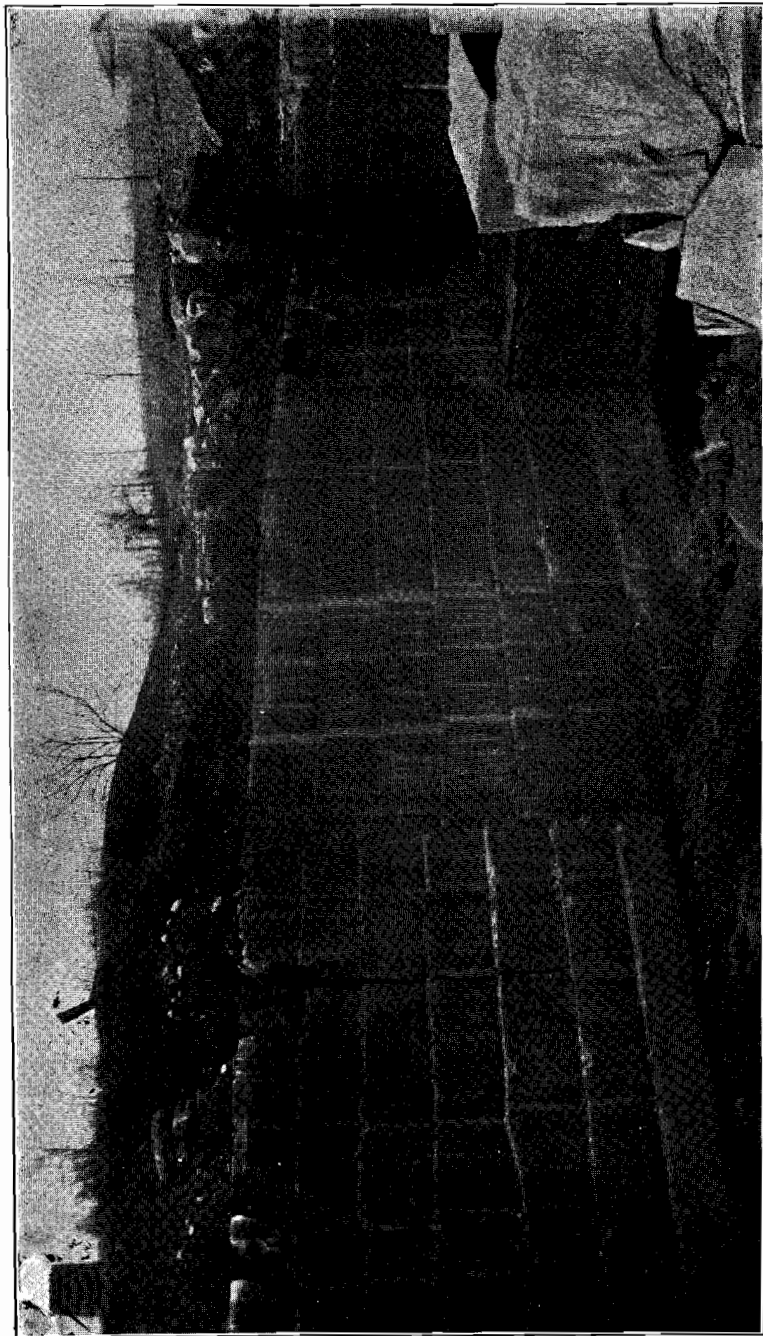
LOCAL FEATURES OF THE BEDFORD OÖLITIC LIMESTONE AND DESCRIPTION OF THE QUARRIES.*

T. C. H. AND C. E. S.

ROMONA AND VICINITY.

The quarries at Romona are the most northern ones in the oölitic stone belt, occurring near the northern limit of the oölite, as shown on the accompanying map. Romona is on the north branch of the White River, on the Indianapolis & Vincennes division of the Pennsylvania Railroad. There is one quarry operating extensively, another on a smaller scale, and several abandoned ones.

*Mr. Siebenthal is responsible for the historical part of this chapter, Mr. Hopkins for the descriptive part.



SOUTH FACE OF ROMONA OOLITIC STONE COMPANY'S QUARRY.

The Romona Oölitic Stone Co.'s quarry.—The quarry belonging to the

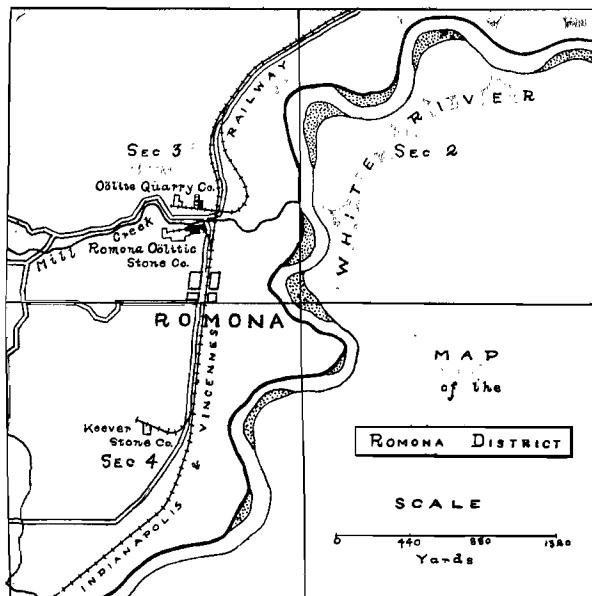


Fig. 13.—Showing location of the Romona quarries.

Romona Oölitic Stone Company was opened by the Gosport Stone and Lime Company about 1868, and has been operated by the present company since 1885. It works a greater thickness of stone than any other quarry in the oölitic region, having nine channel cuts, not less than 60 feet of sound stone exclusive of the stripping.

The stripping varies from zero at one end to 30 or 40 feet at the other, and consists of soil six to eight feet, a hard, semi-oölitic, stylolitic limestone 20 to 25 feet and a compact argillaceous limestone three to five feet. The upper 40 feet of the quarry are buff and the bottom 20 feet blue; but, as in other quarries, the line between the blue and buff is not regular, the blue increasing in thickness toward the west where the covering is thicker. The blue stone is said to be underlain by a few feet of hard, gray, siliceous limestone, underlain in turn by a light cream colored fossiliferous limestone, as shown in a drilling in the bottom of the quarry.

The stone is coarser grained than most of the stone in the Bloomington-Bedford region, also more crystalline and less oölitic. It is about the same in hardness and ease of working as the finer grained, but from the fact of its coarse grain it is not so much sought after for building stone, and a larger proportion of it is used for bridge work and heavy masonry.

There are a few east-west joint seams but no cross (north-south) seams were observed. In some places, as may be seen on the accompanying illustration, the rock has weathered along these seams, forming considerable openings. Fortunately there are not many such, so that the waste from this cause is not great. There are numerous bedding seams in the hard rock overlying the oölitic, but in the quarry rock only two stylolite

(crowfeet) seams were observed, and these were near the bottom. The stone is cross-grained in a few places, the cross-grain dipping north in nearly all cases.

CHEMICAL ANALYSIS OF THE ROMONA OÖLITIC LIMESTONE.*

	Per Cent.
Lime (CaO)	54.82
Lime carbonate (CaCO ₃)	97.90
Magnesia (MgO).....	.31
Magnesia carbonate (MgCO ₃).....	.65
Ferric oxide and alumina .....	.18
Carbon dioxide (CO ₂)	43.49
Insoluble residue (SiO ₂ , etc.)	1.26
Total	100.06
Specific gravity.....	2.48

Sample for analysis dried at 135 C.

CRUSHING TESTS OF ROMONA OÖLITIC LIMESTONE.†

- No. 1. 6,800 pounds per square inch broke with 2 good pyramids.
 - No. 2. 6,400 pounds per square inch broke with 2 good pyramids.
 - No. 3. 7,800 pounds per square inch broke with 2 good pyramids.
 - No. 4. 11,200 pounds per square inch broke with 2 good pyramids.
- Absorption 1-39 or 2.59 per cent.

No. 4 was said to be on edge, which is commonly supposed to be a much weaker position for the stone. The probable reason for its greater strength is that it was quarried in 1895 and hence much better seasoned than the other specimens, which were quarried in 1896, but a few months or weeks before they were tested.

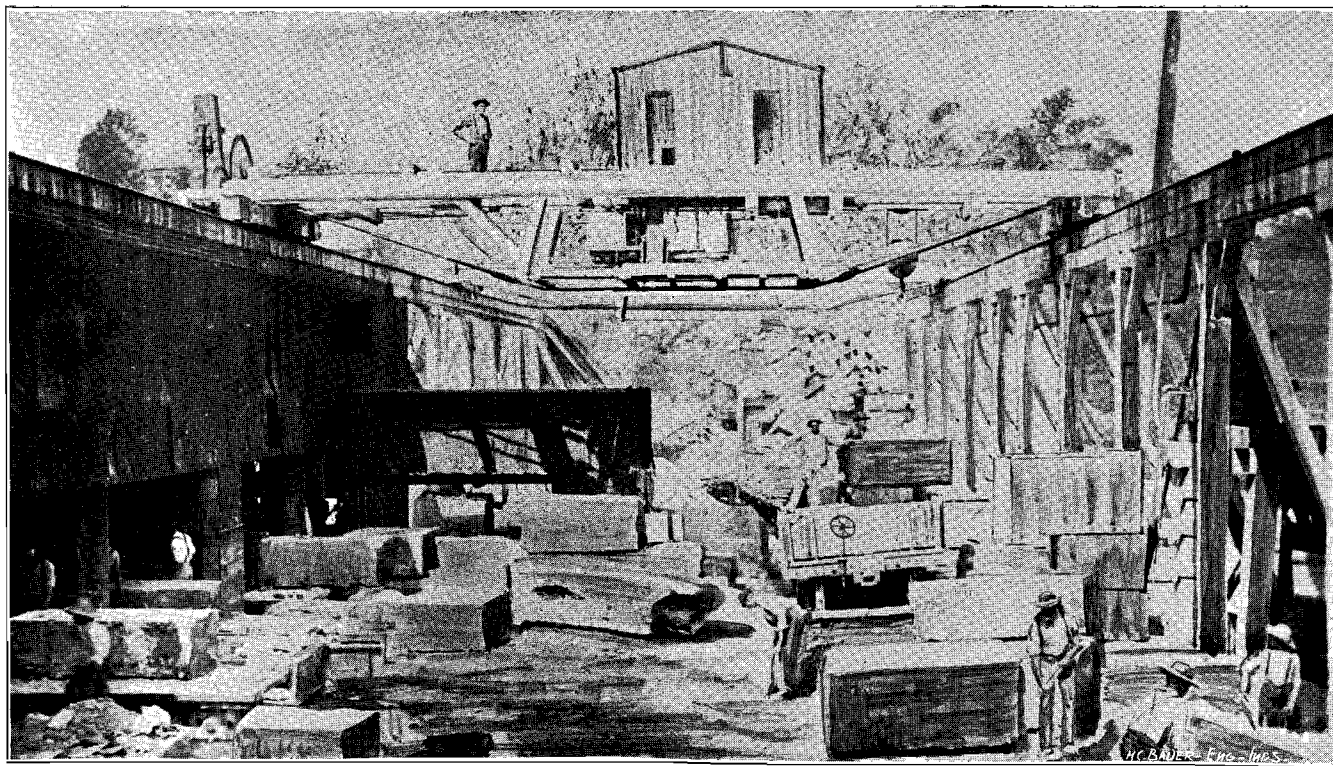
The quarry is close to the Indianapolis & Vincennes Railroad and has a branch from the quarry and the mill to that road. The quarry is well equipped with channelers, steam drills, derricks, steam hoists and a well-furnished mill. The mill contains saw-gangs, planers, jointers and diamond saw for cutting and working the stone, and two overhead travelers for handling it. There are also a large number of stonecutters at work finishing the stone by hand.

The accompanying illustrations, Plate XXVII and Fig. 14, represent different parts of the Romona quarry, showing the thickness of the stone, the amount of stripping and the vertical weather seams.

The diamond saw used here is the only one in the oölitic region. It is said to cut at the rate of about 33 inches per hour, sometimes as high as 40 and sometimes as low as 20 inches, while the ordinary band-saw cuts at the rate of three or four inches per hour. It leaves a smooth and more regular surface, but the saw is liable to bow and make a curved

* Made by Prof. W. A. Noyes, Rose Polytechnic Institute, Terre Haute.

† Made by Prof. M. A. Howe, Terre Haute.



PORTION OF THE MILL, YARD AND TRAVELERS OF THE ROMONA OOLITIC STONE COMPANY.

surface. Its chief advantage over the common band-saw is in trimming or dressing blocks; where the stone is to be sawed in slabs, ten inches or less in thickness, the band-saw is used.

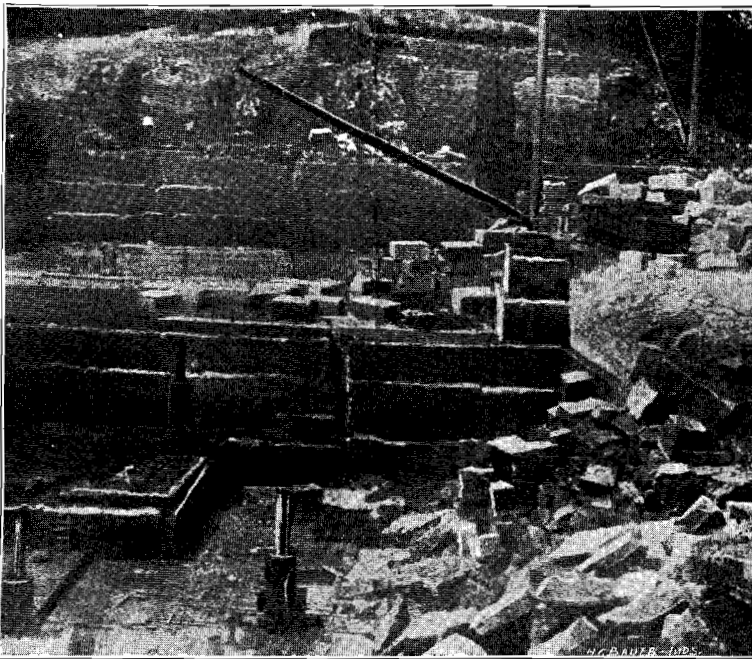


Fig. 14.—Center view looking west in the quarry of the Romona Oölitic Stone Company Romona, Ind.

The company states that for cutting into slabs less than 10 inches thick the band-saw is possibly a little cheaper, but where the stone is cut a foot or more in thickness the diamond saw is cheaper, hence the advantage of having one in a large mill along with the gang-saws. The machine is very expensive, and the expense in keeping it running is in replacing the teeth that wear out and drop out. By close watch and occasional turning, the teeth may be made to do good work longer than they otherwise would. It would seem that the chief advantage of a saw of this kind is in cutting or trimming large slabs or blocks, and that the work could be more economically done in a large mill by having one for this use, while the slabbing is done by band-saws.

In a Connecticut mill, where a similar saw is used, it is called a stone-cutter, in distinction from the band-saw or slabber. It leaves a surface nearly as smooth as a sand-rubbed face.

The stone from this quarry is nearly all used for bridges and heavy masonry, a comparatively small percentage of it being used in buildings.

As it does not have quite so fine a texture, it will not take such fine carving nor give as smooth a surface as the finer grained stone. It makes as strong and durable a stone as the other, and when the fashion changes will look as well in rock face or tooled surface for building purposes. It would look well in combination with the finer grained stone, by using the coarser grained for facing and the finer for trimming.

The Lilly quarry.—The Lilly quarry, which lies just across the narrow valley about 250 yards northeast of the Romona quarry, was opened by the Oölitic Quarry Company in 1890 and the mill was added in 1892. It has not been in operation during the past year, but the mill and most of the machinery remain, and it may be again operated on the revival of business.

It has switch connection with the Indianapolis & Vincennes Railroad, over which the stone has been shipped. The quarry is less favorably located than the Romona quarry, across the hollow. It is much lower than the railroad, which crosses the valley on a high trestle, and the company has been at the expense of constructing a long branch running through under the railroad and making switch connection with the road about a quarter of a mile further east on the south side.

The thickness of workable stone is less and the stripping greater than in the other quarry. The present quarry face shows (1) a thickness of nearly 10 feet of sand and soil, partly glacial deposit; (2) eight to ten feet of hard, compact, thinly stratified, shelly limestone; (3) 15 to 18 feet of light colored hard oölitic limestone, with numerous toe-nail seams, some on each channel cut; evidently the greater part if not all of this part of the bed has been waste material; (4) five or six feet of compact argillaceous limestone; (5) 20 to 30 feet of oölitic stone, the commercial part of the bed. There is a conspicuous stylolitic seam at the top of the oölitic stone, separating it from the overlying argillaceous limestone. There was only one horizontal seam observed in the face of the quarry stone, and that is an open seam near the middle of the face. There are very few vertical seams, and these not running to any great depth, so that there is very little waste in the quarry bed itself, the expense being in the heavy stripping.

The stone does not differ greatly in texture from that in the Romona quarry, being comparatively uniform, coarse grained, crystalline and fossiliferous. Both buff and blue stone occur, there being apparently a greater proportion of the blue to the buff than in the Romona quarry. The cross grain nearly all dips to the north. The product for 1894 is said to have been used for curbing and bridge piers, and bridge work altogether in 1895.

The Bienert quarry.—The Bienert quarry, which is a half mile or more southwest of the Romona station and a hundred yards west of the railway (the Indianapolis & Vincennes Railroad), with which it has switch

connection, was opened by the White River Stone and Lime Company (Simpson & Archer) in 1870. A limekiln was erected and both lime and dimension stone were furnished for a number of years; a rock crusher was added later, but the business has not flourished for several years, and was sold last year (1896) at Sheriff's sale to the Keever Stone Company, of Columbus, O., who have begun active operations.

The limekiln was not in operation in the early part of the year, but was later in the summer.

With a good quality of dimension stone, and the limekiln and rock crusher to use all the waste stone and stripping, the business ought to be profitable.

The crushed stone has been used partly for railway ballast and partly for pikes and is said to have been shipped in considerable quantities. If this crushed stone and lime have paid for their removal it has been a profitable undertaking, as the top stone has by this means been removed over an area of an acre or more, leaving the oölitic stone bare for channeling. Dimension stone has been removed from part of the area, having been channeled three cuts deep about 21 feet. There is a stylolitic (toe-nail) seam through the upper cut, the other two being free from such seams. There are a very few vertical seams.

This part of the stone that has been quarried appears to correspond to the overlying stone in the upper Romona quarries that has been thrown in the waste almost entirely there. If this is the case the bed corresponding to the quarry bed at the upper quarry has not been touched yet at the Bienert quarry. A workman at the quarry stated that a core-drill had been put down, showing three feet of "soapstone," the argillaceous limestone and 25 or 30 feet of good oölitic stone below the bottom of the present quarry floor. If this be the case, there is certainly a large quantity of stone here that can be removed very cheaply.

The Keystone quarry.—Along the I. & V. R. R., about midway between Gosport and Romona, is an old quarry that is said to have been abandoned about six years ago, and is known as the Keystone Quarry. The stone is not oölitic and appears to underlie the oölitic stone, as farther down the railway the oölitic stone is observed with a southwest dip which, if continuous, would bring it some distance above the horizon of the stone in the Keystone Quarry. It is not known to the writer for what the stone was used or how many years the quarry was operated.

The Old State House quarry.—About two and a half miles east of Spencer, on the Denkwalter place, is an old quarry known as the State House Quarry, as it furnished a considerable part of the stone for the State House in Indianapolis; most of the basement story of the State House is said to have come from this quarry. When the quarry was in operation there was a branch railway to the I. & V. R. R. on the north side of White River. An ice jam one spring, about 12 years ago, tore

away the bridge crossing White River and it was not rebuilt (it is said to have been built temporarily to remove the machinery), and the quarry was abandoned.

The quarry is on the south side of a small creek from the southeast. The opening covers an area of about 25 x 50 yards, 35 to 40 feet deep, having in some places six channel cuts, in some places only two. The bottom of the quarry is covered with water so that the character of the stone is not discernible. Above the water there are four stylolite (toe-nail) seams. There are several joint seams running east and west, but no north-south ones were observed.

The stone in many respects resembles that in the Romona quarries, but is more cross-grained and quite hard on the exposed surface. Much of the stone is conspicuously cross-grained, the false bedding dipping west 25° at the bottom of the quarry and east at the top of the quarry. All the exposed faces are much darker than the fresh stone, but none of the quarry faces are disintegrating.

There is a layer of compact, smooth-grained limestone overlying the oölitic limestone having a maximum thickness of about 10 feet, overlain in turn by one to two feet of soil.

There are some bold outcrops of the oölitic stone along the creek at and near the quarry, some perpendicular and overhanging bluffs 30 to 40 feet high; the stone in some places massive, in some places stratified, frequently shelly and exfoliating for a few feet above the water.

While there is much good stone at this locality, there would necessarily be much waste in quarrying it, and the present prices of stone and the active competition there is in the trade would not justify the expenditure necessary to rebuild the bridge across the White River.

STINESVILLE—BIG CREEK DISTRICT.

Oölitic limestone has been quarried in varying quantities at Stinesville and vicinity for many years. There are different quarries in the vicinity, but only two were in active operation during the year 1896, and one of them closed late in the summer.

The stone in nearly all the quarries is of good quality, and large quantities of first-class building stone have been shipped from this vicinity; but in nearly all the openings the stone has weathered deeply, causing much waste in the quarries. The exceedingly low price of stone and the active competition in the trade have placed these quarries at a disadvantage with others having less waste and a greater thickness of stone. Many of the quarries that are now idle will, no doubt, reopen when the stone trade revives, as the stone is of good quality when selected with care.

Probably the first to open a quarry in the neighborhood of Stinesville was Richard

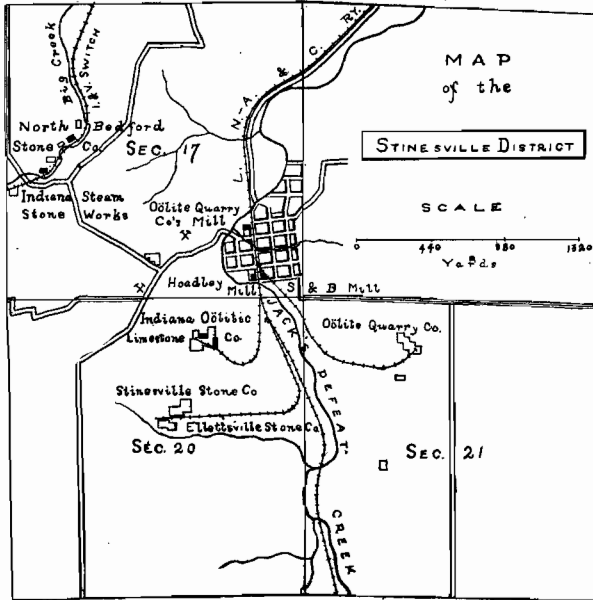


Fig. 15.—Showing the location of the quarries in the vicinity of Stinesville.

ville was Richard Gilbert, who in 1827-8 quarried oölitic stone on the east bluff of Jack's Defeat Creek, about three-quarters of a mile south of that town. Others followed his example and many small openings were made. From such quarries as these came the stone for the piers and abutments of the bridges over White River at Gosport and the

lower bridge over Bean Blossom Creek.

Though enjoying an excellent reputation at home, for many years after the opening of the first quarries the oölitic limestone was comparatively unknown outside the counties in which it occurs.

But with the completion of the New Albany & Salem Railroad (now L., N. A. & C. R. R.), in 1854, the stone assumed commercial importance. On the 31st of December, 1853, Edward M. Watts and William M. Biddle, of Pennsylvania, purchased twenty acres of land on Big Creek about three-quarters of a mile west of Stinesville. On the 26th of June, 1854, they purchased an additional twenty acres adjoining the first purchase. Here, as soon as tools and machinery could be shipped from Pittsburgh, they opened a quarry and prepared to do business on what was then considered a large scale. A substantial steam stone mill of six gangs, rocker-shaft pattern, was erected, and in 1855 they were prepared to furnish both rough and sawed stone to the trade.

The stone was blasted from the ledge in large blocks; these blocks were loaded on heavy wagons, or swung under others which had rear wheels of twelve feet diameter, and hauled by three ox teams to the mill. When cut into the desired dimensions they were loaded on the wagons again and hauled a mile over a rough road to Stinesville to the New Albany & Salem Railroad. The stone was marketed under the

name of White River Stone and enjoyed a good sale, principally in Louisville, New Albany and Jeffersonville. But their methods were crude and the work slow. It is said that a single shot broke off from an overhanging ledge enough rough stone to supply the mill two years. The heavy expense attendant on shipping the stone ate up the profits, so work languished and the quarry was finally abandoned in 1868. Biddle and Watts did not give the business their personal attention, but operations were in charge of John Matthews, an English quarryman, who had lately come from the Dean Marble Quarry, near Madison, Ind., then the most noted quarry in the State. During its later years the Biddle & Watts quarry was in charge of Captain John Love, one of the firm.

The Chicago and Stinesville Stone Company was organized in 1889, but the name was later changed to the Big Creek Stone Company by order of the Court. This company purchased the Captain Love quarry and land, the machinery having been previously sold, and constructed a switch five miles long to the I. & V. R. R., joining it two miles west of Gosport. A steam mill with two saw gangs was erected about 75 yards down the creek from the site of the old Biddle & Watts mill. A good business was done by the new company until August, 1893, when the cancellation of orders, which succeeded the financial panic, forced the company to close down and go into the hands of a receiver. The company was reorganized in February, 1895, under the title, "*Indiana Steam Stone Works.*" The new company made a new opening opposite the site of the old Biddle & Watts quarry. The work of exploitation was carried forward rapidly and quite a large amount of stone was gotten out that year. Very little has been done the current year, but next year the company expect to remodel the mill, put in four new saw-gangs and operate the quarry to its fullest capacity.

The Big Creek quarry is the one farthest south. It contains the lightest colored stone of any observed in the oölitic region. While the fresh stone is light colored, it becomes even lighter on exposure, as there is a marked percentage of organic matter that evaporates on exposure. The stone has a close, uniform texture, except in a few places where the fossils make it irregular. The greatest defect is the stylolite (crowfeet) seams, which are sufficiently abundant to cause a great deal of waste, some of the black points running to a depth of six inches or more. Not only do the points from the seam extend deep, but the seams are not always parallel, sometimes running up or down a foot or more from the general level. The weathered stone at the top is very fossiliferous, and some layers through the body of the rock contain a great many fossils.

The northernmost opening of the Big Creek quarry, the one near the Big Creek mill, shows a heavy bed of stone of good quality but much weathered. Irregular weathered fissures, a foot to three feet wide, have formed along the vertical seams and a few horizontal seams appear near

the base. See figure 2, Plate XXI for view of the face of this quarry. The water in the opening conceals the bottom of the stone, so that the thickness of the bed is not shown. There are six channel cuts extending about 40 feet above the water, which is said to be 16 feet deep, thus giving a total thickness of between 50 and 60 feet. In the bottom layer exposed, the sixth from the top, is a layer of laminated clayey limestone, five or six feet thick. The stone immediately overlying this compact stone is very fossiliferous, containing large brachiopods and cephalopods. The part immediately underlying the clayey layer appears more compact and composed largely of bryozoa.

There are no stylolitic (crowfeet) seams except near the top, where there are two about a foot apart, the greatest waste being along the vertical seams.

Below is given the results of chemical and physical tests made of samples of the stone from Big Creek quarries, furnished by the Indiana Steam Stone Works.

ANALYSIS OF OÖLITIC LIMESTONE FROM BIG CREEK QUARRIES.

Analysis based upon material dried at 100° Centigrade.

	No. 1. Per Cent.	No. 2. Per Cent.
Calcium oxide, CaO	52.53	52.12
Magnesium oxide, MgO.....	2.10	2.21
Ferric oxide, Fe ₂ O ₃	0.64	0.71
Silica, SiO ₂	0.15	0.50
Carbon dioxide, CO ₂	43.49	43.27
Water, alkalis, etc., traces, not determined.....	1.09	1.19
	100.00	100.00

L. A. STREAKER, *Analyst*.
ROBT. E. LYONS.

No. 1 is from the interior of the bed, No. 2 from the upper harder layers. The lime in No. 1 is equivalent to 93.80 per cent., lime carbonate in No. 2 to 93.07 per cent.

CRUSHING TESTS OF OÖLITIC LIMESTONE FROM THE BIG CREEK QUARRIES.

- No. 1. 6,600 lbs. per square inch, broke with two fair pyramids.
- No. 2. 4,100 lbs. per square inch, specimen imperfect, faces not parallel.
- No. 3. 6,200 lbs. per square inch, specimen imperfect, faces not parallel.
- No. 4. 2,800 lbs. per square inch, specimen imperfect, faces not parallel, split off on one side, crushed on edge.

Absorption 1-17 or 5.75 per cent. (For fire tests see page 317.)

The *North Bedford Stone Company* was organized in 1889 and opened a quarry on Big Creek, about a quarter of a mile north of the *Indiana Steam Stone Works*, on the Big Creek branch of the I. & V. R. R. A substantial mill was erected, with five gangs of saws, and a good business was done until the panic of 1893, when the Company went into the hands of a receiver, Hon. Smiley Chambers, of Indianapolis, acting in that capacity.

At the mill of the North Bedford Company is an opening where a small quantity of stone has been removed. The character of the stone is similar to that in the next larger opening north of the mill, except that it has weathered much deeper.

In the opening north of the mill, the most eastern or northern one on Big Creek, the stone is overlain by a heavy bed of glacial material, 21 to 25 feet, the bottom of which consists of a dove-colored clay, containing many pipes of iron ore, the upper part composed of sand and pebbles. The oolitic stone is dark gray and buff to yellow in color, with some cross-bedding. Some layers are fossiliferous, containing large fossils, which, in places, have leached out, giving the stone a cavernous or pitted appearance. The bottom of the opening is concealed by water, and the total thickness of the bed cannot be seen from the opening.

All of the quarries on Big Creek are on a branch from the Indianapolis & Vincennes R. R., which crosses White River and connects with the main line a short distance below Gosport. While much good stone has been removed from the quarries and much remains, there is much more waste stone to be handled than in other more favored localities.

The Terre Haute quarry.—*Cosner & Davis*, about 1880, opened a quarry north of the forks of the county road, a half a mile west of Stinesville, and later sold it to Lyne, Chadwick and others comprising the *Terre Haute Stone Works Co.*, who operated it in connection with a mill in Terre Haute. A large amount of stone was taken out here, all of which had to be hauled to the railway. An attempt to put in a switch connection with the L., N. A. & C. R. R. resulted in litigation, and before it was decided in their favor the company concluded to open up at the present site of the Terre Haute Quarry, one-half mile southeast of Stinesville. Switch connection was made with the L., N. A. & C., and a mill built at Stinesville. Both quarries and mill were purchased in 1892 by William Lilly & Co., operating under the title of *Oolitic Quarry Co.*, the same company owning one of the quarries at Romona. In the quarry southeast of Stinesville the stone varies in different parts of the opening from two to four channel cuts deep (13 to 25 feet). It is overlain on the east side by from two to three feet of compact limestone, but elsewhere is overlain by soil only, and the upper surface is weathered very unevenly. There are a few crowfeet seams and a number of vertical ones, the east-west ones being most numerous. There is considerable

cross-bedding in places on the quarry face, and while there is considerable waste in working this quarry, there has been a great deal of good stone quarried.

The opening in the old Terre Haute quarry, about half a mile west of town, is about 120 x 250 feet and 25 to 30 feet deep. There is no switch to the quarry, and the stone was hauled by oxen to Stinesville and loaded for shipment. There are numerous east-west seams, but no north-south ones were observed. The north face of the quarry is a joint seam, which, while regular in its general direction, has a much roughened surface, much ridged and marked, showing considerable cross-grain and lack of uniformity (see No. 3, in plate XX). The texture for the most part is coarse and fossiliferous. The bryozoa predominate among the fossils, but there are many gastropods, brachiopods and a few trilobites. The fossils are abundant throughout all the rock examined, but in a few places the larger forms are segregated more than elsewhere. While this stone would make a fairly good and durable building stone, it is not adapted to carved work or smooth dressing, and is not the kind most in demand at present.

Other quarries were opened up about the Old Terre Haute quarry, though none of them had railway connection and consequently did little quarrying. Limekilns were operated in connection with some of these, but lime made from the oölitic limestone, while white and pure, did not, apparently, find a ready market.

The Griswold quarry.—One of the largest and best equipped quarries in the district is that known as the Griswold quarry, located about a quarter of a mile southwest of the Stinesville station on the Monon railway. There is a switch connection from the quarry to the railway. There are two mills at the quarry, equipped with saws, planes, steam travelers and a good supply of quarry machinery. The quarry was opened in 1880 by Charles Eppinghausen, and purchased in 1890 by the Indiana Oölitic Limestone Company, who put in a new mill and new machinery. The quarry was idle the latter part of the summer of 1896, the first time, it is said, since it opened in 1880.

The thickness of the stone quarried is about 35 to 40 feet, and it is overlain by four to six feet of compact limestone, which had weathered away over part of the area quarried, and which does not appear in the quarries a quarter of a mile farther south. There is a thickness of two to three feet of overlying soil. The stone has been removed six channel cuts deep, but the oölitic stone extends still deeper. There are several open weathered joint seams filled with residual material. These are all on the east-west system of joints, none of the north-south ones showing on the quarry walls. There are a few stylolitic (toe-nail) seams, but they are not numerous or large.

The stone has a medium fine grain and buff color, and shows considerable cross-grain in places, which does not appear to be greatly pronounced, nowhere showing a cleavage or ready parting on the cross-bedding.

The supply of good stone here is almost unlimited, and under any ordinary conditions of trade it ought to be quarried with profit.

Stinesville Stone Company quarry.—The quarry of the Stinesville Stone Company (Malone & Pickel) is about a quarter of a mile west of south of the Griswold quarry. The quarry was opened in 1889 by the Stinesville and Bloomington Stone Company, composed of James Williams and others, and sold to the Stinesville Stone Company in 1895. They are working six—and in some places seven—channel cuts of stone. The upper part of the bed is much weathered and the upper cut—in some places the two upper cuts—largely waste. The total thickness of the bed is about 40 feet, including 30 feet of good stone.

There are a number of vertical seams, both east-west and north-south ones. There are very few cross- or horizontal seams. One layer three feet from the top is called the "gloss" layer, said to have a gloss like silk. Much of the stone is cross-grained, particularly in the upper part of the bed. There is no blue stone. While it is all buff it is a little darker in the bottom of the quarry than in the top.

The company has no mill at the quarry, but saws its stone at the mill of the Stinesville & Bloomington Co., or at their own mill at St. Louis. They utilize nearly all the waste from the quarry by shipping it to the Illinois Steel Co., Chicago, for use as furnace flux. It is the only quarry that was in operation at Stinesville in August, 1896.

The Ellettsville quarry, which adjoins the one above on the south, is a smaller opening, first operated in 1891, but not in operation in the summer of 1896. The stone is similar in character to that in the other quarry. At the east end of the opening it is weathered deeply, much of the upper cuts being waste. At the northwest end there are fewer seams and a greater percentage of clean solid stone. The stone is nearly all buff but there is a faint bluish tint at the base.

The Dunn Stone and Marble Co., the Monon Limestone Co., and the Stinesville Oolitic Stone Co., have holdings of stone land in this vicinity, but as yet no quarries have been opened by them.

ELLETTSVILLE DISTRICT.

In 1862, John Matthews opened a quarry one mile north of Ellettsville. Two years thereafter he began the erection of a mill and pushed the business with great energy. From the first the firm of John Matthews

& Sons realized a good profit from their business. The introduction of

steam channeling machines and steam hoists gave a new impetus to the stone industry. The first channeling machine operated in the oölitic stone belt was a Wardwell, purchased by John Matthews & Sons about 1877, at a cost of \$6,000, four times the manufacturer's price to-day.

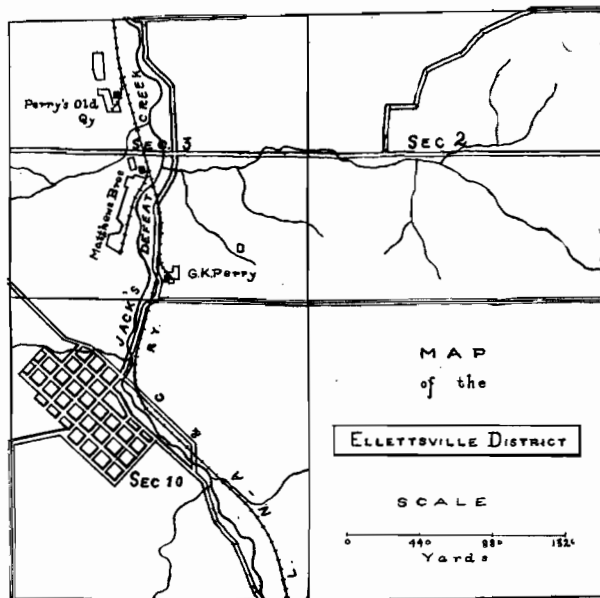


Fig. 16.—Showing the location of the quarries near Ellettsville.

This machine is still in use at this quarry. After the death of John Matthews the firm name was changed to Matthews Bros., and under the direction of Mr. Fred Matthews the works are still in active operation.

John Kostenbader & Co., in 1864, opened a quarry about half a mile north of the Matthews quarry. This quarry was worked out and abandoned sometime in the seventies.

In the spring of 1866, Maj. H. F. Perry opened a quarry between the Matthews and Kostenbader quarries. The machinery of the Biddle & Watts mill was transported here and set up. The old engine, which before its service with Biddle & Watts had done duty on an Ohio River steamboat, might have been seen in operation as late as 1895. A few years after the opening of the quarry Captain G. K. Perry became a member of the firm of *Perry Bros.* Later the quarry was worked out and abandoned and a new one opened east of the railway and but half a mile north of town. A new mill was erected here, though the old one is still in operation. In 1895 H. F. Perry retired from the business, leaving G. K. Perry sole proprietor.

In 1869 *Sharp & Hight* opened a quarry a little south of the Matthews quarry, but at the death of the owners, which occurred a few years afterward, the plant was sold to the Matthews. In 1896 Captain Perry

opened another quarry in the field about a quarter of a mile northeast of his lower mill.

In 1872 *John Matthews & Sons* and *C. F. Kelly & Perry Bros.* opened quarries on the west side of the L., N. A. & C. Railroad, about midway between Ellettsville and Stinesville, but after three years' operation it was found that they could not be profitably worked on account of the number of dry seams and joint cracks, so they were abandoned. The Cornelius quarry, on an adjoining tract, operated during the same time, suffered a like fate for similar reasons.

There are two companies operating quarries at Ellettsville, one since 1862 and one since 1866. These quarries, which have been in continuous operation for thirty years or more, have furnished a great deal of excellent oölitic limestone to many widely separated points. The quality of the stone in these quarries is fully up to the average for the whole district, yet, as at other points, the stone is not all first-class by any means. The stripping is not excessive, yet in some places heavy enough to be burdensome; there are a number of crowfoot seams and in several places coarsely fossiliferous areas and some cross bedding, all combined with the fact that the bed is not heavy, are sufficient to show that careful business methods are necessary to successfully compete with other points. Each company has well-equipped mills and is supplied with good quarry machinery.

The quarry opening at Perry's upper mill, operated for many years, appears to be at least temporarily abandoned by Mr. Perry, who has started a new opening in the field about a quarter of a mile north of east of the upper mill. At the new opening the core drill is said to have shown thirty-two feet of uniform buff oölitic stone. The stone that has been removed, but one channel cut (six feet) deep, July 2, 1896, is a fossiliferous buff stone, fairly uniform in texture, being a little coarse in places. There is one stylolite (crowfoot) seam and several vertical ones, and the stone is considerably weathered along the vertical seams, which are quite open in places.

The opening at the mill has several interesting scientific features. It shows considerable cross-bedding, which runs in different directions, and shows the contact between the oölitic stone and the overlying compact (Mitchell) limestone, which in most places is quite regular but here follows a quite irregular jagged line (see Plate XXI, No. 6). The south end of the quarry shows a rather curious intermingling of the buff and blue stone. The quarry is about 100 yards long and 40 to 50 yards wide. It is four channel cuts (about 25 feet) deep at the middle and north end and three cuts at the south end. Part of the stone has a remarkably fine grain, possibly not surpassed anywhere in the belt, but it is not uniform throughout the quarry, as in some places it is coarsely fossiliferous.

The opening at Perry's lower mill, a mile and a quarter north of Ellettsville, on the west side of the railroad, has not been worked for a number of years. It covers an area about 50x125 yards, four to five cuts (25 to 30 feet) deep. It is overlain by 10 to 12 feet of laminated compact limestone, which lies on the oölitic quite conformably in contrast with that at the upper mill. There are numerous vertical east-west joint seams and one or two crowfoot seams.

In an old abandoned opening, about 200 yards north of the quarry at the mill there is a local change in the face of the quarry. Apparently the compact limestone that overlies the oölitic stone elsewhere, here appears in the face of the quarry with good oölitic stone overlying it. A section of the quarry face shows eight feet of semi-oölitic stone, two to six inches of hard compact limestone, four to six feet of good oölitic stone, two to four feet of compact earthy limestone, and ten or more feet of good oölitic stone.

Matthews Bros. quarry.—The Matthews Bros. quarry is on the west side of the railroad and the valley, and between G. K. Perry's upper and lower mills. The quarry extends along the creek bluff for more than a quarter of a mile, and is worked back into the bluff until the thickness of the stripping prevents further work with profit. As might be expected, along a face of this length there would be some variety in the stone. At the north end in places the rock is coarsely fossiliferous, containing many well preserved specimens of cephalopods and gastropods. At the extreme south end the rock exfoliates along the exposed channel face to some extent, that is—it flakes or peels off parallel with the surface, due to the freezing of the moist stone. In places near the middle of the quarry the stone is almost entirely made up of the oölitic or rounded particles.

The east west vertical seams occur at intervals of 20 to 40 feet along the face. There are very few cross-seams. Several stylolitic (crowfeet) seams occur, but they are not numerous. In some places there are segregations of iron oxide and organic matter along these seams.

Most of the stone is buff in color, yet both buff and blue are obtained, in some places intricately intermixed.

The company has a large mill, and has furnished a great deal of good building stone to the market during the many years they have been in business here.

Matthews Bros. have made a small quarry opening on the hill east of the railroad, about a quarter of a mile east of Perry's upper mill. No railway connection has been made to the opening, and it is not now in operation. The rock is coarsely fossiliferous in places, and contains numerous seams, both vertical ones and stylolite (crowfoot) seams. Many of the stylolitic points along the seam are capped with fossils, most commonly cup-coral (*Zaphrentis*).

Near the middle of section 7, two miles east of Matthews Bros.' mill, is one of the thickest beds of oölitic stone anywhere observed in the oölitic region, so far as can be judged by the outcrop and depending on the accuracy of the aneroid barometer, which makes the thickness of the oölitic stone at this point 100 feet. It is not uniform from top to bottom, and part of the bed is concealed by soil, but most of that exposed is of a quite fine grain and all buff on the outcrop.

BLOOMINGTON—HUNTER VALLEY DISTRICT.

Possibly the first use of oölitic stone in Monroe County was in the county court-house, which was begun in 1819. The body of the building is of brick, but the foundation, window sills and lintels are of oölitic stone. John Ketchum, the contractor, quarried the stone on the Ketchum farm, hauled it eight miles over oölitic stone and erected it upon oölitic stone of as good quality as the kind chosen. The quality of the stone selected speaks for itself, as it stands in the court-house after an exposure of nearly eighty years.

As early as 1856 stone was sawed by hand, in Bloomington, by one Jesse Carson (or DeCourey), and some of his work can still be seen in old buildings and in monuments in the cemetery west of the city. But the stone business in this locality did not assume any commercial importance until the development in 1891 of the quarries in what is known as the Hunter District, one and a half miles northwest of the city.

The Morton C. Hunter Stone Company, organized in Bloomington, made a careful examination of the stone in Hunter Valley by core drilling, and, having satisfied themselves that it existed in vast quantities, and that its quality would meet all the requirements of builders, proceeded at once to put in a branch, more than a mile in length, from the L., N. A. & C. Railway to this tract, and to put machinery to work quarrying the outcrop. A substantial mill was erected. The stone found a ready market, and the success of the Hunter Company led others to venture into the same field.

The Chicago and Bloomington Stone Company was the first to follow the Hunter Company, opening in 1892 what is known as the Johnson Quarry, a short distance northeast of the Hunter quarry. The quarry is operated in connection with mills in Chicago by its owners, who are cut-stone contractors.

The Norton Stone Company was the next in the Hunter district. In 1892 a quarry was opened and a mill built southeast of and just across the valley from the Hunter quarry. In March, 1895, the Norton quarry was purchased by the *Consolidated Stone Company*, becoming "Consolidated No. 1" of their series of quarries.

In December, 1896, the Consolidated acquired the Hunter quarry which they had been operating for some time under lease. It is known as "Consolidated No. 2."

Perry, Matthews & Perring followed in 1893 by opening the Crescent quarry, a half mile east of the Hunter. The *Star Stone Company* in 1895 opened the Star quarry, a half mile north of the Crescent quarry. *Hunter Bros.*' quarry, just west of the Star, followed in 1895, and in the same year the *Hunter Valley Stone Company* opened a quarry alongside of the Crescent. In 1889 the *Bloomington Oölitic Stone Company* opened a quarry in the southwest part of the city of Bloomington. After a few years' operation it was found unprofitable, partly because of the hardness of the stone and partly because of the expense of getting rid of the spalls and other waste. The quarry was abandoned in 1893. In 1895 the property was purchased by the *Henley Stone Company* as a site for a stone sawmill, which they proceeded to erect, and which has been running steadily ever since.

The *Central Oölitic Stone Company* was organized in 1890. The next year a quarry was opened and a mill erected on their property in the northern part of Bloomington. The quarry was abandoned after a year or two, but the mill is still in operation.

Thus, including the two mills in Bloomington, there are seven active quarries and four mills in the district, besides several small abandoned quarries.

The good stone through Hunter Valley is 25 to 40 feet in thickness, from three to five channel cuts in the different quarries. It varies in character, both in grain and color. Both fine-grained and coarse-grained stone occurs, and both blue and buff colors. The stripping is light at all the quarries, very light compared with that in many other localities. Although one of the newest, it is, at the same time, one of the most productive districts in the State. During the summer of 1896, when so many quarries were closed, all the quarries in the valley were in operation except one.

A branch railway, known as the Hunter Switch, connects all these quarries with the Monon Railway, a little more than a mile distant.

The *Consolidated Quarry No. 1* (Norton) is the one furthest south in the valley, and on the east side. It is about 150 yards long and 30 feet deep. The stone is covered with a loose, brown, sandy clay two to four feet thick, and in most places there is a thickness of one to six feet of the upper part of the bed much weathered, often into loose fragments in the residual soil. There are a few vertical seams, but only one bedding seam was observed. The grain is tolerably fine and uniform, with few large fossils. The slope above the quarry is very gentle, so that twenty acres or more of stone are available here with but little more stripping than that on the present face.

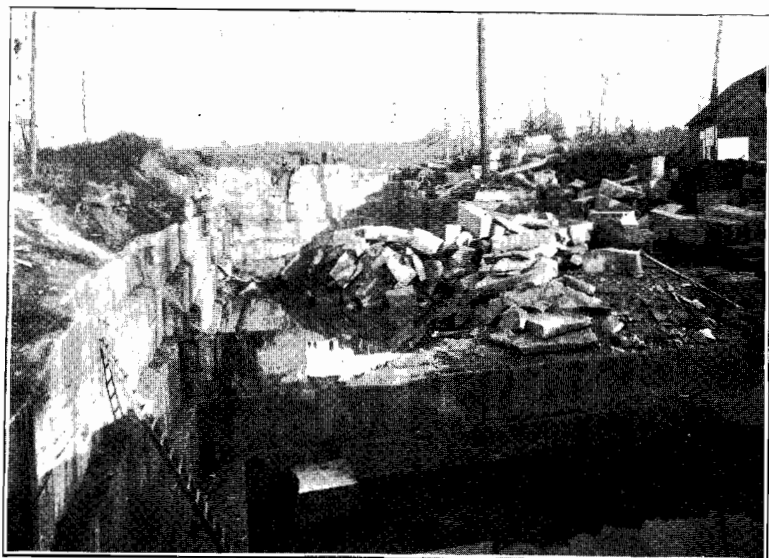
The Hunter Quarry (Consolidated No. 2) is on the west side of the valley about 200 yards northwest of No. 1. The stone is very similar to that in No. 1, and the quarry is about the same size. There is considerable mixed buff and blue stone, as the line of parting between the two colors is very irregular. The bottom of the bed is blue, and the buff averages from ten to fifteen feet of the top of the bed, but in some places the line of parting may be twenty feet from the top, and in one place the buff extends to the bottom of the quarry. At the south end of the quarry the upper part of the bed contains many small calcite veins—"glass seams"—which interfere somewhat with the working of the stone where they occur. In a few places the stone is decidedly oölitic, made up almost wholly of rounded particles. Much good stone has been shipped from these two quarries in the past few years.

The Johnson Quarry, operated by the Chicago and Bloomington Stone Company is the next one north of the Hunter quarry and on the opposite or east side of the valley. The stone is similar in character to that above, but has not been quarried so deep—three and four channel cuts. The opening is not quite so large as the ones above, but a large additional area has been stripped ready for quarrying, showing a comparatively even surface beneath the soil covering on which the channeler can begin with little expense. (See Plate XXI, No. 3.)

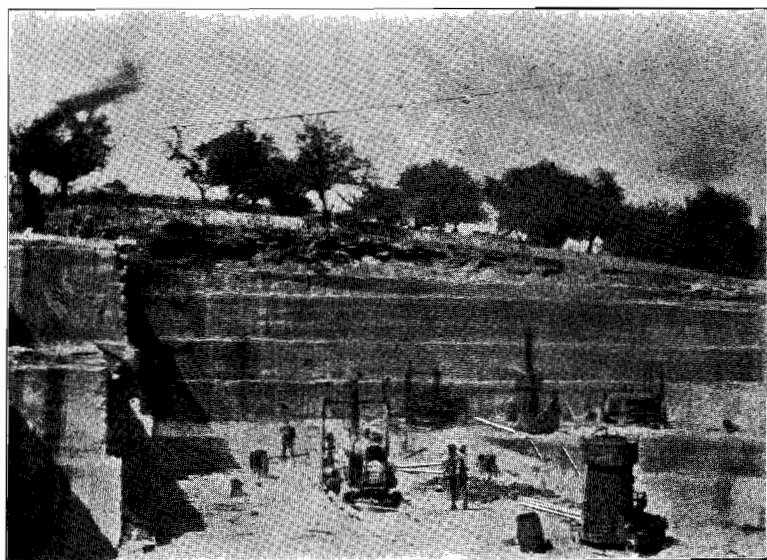
The Hunter Valley Quarry is in a tributary ravine a quarter of a mile east of Consolidated No. 2 (Hunter) quarry. It is one of the newer quarries of the district, having been in operation only a year or two. The entire thickness is not shown in the opening, which at present is about 20 feet deep in the buff stone. The upper part of the bed is much corrugated and weathered very irregularly, in marked contrast with the Johnson quarry, less than a quarter of a mile to the northwest, where the surface beneath the soil is comparatively level. Compare Figs. 1 and 2 on Plate XXI.

The Crescent Quarry, which lies just south of the Hunter Valley quarry, is an older, larger quarry, having two openings, one of which is about 100 yards long, 30 yards wide and six channel cuts 35 to 40 feet deep. The stone is buff near the top, with a blue-gray tint at the bottom of the opening. It has a medium coarse fossiliferous texture, which in a few places is quite porous from the casts of fossils which have leached out. There are a few vertical seams, and the upper two to three feet of the rock is weathered, loose and shelly, but the line of parting between the shelly stone and the sound stone appears to be quite regular. There is a thickness of two to four feet of sandy clay overlying the oölitic stone.

The Hunter Bros. Quarry is in a small tributary ravine less than a quarter of a mile northeast of the Johnson quarry. The quarry was not in operation in 1896, the hole being partly filled with water. Four channel cuts (about 25 feet) are exposed and there is not less than one,



1. VIEW LOOKING SOUTH IN THE STAR QUARRY.



2. CONSOLIDATED STONE CO., QUARRY No. 4, DARK HOLLOW.

probably two, covered with water. The upper part of the bed is buff, which extends down into the third channel cut from the top. The lower part of the bed is blue. There are a very few vertical seams, but no stylolitic (crowfeet) seams were observed. The stone is medium coarse-grained and comparatively uniform in texture.

The chemical analysis of the stone from this quarry shows a remarkably pure carbonate of lime.

CHEMICAL ANALYSIS OF OÖLITIC LIMESTONE FROM HUNTER BROS.' QUARRY.

	PER CENT.
Lime carbonate (CaCO_3).....	98.11
Magnesia carbonate (MgCO_3).....	.92
Iron and alumina ($\text{Fe}_2\text{O}_3 + \text{Al}_2\text{O}_3$).....	.16
Insoluble residue.....	.86
Total.....	100.05
Specific gravity.....	2.46
Absorption of water in 24 hours.....	5.18

The crushing tests show a freestone of great uniformity.

	LBS PER SQ. IN.
No. 1. On natural bed.....	5,900—2 fair pyramids.
No. 2. On natural bed.....	6,900—2 good pyramids.
No. 3. On natural bed.....	4,400—one side split off.
No. 4. On edge.....	4,200—one side split off.
Average of the four.....	5,350
Average of the first two.....	6,400

As specimens three and four did not have parallel sides, the last figure, 6,400, is the fairer average of the strength of the stone. It stood the fire tests as well as any of the specimens tested. (See page 317.)

The *Star Quarry* is almost 100 yards southeast of the Hunter Bros. quarry. It shows a fine body of stone similar to that in the adjoining quarry. The opening is about 100 yards long by 25 or 30 yards wide and 40 feet deep at the deepest point, having six channel cuts of stone. The stone is nearly all blue, but there is a little buff on the top at the east end, which contains some "bastard limestone," an impure very hard form. See Plate XXIX, which shows a picture of this quarry.

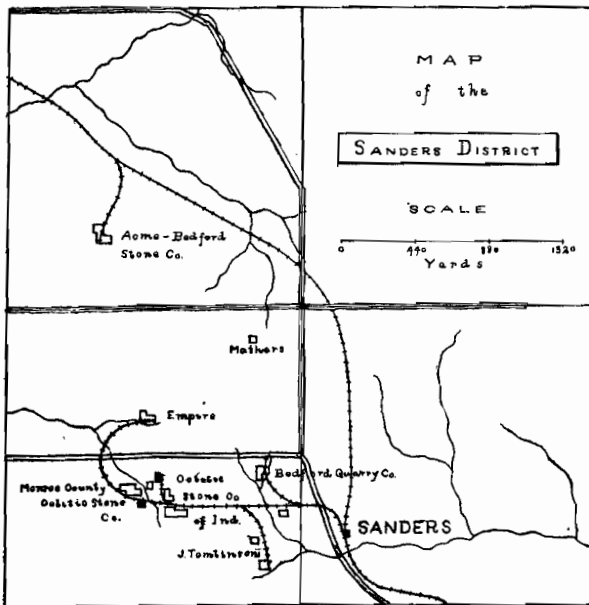
If one might judge from the character of the stone in the quarries open, and the appearance of the outcrops of oölitic limestone in the Hunter Valley, the prediction might well be made that the stone industry will greatly increase and the production here be much more than in the past. There are several features in regard to its occurrence that favor its removal with profit. The stripping is comparatively light, the stone is not so deeply or badly weathered as in many other localities. There is a fair thickness of stone. There are not many seams, either vertical or horizontal, and not many large fossils. A considerable portion of the stone is blue, and as the market demand at present is for the buff, that

may be against its more rapid development, but it is only a question of time, possibly a short time, until the demand for the blue will again increase.

There are several quarry openings in and near the city of Bloomington, but all have been abandoned. There is an old quarry one or two blocks east of the Indiana University Campus, apparently in strata underlying the oölitic. The stone outcrops also on the University Campus. There is a small quarry about half a mile southeast of the University, another in the town on Second street, about a quarter of a mile north of east of the old University building, another at the Henley mill, a quarter of a mile west of the depot, one at the Central mill along the Monon Railway in the north part of town, and two or three small quarries west of the Monon and south of the town, between the Bloomington and McDoel stations, but they have apparently all been abandoned permanently, and a description is not necessary. Considerable stone in the aggregate has been taken from all of them combined, but no large quantity from any one of them. Good stone could yet be obtained at many of them, but the quantity, quality and cost of quarrying militate against its further development in competition with more favored localities.

THE SANDERS DISTRICT.

The pioneer company in the Sanders district was the *Oölitic Stone Company of Indiana*,



company of Indiana, which, in 1888, opened a quarry and constructed a branch connecting with the L., N. A. & C. R. R., and costing \$10,000. In 1890 David Reed obtained control of the quarry, and it was at once taxed to its utmost to furnish stone for the construction of the Auditorium, Chicago. In 1894 he opened another quarry north of

Fig. 17.—Showing location of the quarries in the vicinity of Sanders. quarry north of the switch and in 1895 erected a mill.

The *Monroe County Oölitic Stone Co.* organized in 1889, opened the Adams quarry, and erected a mill just west of the Reed oölitic quarry.

In 1891 the *Bedford Quarry Co.* opened a quarry east of Reed's Oölitic, which is known as Reed's Bedford. It is now in active operation.

The *Empire Stone Co.*, in 1892, opened a quarry north of the Adams quarry and on an extension of the same switch. The *Empire quarry* has not been in operation for a year.

In 1892 *John Tomlinson & Son*, of Chicago, opened quarries south of Reed's Bedford quarry. They ran for two years, since which they have been idle.

In 1893 the *Bloomington-Bedford Stone Co.* opened a quarry known as the B. & B. quarry, something over half a mile north of the *Empire quarry* and near the main line of the L., N. A. & C. R. R. A great amount of money was spent in developing the property, but it proved to be unprofitable and was abandoned. It was leased in 1895 by the *Acme-Bedford Stone Co.* and purchased by them in 1896. They developed the quarry in another direction with most promising results. The quarry is operated in connection with extensive mills in Chicago belonging to the same parties.

The *Matthews Stone Company* was organized in 1892, but no opening was made until 1895. Their quarry lies about half a mile southeast of the B. & B. quarry. As yet it has no railway connection and has been idle the present year. In fact nothing has been done beyond a little preliminary work.

There are now, as stated, nine quarry openings on the branch railroad at Sanders and two others along the Monon between Sanders and Clear Creek Station, within two miles of Sanders. Six of these were in operation in July, 1896. One, from which apparently no good stone was obtained, is permanently abandoned and four are temporarily idle.

The quarries in operation are Reed's Bedford quarry, in the northeast quarter of the southeast quarter, section 33 (8 north, 1 west); Reed's Oölitic quarry, two openings, northwest quarter of southeast quarter, same section; Adams' quarry, two openings, northeast quarter of southwest quarter, same section, and the Bedford and Bloomington quarry, in the southwest quarter, section 28 (8 north, 1 west). The Tomlinson quarries, two openings, the *Empire* and *Matthews quarry*, each one opening, are temporarily idle.

The average thickness of the oölitic alone in the district is about 35 to 40 feet, with a maximum of possibly 50 feet. The workable portion of the stone varies from 12 to 40 feet, depending on the depth to which the weathering influences have extended and the local variations in the texture.

In several of the quarries, noticeably the most southerly ones, there are numerous large, vertical fissures, extending through the limestone, most

of them having a general east-west (a little north of east and south of west) course, only a very few north-south ones occurring, and those quite small. These fissures are due to weathering along the joint planes, and vary from a few inches to eight feet or more in width. They are now filled with the residual red clay. As a rule they are widest at the top, but their walls are often quite irregular, as in all cave-like openings. Hence there is a great quantity of waste rock to handle. Some of these open seams extend but two or three feet below the surface, while others run as deep as the stone is quarried—20 feet or more. These fissures are less pronounced, and almost disappear where there is any considerable thickness of overlying rock to protect them from the weathering influences.

Except in the much weathered portion at the top there are few horizontal or bedding seams. There are several stylolite or "toe-nail" bands in three of the quarries, but none were observed in the other quarries. Cross-bedding is shown in several of the quarries, but is not so prominently marked as in some other localities. It is shown in the Adams quarry, the Matthews quarry and the Empire quarry, the latter in some places having a marked cleavage along the false bedding.

The texture varies slightly in the different quarries, and, to some extent, in different parts of the same quarry. However, excepting the few more coarsely fossiliferous layers, the texture is medium coarse and semi-crystalline, with numerous oölitic or rounded grains. It is fully up to the average in resonance, compactness and low porosity. While soft in the green state, it seems even harder than the average, when seasoned. The coarsely fossiliferous bands, as in other localities, frequently are porous from the leaching out of the shells.

The proportions of the buff and blue stone vary greatly in the different quarries, and as the parting between the two colors is very irregular, there is much variegated stone that is remarkably uniform in everything but color. The contrast between the two colors is not striking, yet, unfortunately, it is more pronounced on the exposed channel face than on a fresh fracture. In some of the openings only buff stone is quarried. The distribution of the blue and the buff in the B. & B. quarry is different from that in other places, and apparently contradictory to the commonly accepted theory. It may be one of the exceptions we hear of that it takes to prove the rule. In the first opening on the edge of the outcrop near the surface there was much blue and variegated stone, while in the present deeper opening, higher on the hill, the rock is all buff. In Reed's Bedford quarry, in the Tomlinson quarries and in the Empire quarry both blue and buff occur with very irregular parting, the buff running deepest along the vertical joints, and the blue forming an irregular band along the stylolite seam. (See plate XIX.)

In the larger openings of Reed's oölitic quarry they have channeled to the bottom of the oölitic stone, six channel cuts deep in one place, showing the bottom layers to be very fossiliferous. In the smaller opening the quarry stone is overlain by a dull brown, fine-grained, impure, soft, earthy rock, four to six feet exposed, overlain by three to four feet of sandy clay. The part of the oölite immediately underlying the impure rock covering is in places very coarse-grained, coarsely crystalline, and contains many fossils. (See Plate XIX.)

The blue stone in the Empire quarry in places contains numerous small, rounded, black specks which do not appear in the buff.

The stone in the B. & B. quarry is quite fossiliferous, and in places contains more oölitic or rounded particles than that in the surrounding quarries. The foreman reported that a core drill had been sunk 70 feet without reaching the bottom of the oölitic stone, but that at that depth the rock, while still oölitic, was too hard to be worked with profit, and the drill was stopped.

There is the following machinery in this region, July 3, 1896: 21 channeled, 11 of which are in operation, and one is under water; 11 derricks; five steam drills; eight saw gangs, and eight steam pumps.

The conditions for the economic production of good stone in this (Sanders) district are probably above the average, as the workable stone has a fair thickness and the stripping is not heavy. The greatest waste is that caused by the irregular vertical seams and the intermingling of the buff and blue colors. Large quantities of quarried stone are seasoning at each of the quarries, except the Matthews quarry, which is quite new, and has produced but very little stone so far.

CLEAR CREEK VALLEY BETWEEN CLEAR CREEK STATION AND HARRODSBURG.

Time did not permit a detailed examination of the Clear Creek Valley outside of the quarries in operation, but some of the most promising outcrops were hastily examined and the results here noted.

There are probably as many large and promising outcrops of oölitic limestone along this part of Clear Creek Valley as in any other area of equal size in the whole oölitic area. But the only quarry opening that has been made was a failure. There is no doubt that there is a vast quantity of good stone in this region, but it yet remains to be seen how successfully it can be produced in commercial quantities in competition with the other districts. As may be seen on the map, the deposits are removed some distance from the railroad, which is the principal reason why they have remained undeveloped. A new line of road is contemplated down the valley, which, if built, will, no doubt, open up a number of new quarries at once.

It must not be understood that the following are all the good exposures of oölitic stone that there are in the area, or that they are necessarily the best. They are the ones observed by the writer, who was directed to what were said to be the most promising outcrops.

About a mile southwest of Sanders, along a small tributary of Clear Creek from the east, in the northwest quarter of section 4 and the northeast quarter of section 5 (7 north, 1 west), the limestone is exposed along the watercourse and on the slope south of the stream. In section 4 there is a massive ledge of the stone exposed along the stream 8 to 10 feet thick free from seams, of fine grain, slightly crystalline, and slightly cross-grained in a few places. The record of the core-drill* put down at this locality gives:

“Fairly good buff stone..... 12 feet.
Very fine quality blue stone 30 feet.

One crow-foot $12\frac{1}{2}$ feet from the top. Did not drill through the ledge because of accident to the drill.”

A boring in the west half of the northeast quarter of section 5 (7 north, 1 west), a little more than a quarter of a mile west of the above, shows:

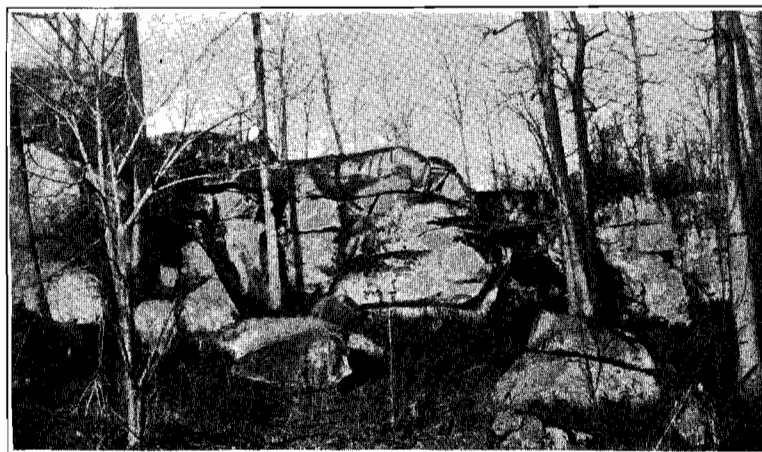
“Splendid buff stone 51 feet.
Fairly good blue stone 12 feet.

No crow-feet, flint or dries, or anything detrimental whatever. The stripping will probably be from two to eight feet thick, and mostly soil.”

The surface of the stone on the outcrop at this point is nearly all smooth, firm and compact, with rounded corners. It shows rather pronounced cross-grain in two places, and a hundred yards or more further west, at the point of the hill, there is a ledge three to four feet thick of coarsely fossiliferous stone rapidly disintegrating into loose sand, yet the greater part of the stone exposed here is comparatively solid.

On the west side of Clear Creek, in the east half of section 12 (7 north, 2 west), south of Victor Postoffice, there is one of the largest outcrops of the oölitic stone observed anywhere in the State. The massive oölitic stone, 40 to 50 feet thick, forms a bold perpendicular bluff overlooking Clear Creek. From this bluff in places huge bowlders, 20 to 100 feet in diameter, have broken away from the face of the ledge and lie scattered along the base of the bluff. The accompanying illustration (Plate XXX) shows a view of this bluff, the upper part showing a view of the bluff from a little distance, the lower part a nearer view of a portion of the face. Weathering brings out a few vertical seams, but very few, and these, as will be noticed, are remarkably regular, so that even near the bluff where the weathering agencies have penetrated there will be

*All of the drill records given in this chapter are copied from the statements made and sworn to by the drillers before a notary public, and by drillers who have worked in different parts of the oölitic region for a number of years.



1. OUTCROP OF OOLITIC LIMESTONE.

On Lot 18 of the Buff and Blue Oolitic Stone Co., on west bluff of Clear Creek,
Sec. 12, T. 7 N. R. 2 W.



2. NEARER VIEW OF PORTION OF THE ABOVE BLUFF.

little waste from the seams. The stone is remarkably uniform in grain, color and durability.

The sound stone extends to the top of the bluff, there being no soil at the edge of the bluff, and the slope back of the bluff being a gentle one. An outcrop in the field between this bluff and Victor Postoffice shows a coarsely fossiliferous stone.

In a small ravine, 100 to 200 yards southwest of Victor Postoffice, near the middle of the north half of section 12 (7 north, 2 west), is a large outcrop of oölitic stone, which is very much cross-grained and weathered very unevenly. Most of it is fine grained and light colored.

Along the south side of the branch west from Victor Postoffice, through the northwest quarter of section 12, massive oölitic stone of good quality outcrops in a number of places.

In the southwest quarter of section 2 (7 north, 2 west), on the south side of the branch, is a low bluff of remarkably sound, compact, flawless stone, extending along the watercourse for 200 or 300 yards without a seam. The total thickness of the stone is not shown at this point, and while the stone in the part of the bed concealed may be uncertain in quality until further tested, that part of it exposed is as uniform in color and texture as any observed in the oölitic area.

In the southwest quarter of section 36 (8 north, 2 west), on the south side of Happy Creek, is a massive ledge of buff oölitic limestone, free from seams and flaws, the surface being so smooth and even that it is difficult to chip off a fragment with the hammer. There are a few streaks of coarsely fossiliferous stone, and in one place a compact, semi crystalline area, but all parts weather evenly. The stream has cut a channel into the rock, but in only one or two places has it undermined the bluff. (See Plate XX, No. 2.)

In the northwest quarter of section 36, on the north side of the small branch, is a promising outcrop of 25 to 30 feet of oölitic limestone, and more, how much is not known, concealed below the bottom of the valley. The stone is fine grained, uniform and durable, weathering evenly and in good position for quarrying.

On the southwest side of the same branch, about a quarter of a mile west of the above, is a massive ledge of the most solid, compact limestone observed in this region.

A mile south of Victor Postoffice, on the west side of Clear Creek and a few yards south of the wagon road, in the northeast quarter of section 13 (7 north, 2 west), a small watercourse has cut a deep narrow gorge into the oölitic stone, exposing a thickness of 25 to 30 feet of nice-looking stone, the bottom being concealed so that the total thickness is not shown. It varies somewhat in texture, part of it having a fine grain, other parts rather coarsely fossiliferous. The greater part weathers rather evenly on the face of the gorge, but in a few places is much corrugated and pitted,

showing uneven weathering. The stripping here would be very light, as the slope back from the bluff is very gentle.

In the northwest quarter of section 13 (7 north, 2 west), is a large outcrop of stone similar to that mentioned above in the northeast quarter. It is exposed in several small tributary ravines, and shows a bed of stone not less than 40 or 50 feet thick, varying somewhat in texture at different points. In most places the upper surface is weathered to considerable depth, and will be found to be ridged and uneven, but much nice stone occurs in different parts of the bed.

The following drill records show stone of good quality in the localities mentioned. The appearance of the outcrop adds but little to the record of the drill. The quotations are from the certified records of the driller.

1. "In the northwest quarter section 19 (7 north, 1 west), 35 feet first-class buff stone. This is the first stone that I have drilled and found no flint, no crowfeet, no dries, or anything detrimental."

2. "N. W. S. W. section 19 (17 north, 1 west).

Dirt stripping	3 feet.
First-class buff	38 feet.

Two crowfeet near the bottom eight inches apart, and one six feet from the top."

3. "Southeast quarter section 24 (17 north, 2 west), 26 feet in buff stone of a very fine quality. This makes four ($6\frac{1}{2}$ feet) cuts without a thing to injure the stone except two small crowfeet close together about six feet from the top, and I can safely say there will be at least one more cut in the rise of the hill."

4. "Southwest quarter section 24.

First-class buff stone	32 feet.
Blue stone	12 feet.

Clear of any defect except two small crowfeet."

The Cleveland Stone Co.'s quarry.—A quarry of oölitic stone was opened and operated for a time, some years ago, by the Cleveland Stone Co., on the bluff east of Clear Creek, in the northwest quarter of section 20 (7 north, 1 west), a little more than a mile north of Harrodsburg. There was a branch run out from the Monon railway a distance of a mile and a half. The quarry was well equipped with machinery, and a great deal of work was done, but the venture was not a profitable one. The machinery was removed, the track has been partly torn up and the quarry abandoned.

The oölitic stone lies near the top of the hill overlain by eight to ten feet of soil, but no other rock covering, and has weathered deeply. Irregular openings, one to three feet wide, occur along nearly all the joint seams, extending in most instances to the bottom of the quarry. This causes a great quantity of waste. Added to this are a great many crowfeet seams, one or two in nearly every channel cut. The upper surface

is much ridged and corrugated. The upper part of the bed at the north end is quite hard, containing some chert, which is said to have interfered with channeling. A layer three to five feet thick a few feet from the top is very fossiliferous, containing a great many well preserved fossils. This layer rapidly disintegrates into a calcareous sand, with the fossils in the debris. The stone is all buff in color, no blue stone appearing in the opening.

The occurrence of the hard layer on the top, the fossiliferous disintegrating layer, the numerous crowfeet layers, and open vertical seams, all combined, produce too much waste to lift the little good stone with profit.

LAWRENCE COUNTY.

(Bedford and Vicinity.)

The oölitic limestone quarries of Lawrence County cluster around Bedford, in the north central part of the county. There are several stone mills but no quarries in the town of Bedford, the nearest quarries to the town being the Blue Hole quarries on the east side of town. There are no active quarries immediately south of the town, but there are east, northeast, southwest, northwest and north, the largest and most productive quarries being northwest of town on Buff Ridge and in Dark Hollow. Some of the largest quarries in the State, and among the largest in the United States, occur in this locality.

The quarries are located either on the main lines of or on switches connecting them with the L., N. A. & C. R. R. main line and Bedford, Switz City branch, the Belt R. R., the E. & R. R. R., and the B. & O. S W. R. R.

The stone varies in the different quarries, often in the different parts of the same quarry in thickness, color, hardness, and coarseness of texture.

Peerless Station.—The Peerless quarry, which was opened in 1890, is situated about four miles north of Bedford, in section 26 (6 north, 1 west), along the main line of the Monon Railway, with which it is connected by switch. It lies near the top of the hill, east of Peerless Station, on the east (south) side of Salt Creek.

There is no rock overlying the oölite, and as a result the upper part of the oölitic bed is very much weathered. The weathering agencies have penetrated along the joints and lines of weakness, making numerous irregular vertical fissures of varying width and depth, some extending but a few feet below the surface and some to the bottom of the bed. The rock is overlain by two or three feet of residual clayey soil, which also fills the fissures or open seams. Thus while there is but little rock stripping, there is a great deal of waste along the fissures, which likewise

interfere with the channeling, and cause an additional expense outside of the mere waste rock.

The stone in the Peerless quarry shows considerable cross-grain, yet not sufficiently pronounced to produce a ready parting or cleavage on the false bedding, as in some other places. Except the cross-bedding, the stone is comparatively uniform in structure, grain and color, being fine-grained, equal to or below the average in fineness, and having a light buff color. The stone obtained is of good quality; it is merely a question of whether it can be worked profitably in competition with other quarries where there is less waste. It is well equipped with quarry machinery, but is not in operation at present (July, 1896).

The oölitic limestone, very similar in quality to that at the Peerless quarry, outcrops along the slope of the ridge east from the quarry and is exposed in considerable quantities along the wagon road a half mile east of the quarry.

There is a similar exposure on the hill a mile north of the quarry, in the northwest quarter of section 25 (6 north, 1 west), which has been core-drilled preparatory to further exploitation. The stone, as it appears in the outcrops, is of good quality, but, like that at the Peerless quarry, it is liable to have many weather seams, as it lies at the top of the hill with no other rock and little soil covering. The outcrop shows some massive ledges of fine stone.

Thornton's Quarry is in the northwest corner of section 34 (6 north, 1 west), a half mile southeast of Peerless Station and three miles in a straight line north of the northwest corner of the city of Bedford. It is connected by a switch with the Monon Railway and is not very distant from the Peerless quarry, which it resembles in some respects, being situated near the top of the hill, but it differs from the Peerless in having a heavier covering and hence fewer open seams and less waste rock. In the southeast corner of the opening is a bed of six or eight feet of overlying impure compact limestone, which bids fair to increase in thickness as the stone is quarried further back into the hill.

The contact of the oölitic stone and the overlying rock in Thornton's quarry departs from its customary regularity, as observed in most other places, and dips toward the southeast along both the east and south faces of the quarry. The false bedding likewise dips in the same direction but at a steeper angle than the line of contact. The bottom of the oölitic, which is not now exposed, is said by the quarrymen to dip in the same direction, as at the north end of the quarry the bottom of the lower channel is within 18 inches of the bottom of the bed, and 80 feet further south the bottom is four feet below the quarry floor.

The oölitic stone is about 25 feet thick, varying from two to four channel cuts in depth. The depth of overlying soil is two to four feet.

The stone has a light buff color and medium fine grain, comparatively uniform both in grain and color, resembling the stone in the Peerless quarry. The quarry was opened in June, 1895, by the Bedford Steam Stone Works.

Buff Ridge quarries.—The Buff Ridge quarries rank among the oldest, the largest and the best along the entire oölitic limestone belt. There are at present four active quarries and three abandoned ones. Two of these, the Hoosier and the P., M. & B. quarries, are two of the largest quarries in the State.

Hallowell Stone Company's Quarry is a new one just opening on the southwest quarter of section 28, nearly half a mile northwest of the P., M. & B. quarry. There is no switch to the quarry and no stone has been shipped (July, 1896). The stone lies near the base of the hill on the north slope. The total thickness of the stone is not yet exposed, as they are only starting the second channel cut.

In the opening already made the stone is variegated buff and blue, the parting between the two colors being along a very irregular line. There is considerable cross-grain in some places, the stone having a perceptible cleavage along the false bedding. There are numerous small scattered crystals of calcite in the stone, in some places fine veins of calcite and in a few places iron pyrites along a cleavage plane.

As the slope is steep, there will be a heavy covering over the stone when it is quarried any considerable distance back in the hill and will probably be largely bluestone.*

The P., M. & B. (Perry, Matthews & Buskirk) Quarry, which was opened in 1889, is situated in the northwest quarter of section 33 (6 north, 1 west), nearly a mile north of the village of Oölitic and about three miles northwest of the city of Bedford. It is connected by a short branch with the Monon Railway at Horseshoe. The present quarry opening covers an area of between 25 and 30 acres and the company is stripping an area of several acres more on both the north and south sides of the quarry. It at one time consisted of several openings, which have run together until it is now all in one big quarry, with switches running to various parts of it and work going on at five different places, some of them two or three hundred yards apart.

The stone has been quarried in many places six or seven channel cuts deep—40 to 45 feet—the thickness of stone quarried depending generally on how much has been removed from the top by weathering agencies. There are a few, but not a great many, seams, the ones running east and west being nearly all vertical, while the north and south ones incline sometimes 10 or 20 degrees to the east. With the exception of one stylolite (crowfoot) seam near the top there are no horizontal seams or bedding planes of any extent.

*Since the above went to press, I have learned that the quarry has been abandoned.

Practically all the stone quarried now is a light buff color. Some bluestone occurs near the middle of the quarry, but is not worked at present. Throughout the greater part of the quarry the stone has a uniform fine grain, but there are a few irregular patches where it is much coarser and more crystalline.

There is no overlying rock on the north side of the quarry, and the much weathered upper surface is covered with several feet of residual soil, through which points and spurs of the irregular upper surface of the rock project in places. On the south side of the quarry the oölitic stone is overlain by one to four feet of the close-grained, impure, rough, weathering Mitchell limestone, which in some places contains a fissile, shaly layer six inches to eight inches thick. The parting between the oölitic and the overlying stone is comparatively regular, so that on the south side the entire thickness of the oölitic stone is available.

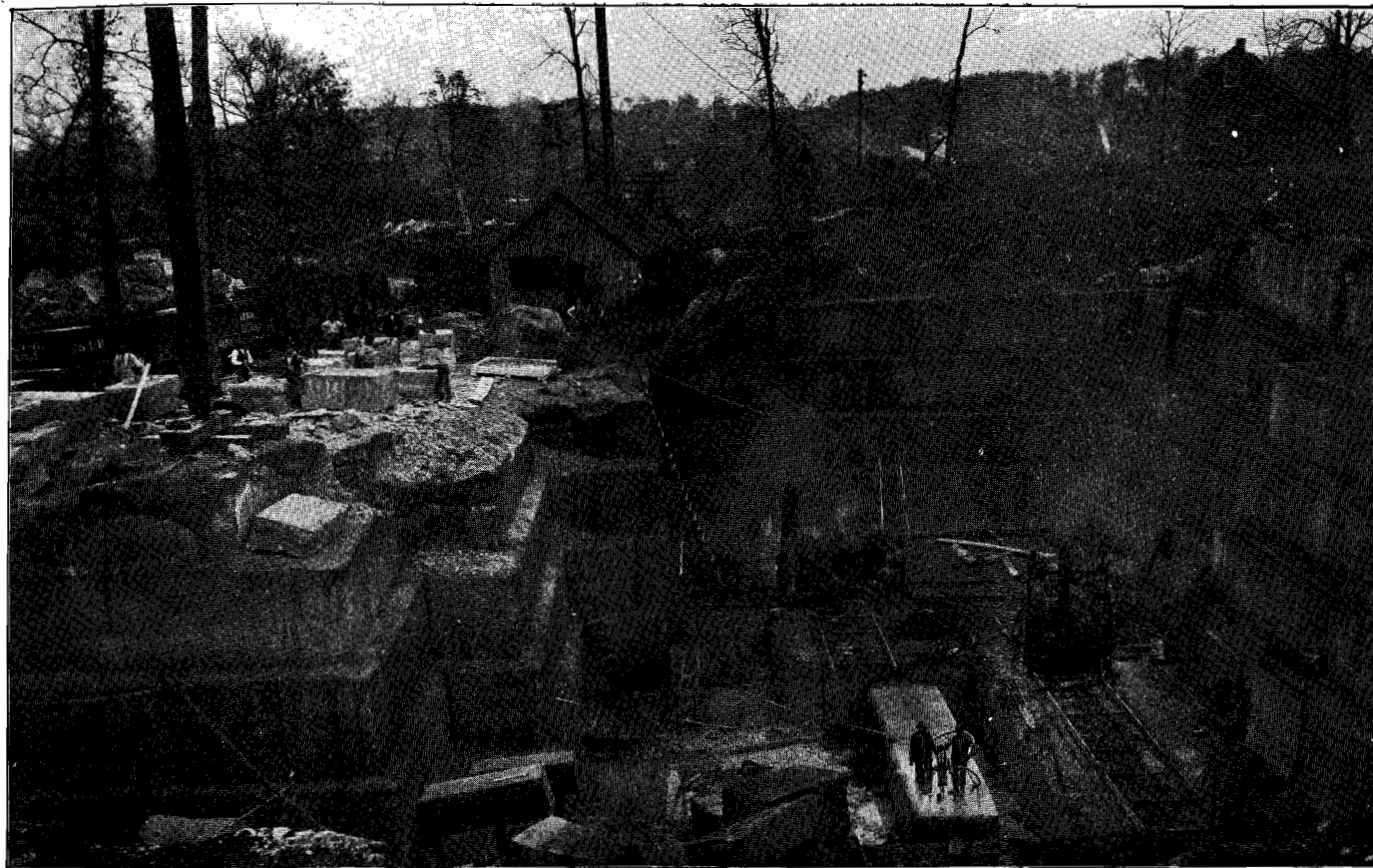
Hoosier Quarry No. 2 (now abandoned) is situated east of the P., M. & B. quarry, separated at the one corner by only a few yards of rock. The quarry opening is about 50 by 75 yards in extent and four, in some places five, cuts deep. It was opened by the Hoosier Stone Company in 1885-6, and among other contracts furnished stone for the Memphis bridge.

The character of the stone is very similar to that in the adjoining quarry, but there are more seams and heavier stripping. Besides the six feet of compact impure limestone similar to that in the adjoining quarry there is overlying that five or six feet of hard, much weathered oölitic limestone and two or three feet of soil, making 12 or 15 feet of stripping in all. The heavy stripping, along with the greater waste on account of seams, is probably the reason for abandoning the quarry.

In a few places the stone approaches a true oölite in texture, being made up almost entirely of small, rounded particles.

The Buff Ridge Quarry.—The Buff Ridge quarry lies about 150 yards southwest of the P., M. & B. quarry, on one terminus of the Belt Railway. It was opened by the Hoosier Stone Company in 1891. The stone is much like that in the adjoining quarries, a uniform, fine-grained, light buff-colored, semi-crystalline limestone. On the northwest side it is overlain by five or six feet of the compact rough weathering limestone, overlain in turn by several feet of compact oölitic stone and two or three feet of soil. At the south end there is no overlying rock, and the rough, deeply corroded upper surface of the oölitic stone is covered with the residual sandy clay. The stone has been quarried six cuts deep, the upper one being mostly waste rock.

In one place between the compact stone and the underlying oölitic is a layer of blue-brown shale six or eight inches thick. The quarry is a most promising one and is now (July, 1896) in active operation.



PORTION OF THE HOOSIER QUARRY.

In the foreground a long block has been turned over, which is being drilled preparatory to breaking into smaller blocks.

Hoosier ("Old Hoosier") Quarry is one of the oldest and largest quarries in the district. It was opened in 1879 and has been in active operation ever since, having in that time produced immense quantities of stone, which has been shipped to all parts of the United States: From 1883 to 1892 it was operated by the Hoosier Stone Company; 1892 to 1894, by Bedford Stone Quarries Company; 1894 to 1897, by Bedford Quarries Company.

Like the large P. M. & B. quarry it consisted originally of several openings, which have since run together into one large opening covering about 25 acres, and five to seven cuts, 35 to 50 feet deep, in different parts of the quarry.

The stone along the south and east side contains at or near the top a layer five or six feet thick of the earthy, shaggy-weathering, impure Mitchell limestone, which apparently almost disappears on the north side. It is separated into two layers in places by the harder oölitic stone, and is quite hard and compact in some places, while in others it is friable, cavernous and contains considerable travertine. A thickness of several feet, including this so-called "bastard limestone," is waste material. Farther to the north this nearly, if not quite, disappears. The company has recently stripped over an area of several acres, and is now (July, 1896) beginning to channel at a level of 15 to 20 feet above the present quarry opening. So far as exposed, this stone appears to be coarser grained and lighter colored than the underlying quarry rock. It has a very irregular upper surface with numerous deep, weathered fissures. It is quite probable that much of this overlying rock will be waste material, but it is sufficiently thick to protect the underlying stone, thus affording a greater thickness of the handsome, fine grained oölitic stone. Plate XXII shows the channeler at work starting an opening in this part of the quarry.

On the south side of the quarry the top of the fine oölitic stone is much weathered, there being no overlying rock, the roughly corrugated surface being covered with residual clay and soil.

The stone throughout a large part of the quarry has a remarkably uniform fine grain and light buff color. Near the middle of the north side the bottom of the quarry is blue stone, of which considerable quantities have been removed. The blue stone quarried, however, is but a small part of the total product.

The quarry has been very successfully operated. The company, by quarrying at several places in the quarry and at several different levels at the same time, is prepared to take advantage of the slight difference in texture that may occur and at the same time prepared to rush an urgent job very rapidly.

The company disposes of vast quantities of its waste rock by having a large rock crusher to make it into railway and road ballast. The Belt

railway is already ballasted with this stone and is probably one of the best ballasted pieces of road in the country. The spaces between the ties are filled up and the stone extends out about a foot beyond the ties. A top dressing of finer crushed material which has been put on this has hardened.

The Oölitic quarry, about 100 yards southwest of the "Old Hoosier," and the Brickyard quarry, south of the "Old Hoosier," have both been abandoned.

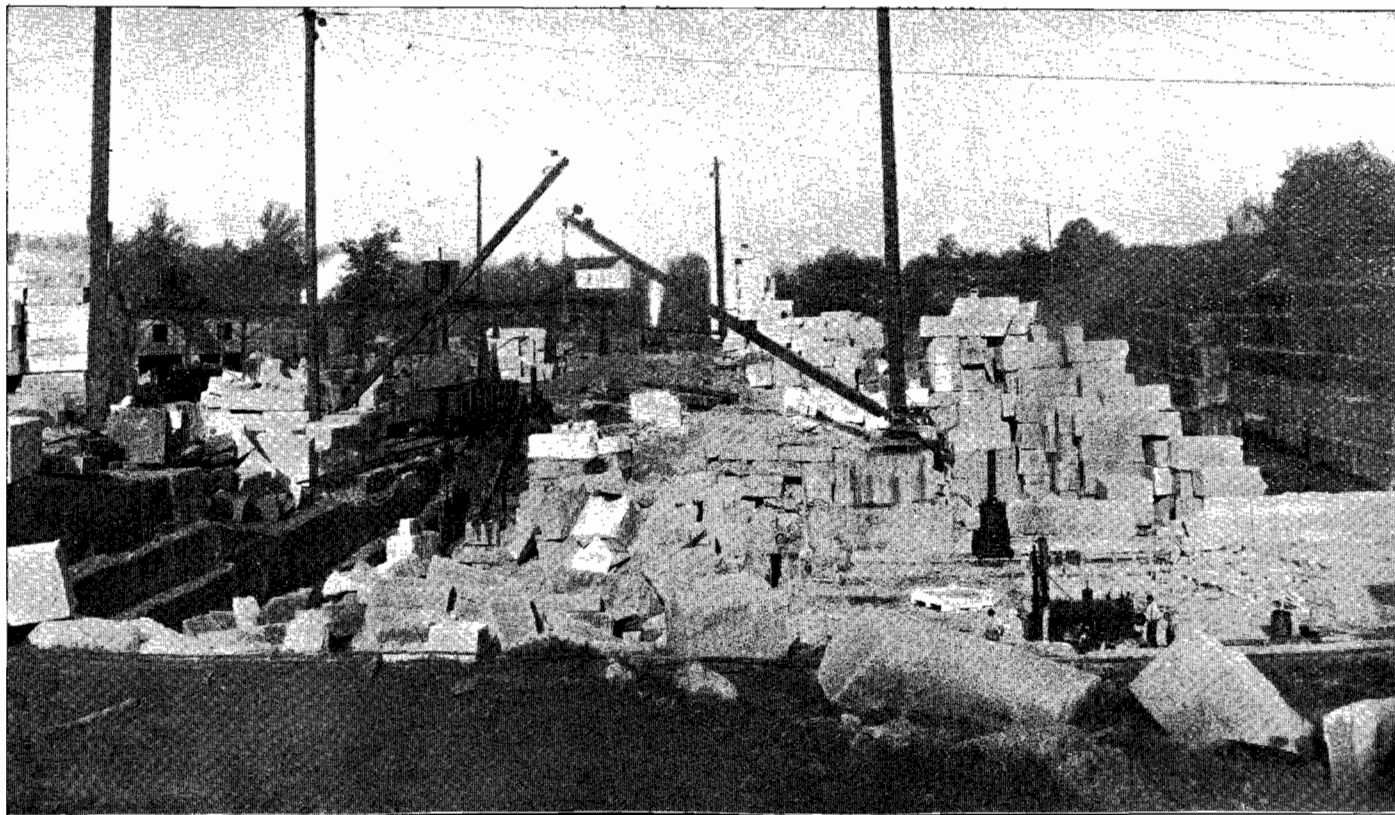
Reed's Station quarries.—David Reed was the first to open a quarry in this district, which he did in 1882, operating as the Bedford Quarry Company. Several openings were made and a well-equipped mill erected. A good business was done, and the little village, Reed's Station, grew up around the quarries. But when Mr. Reed secured the contract of stone for the Chicago Auditorium building he found that he could not get stone fast enough from this quarry, and the quarry at Sanders was purchased, as has been noted on page 370, since which time the property at Reed's Station has not been in such active operation.

The quality and character of the rock at Reed's Station is very much like that in the Buff Ridge quarries just described. There is, however, more waste rock and more stripping, the latter caused by the different topographic position of the stone. The Buff Ridge quarries are opened on the top of the hill where the stripping is not heavy. The Reed's Station quarries are on the north face of a higher hill on the opposite side of Goose Creek, and are quarried on the outcrop back in the hill until the expense of stripping becomes too great.

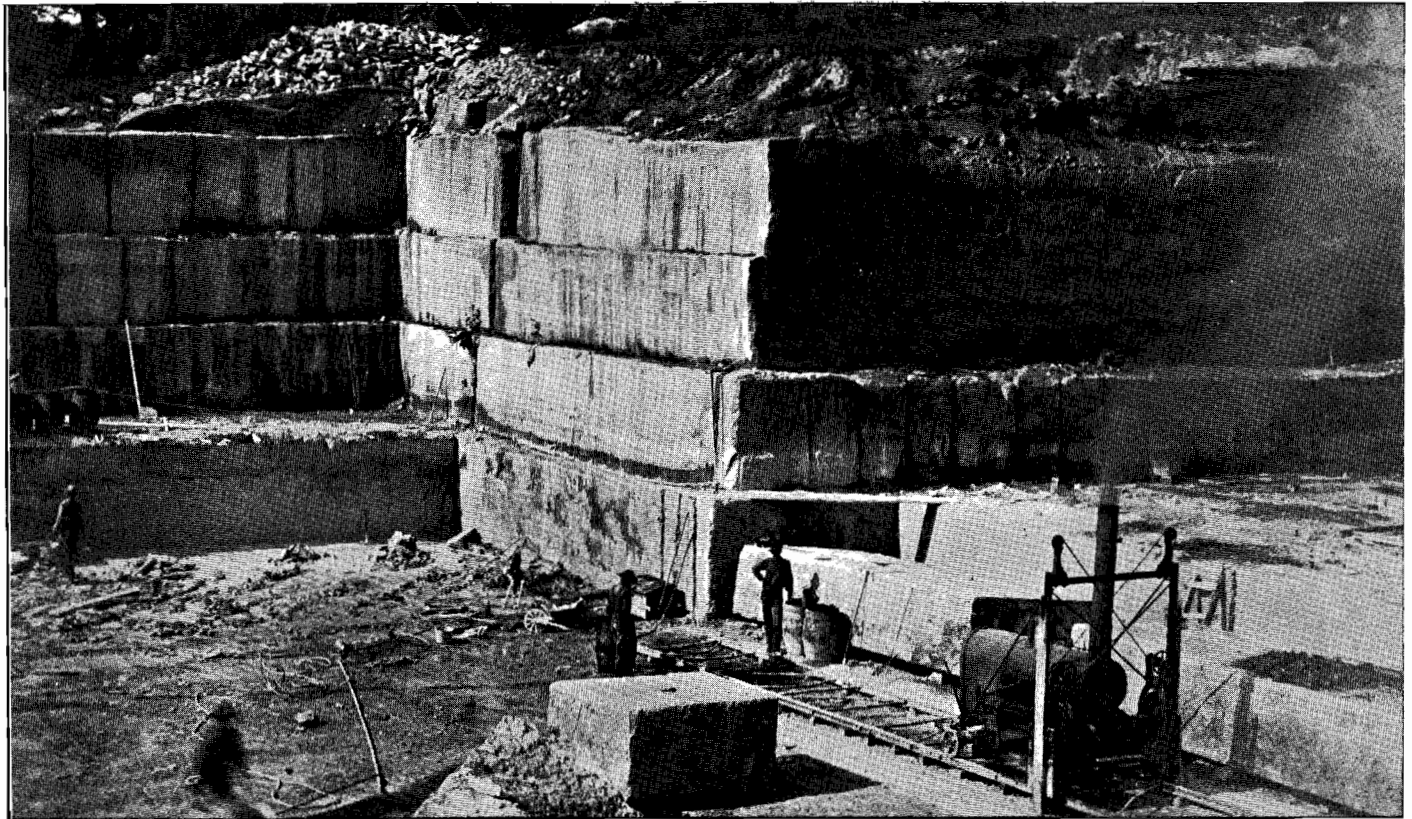
As is generally the case on bluff exposures, there are more weather seams than in openings made on the hilltops.

The quarries are all idle now except that belonging to the Bedford Indiana Stone Company ("The Robin Roost quarry"), which was opened in 1885 by Crim, Duncan & Co. In 1891 the property was disposed of to the *Indiana Stone Company*, which in time leased and later, March 15, 1893, sold the quarry to the Bedford Stone Company, which had previously purchased the Mitchell Hollow quarry. November 14, 1894, the Robin Roost quarry and associated properties came into possession of the Bedford Indiana Stone Company, which company is to-day one of the large producers of oölitic limestone.

The stripping along the abandoned face varies from 6 to 20 feet, consisting largely of the compact, clayey, rough weathering, impure ("bastard") limestone with, in places, streaks of hard oölitic limestone, but the latter in no place occurs in such quantity and quality as to have any commercial value, so that it all goes in with the waste. In one place the granular, compact rock overlying the oölitic is 6 to 10 feet thick, blue weathering to buff along the seams, and overlain by six to eight feet of light buff, compact, semi-crystalline limestone.



NORTHERN PORTION OF HOOSIER QUARRY, LOOKING WEST.
Showing method of quarrying, handling and stacking stone.



HOOSIER QUARRY, NORTHEAST CORNER.

Showing thickness of stripping, method of quarrying, and Wardwell channeler in operation.

The overlying rock is in places very fossiliferous, the fossils being remarkably well preserved, and the inclosing rock at the surface having disintegrated the fossils occur intact in the surface soil.

The rock is very much cross grained in places, conspicuously so at the north end of the Robin Roost quarry and in the abandoned quarry opening immediately north of the Robin Roost quarry. The cross-grain is so pronounced in places as to cause a cleavage along the planes. This is of local occurrence, as large quantities of good stone uniform in texture have been removed from the different quarries.

The greater part of the stone is buff, but the bottom of the deeper openings is blue. Where the opening is eight cuts deep the blue stone extends into the third cut from the bottom.

Large stylolites (crowfeet) occur in several places, which cause almost as much waste rock as the vertical seams.

On the outcrop, where not covered by the overlying impure limestone, the stone has weathered with a rough corrugated surface causing several feet of waste rock exclusive of the residual clay soil. At the abandoned quarries northwest of the station, numerous open weather seams penetrate the mass of the rock.

The thickness of the rock quarried varies in different places from two or three channel cuts to six or eight cuts (15 to 60 feet).

There are two mills here, Reed's at the station, and Bedford Indiana Stone Co., a quarter of a mile south of the station, having in all eleven saw gangs, three planers, one header and three steam travelers. There are six derricks, nine channelers (five idle July, 1896) and two drills.

DARK HOLLOW DISTRICT.

On November 24, 1877, shortly after the completion of the Bedford & Bloomfield Railroad (now a division of the L., N. A. & C. R. R.), the Dark Hollow Stone Company was organized and in May, 1878, opened the first quarry in the Dark Hollow district. This quarry was very successful from the start, and in three years' time had paid back in dividends an amount equal to its original cost. Their first large contract, and indeed the first large contract calling for Bedford stone, was for the Indiana State House. In 1890, this company was succeeded by the Dark Hollow Quarry Co. The latter company was forced by the recent business depression into a receivership. It was reorganized November 30, 1894, under the title *Consolidated Stone Co.*, the quarry becoming No. 3 of that company's quarries.

In the autumn of 1895, the Consolidated Stone Co. opened a new quarry, No. 4, just across the hollow from the older quarry, which promises to become a valuable property. See Plate XXIX.

The Hallowell Quarry lies immediately north of the original Dark Hollow quarry, the quarries each working up to the dividing line. It was first opened in 1878, by Hinsdale-Doyle Granite Co., to furnish buff stone for the City Hall of Chicago. In 1882 it came into the possession of its present owners, *The Hallowell Stone Co*

The Bedford Steam Stone Works opened a quarry in 1886, just northwest of the Hallowell quarry, but on the north side of Dark Hollow. It was abandoned at the end of 1893, and a new opening secured about three miles due north of Bedford.

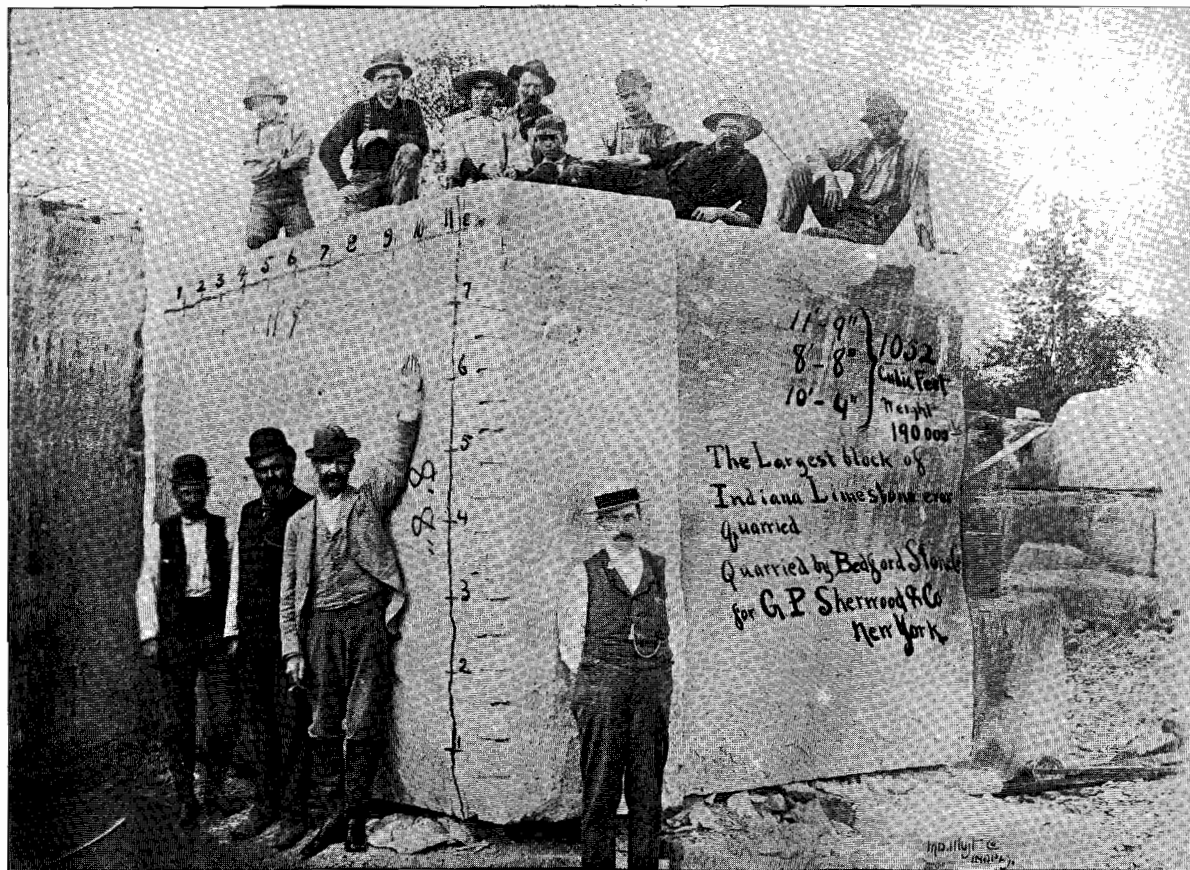
Both the Monon and the Belt Railroads have branches to these quarries. The Consolidated Stone Co. has a mill at one of their quarries, but the Hallowell Co. has its mill in Bedford, where the stone to be sawed, planed, or dressed, is sent.

The Hallowell Stone Co. uses the wire saw for cutting stone from the quarry, the only one used in the State. It was first tried a number of years ago and soon abandoned; later they used it in the yard for sawing blocks, and recently they have put it into use in the quarry again, where it is now (July, 1896,) in operation.

The oölitic stone is quarried on both sides of Dark Hollow, most of the quarries being on the south side. Thornton's quarry, the first one opened on the north side, is now abandoned. The Consolidated No. 4 has been recently opened on the north side, and is one of the most promising quarries in the State. It misses the mixed stone that stopped the other quarry on the north side of the hollow. The stone, as far as channeled, five cuts deep, is all buff of uniform grain and texture, very few seams and comparatively light stripping, three feet to five feet of soil and overlying compact rock. The slope back from the quarry is very gentle, so that a large area can be worked before the stripping becomes too heavy for removal. The oölitic limestone forms a bold outcropping ledge on either side of the quarry, which, while somewhat seamed and fissured, shows a comparatively bold outcrop with a face more even, smooth and regular than the average exposure. There are no horizontal seams, except a stylolite or crowfoot layer near the top, close to the contact with the overlying rock.

On the south side of Dark Hollow the quarries are along the face of the bluff and up a small ravine, and worked back into the hill until the thickness of the overlying material becomes too great for removal.

As is the case on the north side, the stone is remarkably uniform in texture and color. The stone is nearly all buff, a little blue occurring near the bottom in some of the openings. The vertical seams are remarkably even and regular, in many places almost as smooth as channel cuts, hence waste is very small compared with that where the seams are irregular and open.



IN THE QUARRY OF THE BEDFORD INDIANA STONE COMPANY.

The overlying compact limestone rests upon the oölitic with remarkable uniformity, in many places the parting between the two being marked by a stylolite (crowfoot) layer.

The Hallowell Company is now working on the remnant of rock left between their main quarry opening and the valley, practically on the outcrop of the rock. The comparative scarcity of seams here where ordinarily they would be more abundant speaks well for the homogeneity of the stone. There is considerable travertine in the abandoned opening west of the present working, which fills the seams and cavities in the rock.

In the Thornton quarry, the farthest one north, there is more blue stone than in any of the other openings. The greater part of the two upper cuts is buff and the large part of the remainder blue, but the buff follows the vertical seams through the blue, varying from a few inches to several feet. Likewise the blue frequently follows a stylolite (crowfoot) layer horizontally through the buff, thus causing great quantities of mixed stone.

The *Baalbec* quarry, though not exactly within the Dark Hollow District, lies near that district. It was first opened, shortly after the completion of the B. & B. R. R., by Hon. M. F. Dunn and Judge Francis Wilson. This was before the introduction of channeling machines, and when the firm worked back into the hill and struck a solid ledge which they were unable to work with the facilities at hand, they became discouraged and abandoned the quarry. The Baalbec quarry was leased in 1890 by the Acme-Bedford Stone Company and operated by them until 1894. In 1895 the Acme-Bedford Stone Company abandoned the Baalbec quarry and leased the B. & B. quarry in the Sanders District of Monroe County.

SPIDER CREEK QUARRIES.

Southwest of Bedford along the E. & R. Railroad there are several oölitic quarries, but only one, the Norton quarry, in operation at present.

The oölitic stone outcrops in the northeast quarter of section 22, township 5 north, range 1 west, close to the city limits, and from thence down Spider Creek Valley, both along the main creek and in the small tributary ravines to White River and along the White River bluffs.

In general the stone along Spider Creek is coarser grained and harder than that a little further north. It varies, however, in different parts of the valley and at different depths in the bed.

The *West Bedford Stone Company* opened a quarry and built a mill in 1892 about one-half mile northeast of the Norton quarry. The company ceased operations in 1893, and in 1895 the mill was purchased by

the *Climax Stone Company* and moved to the northwestern part of Bedford between the E. & R. R. R. and the Bloomfield branch of the L., N. A & C. R. R. The quarry machinery proper is yet in position.

The exposed rock is badly disintegrated in places to a depth of two or three feet. In the interior on the fresh surface it is quite firm and coarsely crystalline, in places having small patches of semi-compact stone. The top of the bed contains a great many well preserved fossils, which remain in the residual material as the rock decays.

Both buff and blue stone occur. The oölitic stone is overlain by a compact sandy limestone, which is 10 feet thick on the quarry face at the base of the hill, and contains numerous fossils and cavities varying from a half inch to two or three inches in diameter, some of them lined with crystals, others not.

Norton's Bluestone quarry in section 22, northwest quarter of southeast quarter (5 north, 1 west), was opened by Cosner & Norton in 1888, and has been in continuous operation since that time, but since 1895 operated by the C. S. Norton Blue Stone Company.

The rock is more uniform in character than that at the West Bedford quarry. The quarry is on the bluff on the east side of a small ravine from the southeast, and on the present face has a covering of from 10 to 15 feet of compact limestone, the bottom being more or less sandy.

The stone has been quarried to a depth of six channel cuts, about 40 feet, the upper part of the bed containing many small cavities, and hence much waste. Below the second cut the stone is an almost uniform blue color, with but very little waste, as there are but very few seams, and those that do occur are close joints. The stone contains some cross-bedding and does not cut quite so easily nor to such a smooth finish as the finer-grained stone, but it presents a handsome appearance with either rock or tool-dressed surface. Most of the product is shipped to New York City and used for building purposes.

The railway cut on each side of Norton's quarry shows a somewhat similar stone, but more of the buff stone than in the quarry.

In the abandoned quarry opening across the creek from Norton's quarry, and about 100 yards below it, the stone is much more cross-grained and quite porous in places. It contains numerous stylolite (toenails) and seams, both horizontal and vertical, thus causing a great quantity of waste rock, probably the reason the quarry was so quickly abandoned. It was opened first by the Bedford Blue Stone Company in 1889, who made a second unsuccessful opening in 1893.

The stratified compact stone overlying the oölitic has numerous geodic cavities containing quartz crystals. There are also many small stylolites in this compact limestone, five or six layers in the space of a foot.

In the numerous railway cuts between Norton's quarry and the river the oölitic stone is almost universally coarse-grained.

There is an old quarry opening on the south side of the railway in the southeast quarter of section 21 (5 north, 1 west) where some stone was quarried years ago by hand. It is finer-grained than much of the stone along this valley, and much more uniform. The stone, both on the quarried and on the natural rock face, is smooth, regular, sharp-angled, and has the appearance of great durability.

There is an old limekiln on the north side of the railway in the southwest quarter of section 22 (5 north, 1 west).

The Bedford Building Stone Quarry (sometimes known as the Gowen or *Limekiln quarry*) is in a small ravine on the east side of the creek in the northeast quarter of section 28 (5 north, 1 west). The quarry was opened in 1891, but ceased operations in 1893.

The stone has been taken from two openings at the head of the ravine, and while large quantities of stone have been removed, judging from the outcrop, the quarry face and the dump piles, much of it has been waste.

The stone has been quarried to a depth of 25 or 30 feet. There are numerous seams, both vertical and horizontal, along which the disintegrating forces have been at work. Some of the vertical seams extend to the bottom of the bed, but the horizontal ones are confined to the upper part of the bed. The three bottom cuts (18 or 20 feet) contain sound, compact stone of rather uniform, coarse texture, but much variegated in color. While the blue stone prevails at the bottom and the buff at the top, there is much intermingling of the colors between the top and the bottom. Some patches are coarsely fossiliferous, containing large brachiopods and gastropods.

The oölitic stone is overlain by 12 to 15 feet of laminated, argillaceous blue and buff limestone containing numerous geodic cavities, which is overlain by 20 feet or more of compact "lithographic" limestone which has been quarried and burnt into lime at the north quarry opening. No particulars could be obtained as to the amount burnt or use made of it.

Good bluffs of oölitic limestone occur along the north side of White River west from the Limekiln quarry.

SOUTH OF BEDFORD.

Along the Monon Railway, south of Bedford, a quarter to a half mile or more south of the city limits, there are several abandoned quarry openings, which were operated many years ago, and from which considerable oölitic limestone has been removed, but all are now idle. Part of it has evidently been burnt to lime, as there are three abandoned kilns near the quarries. They are said to be among the oldest quarries in the region.

At the first quarry south of the town, on the west side of the railway, there is an exposure of 12 to 15 feet of solid oölitic limestone, overlain

by 10 to 50 feet of compact (Mitchell) limestone. The oölitic stone is harder, more crystalline, less fossiliferous and freer from seams than the average, but there is too much material on top of it for it to have any economic value. The total thickness of the bed is not shown.

On the opposite side of the railway east of the limekiln, there has been a thickness of 10 to 12 feet of the oölitic stone quarried, along with 12 to 15 feet of the underlying (Harrodsburg) limestone, upon which the oölitic lies quite conformably separated by a stylolite (crowfoot) seam.

Along the railway, further south, half a mile south of the city limits, there are several rock cuts in which the oölitic stone is exposed in the bottom of the cut, overlain by 25 to 30 feet of compact limestone, which contains layers of partly oölitic.

About a quarter of a mile south of the limekiln above mentioned, are two other limekilns on the east side of the railroad, and on the east side of the ravine opposite these kilns is the best exposure of the oölitic stone in this vicinity. Considerable stone has been quarried by hand. There is no sign of any channeling. It is probably as handsome a stone as any in the oölitic region, and one wonders on looking at the quarry why it was abandoned. It is true, the bed is thin, much below the average for the region—about 20 feet. But on the other hand there is little waste and little stripping. It is both overlain and underlain by a compact, dull-looking limestone. The thickness overlying varies from 0 to 3 or 4 feet along the bluff, and the slope back from the edge of the bluff is very gentle. Despite the fact that the bed is thin, it is a more promising locality than many that are worked elsewhere.

EAST AND NORTHEAST OF BEDFORD.

All the quarries east and northeast of Bedford, with one exception, were in operation the past summer (1896), but operated on a very small scale compared with what they had evidently done in previous years. There are two large quarries on the east side of Bedford bordering on the city limits, one of which, the *Blue Hole quarry*, ranks among the largest, the oldest and best known in the area.

The *Blue Hole quarry* was first opened by Nathan Hall, as has been previously noted. In 1878 the property was purchased by the Hinsdale Doyle Granite Company, who put in a complete equipment for quarrying, and built a switch nearly a mile long to the L., N. A. & C. railroad. Later the company was reorganized as the Chicago and Bedford Stone Company, in whose possession it now is.

The general features of the stone are similar to those south of Bedford. The bed is comparatively thin (from 20 to 30 feet), overlain by a compact, impure limestone, and underlain by the hard, semi-crystalline Harrodsburg limestone. The watercourses have cut deep ravines into



THE MAJESTIC BUILDING, INDIANAPOLIS, IND.

Constructed of Bedford Oolitic Limestone.

the limestone, exposing the oölitic stone near the heads of the ravines in and near the bottom, but the rapid descent of the streams leaves the oölitic bed on the slope of the hills, generally as a rather prominent ledge, down the ravine.

The most serious drawback to more extended operations is the heavy stripping. In both of the quarries east of town the oölitic stone has been quarried back into the bluff until the overlying material is 25 to 40 feet thick.

In the Blue Hole quarry work has been abandoned on the south side of the valley, and is being extended east along the north side of the valley.

The greater part of the stone has a fine, homogeneous grain, but there are a few streaks coarsely fossiliferous, a conspicuous one along the south side of the valley which shows plainly on the old channeled quarry face where it is scaling off or exfoliating. The scaling over the south wall extends to a height of 10 to 12 feet from the bottom, but is the worst in the coarsely fossiliferous layer. It is evidently due to freezing on the wet, fresh surface, as the waste stone in the dump shows no crumbling. There are several stylolite seams and a number of joint seams. Both the blue and the buff colors occur.

All the work in late years has been on the north side, where the stone appears to be uniform in texture and does not have so many stylolite seams. The few joint seams that occur are small, and there is comparatively little waste in the oölitic bed, but the stripping is very heavy. They are starting the fifth channel cut near the north end of the opening.

Immediately north of the opening of the Blue Hole quarry is an old quarry, the Nathan Hall quarry, said to be one of the oldest quarries in the region, worked many years ago, before the use of the channeler, when the work was done by hand. On the old quarry face and on the loose boulders the only effect of exposure observable is in the darkening of the surface.

The Benzel Quarry, opened by the Bedford Blue Stone Company in 1890, shows on the present quarry face six to ten feet of shelly, weathered semi-oölitic limestone underlain by 25 to 30 feet of compact impure limestone and 23 feet of clean oölitic stone, three or four feet of "soapstone" and 18 feet of hard blue semi-crystalline limestone which contains considerable carbonaceous matter and is now being quarried. They went down into this second channel cut this summer, but have quarried none of it for the market so far.

In the middle of the quarry the blue stone extends to the top of the oölitic bed, but at either end the buff stone occurs in the upper part of the bed. As the parting between the blue and the buff is quite irregular there is considerable mixed stone. The buff runs deeper at and near the joints.

The Brown Quarry. The Brown quarry, opened by the Bodenschatz-Bedford Stone Company in 1890, is about half a mile northeast of the city limits and more than a mile north of the E. & R. railway, with which it is connected by a branch joining the main line at the mill of the Bedford Stone Mill Company. The oölitic stone is thicker than at the Blue Hole quarries, but there is much more waste rock. There are more stylolitic seams and the joints are more deeply weathered than further south. There are two openings, one on each side of the railway track. The upper (eastern) one has been channeled five channel cuts deep. The one on the lower (west) side shows five cuts, and the bottom covered with water may conceal one or two more. There appears to have been very little stone quarried here this year (1896). The large amount of waste stone probably makes it unprofitable at the present price of stone. This stone is used for monumental purposes almost altogether, very little building stone being quarried.

The Salem-Bedford Quarry is about a quarter of a mile northwest of the Brown quarry and about half a mile northeast of the Salem-Bedford mill. The quarry was opened and the mill built in 1892. There are three separate openings, all of which are idle (July, 1896), whether permanently or temporarily abandoned is not known. The numerous stylolitic (crowfoot) seams and the irregularity of the parting between the buff and the blue are the objectionable features. Most of the stone that can be obtained free from these defects is good stone; only in one place was it found to be coarsely fossiliferous. The most promising opening of the three is the last one made, the one furthest west. Only two channel cuts have been made in it, the upper showing the weathering influences, but the second showing a fair quality of blue stone.

The Standard Quarry was opened in 1893 by the Standard Stone Company about one mile northwest of Bedford on a branch of the Bedford Belt Railway.

Both buff and blue stone are obtained of a medium fine uniform grain. The east-west joint seams are numerous, but are not much weathered, mostly close joints. The quarry stone is overlain by 12 feet to 15 feet of compact sandy and a coarsely crystalline limestone. The thickness of the oölitic stone is about 25 feet.

THE HELTONVILLE LIMESTONE STRIP.*

Commencing at Limestone Hill, eight miles southeast of Bloomington, and extending east of south through Heltonville to, and probably beyond, Fort Ritner, Lawrence County, is a band of limestone from one-half to one and a half miles in width, bordered sharply, both east and

*All the matter under this head and the Mitchell Hollow, Fort Ritner and Fishing Creek districts was written by Mr. Siebenthal.

west, by Knobstone, and known in that neighborhood as the "Limestone Strip." Isolated patches of similar limestone occur north of this strip and in line with it. The strip is well developed in the vicinity of Heltonville, Lawrence County, where it gives exposures of the Harrodsburg, Bedford Oölitic and Mitchell limestones.

At many points the Knobstone contains intercalated lenticular beds of limestone, and it is possibly conceivable that the conditions which prevailed while these beds were being deposited might have been extended over a narrow territory like the Heltonville strip. However the fact, first, that Knobstone has not been found overlying this limestone, and second, that it shows the lithological facies of the Harrodsburg, the Bedford Oölitic and the Mitchell limestones, and the faunas of these formations, identifies it with them and shows conclusively that it is a narrow band of those formations, occupying a depression in the Knobstone, and not an included member of the Knobstone.

This depression may have resulted from a double fault or may be an old erosion channel. Some things seem to point to one as the origin and some to the other. The facts at hand incline us to the latter view. The most palpable objection to this view is the fact that no non-conformity exists between the Knobstone and the Harrodsburg limestone at their contact a few miles west of the strip. Another objection is that the bottom of the channel, at present at least, is not at all of uniform elevation throughout its length. The principal objections to the view of a double fault are two—at no point was a direct vertical contact of limestone and Knobstone visible, nor was there to be seen any of the tilting, crushing and shattering which usually accompanies faulting. On the other hand, as the vicinity of the contact line is approached the shaly members of the limestone become more and more argillaceous and apparently pass over into the Knobstone. To determine the exact conditions under which the limestone strip was laid down would require more extended study than was consistent with the scope of this report. What has been done was to trace upon the accompanying maps the outcrop of the Bedford oölitic and to examine the bed more carefully at the places where it is now being quarried, namely at Heltonville and Fort Ritner.

The Heltonville Oölitic Limestone Company opened a quarry in 1890 in the vicinity of Heltonville, T. 6 N., R. 1 E., sec. 25, S. W. N. W. qr., which is equipped with two Wardwell channelers, steam drill, derrick, power, etc., and employs from 10 to 25 men. Three channel cuts six feet six inches each are made in fine-grained buff oölitic, and below that is channeled 10 feet of so-called Troy marble. The latter is a massive bryozoic development of the upper member of the Harrodsburg limestone. It does not take a very good polish owing to the openness of the bryozoa, but on a bedway face the lacework effect of the delicate bryozoa is very beautiful. Along the south bluff of Leatherwood Creek

just north and east of the Heltonville quarry the oölitic is very fine grained and white. About a half mile up the creek from the quarry the limestone is shut off sharply by the Knobstone. The oölitic caps the ridge across the creek north of the quarry, as indicated on the map (Bedford sheet), and shows in two small patches in section 31 of township 6 north, range 2 east. South of these occurrences no oölitic is met with until in the vicinity of Fort Ritner.

SOUTHEAST OF BEDFORD.

Mitchell Hollow, Palestine, Fort Ritner, Rock Lick, Fishing Creek.

The Tanyard Stone Company, organized in 1890, opened the *Mitchell Hollow quarry* on the Bedford branch of the B. & O. S.-W. Railway, about three miles southeast of Bedford (T. 5 N., R. 1 E., sec. 30, sw. $\frac{1}{4}$). The quarry in 1892 passed into the hands of the Bedford Stone Company, by whom it was abandoned in 1893.

The oölitic limestone here is about 33 feet in thickness, overlain by a six-inch stratum of dark blue shaley limestone containing many small cup corals, which is in turn overlain by eight feet of massive, fine-grained buff and blue Mitchell limestone with a spongy weathering. The oölitic is divided by three bad toenail seams into four beds which, beginning at the top are respectively three feet, 16 feet, five feet, and nine feet in thickness. The upper bed is medium fine grained, mixed buff and blue, badly cross-bedded and fractures along the cross-bedding. The second bed is the principal quarry bed. It is of medium fine grain, but contains patches of much coarser stone, is badly cut up by vertical seams, and badly mixed buff and blue. These latter features caused the quarry to be abandoned. The third bed is rather coarse grained dark blue limestone. The fourth bed was concealed by water at the time of my visit, but is probably similar to the third bed.

The *Tanyard Creek Stone Company*, incorporated at Chicago in 1890, opened a quarry and built a mill on Tanyard Creek just north of Palestine Station on the B. & O. S.-W. Railroad. The property was sold in 1892 to the *White River Stone Company*, who made a new opening about a quarter of a mile southeast. This was sold under foreclosure in 1895 to the *Bedford Sterling Stone Company*, who are at present operating the quarry, known as the Tanyard or White River quarry. The stone has a rather coarse grain, and is both buff and blue in color, with considerable mixed stone, due to the intermingling of the two colors. Some of the blue stone is exceptionally dark in color, caused by an excess of carbonaceous matter. It acquires a deeper, darker color on exposure, possibly due to the heat of the sun drawing the carbonaceous matter to the surface. The stone has been quarried four channel cuts, about 25 or 26 feet deep.

There are no bedding seams except a stylolitic layer near the top of the quarry, and the joint or wall seams are not numerous. There is but little waste in the quarry, except from the mixed colors, which is waste only in first-class dimension stone, and may be used for bridge or foundation stone. The oölitic stone is overlain by four to 15 feet of sandy clay, which contains remnants of compact stratified limestone. There is a mill with two gangs of saws at the quarry. There is another smaller opening about 100 yards west of the one above described from which bridge stone has been quarried.

Fort Ritner District.—*A. Luedtke's* quarry is in the southwest quarter of section 11, 4 north, 2 east, about a mile and a half east of north of Fort Ritner. It works an isolated patch of oölitic similar to the occurrence at Heltonville and lying in the same limestone belt. The site was first prospected in 1858 by one Needham, who afterward located the Salem quarries. It was first opened in 1860 by George A. Smith, who shipped stone that year to Cincinnati for Lincoln Park. He was succeeded by Enoch Dixon, who operated the quarries many years, employing 10 to 15 men. Dixon was later succeeded by the present owner, A. Luedtke. The quarry has no switch connection, but the stone is hauled on wagons to the B. & O. S. R'y at Fort Ritner. The market has been mainly local, the stone being used for bridge piers, etc., and buildings in Seymour, Brownstown, etc. The ledge shows eight feet of good quality very light buff stone underlain by four to six feet of good blue stone, which takes a nice polish. The oölitic stone is overlain by a flaggy, blue stone which has been quarried extensively for flagging and curbing. A hand-power derrick is the only piece of machinery at the quarry.

C. Dixon's quarry, which lies just over the hill east of the Luedtke quarry near the center of section 11, 4 north, 2 east, has been but recently opened, and has about the same thickness of oölitic. The upper part is a very good quality, but the lower portion is coarser-grained and quite fossiliferous. Very little stone has been taken out except for a few monument bases, and there is not even a derrick at this quarry.

Rock Lick District.—Two quarries have been opened in this district, both abandoned several years since. The quarries are reached by a branch from the B. & O. S.-W. R'y, leaving the main line just east of Mitchell.

The first quarry opened was the *Big Four quarry*. The quarry which is near the center of section 31, 4 north, 1 east, was opened in 1889 by parties from Mitchell, and abandoned after three or four months. The oölitic limestone, which shows to a depth of 14 feet, is coarse-grained and has a very fetid odor on fresh fracture. Two cuts were channeled, which disclose many bad seams. The hill rises steeply from the quarry opening, and the stripping soon becomes very heavy. These causes led to the early abandonment of the quarry.

Leeds, Chanler & Starr, of Chicago, in February, 1890, opened a quarry 400 yards north of the preceding. Two five-foot buff cuts were made and taken out, and a third, a blue one, channeled but never taken out. The two buff cuts are traversed by three horizontal "toenails," which have thickening and thinning shaly places. Three large vertical seams run back into the bluff. The rock is very hard and injured by mixing of colors. It is not very fossiliferous. The total thickness is not less than 18 to 20 feet, which is above the average in this neighborhood.

Fishing Creek District.—The productive area of Fishing Creek includes the outcrop on both sides of the creek south from Lawrenceport for a distance of two miles. A good quality of fine-grained buff oölitic stone outcrops in the street in the south part of the village and shows at different points along the roadside south for a mile and a half. Where the Mitchell and Bono road crosses Fishing Creek at the south side of section 35, township 4 north, range 1 east, the oölitic shows to a depth of 30 feet on the west side of the creek and to a depth of 40 feet on the east side. The section exposed on the west side shows, eight feet from the bottom of the oölitic, three feet of shaly limestone and two feet of shattery limestone, which do not appear on the east side, where the grain also seems finer. Bores in this neighborhood report from 24 to 43 feet of buff oölitic. Along the drain which flows into the creek from the east, just south of the road referred to, the oölitic shows to a depth of 40 feet, the upper 15 feet of which is a fine quality of fine-grained oölitic and the remainder fair quality, all showing good weathering qualities. In the northeast, southwest quarter, section 2, 3 north, 1 east, the west bluff of Fishing Creek shows 36 feet of oölitic limestone, the upper 10 feet of which is fair medium, fine-grained, underlain by six feet of splendid fine-grained, underlain in turn by 20 feet of medium, coarse-grained, but fair quality of oölitic stone. The weathering qualities of each member is of the best. Taken all in all the Fishing Creek district is one of the most promising in the oölitic belt, and fully deserves the development which awaits it at no greatly distant date.

Salem and vicinity.—Time did not permit a detailed study of the area much south of Bedford or a detailed mapping of the area south of that shown on the Bedford sheet. But a brief examination was made of the Salem quarries and one or two others in the vicinity and the notes here recorded in the absence of more detailed work.

The quarry of the Salem Stone and Lime Company, now the Salem-Bedford Stone Company, is on the south side of the Monon Railway, about half a mile west of the town of Salem. The quarry was for many years worked quite extensively and produced some excellent building stone which went into fine buildings. The Georgia State House is constructed of this stone, as is the Salem Court House, one of the neatest



OUTCROP OF OOLITIC LIMESTONE ON BLUFF WEST OF TWIN CREEK, WASHINGTON COUNTY.
Harrodsburg limestone in the foreground. Bedford white limestone at the top.

court houses in western Indiana (see plate XXXVIII). There are a half dozen different but closely adjoining openings along the bluff running south from the railway on the west side of the branch road made by the company. The bottom of the stone is concealed either by water or debris at present, so that the total thickness of the stone is not shown. The walls show from three to five channel cuts, or from 20 to 30 feet, with three to 20 feet of rock and soil stripping. No stylolitic (crowfoot) seams were observed. There are a few incipient bedding seams and some cross-bedding, rather pronounced in a few places. There are a few joint seams, but they are neither large nor numerous.

The stone has a medium fine grain; no large fossils were observed. The greater part of the stone is buff, yet in a few places a little blue stone occurs.

There is a large stone mill and a number of limekilns at the quarry, but the mill is now idle. Most of the channelers have been removed and there appears to be very little dimension stone being quarried (1896).

A unique feature of this quarry is the absence of the large dump piles of waste stone, the universal accompaniment of the quarries elsewhere. The explanation of this is found in the limekilns at the quarry, where all the waste stone is burnt to quicklime and marketed in that form. The only stone that is being quarried at present (July, 1896) is the broken stone for lime burning (see p. 336).

On the north side of the Monon Railway, on the west side of Salem, there is a large quarry in the limestone underlying the oölitic (the Harrodsburg stone), where limestone is quarried and crushed in a steam crusher for railway ballast. Stone is shipped from this crusher at the rate of 80 to 100 cars per day (July, 1896). There are two varieties of stone—a compact blue stone with conchoidal fracture and a gray crystalline stone. At Spergen Hill, four miles east of Salem, is an outcrop of oölitic limestone famous for the great number of well-preserved fossils which it contains. It is probably one of the most prolific fossil localities in the State. Many of these fossils are pictured and described in the 12th Annual Report of the State Geologist of Indiana, 1882. The stone has but little economic value in this locality.

Twin Creek.—On Twin Creek, about two miles north of Smedley Station on the Monon Railway, and seven or eight miles north of west from Salem is a promising outcrop of oölitic limestone. It is exposed on both sides of the creek in bold cliffs at or near the top of the bluff, in some places forming perpendicular or overhanging ledges. There are clean exposures of not less than 25 to 30 feet* of oölitic stone and the total thickness may be greater than that, as in no one place are both the top

*Having no barometer with me, all the dimensions of this locality are estimates made by the eye.

and bottom of the bed clearly exposed. A few small stylolitic seams were observed, and there are a few joint seams, all of which appear to be regular. The weathered surface is in most places comparatively even and smooth.

The bluff at one place shows 25 to 30 feet of massive oölitic limestone overlain by 10 to 20 feet of coarse, partly oölitic laminated stone, overlain by 8 to 10 feet of earthy, sandy limestone overlain by blue limestone. The massive ledge has a fairly uniform texture of medium fineness and buff color. It appears to be a little more crystalline and harder than the stone further north.

The Twin Creek Stone Land Company of Salem, who own the greater part of this bluff on the east side of the creek, sent in samples for testing, the results on which show for the crushing strength:

Tested on natural bed, No. 1.....	11,700 pounds per square inch.
Tested on natural bed, No. 2.....	6,900 pounds per square inch.
Tested on natural bed, No. 3.....	11,100 pounds per square inch.
Tested on edge, No. 4.....	8,900 pounds per square inch.

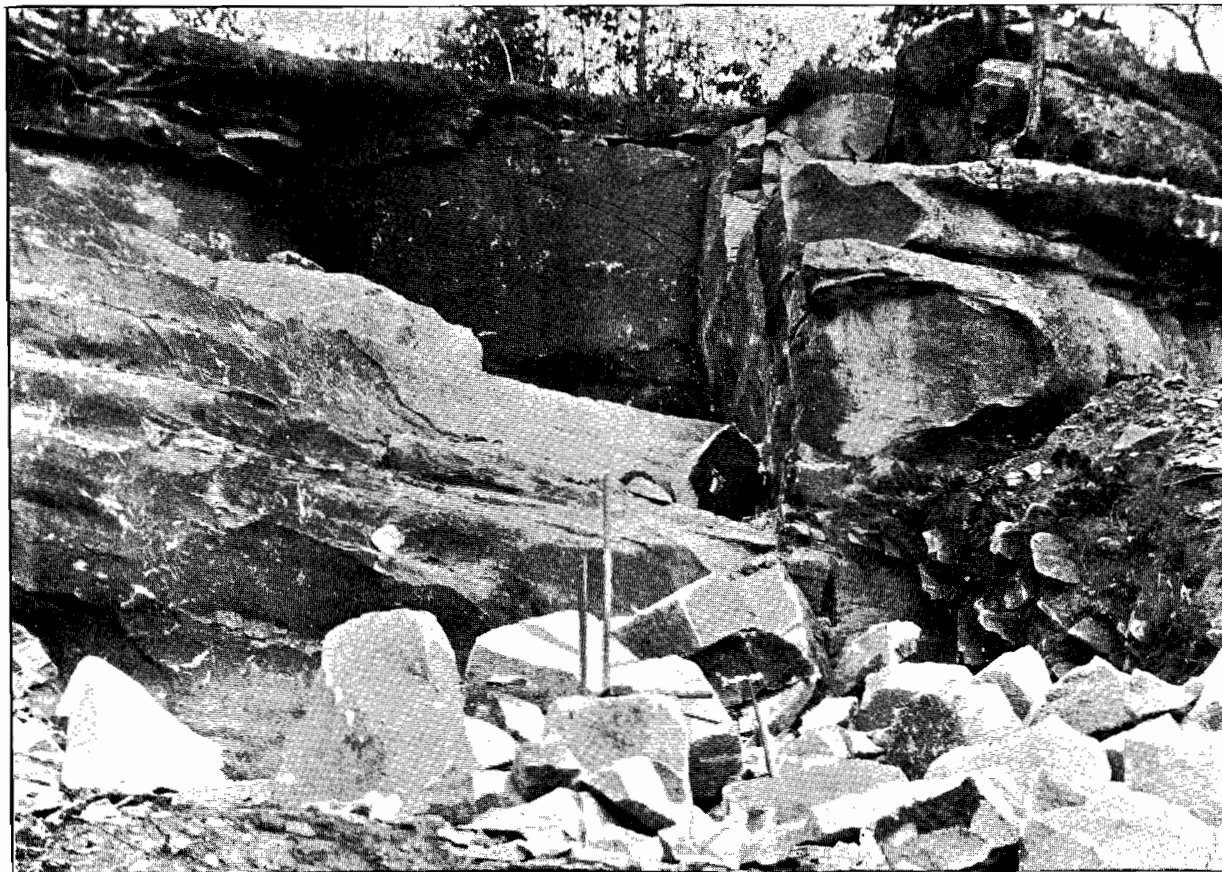
The average of all being 9,400, the average on the natural bed, 9,900; but as No. 2 was an imperfect sample, the side chipping off before breaking, the average for the good specimens on the natural bed would be 11,400, a result higher than that for any of the other specimens of oölitic limestone tested in the same lot with one exception. The absorption shows it about equal to the average oölitic limestone in this respect, 1 in 31. Its specific gravity is a little higher than any of the other limestones tested. The chemical analysis shows it to be a very pure carbonate of lime, closely resembling the oölitic stone from other localities in this respect.

*Chemical Analysis of Twin Creek Oölitic Limestone.**

	Per cent.	Per cent.
Residue insol. in acid	0.76	
Lime (CaO)	54.97	
Or lime carbonate (CaCO ₃)		98.16
Magnesia (MgO).....	.46	
Or magnesia carbonate (MgCO ₃) .....		.97
Carbon dioxide (CO ₂).....	43.68	
Alumina and ferric oxide .....	.15	
Total.....	100.02	

There has not been sufficient work done in this locality to fully establish the quantity of good stone. However, the little work that has been done (see plate XXXVI) only strengthens the favorable impression that one gains from observing the outcrop. Unless defects are brought to light by further development, that do not now appear, we may expect to find

* Made by W. A. Noyes, Rose Polytechnic Institute, Terre Haute.



A NEAR VIEW OF PORTION OF THE BLUFF SHOWN ON PLATE XXXVI.

this a productive locality in the future. See the accompanying illustrations, plates XXXVI and XXXVII.

Stone for local use has been quarried on the bluffs on each side of Twin Creek for a number of years.

Oölitic stone is reported south from Salem to the Ohio River, but no opportunity was offered to examine it. So far as could be ascertained, it has been quarried at only one locality, Stockslager's quarry, near Mauckport, in Harrison County, on land now owned by David W. Jacobs. The quarry has not been operated for a number of years. A chemical analysis of the stone is given in the table on page 320. The stone is said to be whiter and more oölitic than that near Bedford. Some of it has been burned to lime and is said* to yield a pure white lime, which, besides its local use, is said to have been shipped south on the rivers to Mississippi and Louisiana for use in purifying sugar.

CHAPTER V.

OÖLITES AND OÖLITIC LIMESTONES IN GENERAL.†

Definition. The word oölite literally means egg-like, more specifically, like fish-eggs, and is used to designate rocks made up wholly, largely or partly of rounded particles, resembling fish-eggs in shape and often in size. The term *oölite* is sometimes limited to rock composed entirely or nearly so of the rounded particles, using the term oölitic limestone if there is much other material with the rounded particles. Hence we have the expression "more oölitic" or "less oölitic," as the proportion of rounded particles to the whole mass increases or decreases. The word is used with different signification by different writers, as will appear in the following pages.

The greater part of the literature on the subject is in German, particularly on the structural part. The French and English have written a great deal on the stratigraphy and paleontology of the oölite of Cretaceous age, but very little on the petrographic character of the rocks. The Americans have very little on the subject, as it is not a widespread formation in this country, and regions where it does occur have not been studied very thoroughly.

*John Collett, Report on Harrison County. Geol. Surv. of Ind., 1878, p. 412, where a short description of the stone is given.

† There is no genetic difference between pisolite and oölite, the only distinction being that of the size of the constituents. As opinions differ as to where to draw the line, the pisolite will be considered in this paper simply as a variety of oölite.

The most specific treatment of the subject is in Zirkel's *Lehrbuch der Petrographie*, to which we are indebted almost entirely for the following classification.

Varieties of oölite.—On the basis of composition, oörites may be divided into calcareous, siliceous, argillaceous and ferruginous. The first is the largest and most important class, the others much more limited in their occurrence, and the following remarks refer almost wholly to the calcareous or lime oörites.

The little spheroids are sometimes made up of concentric layers, sometimes radially fibrous, sometimes both, sometimes neither. This gives a suggestion for a division of the subject into (1) oörites proper, (2) oöolithoids, (3) pseudoörites.

I. *Oörites proper*, or oörites in the narrow sense, include those with a distinct concentric or radiated structure, and may include three varieties: (1) The first or Carlsbad type is made up of concentric shells of aragonite with no radial fibres, the negative vertical axes of the aragonite having a more nearly tangential direction, except in the outer periphery, where they stand radial. (2) In the second variety the spheroids are formed of more or less concentric layers, the individual layers consisting of small radial calcite fibres, which have a negative principal axis nearly radial, the usual structure of the oölite grains of the English Jura and the larger grains of the rogenstein. In the rogenstein a fine layer of clay often separates the individual layers of calcite. (3) A third variety has radiated, but no concentric shelly structure—many of the smaller rogenstein grains.

In all three of the above varieties the grains have a kernel of foreign material which may be quartz, feldspar, limestone, shell fragments, crinoid pieces, foraminifera, bryozoa, coral sand, or fragments of oölite itself. In the so-called Riesenoölite (giant oölite) of Sasso Mattolino the kernel of the large pisolitic grains consists of a coarse aggregate of either calcite or dolomite grains with stratified iron oxide.

II. The second generical class, *oöolithoids*, or oölite in the broad sense, may be subdivided into four varieties:

1. Consisting of concentric layers of alternating zones of very fine crystals and coarse crystals. The layers may be alike chemically, but vary greatly in structure, color, shape and size.

2. A second variety in which the concentric structure is a marked chain-like folding upon one another.

3. The concentric separation of the inner part of the spheroid by foreign coloring matter.

There is no radial structure and no foreign kernel in any of these three varieties.

4. A fourth variety consists of those made up of many systems of tufted calcite rays thrust upon one another.

III. *Pseudoöolites*. A third class, still further removed from the true öolites, is the pseudoöolite which has only the outer rounded form in common with the other classes. Four varieties are given:

1. In which the rounded bodies have only a slight local difference from the matrix. An individual structure wholly wanting. The outer limits not sharply defined. This may consist of (a) very fine crystalline particles in a coarsely crystallized mass; (b) coarsely crystalline particles forming a rounded granular heap in a finely crystalline mass, and (c) the spheroidal parts formed by the concentration of the colored bitumen in the interior.

2. Öolitic grains consisting of rounded fossil fragments covered here and there with a thin coating of carbonate. The öolitic limestone of Indiana.

Steinman found these fragments covered with a thin coating having the microscopic structure of a sponge. In some of the older Tertiary the kernel of gasteropod shell is covered with a vegetable coating, Lithothamnium.

3. The apparently öolitic grains are only fragments of a crystallized granular limestone, polished by friction and cemented by limestone.

4. In a fourth variety the concentric coatings form on little insect eggs. Such were observed by Virlet d'Aoust in the seas of Chaleo and Tecoco in Mexico.

C. W. Gumbel* gives a three-fold division of the subject into 1, *Extoöoliths*, those formed by outward growth from the interior; 2, *Entoöoliths*, formed by inward growth or filling of a cavity, and 3, *Dimorphoöolite*, a combination of the two where the interior of the shell is filled with crystalline material, and the exterior coated with concentric layers. This includes only the first division given by Zirkel, and does not recognize the other two divisions.

Prof. Merrill† says that öolitic limestone is made up of carbonate of lime in three forms: 1, minute subangular shell fragments; 2, concentric coatings; 3, colorless crystals filling interstices.

Geikie says (Text Book, p. 119), that öolite is a limestone formed wholly or in part of more or less perfectly spherical grains resembling the roe of a fish, each grain consisting of concentric shells of carbonate of lime, frequently with an internal radiating fibrous structure. He does not recognize Zirkel's öolithoids and pseudoöolites.

L'Apparent distinguishes two varieties: 1, *Extoöolithes*, and 2, *Entoöolithes*, as given by Gumbel.

Prof. Sorby, in his address before the British Association, described three types of öolitic grains: (1) Concentric, as the Carlsbad Sprudelstein; (2) radiate structure consisting of concentric layers of calcite with

* Neues Jahrbuch of Min., u. s. w., 1873, pp. 303-4.

† Stone, Vol. 1, p. 295.

their principal negative axes arranged radially; (3) recrystallized from aragonite into calcite.

Barbour and Torrey, in the *American Journal of Science**, describe two varieties of Iowa oölite, one with concentric structure, another with a sort of brecciated spherule composed of mosaic of exceedingly small fragments cemented together about a center. They resemble each other chemically and microscopically, the distinction being a microscopic one.

Dr. Rothpletz, in the *American Geologist*,† describes a snow-white oölite of vegetable origin on the shore of Great Salt Lake, where the lime is inclosed in the form of rounded tubercles which often mass themselves into larger irregular tubercular bodies which always inclose numerous dead algæ cells.

He describes three varieties: (1) Irregular tubercular bodies; (2) spherical or oval forms; (3) long, thin rods. The rounded or oval forms are, both by their external form and by the microscopic structure, true oörites. Around an immense nucleus are laid concentric shells with radial arrangement of the calcite crystals. But minute scattered granules occur in both the nucleus and the shell. By dissolving the lime slowly in very dilute acid the granules remain behind in exactly their original position and are seen to be dead and crumpled *Glæo capsula* cells, thus showing the vegetable origin of the oölite.

Origin of calcareous oörites.—If we use the term oölite in its wide sense, we would expect the different varieties to be formed in different ways. Using the term in its restricted sense, however, we find different opinions as to the origin.

Geikie says each grain consists of successive concentric shells of carbonate of lime, frequently with an internal radiating fibrous structure, and was formed round some minute particle of sand, or other foreign body, which was kept in motion so that all sides could in turn become encrusted. Oölitic grains of this kind are now forming in the springs of Carlsbad; but they may, no doubt, also be produced where gentle currents in lakes, or in partially enclosed areas of the sea, keep grains of sand or fragments of shells drifting along in water which is so charged with lime as to be ready to deposit it upon any suitable surface.

Prof. Merrill expresses about the same views, stating that by the evaporation of sea water the pellicles were deposited on the little grains which were kept in gentle motion by the waves. After the elevation above sea water the crystalline parts were deposited. (Stone, April, 1889.)

Prof. Seeley, in Phillips' *Manual of Paleontology*, says there can be no doubt that the formation is due to the evaporation of the surface of

* *Third Series*, Vol. 40, p. 246.

† Nov., 1892, p. 379.

the sea, so that a film was formed around some shell fragment and continued to increase in size as it fell through the water, until it sank to the bottom. This, he states, accounts for the uniform size of the grains in the same stratum.

In a paper before the British Association (1888), the same writer states that oölitic texture might originate in many ways. He thinks that many oölitic grains are pseudomorphs. In the magnesian limestone grains of dolomite present all the characters of oölite. It is so common for large foraminifera to be the nuclei of oölitic grains in the Carboniferous limestone of England as to almost justify Dr. Carpenter's view that oörites are foraminifera limestone where the foraminifera are coated with calcite. The small size of some grains is due to the transforming power of the current which is assumed to have formed them by rolling. He remarks on the close resemblance of the internodal grains of the nullipores to oölitic grains. These grains show a concentric structure as well as a radiated tubular structure which would favor recrystallization such as commonly occurs.

In a private communication he states that his conclusion in regard to nullipores was the result of his examination of the weathered surface of the Portland oölite in the University of Cambridge and subsequent examination of many oörites in Great Britain and other parts of Europe. He believes there are several types of oölitic grains which can not be explained in this way.

Prof. Sorby (An. Add. Br. Assoc., p 44), says that the concentric sprudelstein of Carlsbad is not formed by the normal deposition of crystals from solution, but by the more or less mechanical accumulation of minute prismatic crystals, with their longer axes parallel to the surface of growth. The minute crystalline nuclei were mechanically accumulated round a center like the layers in a large rolled snowball. True chemical deposition may have been going on at the same time.

In recent oörites of Bahama and Bermuda the spherules were formed in water muddy from decayed shells and corals, and the purely chemical deposit served simply to collect the fragments into spherules. The grains show a granular and crystalline structure in varying proportion in different grains and different layers. Secondary crystallization has sometimes taken place since deposition.

The oölitic grains in the Jurassic rocks indicate the original deposition of calcite round nuclei gently drifted along by currents of the ordinary temperature which caught up more or less of the surrounding mechanical impurities.

Prof. Dana (in Corals and Coral Islands, pp. 153 and 156), describes two different formations of coral oölite. (1) The coral fragments on the beach are worn into sand grains and coated and cemented by alternate moistening and drying through the action of the tides. They form regular

layers from a few inches to a foot in thickness, and consolidated to a line a little above high tide. (2) A second variety is formed on the islands above the action of the tide on the sand banks of wind drift origin, and consolidated by infiltrating waters.

The oölites on the shore of Great Salt Lake, as described by Dr. Rothpletz, are evidently of vegetable origin.

W. H. Thompson (in 16th An. Rep. Geol. and Nat. Hist., Survey of Indiana, 1888, p. 81), referring to the Indiana oölite, says that the more it is studied, the more it appears to be the result of calcareous sediment deposited at the bottom of a deep trough in an otherwise shallow sea. The minute shells are cemented together with a cement composed of fine fragment dust of other shells and an immediate setting of Ca CO_3 , rendering the whole mass homogenous, elastic and resonant.

Maurice Thompson says (17th An. Rep., '91), the special conditions under which the Indiana oölitic limestone was deposited were a deep, still sea teeming with minute shell-bearing animal forms—a sea whose shores were lined with the deposits of still older seas from which the water took up the lime in solution which precipitated along with the animal remains as a cement.

A. Knop (Neues Jahrbuch, '74, pp. 281–288), laments the fact that little has been done to explain the origin of oölites, and finds but little literature on the subject. He says that oölites whose form and structure are very similar, may have an entirely different origin. The Carlsbad Sprudelstein is cited as an example of the inorganic origin. The infilling of cavities in melaphyre, basalt, etc., is cited as proof that the spherules may be formed from the periphery inward. He examined many oölites and found none incrusting quartz sand grains, the centers being generally filled with calcite.

Knop describes oölite grains formed by the deposition of lime on carbonic acid gas bubbles. He found considerable deposits of this kind in the watercourses by Nauheim. By observing in his aquarium the great army of young brood of a sort of *Limnæus* and the very few individuals that came from it, he saw in the great mass of empty shells heaped up at the bottom of the ditch, a source of oölite, which would be formed by filling up the interior and coating over the outside. He thinks this applicable to the hornstone oölites of the anhydrite group of Pforzheim and Durlack.

Virlet d'Oust is also of the opinion that oölites can originate through the filling of existing cavities. He was led to this view by observing on the shores of Mexican seas milliards of insects which laid their eggs, the crusts of which would form foundation for the inner incrustation.

Leopold Von Buch, in his description of the Canary Islands, considers the oölite to be formed of broken shell fragments rounded by the waves and solidified by the deposition of lime out of warm sea water.

Ehrenberg thinks that the oölite grains of many limestones are derived from foraminifera, whose shells are rarely well preserved.

An interesting and somewhat surprising explanation of oölitic structure is offered by Mr. Wethered* of England, viz. : That it is organic, formed by a concentric wormlike organism which he gives the generic name of *Girvanella*, and distinguishes two species in the carboniferous oölite and two in the Jurassic oölite.

The best examples occur in the Corraline oölite, where he distinguishes the following types of oölitic spherules: 1. A spherule with a minute loosely aggregated form of *Girvanella* tubules as a nucleus surrounded by an irregular sort of concentric arrangement. 2. The same form of *Girvanella* in loose aggregations or surrounding foreign objects. 3. A spherule made up of loosely aggregated, very vermiform tubuli, which are larger. 4. The nucleus consists generally of calcite, and the concentric arrangement has a granular crystalline appearance, in which occasional outlines of tubuli appear. 5. A spherule with well defined concentric arrangement around a nucleus. He states that it has been the object to produce evidence that oölitic structure is not always of concretionary origin. He is not prepared to maintain that it is all organic, but it may be.

As explained elsewhere in this paper, the Indiana oölitic limestone is a mass of fossil foraminifera and allied shell forms.

Distribution of calcareous oörites.—The principal deposits of calcareous oörites in the United States are in the Lower Carboniferous limestones in the Mississippi Valley. So far as known to the writer, none of any note occur in this country in any other formation. The oölitic limestone occurs in irregular insular areas of varying extent in Indiana, Kentucky, Illinois, Iowa, Missouri and Arkansas. The details of its occurrence, development and use are but little known. Despite its present and prospective value, comparatively little has been written on the subject. There are a few brief papers of a very general character in the Indiana Geological Survey reports; the name occurs in a few places in the Kentucky reports, once in the Illinois reports, twice in the Iowa reports, and several times in the old Missouri reports of 1873-74. Short descriptive articles of a more or less general nature on the oölitic limestone of Indiana have appeared in *Stone, Mineral Industry and Mineral Resources*, the first named containing a good illustrated article on the Bedford quarries.

Oölitic stone is said to occur in Kentucky in Christian, Caldwell, Mead, Grayson and Todd Counties. So far as could be ascertained from the literature and by correspondence, the only place that it is quarried to any extent is in the vicinity of Bowling Green, where a quarry has been in operation for a number of years. How extensively it is worked at

* Mr. E. Wethered on Oölitic Structure, in *Quar. Jour. of the Geol. Soc.*, Vol. XLVI, No. 182, p. 270, May 1, 1896.

present is not known to the writer, as letters addressed to the company elicited no reply. It may be like many other quarries in the country at present, not in operation. The stone is spoken of favorably in the Philadelphia markets. A short description of it in the *Mineral Resources of the U. S. for 1889-90*, p. 395, states that it closely resembles the oölite of Portland, England, both in appearance and composition. The Kentucky stone has 95.31 per cent. of the carbonate of lime, and the Portland stone 95.16 per cent. In places it is compact and semi-crystalline, and in some places composed almost entirely of oölitic particles.

Oölitic limestone is said to occur in Illinois at Jonesboro, Union County, and to have been quarried to some extent at Rosiclare, Hardin County. (See anal. on p. 320).

A. H. Worthen* says: "The oölite beds of this group (St. Louis) in the vicinity of Rosiclare and elsewhere may be easily cut into any desirable form, are susceptible of a high polish and make a very handsome ornamental stone. At some localities this rock is beautifully veined with white calcareous spar." With an analysis by Henry Pratten in Vol. III, pp. 288, 289, *Geol. of Monroe County*, he mentions the occurrence of 15 feet of light gray, nearly white oölitic limestone in massive beds.

Oölitic limestone occurs in *Iowa* in Marion, Grundy and Des Moines Counties. It is not known to the writer whether it is now quarried to any extent or not. It was quarried at Kilbourne and Pella some years ago, and may be at present.

In Missouri oölitic limestone occurs in Andrew County.

In Arkansas it occurs in Independence County near Batesville, in Carroll County near Eureka Springs, and at two points in Madison County. At all these points it has been used for burning into lime. At two points it has been quarried in small quantities for building stone and that near Batesville has also been used for ornamental purposes. The Batesville stone is harder and more crystalline than any other oölitic limestone known to the writer. The Madison County stone is more oölitic, that is, contains a greater portion of rounded particles than any of the other varieties.†

In Alabama oölitic limestone is quarried rather extensively at Rockwood, Franklin County, about two miles west of Darlington on the Birmingham, Sheffield & Tennessee River Railroad. The quarries are known as the Darlington quarries, and connected by branch railway to the main line. They have been operated for a number of years by the T. L. Fossick Company. The stone is said to occur in a massive bed of great thickness and extent. It is quarried and sawed like the Indiana stone. The company has two large mills of eight gangs each. The stone

* *Geol. of Hardin Co. in Econ. Geol. of Illinois*, Vol. I, 1882, p. 318.

† For particulars see Vol. IV of the Annual Report for 1890 of the Geol. Surv. of Ark., by T. C. Hopkins.

in the sample furnished by the company is a very light buff and exceptionally fine grained, the oölitic particles being very minute. It has been used quite extensively for building in the South.

In England oölitic limestone occurs in great quantities in newer rocks than the heavy beds in this country. They are of Jurassic age and divided into (1) the upper or Portland oölite, (2) the middle or Oxford oölite, and (3) the lower or Bath oölite. Building stone is obtained in large quantities from all three divisions, especially the first, which is one of the best known building stones in England. So far as known to the writer, it is not imported to this country in any appreciable quantity.

Similar stones of the same age as the English ones occur and are used extensively on the continent.

Oölitic limestone of Cretaceous age is reported from Brazil, South America.

Oörites of recent age occur on the Bahama and Bermuda Islands.

Siliceous Oörites—It may be interesting to note in this connection the occurrence of certain deposits of oölite that texturally resemble the calcareous oörites, but differ from them in composition by having silica in place of the lime. As these have been rather minutely described by previous writers, we shall simply give a brief resume of the published papers on the subject.

Probably one of the most widely known occurrences of siliceous oölite is that at State College, Centre County, Pennsylvania, where it occurs in chert segregations in the Lower Silurian limestones of Nittany Valley. Mr. George Wieland took such an active interest in the study of this rock, and in sending samples of it to all parts of the world that it is known locally as "Wielandite."

Four papers have been published on this oölite. The first in order of time was by Prof. Barbour and Mr. Torrey*, in which they give a brief illustrated description of some of the forms and some analyses. They give it as their opinion that it is derived from calcareous oölite by replacement, giving as proof two intermediate grades. One analysis shows silica 3.7 per cent., and lime carbonate 88.71 per cent., the other forming a sharp contact with the first contains silica 56.5 per cent., and lime carbonate 16.84 per cent., and the true siliceous oölite contains 95.83 per cent. silica and 1.9 lime, while a single granule from the siliceous oölite shows 99.99 SiO₂, the other .01 per cent. being iron. The spherules of the siliceous oölite are darker than the body of the rock, while in lime oörites they are generally lighter. They have a concentric structure of alternating light and dark bands around a real or imaginary centre. In some spherules the nuclei consist of organic remains, in others crystals or fragments of inorganic material.

*The American Journal of Science, September, 1890.

The second paper on this Pennsylvania oölite is by Mr. George Wieland*, and contains a brief sketch of its geographical occurrence.

The third and most complete paper on the subject is by Dr. W. Bergt,† who recognizes two distinct varieties of the oölite; one, much like rogenstein, consisting of tolerably thickly pressed spherules about 1.5 mm. in diameter; the other, a finer-grained, less regular variety. In the first the spherules appear to the naked eye to have a dark kernel surrounded by a white ring. Under the microscope it shows a transparent middle surrounded by a white opaque border. It has generally a very regular circular outline, but it is sometimes elliptical. The centre consists of a rounded quartz grain which contains small dust-like fluid inclusions, air bubbles, hair-like streaks (rutile needles) rarely small crystals of green hornblende (?) and six-sided brown mica, which indicate an altered eruptive rock as a source of the quartz. Sometimes the centre is made up of a saecharoidal, colorless quartz aggregate, which bears no evidence of destruction in itself, but has the appearance of grains which have mutually hindered themselves in crystallization, similar in appearance to quartz in fine fissures.

Sometimes the finest grained substance appears as the inner kernel or immediately surrounding the quartz grain.

In some spherules elongated quartz individuals form a zone between the coarse and the fine-grained aggregate. In some of the spherules radiated fibrous chalcedony forms entire or partial zones.

The ground mass of the stone forming the cement binding the spherules together consists of drusy quartz with one end pointing toward the centre of the interspace. Occasionally in this ground mass appear incipient beginnings of spherules.

Sometimes the spherules appear to have dropped out and the cavity filled with drusy quartz or with a single quartz individual.

Another (second) form of siliceous oölite presents a different microscopic appearance. It has the quartz grain at the centre, but the surrounding aggregate of the first variety gives way to the peripheral prismatic quartz. A white or brown cloudy opaque amorphous silica occurs sometimes as an exterior or interior zone. In one form the larger quartz prisms set in like building stones in an arch.

Dr. Bergt says he finds no mention in literature of an oölite similar to this Pennsylvania oölite. Spherulitic forms occur in oölitic opal and chalcedony, but they can be in no way compared with the Pennsylvania oölite.

He raises the question: "Is it primary or secondary?" He does not agree with Barbour and Torrey that it is altered calcareous oölite, but

* In the Mineralogists' Monthly for November, 1890.

† Published in the Gesellschaft Isis in Dresden, 1892, Abh. 15.

thinks it is quartzified, spherulitic chalcedony. He did not see the kernels of organic remains mentioned by Barbour and Torrey.

The fourth paper on the Pennsylvania oörites is by E. O. Hovey,* who also fails to find any of the organic remains mentioned by Barbour and Torrey, and says: "The rock was evidently made from clear quartz sand by the action of alkaline waters depositing silica in the form of chalcedony around the fragments or aggregates of fragments of quartz and making the cement between the spherules of the same substance, while some of the quartz grains were caught in this chalcedony cement without being made the nuclei of spherules."

In volume I (p. 382), Survey of the Fortieth Parallel, an oölitic chalcedony is described. It occurs at Cathedral Bluffs, Utah, at the top of a bed of impure limestone, 100 to 150 feet thick, the upper four or five feet being metamorphosed into chalcedony. The round grains vary from one-thirtieth to one-tenth of an inch in diameter, have a more or less concentric structure and a cryptocrystalline calcareous cement. They are probably crystallitic, and not organic, and may be related to calcareous sands, such as now occur on the beach of Great Salt Lake. (It might be noted that these Great Salt Lake oörites have recently been shown to be organic.) An analysis shows this oölite to contain 74.81 per cent. of silica and the remainder calcium carbonate.

Prof. Broadhead, in Report of Geological Survey of Missouri, 1873-'74, mentions a siliceous chert occurring in Madison, Cole, Morgan, Moniteau and Miller counties. Some of the white regularly rounded grains have a small pit in the center, some are solid. In some of the coarser varieties the grains stand in relief, in some of the finer ones the oölitic character only appears where it is magnified. Sometimes the grains decay first, leaving a spongy chert; sometimes the cement is first removed, leaving a loose mass of grains.

Oölitic chert is described by Dr. Irving in the Wisconsin Geol. Surv. Rep. as occurring in the Lower Magnesian limestone of Wisconsin. He says that the older writers speak of oölitic limestone, but so far as his observation goes he finds the limestone not oölitic, but carrying disseminated oölitic chert. (Vol. II, Wis. Geol. Surv., p. 550.)

At Eureka Springs, Arkansas, the writer found a fine-grained siliceous oölite in the magnesian limestone of Lower Silurian age, probably near the same horizon as the State College oölite.

Mr. Wieland speaks of finding a siliceous oölite in stratified layers near Rockwood, Roane County, Tennessee.

Siliceous oölite is reported † in rocks of Tertiary age in northern New Jersey.

* Bull. Geol. Soc. Am., Vol. V, 1893, p. 627.

† E. O. Hovey, Bull. Geol. Soc. Am., Vol. 5, 1893.

In foreign countries, siliceous oölite occurs as oölitic hornstone in the Trias of the upper Rhine country,* in Assynt limestone at Dunness, England; at Bedford, England; in Belgium; at Aracara, Villa Nova, State of Sergipe, River Sao Francisco, Brazil; on the upper Paraguay; in middle Sumatra; in Siberia, and in Egypt.

Ferruginous oörites.—Oölitic iron ore occurs in German Lorraine at the base of the inferior oölite in a bed 10 to 80 feet thick, consisting of alternations of limonite, limestone and marl. The ore, which is called *minette*, contains 30 to 40 per cent. of iron. Oölitic iron ore occurs elsewhere in Europe and in many places in the United States in the Clinton formation.

Much of the beauxite in Arkansas and Georgia has an oölitic (pisolitic) texture.

Oölitic ice.—The neve or snow at the head of the glaciers frequently acquires an oölitic texture.

* Knop in Neues Jahrbuch, Heft 3, pp. 281-288.

APPENDIX A.

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BEDFORD REGION.

No stone of any consequence was shipped from the Bedford region until after the close of the war, although the railroad was completed to that point in 1852.

The pioneers of the stone business in this section were Nathan Hall, Davis Harrison and John Glover. The quarry operated by Hall and Harrison was one-half mile east of Bedford and is now a part of the Blue Hole quarry of the Chicago and Bedford Stone Company. Up to the close of 1873 all the stone shipped from this quarry was hauled to Bedford by ox teams. The stone was at first sawed out by hand, later on by horse power, and still later a steam saw mill was erected.

The quarry owned by John Glover was alongside the railway and a mile south of Bedford. A switch was laid into the quarry and for a few years quite a heavy business was done here. The stone was of fine texture but hard and hardly free enough on its lower bed to be worked with profit by the methods of quarrying stone then in vogue.

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7. Collett, John, Geol. of Lawrence County in 5th An. Rep. of Ind., by E. T. Cox, 1873, pp. 276 and 309, gives a brief description of the Bedford stone and partial list of fossils.
8. Collett, John, Building Stone, in the 11th An. Rep. Dept. Geol. and Nat. Hist., 1881, pp. 22-42. General Notes, copy of the 10th

census statistics, shipments by carloads, consumption by carloads, analyses, record of tests, transverse and crushing, by Johnson. Building Stone, in 12th An. Rep., 1882, pp. 19 and 20; republished in 13th Rep., 1883.

9. Cox, E. T., Building Stone, in the 8th, 9th and 10th An. Rep. (one Vol.) Geol. Surv. of Ind., 1878, p. 93, gives analyses, tests, etc.

10. Gorby, S. S., Geology of Washington County, in 15th An. Rep., 1885, pp. 136-146, describes the Salem oölitic limestone, gives analyses and list of buildings made of it.

11. Gorby, S. S., Building Stone, mere mention of in the introduction of the 18th An. Rep., 1893.

12. Greene, Geo. K., Geology of Monroe County, in Ind. Geol. Surv., Rep. for 1879-80, describes briefly the oölitic limestone of Monroe County.

13. Hatfield, R. S., Architect, 31 Pine St., N. Y. City, table showing comparative strength of oölitic limestone (Salem) with sandstones from different localities.

14. Hopkins, T. C., Bedford Oölite. The Mineral Industry, N. Y., Vol. IV, 1894, pp. 505-507.

15. Johnson, Thos. H., Exp. Upon the Transverse Strength and Elasticity of Building Stones, in the 11th An. Rep., 1881, pp. 34-42.

16. Mineral Resources, Washington, Annual 1882-1895. Statistics and brief notes on the Indiana stone.

17. Stone, Chicago, Vol. X, No. 2, Jan, 1895. Illustrated descriptive article of the Bedford stone. Many short articles in the previous numbers.

✓ 18. Thompson, Maurice, The Oölitic Limestones of Indiana, in 17th An. Rep., 1891, pp. 43-53, gives brief description and geologic history of the oölitic limestone, with list of quarries and statistics.

J 19. Thompson, Maurice, The Oölitic Limestone of Indiana, in 15th An. Rep., 1886, pp. 28-31, brief description and origin.

20. Thompson, W. H., Indiana Building Stone, in the 16th An. Rep., 1888, pp. 80-81, very brief description of the oölitic limestone. List of the building stones in the State Museum in the same report.

21. Owen, Richard, Report of Geol. Recon. of Ind., made during the years 1859-60, under the direction of the late D. D. Owen, by Richard Owen, Prin. Assist., now (1862) State Geologist, Indpls., 1862, p. 135, Monroe County, gives brief description, analysis of the oölitic limestone at Stinesville, "Monroe Marble Quarry." P. 137, Lawrence County, mentions the limestone at the Dean Marble Quarry.

APPENDIX B.

BUILDINGS CONSTRUCTED OF BEDFORD OÖLITIC LIMESTONE.

The following list will give a good idea of the wide and extensive use of the Bedford oölitic limestone for building purposes. The list does not claim to be complete; it does not contain all, or nearly all, the buildings, but probably does contain the greater part of the large and public buildings in which the oölitic stone has been used. A considerable part of the stone is sold by the quarrymen to contractors in different parts of the country, and frequently the quarryman does not know in what buildings it is used. Not only is much of it used in this way in the large cities like New York and Chicago, but in the smaller ones as well. In a great many of the smaller cities in the eastern States the Indiana stone is used for trimmings with the local stone.

It is worthy of note, the large number of public buildings in which the oölitic stone has been used, not only in Indiana but in other States. Four State capitol buildings are constructed wholly or in part of it; 26 court-houses in Indiana, and possibly others of which we have no record; custom-houses, postoffices, hotels and other public buildings have used this stone profusely.

The large number of buildings (110 and 200 not enumerated) in New York City, which is only a part of the buildings in which it has there been used shows its popularity in that city, a popularity that is still on the increase, as nearly every large producer in the oölitic area gave New York as his principal market last year (1896). One of them stated that 80 per cent. of the buildings now in process of construction in New York are using Indiana stone. This can be taken with some allowance, coming as it does from an interested party.

The list is as authentic as we could make it, dependent as we are almost entirely on the different quarrymen for the data. It is to be regretted that we could not in all cases give the part of the building composed of Indiana stone. Where this could be obtained, it is given; where nothing is said, it is not known. The list shows the stone to have been used in 25 States and one Territory, and one foreign country. It has, no doubt, been used in most of the remaining States, but we have no data to that effect.

The list is given not simply to show its wide and extensive use in architecture, but as a convenient reference, as well, to architects, contractors, builders and others who may desire to observe the stone in use

to see how it stands the exposure, how it harmonizes with other materials, how it is adapted for different parts of the structure, etc. It is arranged alphabetically by States, and by localities in the State, so that any one can see at a glance the buildings of oölitic stone in his vicinity.

LIST OF SOME OF THE BUILDINGS CONSTRUCTED OF BEDFORD
OÖLITIC STONE.

ALABAMA.

Birmingham—Postoffice Building, Peerless Quarry.
Mobile—Convent Visitation, Standard Quarry.

ARKANSAS.

Ft. Smith—Postoffice Building, Peerless and Perry Quarries.

CONNECTICUT.

Hartford—Gas Company's office, Hoosier Quarry, Geo. Keller, architect.

DISTRICT OF COLUMBIA.

Washington—Church of the Messiah, P., M. & B. Quarry.
Gunter Memorial Church, P., M. & B. Quarry.
Levi G. Leiter's residence, P., M. & B. Quarry.
Schneider flat, Peerless Quarry, T. F. Schneider, architect.
Senator John Sherman's residence, Peerless Quarry, T. F. Schneider, architect.
Washington Post building, Peerless Quarry.

FLORIDA.

Tallahassee—U. S. Court House and Postoffice, —— Quarry.

GEORGIA.

Atlanta—State Capitol, Salem Quarry.

ILLINOIS.

Bloomington—Court House, —— Quarry.
Charleston—Illinois State Normal School, Romona Quarry.
Chicago—Academy of Science Building, Lincoln Park, almost entirely from Adams' Quarry.
Armour residence, Michigan Avenue, Adams' Quarry.

Athletic Club, C. S. Norton Blue Stone Quarry.
 Auditorium Building, entirely, Reed's Oölitic Quarry.
 Blair residence, Reed's Bedford Quarry.
 Church of the Holy Angels, Hoosier Quarry, James J. Egan,
 architect.
 Criminal Court, Reed's Oölitic Quarry.
 City Hall, Hallowell Quarry and Blue Hole Quarry.
 Lewis Institute, Hoosier Quarry, Henry Ives Cobb, architect.
 Mandel residence, Dearborn Avenue and Division Street, Dark
 Hollow Quarry. First oölitic stone used in Chicago.
 Polish Catholic Church, North Side, Adams' Quarry.
 Public Library, Reed's Oölitic Quarry.
 Pullman Building, Blue Hole Quarry.
 Ex-Mayor Roache's residence, West Bedford Quarry.
 Martin Ryerson Building, Reed's Oölitic.
 St. James M. E. Church, 47th St. and Ellis Ave., Adams' Quarry.
 St. Martin's R. C. Church, Hoosier Quarry, Schlacks & Ottenhei-
 mer, architects.
 Stensland Building, Hoosier Quarry, Hill & Woltersdorf, architects.
 Studebaker Building, Blue Hole Quarry, Henry Ives Cobb, archi-
 tect.
 University of Chicago (9 buildings), Adams' and Hoosier Quarries,
 H. I. Cobb, architect.
 Y. M. C. A. Building, La Salle St., P. M. & B. Quarry.
 Art Institute, Salem-Bedford Quarry.

The oölitic limestone has been used in a great many buildings, gener-
 ally fronts or trimmings, where it is put in by contractors who purchase
 from the quarrymen, and there is no means of finding where the stone
 has been used. Following are some of the buildings in which it has been
 used, and there are many others: Illinois Central Railway Depot, New
 Cook County Jail, Art Museum, Standard and Lakeside Clubs, The
 Temple, Title Guarantee and Trust Co. Building, Jos. H. Walker Build-
 ing, A. H. Revell & Co. Building, Security Building, Adams Express
 Building, St. Joseph Hotel, and a great many residences, including Potter
 Palmer's, A. V. and G. A. Armour's and others on the Lake Shore drive.
 De Kalb—Northern State Normal School, Hoosier Quarry, C. E. Brush,
 architect.

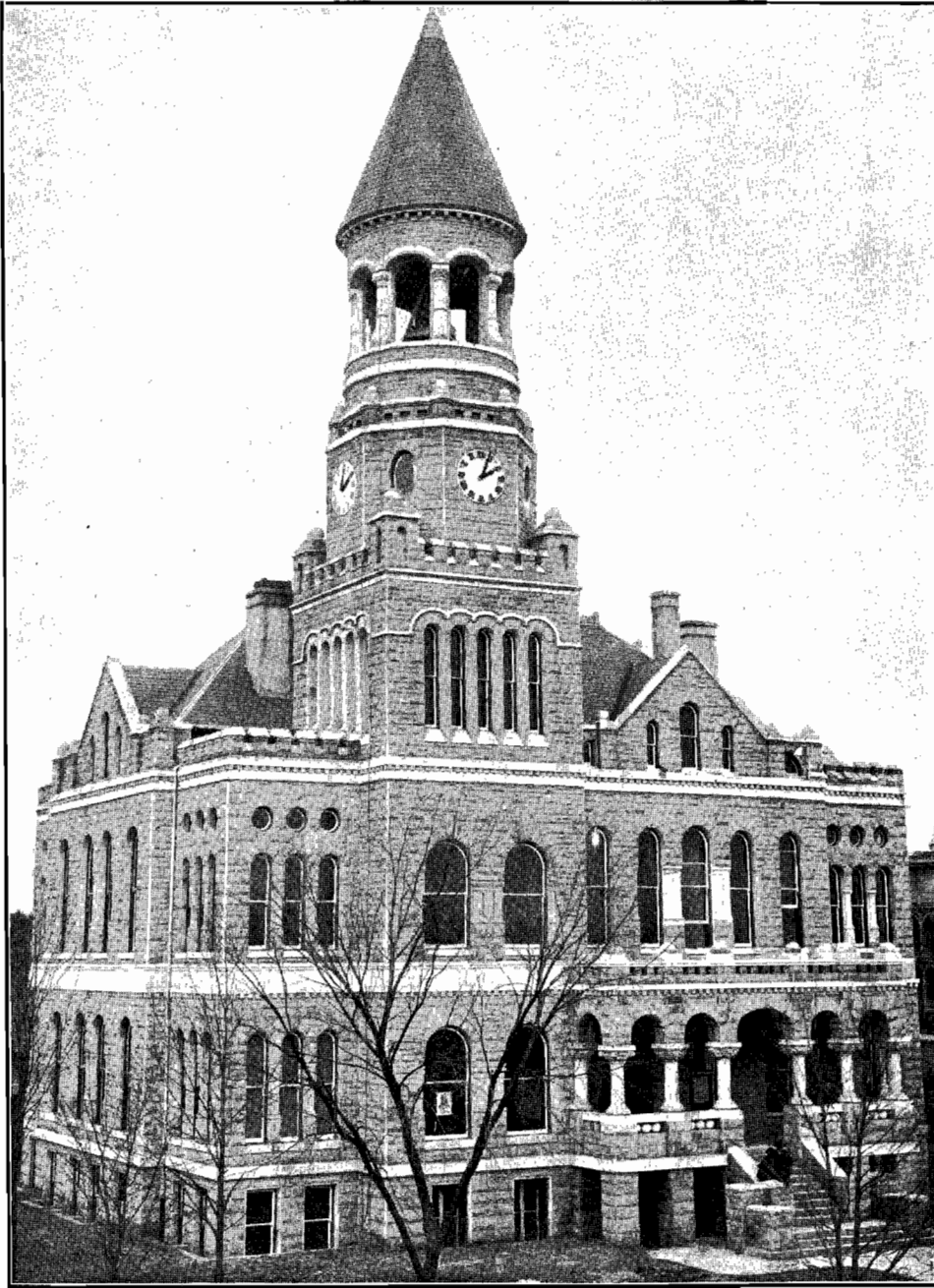
Effingham—M. E. Church, Thornton Quarry.
 Galesburg—Postoffice Building, Peerless Quarry.
 Greenville—Bond County Court House, Matthews Bros'. Quarry.
 Rock Island—Court House, Consolidated Stone Co's. Quarries, Bloom-
 ington and Bedford.
 Springfield—State Capitol, Perry's Quarry and C. S. Norton's Quarry
 (large carved pilasters).

INDIANA.

- Anderson—Masonic Temple, Adams' Quarry.
 Bedford—Lawrence County Court House, quarries near Bedford
 Bloomington—Indiana University, Maxwell Hall, P. M. & B. Quarries.
 Indiana University, Kirkwood Hall, Adams Quarry.
 Adams Residence, Adams' Quarry.
 P. K. Buskirk's Residence, P. M. & B. Quarry.
 I. N. Batman's Residence, Empire Quarry.
 Hill Block, Buskirk Block, Empire Quarry.
 Bee Hive Store, Empire Quarry.
 Monroe County Court House, base. Local quarry abandoned.
 Carthage—Public School Building, Adams' Quarry.
 Columbia City—Whitely County Court House, Hoosier Quarry.
 Columbus—Bartholomew County Court House, Matthews' Quarry.
 Crawfordsville—Wabash College Building (in part), Matthews Bros.' Quarry.
 Evansville—Custom House and Postoffice, Matthews Bros.' Quarry and Perry Bros.' Quarry.
 Asylum for the Insane, trimmings, etc., Matthews Bros.' Quarry.
 Vanderburg County Court House, ——— Quarry.
 Vanderburg County Jail, ——— Quarry.
 Frankfort—Clinton County Court House, Matthews' Quarry, Perry's Quarry.
 Franklin—Johnson County Court House—Matthews' Quarry, Perry's Quarry.
 Greenfield—Hancock County Court House, Matthews' Quarry, Wing & Mahurin, architects.
 High School Building, Matthews' Quarry, Wing & Mahurin, architects.
 Greencastle—DePauw University Buildings, Matthews' Quarry, trimmings.
 Indianapolis—Anschutz Building, Bedford, Ind., Quarry.
 F. M. Bachman's Residence, 13th and Meridian Streets, P., M. & B. Quarry, trimmings.
 Victor Backus' Residence, Perry's Quarry, first story stone.
 Blacherne Flat, P., M. & B. Quarry, trimmings.
 Capitol (1878-1888, \$1,800,000), State House Quarry, Kannamaker & Denig, two miles south of Romona; Matthews' Quarry, Perry's Quarry, Terre Haute Quarry, Dark Hollow Quarry, principal part.
 Chalfant Flat, P., M. & B. Quarry, trimmings.
 Bishop Chatard's Residence, 14th and Meridian Streets, P., M. & B. Quarry.

- Church of the Sacred Heart, Union and Palmer streets (trimmings), P., M. & B. Quarry.
- Citizens' Street Railway Co.'s Office, P., M. & B. Quarry, trimmings.
- City Library Building, Hoosier Quarry.
- E. F. Claypool Residence, 186 North Meridian, probably Big Creek Quarry (1859).
- Commercial Club Building, Hoosier Quarry.
- Conduit & Sons Block, Matthews' Quarry.
- Cordova Building, P., M. & B. Quarry.
- Frank M. Dell Block, P., M. & B. Quarry.
- English Hotel and Opera House, Ellettsville Quarries.
- Fahnley & McCrea Block, Perry's Quarry.
- Fahnley residence (1860-62), 200 North Meridian Street, Big Creek Quarry.
- Fletcher's Bank Block, Perry & Matthews Quarries, P., M. & B. Quarry (addition).
- Gramling Block, 35 East Washington Street, Perry's Quarry.
- Griffith Block, East Washington Street, Perry and Kostenbader Quarries.
- A. C. Harris residence, North Meridian Street, Terre Haute Quarry, rejected stone from Soldiers' Monument.
- Harrison's Bank Building (1856; now torn down; was the first oölitic brought to Indianapolis; sawed pillars) site of new Stevenson Block, Big Creek Quarry.
- Indiana National Bank Building, P., M. & B. Quarry, Consolidated Stone Company, blue base course.
- Indianapolis Water Company power house, P., M. & B. Quarry, trimmings.
- Indiana Trust Company Building, Perry, Dark Hollow and Bedford (Ind.) Quarries.
- Insane Asylum, Matthews' Quarry, trimmings.
- Lemcke Building, Bedford (Ind.) Quarry, trimmings.
- Col. Eli Lilly's residence, P., M. & B. Quarry.
- L. E. & W. Railway offices, Blue Hole Quarry, trimmings.
- Majestic Building, Bedford Indiana Quarry (38,000 cubic feet oölitic).
- Malott Building, 11 and 13 East Washington Street, Matthews Quarry. Burned out, leaving only front wall standing. All but a few blocks were cleaned up and used in rebuilding. Fifth story was damaged most.
- Marion Block, Perry Quarry, trimmings.
- Marion County Court House, Hight's Quarry, Sharp & Hight; Matthews Quarry, Perry Quarry.
- Marion County Jail, Hoosier Quarry.

- McCormick Building, Blue Hole Quarry (trimmings).
 McOuat Block, Kentucky Avenue, Needham's Quarry.
 New York Store Building, P., M. & B. Quarry.
 Occidental Hotel, Ellettsville Quarries.
 Ex-Governor A. J. Porter's Residence, corner 9th Street and
 Capitol Avenue, Ellettsville Quarries, 1867.
 Postoffice Building, Big Creek Quarry.
 Propylaeum, Romona Quarry, P. M. & B. Quarry.
 Richardson's Residence, 162 North Meridian Street, Dark Hollow
 Quarry.
 Roberts Park M. E. Church, 1873, Perry's Quarry, Kostenbader's
 Quarry, Cornelius' Quarry.
 Rush Block, Perry's Quarry.
 St. John's Cathedral (trimmings), Ellettsville Quarries.
 Sayles Building, adjoins Malott Building. Burned at same time as
 Malott Building, but wall was light and stone too badly damaged
 to use again. Bedford Indiana Quarry.
 Scottish Rite Temple, two lower stories oölitic; Perry Quarry.
 C. F. Smith Residence, 13th and Delaware, P. M. & B. Quarry.
 Fine porch only of oölitic.
 Soldiers' Monument, Terre Haute Quarry.
 Schriever Building, corner Prospect Street and Virginia Avenue,
 Perry's Quarry.
 Thorpe Block, Ellettsville Quarries.
 Tomlinson Hall, Perry's Quarry, G. K. Perry (trimmings).
 Willoughby Building, corner Ohio and Meridian streets, P., M. &
 B. Quarry.
 Y. M. C. A. Building, Romona Quarry.
 Lafayette—Tippecanoe County Court House, —— Quarry.
 Lawrenceburg—Dearborn County Court House, Perry's Quarry.
 Liberty—Union County Court House, Thornton's Quarry.
 Logansport—Insane Asylum, Matthews' Quarry.
 Cass County Court House, Hoosier Quarry.
 Soldiers' Monument, Hoosier Quarry.
 Marion—Grant County Court House, ——.
 Michigan City—Public Library, Consolidated Stone Co.'s Quarry.
 Monticello—White County Court House, Star Quarry.
 Mt. Vernon—Posey County Court House, Perry's Quarry.
 Muncie—Grand Opera House, —— Quarry.
 Hon. Theo. Rose's Residence, Adams Quarry.
 New Albany—Floyd County Court House.
 Oldenburg—Sisters of St. Francis, P., M. & B. Quarries. Four build-
 ings: Church of the Sisters of St. Frances, House of the
 Mother Superior, infirmary, power house.



SALEM COURT HOUSE, FROM OOLITIC LIMESTONE QUARRIED AT SALEM, IND.

- Princeton—Gibson County Court House, Perry's Quarry.
 Rensselaer—Jasper County Court House, Matthews' Quarry. Grindle & Weatherhogg, architects.
 Richmond—Wayne County Court House, Hoosier Quarry.
 Rochester—Fulton County Court House, Consolidated Stone Company's Quarries.
 Rushville—Rush County Court House, Consolidated Stone Company's Quarries.
 St. Mary's of the Woods, P., M. & B. Quarries. Six buildings: Church of the Immaculate Conception, House of the Mother Superior, Priest's residence, hotel, power house, bakery; fancy rustic bridge.
 Salem—Washington County Court House, Salem Quarry. (See plate XXXVIII.)
 South Bend—Presbyterian Church, Thornton's Quarry. Clem. Studebaker's residence, Thornton's Quarry.
 Terre Haute—U. S. Government Building, ——— Quarry.
 Tipton—High School Building, Thornton's Quarry.
 Valparaiso—Porter County Court House, Perry's Quarry.
 Vincennes—Knox County Court House, Perry's Quarry, Matthews' Quarry.
 Warsaw—Kosciusko County Court House, Perry's Quarry.

IOWA.

- Cedar Rapids—Union Railway Station, Consolidated Stone Company's Quarries.
 Sioux City—P. O. Building, Consolidated Stone Company's Quarries.

KANSAS.

- Topeka—State Capitol, in part, Salem-Bedford Quarry.

KENTUCKY.

- Covington—Cathedral, Hoosier Quarry, Leon Coquard, architect.
 Danville—M. E. Church, Thornton's Quarry.
 Georgetown—M. E. Church, Thornton's Quarry.
 Lexington—W. S. Barnes' residence, Thornton's Quarry.
 Louisville—The following are some of the buildings in which Bedford oölitic limestone has been used, quarry not known: U. S. Custom House and Postoffice, Louisville Medical College, German Insurance Bank, Fonda Block, Kentucky National Bank, Court House, and H. Strater's residence.
 Paducah—Christian Church, Star Quarry; M. E. Church.
 Richmond—P. O. Building, Peerless Stone Company.

LOUISIANA.

Baton Rouge—P. O. Building, Salem-Bedford Quarry.
 Monroe—U. S. Government Building, — Quarry.
 New Orleans—Cotton Exchange Building, Hallowell Quarry.
 Opelousas—U. S. Government Building, — Quarry.
 Shreveport—U. S. Government Building, — Quarry.

MASSACHUSETTS.

Boston—Algonquin Club Building, Hoosier Quarry, McKim, Meade & White, architects.
 International Trust Co., Hoosier Quarry; Consolidated Stone Co. (Both claim). Wm. G. Preston, architect.
 Beaconsfield Terrace, — Quarry.
 Jordan Building, — Quarry.
 Pope Mfg. Co.'s Building, — Quarry.
 Tremont Temple Building, P., M. & B. Quarry.
 Worthington Building, P., M. & B. Quarry.
 Haverhill—P. O. Building, Peerless Quarry.
 New Bedford—New Bedford Institute for Savings, Consolidated Stone Company's Quarry.
 Worcester—Worcester Savings Bank Building, Consolidated Stone Company's Quarry.

MICHIGAN.

Detroit—Col. H. Hecker's residence, Thornton's Quarry.
 U. S. P. O. Building, — Quarry.
 Grand Rapids—Court House, Perry's Quarry.
 Jackson—U. S. P. O. Building, — Quarry.

MINNESOTA.

Duluth—U. S. P. O. Building, — Quarry.

MISSOURI.

Columbia—State University Building, — Quarry.
 Springfield—P. O. Building, P., M. & B. Quarry.
 St. Louis—Catholic Cathedral, Grand Avenue, Reed's Bedford Quarry.
 Miller residence, Reed's Bedford Quarry.
 Public School Building, Star Quarry.
 St. Vincent's Hospital, Peerless Quarry.
 Union Depot, Tanyard Quarry.

NEW JERSEY.

Jersey City --City Hall, Hoosier Quarry, L. H. Broome, architect.
 Morristown—First Presbyterian Church, P., M. & B. Quarry.
 Newark—Bonnell Building, Bedford, Ind., Quarry.
 Prudential Building, and Postoffice and Custom-house, — Quarry.
 Patterson—City Hall, Hoosier Quarry, Carrere & Hastings, architects.
 Trenton—State Capitol, Salem-Bedford Quarry.

NEW YORK.

Albany—Col. Wm. G. Rice's residence, P., M. & B. Quarry.
 Brooklyn—National City Bank Building, P., M. & B. Quarry.
 N. Y. & N. J. Telephone Building, Bedford, Ind., Quarry.
 Franklin Trust Company Building, — Quarry.
 Star Theatre, P., M. & B. Quarry.
 Buffalo—Avery Building, — Quarry.
 Cortland—Wickwire Mansion, Hoosier Quarry. Samuel B. Reed, architect.
 New York City—Eighty per cent. of buildings now going up in New York are of Indiana oölitic. [Coughlin.]
 Abbey's Theatre, Broadway and 38th Street, Hoosier and Buff Ridge Quarries. J. B. McElpatrick, architect.
 American Society of Fine Arts, 57th Street, between 7th Avenue and Broadway, Hoosier and Buff Ridge Quarries. J. H. Hardenbergh, architect.
 Astor Residence, 5th Avenue and 56th Street, Bedford, Ind., Quarry.
 Ayers Estate Building, Lispenard Street, Hoosier and Buff Ridge Quarries. Cady, Berg & See, architects.
 Bank of America Building, Hallowell Quarry.
 Broadway Cable Power House, Broadway and Huston Streets, Hoosier and Buff Ridge Quarries. McKim, Mead & White, architects.
 Brower House, Broadway and 28th Streets, Hoosier and Buff Ridge Quarries, Alfred Zucker, architect.
 Buek Block, 87th Street, between 8th and 9th Avenues, Hoosier and Buff Ridge Quarries, Charles Buck, architect.
 Candee Block, 60th Street, between 5th and Madison Avenues, Hoosier and Buff Ridge Quarries, John H. Duncan, architect.
 Church of St. Mary the Virgin, 46th and 47th Streets, between 6th and 7th Avenues, Hoosier and Buff Ridge Quarries, N. LeBrun & Sons, architects.
 Coffee Exchange, P., M. & B. and Reed's Oölitic Quarries.

- Colby residence, 69th Street and 5th Avenue, Bedford, Ind., Quarry.
- Columbia College, Natural Science Hall and Hall of Physics, Morningside Heights, Bedford, Ind., Quarry. Two buildings, Hallowell Quarry. One of these buildings contains 300 carloads of oölitic limestone.
- New York Commercial Building* (front), C. S. Norton Quarry.
- Constable Building, 5th Avenue and 18th Street, Hoosier and Buff Ridge Quarries, W. H. Schiskel & Co., architects.
- Corn Exchange Bank Building, Nassau and Beaver Streets, Hoosier and Buff Ridge Quarries, R. H. Robertson, architect.
- Curtis Building, South Williams Street, Bedford, Ind., Quarry.
- Cutting residence, 88th Street, between 2d and 3d Avenues, Bedford, Ind., Quarry.
- Deever's mansions, Manhattan Square, N., Hoosier and Buff Ridge Quarries, Berg & Clark, architects.
- D., L. & W. Railway Building, Hallowell Quarry.
- Dommerich residence, 75th Street, between West End Avenue and Riverside Drive, Hoosier Quarry, C. P. H. Gilbert, architect.
- Emigrant Savings Bank, Chambers Street, Hoosier and Buff Ridge Quarries, W. H. Hume, architect.
- Eastman's residence, 70th Street and West End Avenue, Bedford, Ind., Quarry.
- Emery residence, 68th Street and 5th Avenue, Bedford, Ind., Quarry.
- Fahy's Building, Maiden Lane, Bedford, Ind., Quarry.
- Farmers' Loan and Trust Company Building, Hallowell Quarry.
- German Life Insurance Building, Pine and Nassau Streets, Hoosier Quarry, Lamb & Rich, architects.
- Gibbes' Building, Murray Street and College Place, Bedford, Ind., Quarry.
- Gorard Hotel, 44th Street, Broadway and 6th Avenue, Bedford, Ind., Quarry.
- Graham Building, Duane Street, Bedford, Ind., Quarry.
- Graham Hotel, Madison Avenue and 89th Street, Hoosier and Buff Ridge Quarries, Thomas Graham, architect.
- Herald Building*, Norton's Quarry.
- Dr. Herter's residence, 68th Street and Madison Avenue, Bedford, Ind., Quarry.
- Hoffman House, Broadway and 25th Street, Hoosier, Buff Ridge and Robin Roost Quarries, Alfred Zucker, architect.
- Dean Hoofman's Residence, 73d Street, west of 8th Avenue, Hoosier and Buff Ridge Quarries, J. B. Suook & Sons, architects.
- Hotel Majestic, Central Park, W., and 71st to 72d Streets, Hoosier and Buff Ridge Quarries, Alfred Zucker, architect.

- Hoyt Residence, 75th Street, between 5th and Madison Avenues, Hoosier and Buff Ridge Quarries, Richard M. Hunt, architect.
- Hoyt Residence, 75th Street, between West End Avenue and Riverside Drive, Hoosier Quarry, Babb, Cook & Willard, architects.
- C. P. Huntington's Residence, Blue Hole Quarry.
- Lamb & Rich Block, West End Avenue and 76th Street, Hoosier and Buff Ridge Quarries, Lamb & Rich, architects.
- London & Lancashire Fire Insurance Co. Building, Williams Street, Hoosier and Buff Ridge Quarries, H. J. Hardenbergh, architect.
- Mail and Express* Building, Broadway and Fulton Streets, Bedford, Ind., Quarry.
- Manhattan Hotel, Madison Avenue and 42d Street, Hoosier and Buff Ridge Quarries, H. J. Hardenbergh, architect.
- Manhattan Life Building, 66 Broadway, P., M. & B. Quarry.
- McAdams Residence, 131 West 122d Street, P., M. & B. Quarry.
- Mercantile Building Co.'s Block, northwest corner West End Avenue and 77th Street, Hoosier Quarry.
- Mercantile Building Company's Block, West End Avenue and 78th Street, Hoosier Quarry.
- Mercantile Building Company's Block, West End Avenue and 93d Street, Hoosier Quarry, Little & O'Connor, architects.
- Mercantile Building Company's Block, southeast corner West End Avenue and 77th Street, Hoosier Quarry, Clarence True, architect.
- Merchants' Bank Building, Hallowell Quarry.
- Merritt residences (five), Riverside Drive and 91st Street, Hoosier and Buff Ridge Quarries, Little & O'Connor, architects.
- Metropolitan Apartment Building, Boulevard and 88th Street, Hoosier and Buff Ridge Quarries, Little & O'Connor, architects.
- Mills Lodging House, Bleecker, Sullivan and Thompson's Streets, Bedford (Ind.) Quarry.
- Mt. Olivet Church, 2d Street and 2d Avenue, Hoosier and Buff Ridge Quarries, Cady, Berg & Lee, architects.
- Mutual Life Insurance Company's Building, Hallowell Quarry.
- Mutual Reserve Fund Life Insurance Company's Building, Broadway and Duane Street, Hoosier Quarry, W. H. Hume & Son, architects.
- Office Building, corner 8th Street and Broadway, C. S. Norton Quarry.
- Office Building, northwest corner 12th Street and Broadway, C. S. Norton Quarry.
- Office Building, northeast corner Prince and Broadway, C. S. Norton Quarry.

- Ogden Mansion, Madison Avenue and 39th Street, Hoosier and Buff Ridge Quarry, Peabody & Stearns, architects.
- The Overlook Building, Corlears Hook Park, Bedford, Ind., Quarry.
- Platt Block, West End Avenue, 83d to 84th Streets, Hoosier and Buff Ridge Quarries, Clarence True, architect.
- Postal Telegraph Company Building, Broadway and Murray Streets, Hoosier and Buff Ridge Quarries, George Ed. Harding & Gooch, architects.
- Presbyterian Building, 5th Avenue and 20th Street, Buff Ridge and Hoosier Quarries, J. B. Baker, architect.
- Puritan Apartment House, West End Avenue, Boulevard, 81st and 82d Streets, Hoosier and Buff Ridge Quarries, Little & O'Connor, architects.
- Public School Buildings, 82d Street and West End Avenue, Bedford, Ind., Quarry; 88th Street, between 2d and 3d Avenues, Bedford, Ind., Quarry; 119th Street and Madison Avenue, Bedford, Ind., Quarry; 88th Street and Lexington Avenue, Bedford, Ind., Quarry; St. Ann's Avenue, Bedford, Ind., Quarry; 134 Lenox Avenue, P. M. & B. Quarry; 68th Street, 93d Street and Ridge Street Schools, Quarry.
- St. Andrew's Church, 76th Street, between 9th and 10th Avenues, Hoosier and Buff Ridge Quarries, Cady, Berg & See, architects.
- St. Ignatius R. C. Church, 84th Street and Park Avenue, Hoosier and Buff Ridge Quarries, W. H. Schickel & Co., architects.
- St. Paul Building, southeast corner Broadway and Avenue Street (26 stories), C. S. Norton Quarry.
- San Reno Hotel, 74th and 75th Streets and 8th Avenue, Bedford, Ind., Quarry.
- Hotel Savoy, Terre Haute Quarry.
- Scotch Church, 96th Street and 8th Avenue; Scotch Church lecture room, 95th Street and 8th Avenue, Hoosier and Buff Ridge Quarries, W. H. Hume & Son, architects.
- Schermerhorn Building, 23d Street, between 5th and 6th Avenues, Hoosier and Buff Ridge Quarries, H. J. Hardenbergh, architect.
- Sherry Hotel, corner 5th Avenue and 44th Street, C. S. Norton Quarry.
- Sloane Mansion, 72d Street, east of 5th Avenue, Hoosier and Buff Ridge Quarries, Carrere & Hastings, architects.
- Mrs. Josephine Smith's residence, C. S. Norton Quarry.
- Smith, Gray & Co. Building, Broadway and 31st Street, Hoosier and Buff Ridge Quarries, Buckman & Deisle, architects.
- Syndicate Building, Nassau and Liberty Streets. Hoosier and Buff Ridge Quarries, Lamb & Rich, architects.
- Temple Beth Synagogue, Reed's Oolitic Quarry.

Thompson Residence, 41st Street and Madison Avenue, Bedford, Ind., Quarry.

University Building, Washington Square, East and Washington Place, Hoosier and Buff Ridge Quarries, Alfred Zucker, architect.

Cornelius Vanderbilt residence, northwest corner 5th Avenue and 57th Street (large carved pilasters of), C. S. Norton Quarry, (main body of), Blue Hole Quarry.

Vanderbilt Residence, 5th Avenue, Blue Hole Quarry.

Mrs. W. K. Vanderbilt residence, Madison Avenue and 72d Street, Hoosier and Buff Ridge Quarries, McKim, Mead & White, architects.

Woodbridge Building, Williams, Platt and John Streets, Bedford Ind., Quarry.

Western Union Telegraph Building, — Quarry.

Y. M. C. A. Building, 56th and 57th streets and 8th Avenue, Bedford Indiana Quarry.

The following buildings said to have Indiana limestone, but the quarry not known: The Wilkes, Smith, Stokes, Havemeyer, Decker Bros., Lincoln and Colonial Club buildings, Harlan Library, Holland House, Camden Block, College of Pharmacy, Fuller Building, and about 200 residences.

Scarborough—Memorial Church, Hoosier Quarry, Haydel & Shepard, architects.

Shepard Mansion, Hoosier Quarry, McKim, Mead & White, architects.

Staten Island—Kuhnhardt Memorial Tomb, Bedford Indiana Quarry.

Syracuse—Onondaga Savings Bank Building, Consolidated Stone Co.

NORTH CAROLINA.

Biltmore—Geo. W. Vanderbilt's Residence, Hallowell Quarry.

Charlotte—United States Court House and Postoffice, — Quarry.

OHIO.

Cincinnati—Hamilton County House, Salem-Bedford Quarry.

The following are some of the buildings in Cincinnati in which the Bedford oölitic stone has been used, but the quarry is not known: Denison Hotel, The Fleischman, Armstrong, Auskamp, Jos. Smith, George A. Smith, Smith's Office Buildings, and 60 or more residences.

Columbus—Commercial Club Building, Reed's Bedford Quarry.

Sidney—John Laughlin's Residence, Thornton Quarry.

PENNSYLVANIA.

- Bloomsburg—M. E. Church, Thornton's Quarry.
 Bryn Mawr—College Hall, P., M. & B. Quarry.
 James F. Sinnott's Residence, Hoosier Quarry, Hazelhurst & Huckel, architects.
 Fern Rock—Sydney D. Fisher's Residence, P., M. & B. Quarry.
 Glenside—W. H. Harrison's Residence, P., M. & B. Quarry.
 Harrisburg—State Library, entire, ——— Quarry.
 Lancaster—St. John's Lutheran Church, P., M. & B. Quarry.
 U. S. Government Building, ——— Quarry.
 Merion—Lincoln Godfrey's Residence, P., M. & B. Quarry.
 Newtown—The George School, (trimmings), P., M. & B. Quarry.
 Philadelphia—Manufacturers' Club Building, Hoosier Quarry, Hazelhurst & Huckel, architects.
 Maternity Hospital, P., M. & B. Quarry.
 Tioga Baptist Church, P., M. & B. Quarry.
 Reading—J. H. Sternbergh's Residence (trimmings only), P., M. & B. Quarry.
 Scranton—Public School Building, Adams Quarry.
 Upton—Dr. J. M. DaCosta's residence, P., M. & B. Quarry.

RHODE ISLAND.

- Newport—Robert Goeblet's residence, Blue Hole Quarry.

TENNESSEE.

- Lebanon—Cumberland University, Thornton's Quarry.
 Memphis—Cotton Exchange Building, Griswold's Quarry.
 Morristown—Normal Academy, Thornton's Quarry.

TEXAS.

- Beaumont—Court House, Thornton's Quarry.
 El Paso—U. S. Court House and Postoffice, ——— Quarry.
 Richmond—Court House, Thornton's Quarry.

VIRGINIA.

- Roanoke—Postoffice Building, Salem Bedford Quarry.
 N. & W. Railway Offices, Consolidated Stone Company.

WISCONSIN.

La Crosse—Batavian Bank, Blue Hole Quarry.

Milwaukee—Gaul & Frank Building, Consolidated Stone Company's Quarries.

Winona—U. S. Postoffice Building, —— Quarry.

Milwaukee—Germania Building, Consolidated Stone Company's Quarries.
Public Library, Consolidated Stone Company's Quarries.

VENEZUELA, SOUTH AMERICA.

Caracas—Base of General Bolivar's statue, Thornton's Quarry.

BRIDGES.

Following are a few of the many bridges of Bedford stone.

Missouri River—Bellefontaine Bluffs, Mo.; cost, \$1,500,000; Geo. S. Morrison, engineer; Romona Quarry, 8,000 cubic yards.

Mississippi River—Alton, Ill.; cost, \$1,250,000; G. S. Morrison, engineer; Romona Quarry, 10,000 cubic yards.

Ohio River—Cincinnati, O.; cost, \$1,250,000; M. J. Becker, engineer; Romona Quarry, 9,000 cubic yards.

Chicago River—Twenty-six city bridges over Chicago River. Metropolitan Elevated Railroad river bridge.

Van Buren Street Cable Railroad Tunnel; cost, \$1,000,000; 3,000 cubic yards stone; C. S. Artingstall, engineer.

Three Chicago Water Works Cribs, four miles out in Lake Michigan.

Many bridges on the Illinois Central Railroad. Many bridges on other railroads in Indiana, Illinois and Missouri. All the above from the Romona quarries. There are many others from other quarries, such as one at St. Louis and one at Memphis over the Mississippi and the Ohio River at Henderson, Ky., Cairo, Ill., and three across the Ohio at Louisville.