

THE CARBONIFEROUS SANDSTONES OF WESTERN INDIANA.

AN ECONOMIC REPORT ON THE SANDSTONES OF A PORTION OF WESTERN INDIANA, ACCOMPANIED BY TWO ATLAS SHEETS SHOWING THE OUTCROPS AND DISTRIBUTION OF THE SANDSTONE.

BY T. C. HOPKINS.

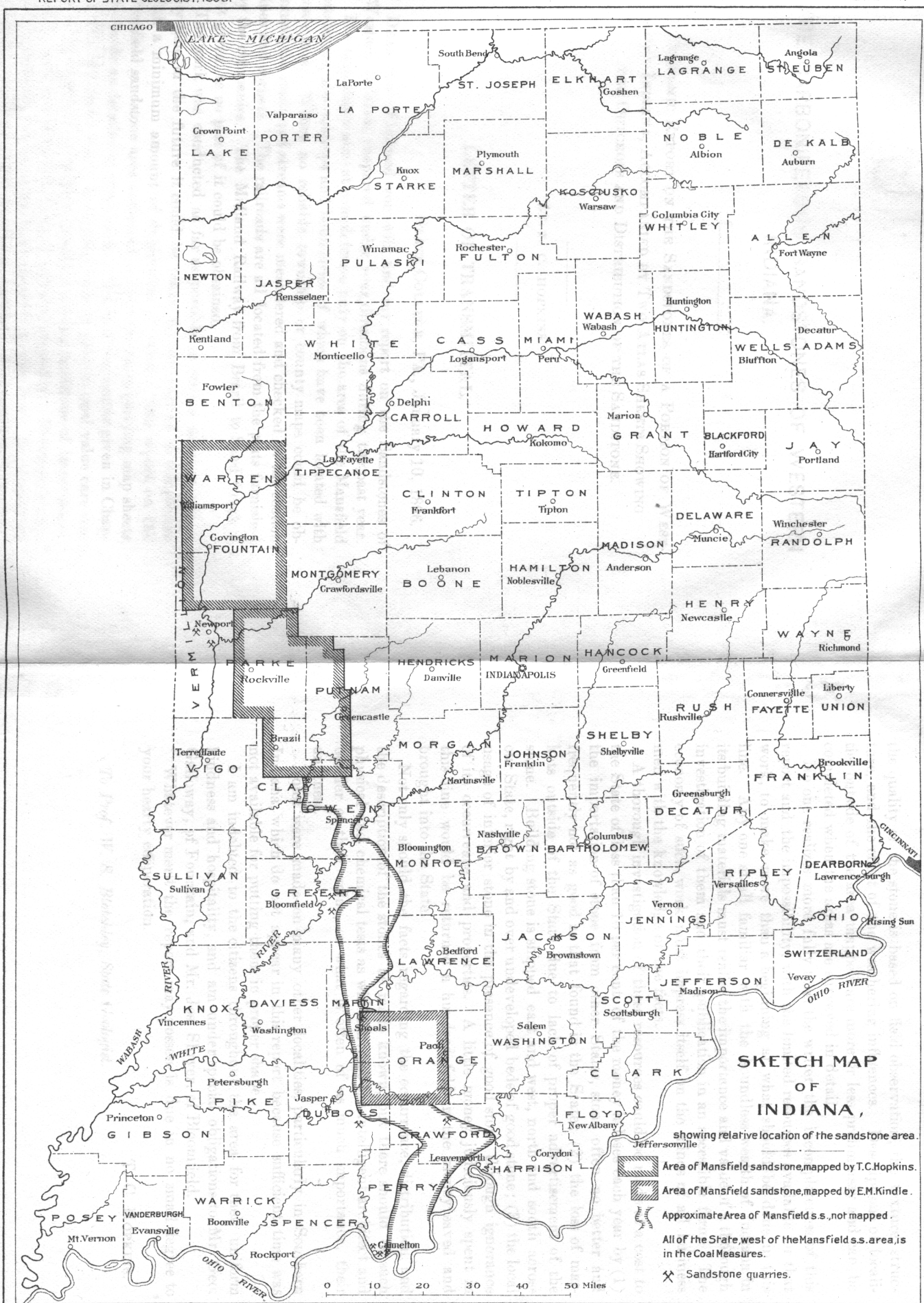
LETTER OF TRANSMITTAL.

STATE COLLEGE, PA., January 10, 1896.

DEAR SIR—Enclosed you will find my report on the Sandstones of Western Indiana, prepared under your directions during the past year.

The map sheets aim at completeness only on the area of the Mansfield sandstone, the outcrops and boundaries of which have been located with some care. Where no reliable township or county maps could be obtained the roads and streams were meandered and checked on the section lines and corners. The railroads are all located from the plats furnished by the companies. The Midland Railway from Brazil to Sand Creek is not given, as no plat of it could be obtained.

The work was conducted as far as possible in such a manner that at any time in the future it could be taken up and carried to completion with a minimum amount of duplication of work. The report on the Mansfield sandstone area embraced on the two accompanying map sheets was made as detailed as practicable. Much of the matter given in Chapter IV. will have only a local value, and to give it local value care was taken to locate as carefully as possible all the sandstone of importance, and to state also where the stone is inferior in quality. Frequently negative information is as valuable as positive on this line. In almost all instances, outside of the few quarries specified, the decision in regard to



the quality of the stone is based on field observation, the texture, structure, and the effect of the weathering influences. Descriptions of localities outside of the area mapped are more or less preliminary and can be completed when the areas are surveyed in detail.

No one realizes more fully than the writer the incompleteness of this report and the impossibility, with the limited resources available for that work, to make more than a beginning at what should be done in this line. Any one at all familiar with the boundless wealth of Indiana in its building materials must realize the importance and value of a thorough investigation of them and their publication in an accessible form. The economy of such work must impress itself on the minds of all business men with the knowledge of the facts.

A thorough investigation of these resources could be made at a cost to the State of less than 10 per cent. of the money it loses each year by (1) the importation of stone from other States, stone often no better and frequently not as good as that found in the State; (2) the loss of markets outside of the State due to lack of proper advertisement of the stone. Building stone is shipped east and west, north and south across our State, right by and over undeveloped beds of good stone; (3) the local usage of inferior stone in the presence of good stone through ignorance of its occurrence and properties. A little money judiciously spent in this line would be returned a hundred fold in the money saved and brought into the State.

Not only should the facts regarding the occurrence, distribution, and the description of the stones be made known, but there should be such physical and chemical tests as will convince the intelligent architect and builder of their value, or what is often of as much importance, their unfitness.

Notes were made on many other localities, particularly in Southern Indiana, which do not appear in this report because sufficient time was not available for putting them in proper shape.

I am indebted to the citizens throughout the area for their uniform kindness and hospitality, and am under special obligations to Mr. Geo. Galloway, of Fountain, and Mr. Jos. Shryer, of Bloomfield.

Whatever merit the report may possess is due in no small degree to your hearty coöperation.

T. C. HOPKINS.

To Prof. W. S. Blatchley, State Geologist.

THE CARBONIFEROUS SANDSTONES OF WESTERN INDIANA.

CHAPTER I.

THE GENERAL CHARACTER AND PROPERTIES OF SANDSTONES.

Definition.—The term sandstone includes the granular sedimentary rocks. The grains commonly, but not essentially, are quartz and the cementing substance, which varies widely in quantity, consists of iron oxide, clay, carbonate of lime, or silica. The two essential characters of a sandstone are (1) the grains, (2) the cement. As the grains increase in size the stone grades into a conglomerate; as they diminish in size it passes into shale or clay; as the grains lose their identity in the rock mass it passes into quartzite. If the cementing substance is wholly lacking there is simply a bed of sand, the condition in which probably all the sandstones were at one stage. By the increase of lime cement the rock passes into limestone; by the increase of the clay cement it grades into shale or clay; by the increase of iron, into iron ore; by the increase of quartz, into quartzite.

The composition and character of the grains.—In nearly all the common sandstone the bulk of the grains and sometimes all of them are fragments of quartz.* Other substances frequently occur in small but varying quantities, the most common of which are amorphous silica, feldspar, muscovite, biotite, magnetite, limonite, hematite, pyrite, and glauconite, less commonly apatite, calcite, augite, hornblende, tourmaline, staurolite, zircon, and rutile. Other rarer accessories are galena, cerussite, malachite, barite, garnet, celestite.†

The grains generally represent the least soluble parts of rocks. The soluble portions of the rocks are leached out by infiltrating waters during

*Calcareous sandstones or sandrocks are not uncommon on the seacoast where limestone or many shells occur, these being ground into fragments and cemented by the deposition of lime carbonate. These are rarely met with among the older sedimentary rocks, as they become modified by percolating waters.

†J. Roth. Allgemeine u. Chemische Geologie, Band II. pp. 608-609

the processes of weathering, while the less soluble portions are transferred by the waves, streams, and currents and deposited as beds of sand and gravel, which harden into sandstone and conglomerates. As quartz is the least soluble of the common rock-making minerals and at the same time one of the most abundant, it thus comes to make up the bulk of the sandstones. However, in the process of degradation not infrequently fragments of fresh material are ground up and deposited in the beds of sand so that sandstones are liable to contain fragments of any or all rock-making minerals.

The grains are usually angular, less commonly rounded, the coarser grained sandstone often consisting of a mixture of the two. Only where the grains suffer friction by wind as in desert sand do they appear to be completely rounded.* Sand grains of very small dimensions, as small as one-tenth of a millimeter, which are transported by flowing water, always remain angular (Daubrée).

Cement.—The common cements of sandstone are clay, iron oxides, calcite, and silica. These may be carried in as sediment in the waters that deposit the sand, or they may be deposited by infiltrating waters subsequently to the deposition of the sand. The material may be deposited with the sand and subsequently changed by the action of infiltrating waters or the materials may be carried in by the waters from some extraneous source. On the character and quantity of the cementing material depends the rigidity or strength, the durability, the workability, and most frequently the color of the stone. Thus from an economic standpoint the cement is by far the more important constituent of the rock, although it frequently forms but a small per cent. of it.

The argillaceous or clayey cement may generally be detected if present in considerable quantity, by giving an earthy odor when breathed upon. It may or may not discolor the stone, the color depending on the purity of the clay; it is more commonly a gray or yellow color, sometimes blue where not much weathered. From the standpoint of durability it is the least desirable of any of the cements, owing to the nature of the clay to absorb water, and thus render the stone liable to injury from frost. The presence of the clay in small quantities intimately diffused through the rock is not necessarily a fatal injury to the stone, as many well-known building stones have a clay cement. It is where the clay is segregated in layers or patches that it is the most injurious.

The ferruginous, or iron oxide cement always colors the stone; the hydrous oxide or limonite forms give various shades of buff, yellow, and yellow-brown, the shade depending on the hydration of the iron and the quantity of it present. The anhydrous or hematite form of the iron gives various shades of red and red-brown depending on the quantity

*Zirkel, Lehrbuch der Petrographie, Vol. III, p. 715.

and character.* Most commonly there is a mixture of shades or colors in the form of spots, stripes, clouds, or veins. The most serious objection to the iron oxide cement is the lack of uniformity in color in the stone. Where the color is uniform, and at the same time pleasing, it makes one of the most valuable building stones, such as the brownstones of Connecticut, Pennsylvania, Lake Superior, and Indiana. Sometimes the iron occurs as finely diffused iron sulphide or ferrous carbonate, and more rarely as the silicate, when the stone has a faint bluish or greenish tint.

The calcite, or lime carbonate cement rarely produces deep or bright colors, and is generally yellow-gray or greenish-gray; it can generally be detected by giving an effervescence with an acid, but it is commonly associated with the carbonates of magnesia and iron, and when the latter carbonates form a considerable per cent. there may be no effervescence with cold acid, but will be when the acid is heated. It makes a durable and desirable stone, providing the texture and structure are all right, but it quite frequently happens that the texture is so close and compact as to make it, exceedingly difficult to work; in some localities where it occurs intercalated with the ferruginous sandstone, it is termed "flint" by the quarrymen, because of its extreme hardness as compared with the more friable ferruginous stone. Very few of the widely known building stones occur in this class.

The siliceous cement is the most durable of any, but if present in considerable quantities it often makes the stone too hard to work with either ease or profit, and changes the sandstone to quartzite, one of the hardest and most durable of rocks. The well-known Sioux Falls stone belongs in this class.

There is commonly a mixture of two or more of these cements as the silica and clay, silica and lime, clay and iron. Not infrequently the pyrite acts as a cement, though not a desirable one.

Bedding surface.—The bedding surfaces are frequently covered with mica scales, clay, marl, or red ironstone. These are desirable, if not present in excess, as they cause an easy parting along the bedding surface, thus facilitating the work in quarrying.

The bedding surfaces are frequently marked by sun cracks, rain drops, ripple marks or wave marks, animal tracks, etc. All of these except the ripple marks denote an exposure of the soft material before it was indurated; probably the bottom of some lake, bay or lagoon has been elevated above the high tide and in drying would form cracks to be filled by later formations and would receive and retain the imprint of rain drops or tracks of animals, etc.

* In the Tertiary sandstones of the Eastern States, the iron cement is largely turgite. In the Triassic and Carboniferous sandstones it is largely limonite. In the Potsdam sandstone of Lake Superior it is mostly hematite.—A. Julien, Proc. A. A. A. S., Vol. 28, 1879, p. 408.

Varieties of sandstone depending on color.—Sandstones are white, gray, drab, buff, yellow, brown, red, blue, green, and black, with many intermediate and intermingled shades of these colors. The white sandstones are generally nearly pure silica and practically free from metallic oxides. The gray contains a slight admixture of clay, iron or organic material. The buff, yellow, and brown colors are due to the presence of hydrous oxide of iron; the red to the presence of hematite; the blue color may be due to finely diffused iron pyrites, or the presence of iron carbonate, or a small quantity of bituminous or carbonaceous matter. The faint pale green tint found in some sandstones is probably due to some form of iron protoxide, possibly the silicate; the bright green is due to malachite. The black color is due to bitumen or carbonaceous material of some kind. The depth of color in a rock depends not so much on the amount of coloring material as on the chemical and physical character of it.

Varieties of sandstone based on texture and structure.—Sandstones may be fine-grained, medium fine, coarse, or very coarse, all of which terms are relative and more or less arbitrary in their usage. Orth* has proposed the following distinction to these general terms:

	Millimeters.
Fine sand, diameter of the grains.....	0.05 to 0.25.
Medium fine, diameter of the grains.....	0.25 to 0.50.
Coarse sand, diameter of the grains	0.50 to 1.10.
Very coarse, diameter of the grains	1.00 to 3.00.
Gravel, diameter of the grains	3 mm. or more.

The texture may be open and porous, close and compact, friable or earthy. The fine angular-grained highly siliceous varieties with little cement furnish the whetstones. The coarse angular-grained, friable, siliceous varieties form the grit and grindstones.

In structure the stone may be massive, heavy-bedded, thin-bedded or shaly, all relative and self-explanatory terms.

Varieties of sandstones based on composition.—As nearly all sandstones are quartzose in grain, the distinctions in varieties are based on differences in the cementing material as follows:

Siliceous or quartzose sandstone is one in which the quartz grains are bound together by a siliceous cement. This may be quartz deposited on the grains and oriented with them so as scarcely to be distinguishable from the original grain, or it may be in the form of an aggregate oriented independently. In rare cases the silica may be deposited in the form of opal. In most cases the cement is present in small quantities. With the increase in quantity of the siliceous cement the stone becomes harder, passing finally into quartzite, in which the separate grains can no longer

* Zirkel's Lehrbuch d. Petrographie, Band III, p. 736.

be distinguished by the naked eye. The quartzose sandstones are the most durable, but are also the most difficult to work.

Calcareous sandstone has the cement of lime carbonate which may be in varying proportions, sometimes as high as 30 per cent. or more.* The lime carbonate is commonly mixed with more or less iron and magnesia carbonate. In some instances dolomite or the double carbonate of lime and magnesia forms the cement. In rare cases gypsum (lime sulphate), barite (barium sulphate), or celestite (strontium sulphate) forms the cement. The calcareous sandstones are mostly a yellow-gray or greenish-gray color, rarely white or yellow, and they are widely distributed, but more common in the younger formations than in the older ones.

Argillaceous or clayey sandstone is one in which the sand grains are held together by a clay cement. It is the most common of all sandstones, and occurs in formations of all ages. They are usually fine-grained, as a current strong enough to move coarse sand would carry all the clay away, and in the gentle current or still water where the clay would settle there would be deposited all the fine sand that remains in suspension. In their deposition they form an intermediate stage between the coarser sandstones and the clays or shales, and naturally grade from the coarser sandstones into the sandy clays and shales with no sharp line of distinction between them. Mica flakes and feldspar grains are common accessories. The clayey sandstones are white, gray, yellow, green or pale red in color.

Kaolinitic sandstone is an argillaceous one in which the cement consists of kaolin, usually white or gray in color. It usually contains reddish-white fragments of orthoclase in either a fresh or decayed condition.

The *marly sandstone* is intermediate between the calcareous and the argillaceous varieties, and has a cement of clayey limestone or marl. It grades into sandy marl.

The *ferruginous sandstone* has a cement of iron oxide, either the hydrous oxide (limonite, göthite, turgite) or the anhydrous oxide (hematite), or it may be in the form of ferrous carbonate. The iron oxide commonly forms a coating around each of the quartz grains, thus binding them together. In the cement between the larger quartz grains are frequently fine particles of sand, mica flakes and grains of the iron oxide. The ferruginous sandstones, as a rule, are very poor in organic remains. They occur in rocks of all ages, especially abundant in the Devonian, Permian, and the Triassic, such as the Old Red sandstone of England and the famous brownstones of the eastern States.

Glaucinitic sandstone is so called from the glauconite it contains. While of some scientific interest it has little economic value.

Bituminous sandstones have a perceptible amount of carbonaceous material diffused through the mass, giving them a dark gray or even black

* Zirkel, Lehrbuch der Petrographie, Band III, p. 724.

color. They are not so common as some of the other varieties, and rarely have any economic value. The bituminous material sometimes takes the form of asphalt.

Varieties of sandstone based on locality.—These may have acquired a geologic significance, and designate a definite horizon, such as the Potsdam sandstone, Calciferous sandstone, Medina, Clinton, Oriskany and Catskill sandstones, etc. Or they may be simply commercial terms without reference to geologic position, and known in the market by the name of the place at or near which they are quarried. The varieties on this basis are almost as numerous as the quarries. Among the best known brownstones are the Portland (Conn.), Hummelstown, Lake Superior and the Sioux Falls, the latter being a quartzite. The Berea and the Cleveland stones of Ohio are widely known. Among the best known sandstones in Indiana are the Cannelton, St. Anthony, Williamsport, Riverside, and Mansfield sandstones.

Uses of sandstone.—Sandstone is subject to all the uses of other building stones. It is probably better adapted to use in heavy masonry, as bridge abutments, foundations, retaining walls, etc., than almost any other class of stones, owing to the greater ease with which it can be quarried. It compares favorably with other stones in superstructures, the far-famed brownstones of the eastern States being one of the most fashionable building stones in the country, while there are others less widely known but equally as good, and often much better from a standpoint of durability. Many sandstones which are good, durable, and desirable wall stones are not suited for trimmings, such as lintels, sills, caps, etc., on account of weak transverse strength. Some varieties, however, especially those with siliceous cement, are very strong in this direction and well suited for such purposes. On account of the varieties in color which can be obtained they are often desirable for architectural effect in trimming buildings of brick or other varieties of stone.

The proportion of the sandstone quarried that is used for building purposes is greater than that of either limestone or granite. The census report gives for 1889 the following percentages of all the stone quarried that was used for building purposes: Sandstone 65 per cent., granite 43 per cent., and limestone 23 per cent.

The harder varieties of sandstone are desirable for steps and pavements as they are not so slippery as limestones and granites. Some of the softer sandstones that are otherwise very durable do not stand abrasion sufficiently well to be used for this purpose. Some of the largest flagstone quarries of the country are in sandstone. It is also used for curbing, sewer caps, etc., but care should be taken to select only the harder forms for such uses.

Sandstone has been used for paving blocks, but only the harder or quartzitic forms are suitable for this purpose. It is suitable for railway

ballast or for macadam for wagon roads. In the latter case there should be a top dressing of gravel or harder rock. Nearly all the grindstones, whetstones and shoe rubbers are of sandstone, where the grains are sharply angular and the cement in small quantities. Sandstone that is light colored, highly siliceous and free from iron is used for glass making. Sandstones that stand the fire well are sought for use in furnace hearths.

The following list, showing the various uses of sandstone is taken from the Stone Industry in 1894, by W. C. Day: *

USES TO WHICH SANDSTONE IS PUT.

FOUNDATIONS, SUPERSTRUCTURES, AND TRIMMINGS.

Solid fronts,	Buttresses,	Capping,	Ashlar,
Foundations,	Window sills,	Belting or belt	Forts,
Cellar walls,	Lintels,	courses,	Dimensions,
Underpinning,	Kiln stone,	Rubble,	Sills,
Steps.			

STREET WORK.

Paving blocks,	Basin heads or	Road-making: {	Macadam,	Sledged stone,
Curbing,	catch-basin covers,		Telford,	Crushed
Flagging,	Stepping stones.		Concrete,	stone.

ABRASIVE PURPOSES.

Grindstones,	Whetstones,	Shoe rubbers,	Oilstones.
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BRIDGE, DAM AND RAILROAD WORK.

Bridges.	Breakwater.	Rails.	Bankstone.
Culverts.	Jetties.	Ballast.	Parapets.
Aqueducts.	Piers.	Approaches.	Docks.
Dams.	Buttresses.	Towers.	Bridge covering.
Wharf stone.	Capstone.		

MISCELLANEOUS.

Grout.	Lining for blast furnaces.	Millstones.
Hitching posts.	Rolling-mill furnaces.	Fluxing.
Fence wall.	Lining for steel converters.	Ganister.
Sand for glass.	Fire brick, silica brick.	Glass furnaces.
Sand for plaster and cement.	Core sand for foundries.	Random stock.
Furnace hearths.	Adamantine plaster.	
	Cemetery work.	

Production of sandstone in the United States.—The value of the sandstone production as compared with that of other stones for the last two years, and the value of the sandstone quarried in the different States for the last four years as compiled by the U. S. Geol. Survey, are shown in the tables in the final chapter.

* The Stone Industry in 1894, by W. C. Day. In the Sixteenth Annual Report of the Director of the United States Geological Survey, Part IV, Washington, 1895.

While there is a marked reduction in the production of sandstone from 1890 to 1894 it may be noticed that Indiana, which ranked 22d in the value of its production in 1890, ranked 15th in 1894.

It might be further noticed that the report shows the production for 1891 in Indiana valued at \$90,000, while the statistics collected by the State Geologist of Indiana for the same year show a value of \$169,411. So the value for 1894 should be \$77,800 instead of \$22,120. Even these values given by the State Survey are low, as it is impossible to get the figures from the small quarries.

Distribution of sandstones.—Sandstones are distributed geologically throughout the sedimentary series from the oldest to the youngest strata. The Potsdam sandstone of early Paleozoic, the Old Red sandstone of Devonian and Permian times, the Millstone grit of Carboniferous and the Portland and other brownstones of Triassic times are all heavy and widespread formations.

Geographically they are almost as widespread as the sedimentary rocks. Extensive beds of valuable sandstone occur along the Atlantic seaboard States in the folded regions of the Appalachians, bordering the coal areas of the Mississippi Valley, bordering the crystalline series in the lake region, and in the Cordilleras of the west. As shown by the statistical tables the States that lead in the production of sandstone are Ohio, Pennsylvania, Connecticut, New York, New Jersey, Massachusetts, and Missouri. In 1890 Colorado and Michigan were important producers.

CHAPTER II.

GEOLOGIC HISTORY OF THE SANDSTONES OF WESTERN INDIANA.

All the sandstones mentioned in this report belong to the Carboniferous age, some in the Lower Carboniferous, some in the Coal Measures. Detailed work was done on only one bed, that at the base of the Coal Measures and termed the Mansfield sandstone. Others are mentioned and certain economic features described as they appear at certain localities without attempt to accurately designate their stratigraphic position or their areal extent, which would require more time than was available in this work.* The general relations of the different sandstone deposits are as follows:

* The reasons for the detailed work on the Mansfield stone rather than on the others are (1) its greater economic importance, (2) the others are associated with other economic products which will require investigation in the future, when the details of both can be worked out together.

I. COAL MEASURES.

1. A series of coal beds separated by sandstones, shales, fire-clays, and, in places, limestone; more or less loosely classified in certain areas, but no reliable general correlations over the whole area; good sandstone in several localities.

2. The Mansfield sandstone and conglomerate, a bed of coarse-grained, massive sandstone at the base of the Coal Measures, contains some conglomerate and is accompanied by some coal, black shale, and fire-clay. It is referred to in former State reports as the Conglomerate and as Millstone grit.*

II. LOWER CARBONIFEROUS OR MISSISSIPPIAN.

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|--|---|---|----------|--|------------|--|---------|--|------------|
| 1. The Riverside sandstone. | | | | | | | | | |
| 2. Several beds of associated limestones, shales and some sandstone, probably corresponding to the following groups. | <table border="0"> <tr> <td>{</td> <td>Chester.</td> </tr> <tr> <td></td> <td>St. Louis.</td> </tr> <tr> <td></td> <td>Keokuk.</td> </tr> <tr> <td></td> <td>Knobstone.</td> </tr> </table> | { | Chester. | | St. Louis. | | Keokuk. | | Knobstone. |
| { | Chester. | | | | | | | | |
| | St. Louis. | | | | | | | | |
| | Keokuk. | | | | | | | | |
| | Knobstone. | | | | | | | | |

There are many local variations in the character of the strata, and it will require more detailed paleontologic and stratigraphic work than has yet been done to give any scientific value to a correlation of them with strata at localities outside of the State.

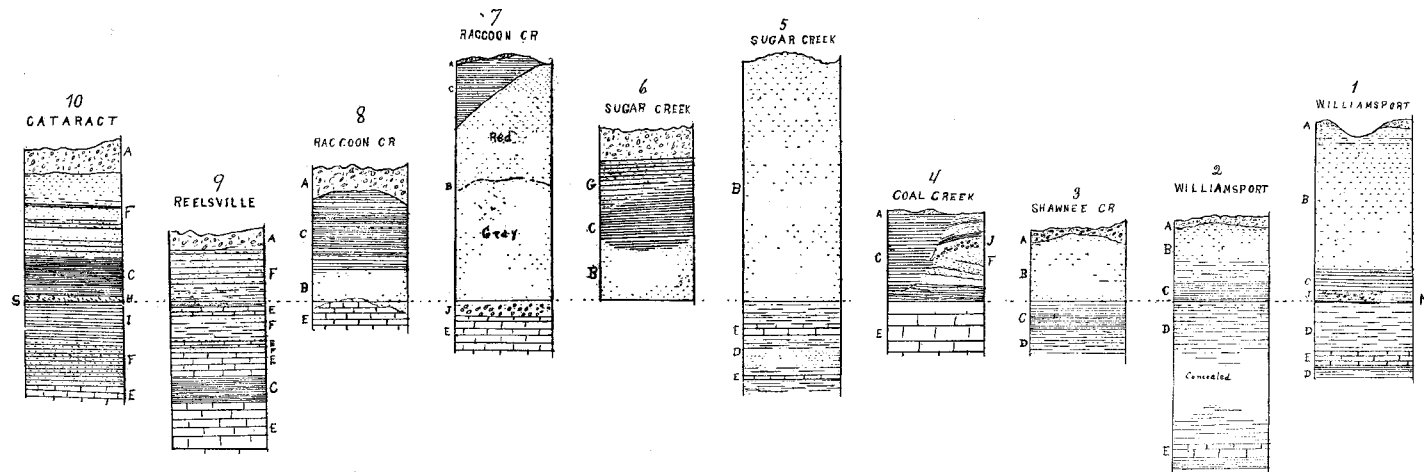
There are heavy beds of sandstone in the Coal Measures at Cannelton, at the Portland quarry in Vermillion county, on Big Vermillion river, on Little Vermillion river, at Covington, at the Glen south of Covington, at Silverwood, on Sugar creek and elsewhere, but not enough is known at present to say whether they all belong to the same or different periods of deposition

In the north part of the area mapped the Coal Measures are underlain by a fine-grained, impure sandstone (the Riverside sandstone of this report), associated with thin layers of limestone in some places. In the southern part of the area mapped (the Brazil sheet) they are underlain by a compact blue limestone, in some places cherty, in some places not. Still further south, about French Lick, they are underlain by alternating layers of compact limestone and coarse, yellow sandstone. The valuable bed or beds of oolitic limestone lie some distance east of the Coal Measures along a certain part of the area, but none of these formations have been accurately delineated either areally or paleontologically.

Some of the local variations of the strata are shown on plate IX., which consists of a series of sections from different parts of the area. These sections are arranged in a general way from north to south, yet it frequently happens that a section less than a mile away may show a greater change than one ten or even fifty miles away.

Unconformity.—The line of parting between the Lower Carboniferous strata and those of the Coal Measures is in a great many places marked by an unconformity shown by the erosion interval and the occurrence of the basal chert conglomerate. Plate X. illustrates some well-marked examples of this unconformity. It would be all the more

* The reasons for the use of the term Mansfield are given in a succeeding chapter.



A SERIES OF SECTIONS ARRANGED IN A GENERAL NORTH-SOUTH DIRECTION, ILLUSTRATING THE LOCAL VARIATIONS IN STRATIGRAPHY.

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| N-S—Line of parting between the Lower Carboniferous and the Coal Measures. | F—Shaly sandstone. |
| A—Glacial drift. | G—Flagstone. |
| B—Mansfield sandstone. | H—Fire-clay. |
| C—Black shale. | I—Green shale. |
| D—Riverside sandstone and shale. | J—Conglomerate. |
| E—Limestone. | |

marked in some places by a longer section. Thus a section across the Wabash River valley above Attica would show in one place 90 feet or more of Coal Measure sandstones in the bottom of the valley, and the Lower Carboniferous rocks on the hills on either side. Likewise on Sugar creek, in one place the massive Mansfield sandstone outcrops 100 feet thick, extending below the level of the creek, while less than a mile away the underlying Lower Carboniferous limestone is 80 or 90 feet above the creek. This is not due to the dip of the strata, which in most places are practically horizontal, but to erosion of the underlying rocks before the deposition of the Coal Measures.

Conditions of deposition.—During the deposition of the Lower Carboniferous limestone there was a long period of quiet seas, and probably little elevation or depression of the earth's crust. At the close of this limestone-making period there was an elevation, probably very gradual, and a long period of oxidation, with more or less erosion, began. Before this had quite reached base level, a higher and more rapid elevation took place, when the streams were all quickened in their erosive power, and the coarse oxidized residual deposits of the preceding period were swept down by the strong currents to the sea shore, to the bays, estuaries and river channels, where they were deposited to form or to assist in forming, the massive, coarse-grained sandstone and conglomerate at the base of the Coal Measures.

Source of material.—The source of all this coarse material is not easy to explain. One naturally looks to what was then the land area to the east, but there are no coarse sandstones and no granitic rocks in that area to furnish the material. There are apparently two sources of coarse, siliceous sediment from the older rocks to the east: (1) the chert in the limestone, and (2) the geodes. That both these are a source of supply is clearly shown in the rocks themselves, in many places the chert pebbles and fragments being found in abundance, not only identical in color and general appearance, but carrying the same fossils as that in the underlying limestone. While the identity of the chert is clear in the coarse basal conglomerate, it is not so evident in the case of the finer grained sandstones, where most of the grains are fragments of crystalline quartz, while the chert is cryptocrystalline, and it is highly improbable that the grains became crystalline after deposition. Furthermore, as mentioned elsewhere the numerous light-colored granular quartz spots in the sandstone are supposed to be chert. Nor can the numerous patches of hard quartz conglomerate have their origin in the chert. Hence, while this is one source, it is not the sole source. The quartz in the geodes is crystalline, and that this is one source of supply for the sand and pebbles can be clearly proven by the presence of geodes and fragments of geodes in the conglomerates. A single hand specimen sometimes contains as high as a half-dozen fragments that still show their

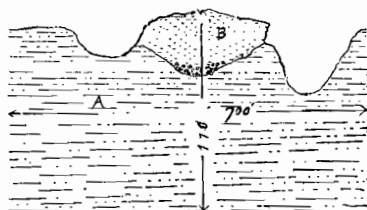
geodic origin. That this is not a sole source of supply is evident for two reasons: (1) some of the quartz in the sandstone contains microlites of apatite, rutile, zircon, and fluid inclusions that do not occur in geodic quartz; (2) the product is greater than the source. While it is true that geodic quartz is abundant in some of the beds, and would furnish a vast amount of sand when ground up by the waves and currents, it is not sufficient to furnish all the material for the Mansfield sandstone.

Thus besides the two sources of the material given there must be at least another and that must be from a region of igneous or metamorphic rocks, or from a rock derived from such a source. Such a source is not to be found east of the sandstone area, but must be sought in the north, northwest, or southwest, and in any case the material must be transported a long distance. Three possible explanations that apparently accord with these conditions might be offered to account for the source of such material: (1) It may come from the crystalline areas of the north, transported by the currents of one or more Paleozoic rivers aided perhaps by floating ice. (2) It might come from the older Paleozoic sandstones (the Potsdam and St. Peter's) of Northern Illinois and Southern Wisconsin brought down by shore currents and floating ice. (3) It might have been carried by floating ice across the shallow interior sea from the crystalline island in the Iron Mountain region in Missouri.*

The most serious objection to any of the explanations, but that of a glacial period, is the presence of so many quartz pebbles of large size which would require currents of almost incredible velocity to transport them in one geologic period from Wisconsin, Michigan, or Canada to Southern Indiana and Kentucky. However, these large pebbles may all or most of them come, as some of them evidently do, from the chert and geodic quartz of the older limestones close at hand.

It may sound unreasonable to many geologists that any appreciable amount of sand or pebbles may come from the geodes, and some to whom I have mentioned the subject think that the amount from such a source would be too small to be worthy of consideration. But I am convinced that a study of the field relations as they exist in Indiana would convince any one of the importance of this source of supply. While sufficient evidence is not at hand to prove that all or even the major portion of the coarse materials *did* come from the geodes, there is conclusive evidence that an appreciable quantity of the quartz pebbles *did* come from

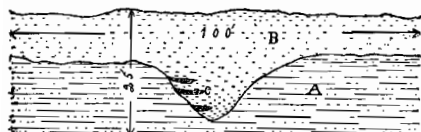
*A fourth possible theory might be suggested, but in the light of present knowledge seems highly problematical, that is a transportation by land from the northern regions by glacial action similar to our recent glacial period. Eastern geologists have shown with considerable clearness the presence of a Carboniferous glacial period in India and in Southern Africa, but there is as yet no such direct or satisfactory evidence that there was such in America, and considering the extent to which the Carboniferous system has been studied in this country, it would seem highly probable that such evidence would have been discovered if it existed.



1. Black Rock.



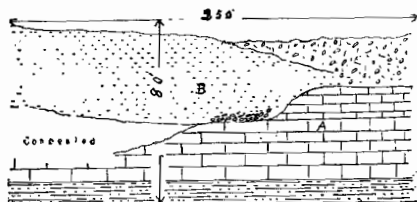
2. Little Pine Creek.



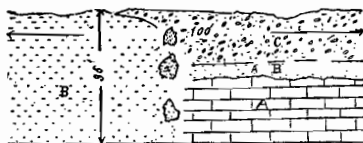
3. Turkey Run.



4. Sugar Creek.



5. Ramp Creek.



6. Byrd Branch.

SECTIONS ILLUSTRATING THE UNCONFORMITY BY EROSION BETWEEN THE LOWER CARBONIFEROUS AND THE COAL MEASURES IN WESTERN INDIANA.

such a source, and it is not impossible or improbable that a considerable portion was so derived.

The sandstones that occur in the productive Coal Measures are in general finer grained than the Mansfield stone, and so far as observed contain no coarse conglomerate. They are less purely siliceous than the Mansfield stone, and possibly a higher per cent. of their materials has been derived directly from the Lower Carboniferous rocks and older strata to the east, which has been carried by the Carboniferous rivers and deposited in the lakes, bays, estuaries, and shallow Carboniferous seas. As there were many more or less shallow basins separated in part by land areas we would naturally expect many local variations in the character of the strata, or rather since we find these local variations along with ripple marks, false bedding, carbonaceous material, etc., we naturally conclude that such was the condition at that time.*

CHAPTER III.

THE MANSFIELD SANDSTONE.†

The Mansfield sandstone, a coarse-grained gray, yellow, red, brown, or variegated massive sandstone is probably the most important sandstone in the State of Indiana, from both an economic and scientific standpoint. There is considerable good building sandstone in the overlying Coal Measures, and to a less degree in the underlying Lower Carboniferous series, but no single formation contains as great a variety or as large a quantity of good sandstone as the one designated in this report, the Mansfield sandstone.

The name.—The formation is named from Mansfield, Parke county, Indiana, a little village on the bank of Big Raccoon creek, twelve miles north of Brazil, with which it is connected by railroad. The name is probably not the most fortunate one from an economic standpoint, but is chosen because: (1.) The stone was quarried at Mansfield for several years and is known to some extent in the markets by that name. (2.) There is a typical and rather extensive exposure of the stone there. (3.) There is no other sandstone at that place with which it need be confused.‡

*The details of the stratigraphy of the Coal Measures will, no doubt, be worked out in connection with the economic report on coal, as the coal beds are the most valuable of the natural products of this area.

†Only the general properties of the sandstone are given in this chapter. The specific characters relating to the stone at the different localities will be found in the following chapter. The description of other stones, as the Portland, Cannellton, etc., will be found in the following chapters.

The same bed of sandstone is referred to in the former state geological reports as the Conglomerate, or sometimes as the Millstone grit. The objection to using either of these terms is that a lithologic term in itself does not properly designate a geologic formation, and even if it did it would not be appropriate in this case, as but a small per cent. of this formation is conglomerate, and a much smaller per cent. is good millstone grit. It might properly be termed the Mansfield sandstone and conglomerate, as the formation contains conglomerate in many places. But if only one term is used it is more properly designated a sandstone, as there is probably more than ten times as much sandstone as conglomerate, and the use of the geographic term definitely fixes the horizon.*

Geologic position.—The Mansfield sandstone lies at the base of the Coal Measures, unconformably upon the Lower Carboniferous limestone, or in the absence of the limestone on Lower Carboniferous sandstone or shale. There is thus a double delimitation below (1) the unconformity which is shown in many places by erosion channels and basal conglomerate, or both; (2) the Lower Carboniferous series with which it can rarely be confused on account of the sharp distinction in lithologic character. It is overlain by a series of shales, sandstones, and coal beds, in some places conformably, in others unconformably, and in general there need be little doubt about the vertical extent of the Mansfield sandstone, as where typically developed it is distinguished by its coarse-grained texture, massive structure, patches of quartz conglomerate, false bedding, and iron secretions. However, there are instances where the correlation is uncertain, as in some localities there is no massive sandstone at this horizon, but shaly sandstone and shales immediately overlie the Lower Carboniferous limestone where, in the absence of fossils, or of a thorough study of the overlying Coal Measures it is not possible to always determine whether these thinly laminated strata are correlative of the Mansfield sandstone, or whether that formation is absent entirely. If the Mansfield stone were always coarse-grained and massive the difficulty would be lessened, but in some places the massive sandstone is accompanied by thinly laminated sandstone and shale, which belong to the same period of deposition.

On the accompanying map sheets all the sandstone occurring at the horizon of the Mansfield sandstone is classed provisionally as Mansfield if there is no stratigraphic evidence that it belongs to a higher horizon.†

Varieties of Mansfield sandstone.—There are a great many varieties of the Mansfield sandstone in both color and texture. In color it ranges

* Sandstone is the broader term of the two. While the distinction between the two is mainly on the size of the particles, conglomerates are composed essentially of water-worn or rounded materials, while the sand grains may be either rounded or angular, and in the finer grained stones are almost universally angular.

† It is possible that some of the thinly laminated sandstone in the area south of Greencastle, and in some other localities along the eastern border of the formation, may be of more

from nearly white through various shades of gray, yellow and red, to dark brown, yet they may all be divided into two general classes; (1) red or brown stone; (2) yellow and gray, with more or less variegated stone in both classes.

1. The *red* color in sandstone is caused either (1) by the grains themselves being red or (2) by a red cement where the grains themselves may be white or colorless, and coated with a more or less thin film of red coloring matter, which may be the cement wholly or in part. Stones of the second class are the more common, and in this class are the brownstones of Indiana.

The coloring matter of the Indiana brownstone is composed of iron oxides, which chemical analyses show to be present in quantities varying from two or three per cent. to nearly 23 per cent. The microscope shows the presence of the anhydrous red hematite accompanied by small quantities of the hydrous yellow and brown oxide. It occurs sometimes in a finely granular condition, sometimes as an impalpable powder in which the separate grains are not distinguishable under the microscope; and in places it is partly crystalline, showing crystal faces three one-hundredths of a millimeter in length.

There are many shades of the red and brown colors, one of the most common being a deep red-brown with a faint purple tinge suggestive of manganese, and having a faint steel lustre in places. It is a handsome and desirable building stone. Another common shade is a lighter red than the preceding, the lighter color being due partly to the greater abundance of the small white granular quartz particles and partly to a thinner coating of the iron oxide on the quartz grains. It is a handsomer stone than the first variety, but not so abundant. Another shade rather abundant at the Mansfield and the St. Anthony quarries has a nearly walnut brown body, with light particles. It is not so handsome as either of the preceding. Another less common variety, which has been called a "flea-bitten fawn skin," consists of a light brown body with light gray spots about the size of one's finger tip. The stone near Green Hill is a light red, a little paler than a cherry. It is the clearest red of any sandstone of the State that occurs in large quantities, and is in no sense a brownstone. The color is uniform over a considerable area. The lighter color is due to the iron oxide occurring in a less quantity, forming but a slight film on the white quartz grains.

There are several other varieties, some lighter, some darker, that occur for the most part in quantities too small to have any economic value. There is a banded variety that occurs in considerable quantities at Mansfield and elsewhere, which is made up of lighter and darker bands an inch or more in width and running at an angle of about 30 degrees to the horizontal, and following apparently the lines of false bedding of the rock. While beautiful in hand specimens, it would be out of place in

walls, nor does it occur in sufficient quantities to be used alone for building.

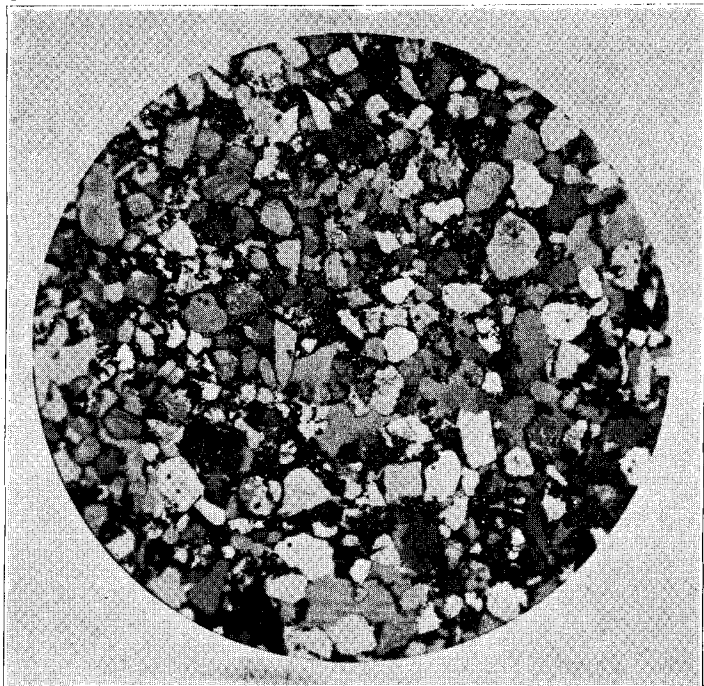
In all the numerous specimens examined, the color is due to the iron oxide in the cement and not in the grains themselves, which are white or transparent when removed from the cement. There are two possible sources for the iron oxide in the sandstone; (1) as sediment deposited at the same time as the sand; (2) carried in by infiltrating waters subsequent to the deposition of the sand. The evidence in favor of the second process is (1) in many places the color grades into gray along very irregular wavy lines which are far from horizontal; (2) the lines of banding follow the lines of false bedding along which the infiltrating waters naturally flow; (3) the iron blisters are evidently ferruginized pebbles [see further under texture], and (4) the patchy occurrence of the sandstone. However, it must be admitted that all these conditions are explained by the first hypothesis if we admit a secondary alteration of the iron by infiltrating waters.

It is possible that in either case the iron might first have been deposited in some other form, such as the sulphide or carbonate and subsequently oxidized, but there appears to be no direct evidence in support of this view.* Some of the phenomena can be accounted for only on the theory of infiltrating waters, and if some of the iron oxide was deposited contemporaneous with the sand it has been modified to some extent by the penetrating waters. Nor is it a surface phenomenon, but the interior of the beds is as deeply colored as the exterior.

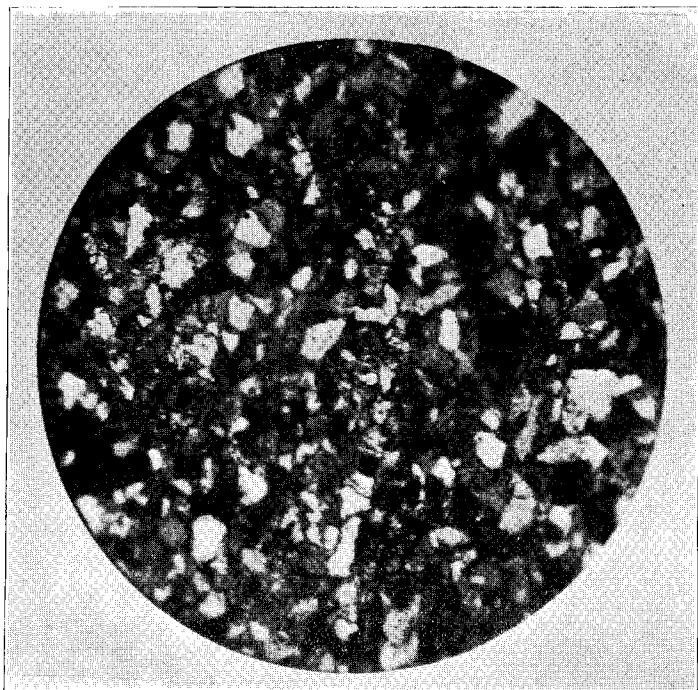
From an economic standpoint the greatest objection to the red or brown stone is that the color is nowhere uniform throughout the bed. In some places the variegations are so abundant that stone of a uniform color cannot be obtained in sizes suitable for building. In other places one color or shade will prevail for six or eight feet where it will give way to another shade through a like thickness, and by careful selection stone of different shades can be separated and abundance of any one color can be obtained. This can be done more economically in the saw-mill than elsewhere by setting the saws to run between the colors. It would necessitate the quarrying of a great deal of stone to keep up the supply of the color that happened to be the most popular.

2. The yellow, buff, and gray Mansfield sandstone is more abundant than the brownstone. The coloring matter in these varieties is the hydrous iron oxide, and in nearly all cases there is a less per cent. of the iron than in the red and brown stone. Some of the lighter colored, nearly white sandstones are almost entirely free from iron. As a rule these lighter colored rocks are softer and more friable than the darker brown stones. Yet this is not always the case, as one of the hardest and

*Dr. J. W. Dawson argues that in the red beds of Nova Scotia the red oxide is derived from decomposed iron pyrites. Q. J. G. S. Vol. V, p. 25.



No. 1.



No. 2.

MICROPHOTOGRAPHS.

No. 1. MANSFIELD SANDSTONE, MANSFIELD, INDIANA. (Magnified 25 diameters.)

No. 2. RIVERSIDE SANDSTONE, RIVERSIDE, INDIANA. (Magnified 70 diameters.)

least friable sandstones in the whole area is nearly white in color. The light gray colored stone is less common than the buff and yellow. The deeper colored ones in many places have iron secretions, either the iron kidneys or segregated veins, the iron secretions frequently gathering along the lines of false bedding.

Structure.—The Mansfield sandstone in most places is a medium to coarse-grained sandstone occurring in a massive bed varying from a few feet to more than 100 feet in thickness. In some places the massive seamless stone is accompanied by a few feet of thinly stratified sandstone, in others by a coarse conglomerate, and in many places by a black shale, fire-clay, and coal. In many places it is characterized by false bedding and iron secretions. Characteristic features of the bed are its massiveness, the prevalence of false bedding, and the occurrence of coarse conglomerate. While common these are not constant phenomena.

The conglomerate occurs in irregular patches varying from a few inches to several feet in thickness, sometimes at the bottom of the sandstone, sometimes at varying levels through the bed. In rare instances there are isolated quartz pebbles scattered through the sandstone, but the more common occurrence is the accumulation of the pebbles in masses with very little, sometimes no intermingled sand.

The false bedding planes in most instances dip 25 to 30 degrees from the horizontal. In general at any one locality these lines of false bedding all dip in the same direction, yet in some instances the false bedding in one layer is dipping directly opposite to that in an adjoining layer. The false bedding is caused by swiftly moving water carrying a heavy load of coarse material, meeting quieter and deeper water, where the load is suddenly dropped. Such a condition is found at the place where a river empties into the sea or lake, in the eddies and pools along a river, and in ocean currents where they sweep over an uneven bottom. Infiltrating waters frequently follow along these lines of false bedding, carrying more or less iron and giving the stone a banded structure.

Texture.—The texture of the Mansfield sandstone through about nine-tenths of the bed is comparatively uniform, but the other one-tenth is quite variable. The mass of the stone consists of a rather coarse but evenly granular quartz sandstone, associated with patches of conglomerate, varying from half an inch to eight or ten feet in thickness, and the pebbles varying from the size of a grain of wheat to those as large as one's head. There is also intercalary shale, shaly stones, fire-clay, coal, and iron ore. The conglomerate pebbles are sometimes of chert from the underlying cherty limestones; in such cases the pebbles are large and sometimes subangular, generally occurring at the base of the sandstone, but not always so. More commonly the pebbles consist of well water-worn quartz and occur either in closely aggregated masses or loosely and

irregularly scattered through the body of the sandstone. The conglomerate is more or less local in its occurrence and while it rarely forms a large part of the bed, over many extensive areas it does not occur at all. It apparently forms much less than 10 per cent., probably not more than five per cent., of the whole formation.

Aside from the conglomerate and shaly patches the sandstone is comparatively uniform in grain and would ordinarily be termed a coarse grained sandstone, yet, according to Orth's classification (see p. 191) it would be termed medium fine-grained sandstone. The following measurements were made in the microscope with a micrometer scale on an average specimen of the stone at each locality by measuring 10 to 20 contiguous grains and taking the average. The largest grain is the largest in the thin section examined, not necessarily the largest in the rock.

Size of grains in the Mansfield sandstone.

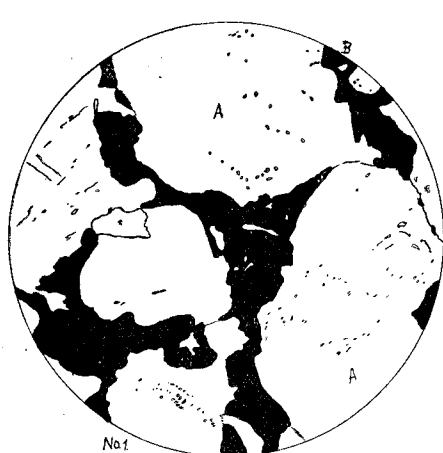
		Millimeters.	Inches.
Mansfield	Average	0.29	0.0114
	Largest	0.65	0.0256
Portland Mills	Average	0.34	0.0134
	Largest	0.60	0.0218
Bloomfield*	Average	0.28	0.011
	Largest	0.45	0.017
St. Anthony*	Average	0.32	0.0126
	Largest	0.48	0.0189
Williamsport	Average	0.19	0.0075
	Largest	0.32	0.0126
Cromwell, Conn. (2)	Average	0.25	0.0098
	Largest	0.60	0.0218

All of the specimens are brownstone but the Williamsport one, which is buff colored.

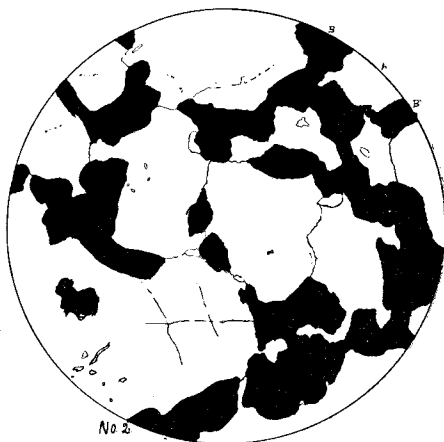
In general the grains are angular, yet in some specimens the larger grains are rounded or subangular. The angularity of the grains has much more to do with the strength of the stone than is commonly supposed, as the angular grains fit more closely together and more closely interlock, and with the same amount of cement will form a stronger stone than a similar stone with round grains, just as a wall of uncoursed rubble is stronger than one of cobble stones. It will be noticed on comparing the different sections on the accompanying figures (plates 11, 12, and 14) that the grains are more rounded in the brownstones than in any of the others, but it will be noticed as well that the brownstones have more cement than the others, except the brown or red stone from near Green Hill, which has less, and which is also one of the most friable stones of the area. Of course much depends upon the character of the cement,

*The Bloomfield and St. Anthony stones are classed provisionally with the Mansfield, but have not yet been proven to be of the same age.

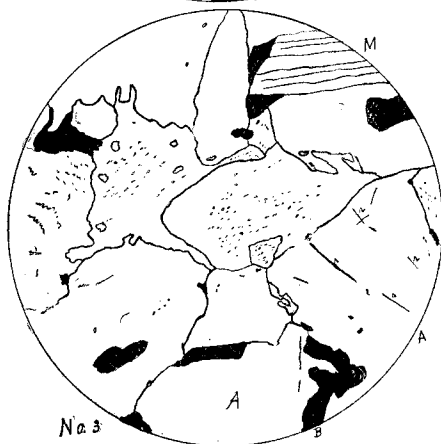
(2) The Connecticut stone is given for comparison.



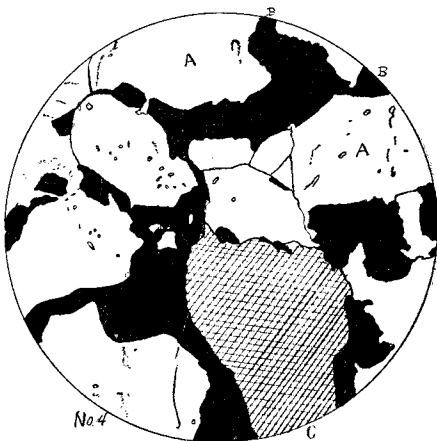
No. 1



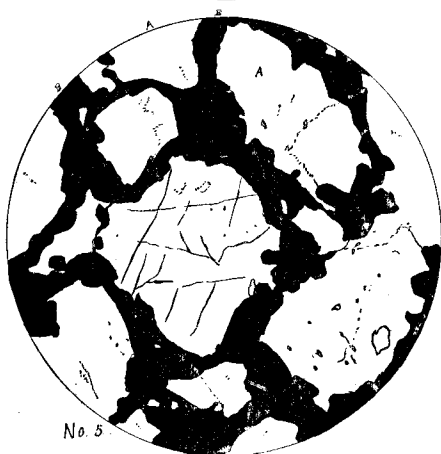
No. 2



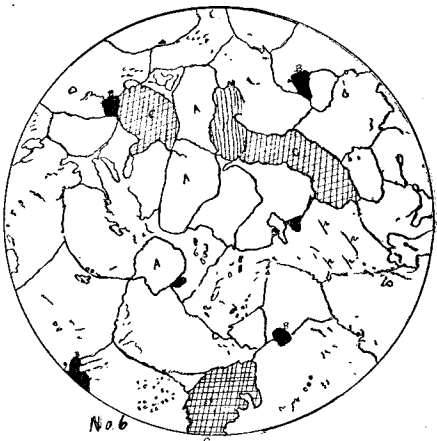
No. 3



No. 4



No. 5



No. 6

(Microdrawings of Indiana Sandstones. Drawn with Camera Lucida. Enlarged 119 Diameters.)

No. 1. MANSFIELD.

No. 2. PORTLAND MILLS.

No. 3. GREENHILL.

No. 4. ST. ANTHONY.

No. 5. BLOOMFIELD.

No. 6. CANNELTON.

A—Quartz.

B—Iron oxide.

C—Quartz aggregate (chert?).

but it can be easily seen that a stone with closely interlocking angular grains like no. 6 on plate 12 will require but little cement to make it comparatively rigid, while abundance of good cement is necessary to give strength to stone like no. 1 on the same plate. It should be noticed, however, that the rounded grains are nearly all more or less etched or notched, thus giving an anchorage to the cement, and where the cement of good quality is present, as it is in the brownstones figured, the stone is sufficiently rigid for most purposes. The reason for rounded grains in some and none in others is due to (1) the greater size of the grains, as grains below a certain size are never rounded, and (2) probably to transportation over greater distance or longer or more violent beach action.

Some of the coarse-grained yellow and gray sandstones, where the cementing material is much less than in the brownstones, are found to be much more friable and porous than either the brownstones or the fine-grained sandstones, which have no more cement but have more angular grains.

In most of the Mansfield stone, but most conspicuous in the darker colored brownstones, are small yellow or light gray specks about the size of the single quartz grains, and to the naked eye looking like a white amorphous powder of some kind. Under the microscope they are found to be composed of finely crystalline cryptocrystalline granular quartz, and are thought to be grains of chert. The reasons for thinking so are (1) the color and general appearance are the same; (2) they appear the same under the microscope; (3) a partial gradation from the chert conglomerate, where the chert character of the pebbles is plainly shown to the naked eye, to the sandstone, where the resemblance is microscopic; (4) there is apparently no other source for the material unless it be deposited by siliceous waters, in which case the spots should not be almost universally isolated, but would be for the most part connected by finer veins of similar material, and would form a cement instead of grains.

Chemical composition of Mansfield sandstone.—The accompanying table shows partial chemical analyses of Mansfield stone from a number of localities, all made by the hydrochloric acid process. No sodium carbonate analysis was made, but in most instances it would show but little difference from that given, as the insoluble part, as shown by microscopic examination, is nearly all quartz. In a few places there are sufficient mica and microlite inclusions in the quartz to reduce the actual silica percentage possibly two or three per cent. below that of the insoluble residue. In some instances, as far as shown by the microscopic examination, the difference would be less than this, so that the insoluble residue percentage is practically very near that of the silica. The water of crystallization and organic matter were not determined; they would in most instances bring the percentage up to 100. There are traces of magnesia and alkali, but in inappreciable quantities. The carbonic acid as given in the table was found by computation, by considering all the lime as carbonate.

Chemical analyses of Mansfield sandstone.

No.	LOCALITY.	Color of Stone.	Color of Insoluble Residue.	Insoluble in H Cl	Alumina Al_2O_3	Iron Oxide Fe_2O_3	Lime Ca O	CO_2	TOTAL.
1	Mansfield.....	Brown.	White.	92.16	.....	6.29	0.05	0.04	98.63
2	Portland Mills.....	"	"	(2) 2.58	19.39	.....	.....	.25	.....
3	Judson.....	"	"	93.21	.51	4.91	.12	.095	98.75
4	Hillsboro.....	"	"	91.65	.56	6.60	.12	.095	98.93
5	Fountain.....	"	"	91.66	.60	6.44	.05	.04	98.72
6	Bloomfield.....	"	"	85.29	.19	11.82	.06	.05	97.43
7	St. Anthony.....	"	"	88.41	.63	8.40	.13	.10	97.57
8	Green Hill.....	Red.	"	98.73	.28	.36	.03	.024	99.40
9	Williamsport.....	Buff.	"	98.57	.05	.65	.02	.016	99.29
10	Fern.....	"	"	(2) .30	1.03	.....	.....	.....	.....
11	Cromwell, Conn.....	Brown.	"	70.84	13.15	2.48	3.09	9.73 Alk	100.00 (4)

(2) Made by Prof. P. S. Baker, DePauw University.

(4) Furnished by the New England Brownstone Co. All the other analyses were made for the survey by H. H. Ballard, at Rose Polytechnic Institute.

It will thus be seen that the stone consists essentially of insoluble material, mostly quartz, and iron oxide, both very durable substances.

Mineralogical composition.—The brownstones consist almost entirely of quartz grains, chert grains, and iron oxides.

The quartz contains microlites of rutile, zircon, and apatite, none of which are abundant, the last one, apatite, being exceedingly rare. The rutile occurs in exceedingly fine, slender needles, that are only visible when highly magnified. Only a small per cent., probably less than 10, of all the quartz grains contains rutile. The zircon occurs in very small irregular, isolated, widely scattered crystals.

In many localities muscovite is present in scattered flakes, but in no place abundant, as it is in some of the overlying Coal Measure sandstone.

No feldspar was observed in any of the brownstone examined, but some of the gray and buff stones, noticeably that at Williamsport, shows the presence of both plagioclase and microcline, the latter in greater quantity, yet neither one sufficiently abundant to have any appreciable effect on the durability of the rock.

The iron oxides forming the cement consist of both the hydrous (limonite) and the anhydrous (hematite) forms. The presence of both oxides is shown by the colors, but the examination was not sufficiently minute to show whether other hydrous oxides, as goethite, turgite, etc., were present with the limonite or not.

Strength of the Mansfield sandstone.—Sandstones, with the exception of the quartzitic ones, are, as a rule, much weaker than the other common building stones, such as granite, syenite, limestone, marble, etc., weaker both in resisting crushing force and in transverse strength. The Mansfield sandstone is probably no exception to the rule as indicated by the result

of the test given below. However, since in our largest structures building stones are rarely if ever loaded to one-sixth or even one-tenth of their ultimate strength, this in itself need not be and is not any drawback to the use of sandstone for building purposes.

There was not a sufficient number of tests made on the strength of this stone to give a fair or reliable average.* The sample from St. Anthony quarry was tested for the survey at the Rose Polytechnic Institute,† and showed a strength of 12,000 pounds for a two-inch cube, equal to 3,000 pounds per square inch. Samples of the Berea, Ohio, sandstone, furnished by the Cleveland Stone Company, tested at the same time, under the same conditions showed a strength of 11,200 pounds and 12,767 pounds respectively. Samples of the Bedford oolitic limestone tested at the same time gave 7,125 pounds per square inch.

The stone is in most places quite soft and friable when first removed from the quarry, but hardens and becomes much stronger when seasoned. No experiments were made to illustrate the difference in strength between the green and the seasoned stone, but there would be quite a marked difference. So soft and friable does the stone appear that many of the citizens refuse to use it in the foundations of their buildings for fear it is not strong enough to support them. This is more commonly the case along the eastern border of the sandstone area where it occurs in the same locality as the compact blue Lower Carboniferous limestone, which in contrast with the softer sandstone makes the latter appear really softer than it is. No instance is recorded of any of it ever crushing under any structure. If the stone is properly quarried and seasoned it will be found on trial to be sufficiently strong to withstand any crushing force to which it might be subjected in any structure;‡ not only that, but it will prove to be stronger after ten years' exposure than at the time it was placed in the wall.

Fire tests.—As with the others, the fire tests are too meager to have any decisive value and are mentioned as only indicative of the possibilities. Samples from the quarry at St. Anthony were tested in the laboratory at Terre Haute with the following results: (1) Cold stone placed in melted lead and allowed to remain until lead would melt on its surface, then placed in the air to cool. Cracks appeared at corners as soon as cooling began. (2) The cold stone in a covered crucible placed in the

*The survey offered to have tests made and publish the results if the quarrymen would furnish the samples and bear the slight expense connected therewith; while others promised to do so only one furnished the samples in time to have the tests made for this report.

†For comparison with other sandstones see tables in the last chapter.

‡In a wall 300 feet high, higher than any that will probably ever be constructed in Indiana, the crushing force from the weight of the wall alone would not exceed 350 pounds per square inch, and the added weight from roof, floors, and contents, would probably never raise this beyond 450 pounds, so that at 3,000 pounds, which will prove to be below the average, the margin is nearly nine to one, and in ordinary uses it will not exceed fifteen or twenty to one.

fire cracked at corner before the lead would melt. (3) The stone heated to temperature of melted lead thrust into water cracked in several places. Similar experiments at the same time on Riverside sandstone and the Berea, Ohio, stone gave practically the same results.

The writer heated to redness a number of small samples from different localities in the flame of a bunsen burner and permitted some to cool in air and some were thrown into cold water. None cracked on heating, about 50 per cent. cracked on cooling and all were more friable and much softer after cooling as though the cement had in a large measure been destroyed.

The tests would, therefore, indicate that the stone, from certain localities at least, would rank very low in its power to resist high temperature. In many places this stone has been used in chimneys and in sugar furnaces by the citizens, and in most instances appears to stand the flames without injury. Experiments elsewhere have shown that as a class sandstones rank below other building stones in this respect.

Absorption tests on Mansfield sandstones.—Absorption tests were made on only two samples, both from St. Anthony. The specimens were weighed, put in water for 25 hours and reweighed; the ratio of absorption was 8.6 and 7 per cent., which, as may be seen by referring to the tables at the end, is above the average. Berea, Ohio, stone, tested at the same time, gave 4.9 and 5 per cent. While there can be little doubt but that the ratio of absorption for the Mansfield stone is high, probably above the average, it may not be so high as that indicated by the figures.

Durability of the Mansfield sandstone.—The Mansfield sandstone is one of the most durable rocks in the State of Indiana, or for that matter in the United States. This statement will be at once disputed by the casual observer or by persons living in limestone regions, but not by a geologist after field examination. The ordinary observer will not believe that the soft crumbling sandstone is more durable than the hard, compact limestone, which in comparison is so difficult to cut and break.

In so far as resistance to crushing is an evidence of durability, as argued by some writers, the Mansfield stone is lacking and would rank among the lowest. However, it is well known to even the most casual observer that this evidence in itself is valueless, as the clay ironstone and the black limestone of this area would have a crushing strength many times that of the Mansfield stone. Yet when exposed under the same conditions, long before the sandstone would be in the least affected, except to become harder, the black limestone would have crumbled to fragments.

Evidence of durability of Mansfield sandstone from composition.—The evidence from the chemical and mineralogical composition of the sandstone is suggestive of a stone of great durability. The quartz grains are practically indestructible, and the ferric oxide under the conditions to

which it would be subject in ordinary structures is one of the most enduring of minerals. In its composition the Mansfield brownstone is superior to the Triassic brownstones, most of which have a high per cent. of alumina.

Dr. Hunt was one of the first to state that, other things being equal, the closer the texture and finer the grain the more durable the rock, and many succeeding writers have overlooked the clause *other things being equal*. Other things are not equal in this case, and in many others, as the Mansfield stone is probably coarser grained and probably as porous as any other rock in the State, yet it is one of the most durable. This is not because of its coarse open texture, but in spite of it.

Condition of the outcrop as an evidence of durability.—To the experienced geologist there is no evidence so satisfactory or convincing in regard to the durability of a rock as a study of its natural outcrops. This, however, like the other evidence, must be taken with intelligence, and is not governed by any fixed rules. In the case of the Mansfield sandstone, the field observations all support the statement in regard to the great durability of the rock, especially as compared with the associated rocks. The characteristic occurrence of the stone is in bold or overhanging cliffs, with frequently many large angular boulders scattered along the base. This is caused by the disintegration and erosion of the underlying rock at a more rapid rate than the sandstone, and when the overhanging cliff projects so far that the weight of the overhanging mass exceeds the cohesive strength of the stone it breaks off and lies in boulders along the base of the bluff then exposed to the weathering agencies on all sides. Yet after centuries of exposure these boulders occur with firm, even surfaces, and sharp angles with scarcely a trace of disintegrated material surrounding them. Some of these dislocated masses are such conspicuous features as to have acquired locally the name of "fallen rock." Such a fall took place on Shawnee creek, near Rob Roy, but two years ago, where several hundred tons of rock broke away from the parent ledge producing a jar equal to a miniature earthquake. Nearly all the exposures of this rock along the watercourses and elsewhere indicate a stone of remarkable durability.

Glacial striæ an evidence of durability.—Another convincing evidence of the durability of the Mansfield sandstone is the good state of preservation of the glacial striæ on its surface in many places. The rock in such instances has withstood the disintegrating forces perfectly since the advance of the glacier many thousands of years ago. In several places these striæ were observed in the watercourses where they have not only withstood the weathering agencies, but for some years at least have withstood the erosive action of the streams. A list of the localities where these markings are well preserved, are given below.

List of localities showing glacial striae on the Mansfield sandstone, with direction of same.—

1. 19 N., 6 W., sec. 8, S. 20° W.
2. 17 N., 6 W., sec. 19, S. 45° W.
3. 17 N., 7 W., sec. 27, S. E. $\frac{1}{2}$, S. 37° E.
4. 17 N., 7 W., sec. 27, S. W. $\frac{1}{2}$, S. 37° E.
5. 16 N., 6 W., sec. 19, S. 25° W.
6. 16 N., 5 W., sec. 32, S. 45° W.
7. 15 N., 5 W., sec. 30, N. W. $\frac{1}{4}$ of S. W. $\frac{1}{2}$, S. 25° W.
8. 15 N., 5 W., sec. 30, N. W. $\frac{1}{4}$ of S. E. $\frac{1}{2}$, S. 25° W.
9. 14 N., 5 W., sec. 8, S. 25° W.
10. 14 N., 6 W., sec. 5, S. 45° E.

Evidence of the durability of the Mansfield stone from old structures.—The commonwealth of Indiana is too young to have any very old buildings from which to study the durability of its building stones, as can be done so profitably with other stone in many continental countries. Yet there are buildings of Mansfield sandstone in Indiana, now in a good state of preservation, that were constructed many years before some of their neighbors built of other stone that are now showing evidence of decay.

The Martindale house, a few miles southeast of Pine Village, Warren county, was built 40 or more years ago.* It is constructed of red sandstone from the quarry south of Greenhill, and quarried by hand, with the liberal use of gunpowder (enough to injure any good stone), yet it appears uninjured by its exposure, not even discolored. The stone at the quarry from which this stone was obtained is more friable than that at almost any other locality in the entire area.

The Barney Brown house, at Rob Roy, Fountain county, is said to have been built 50 or 60 years ago, and is yet uninjured, so far as the stone is concerned, except a slight discoloration. A poor quality of mortar was used, as it has been removed to such an extent as to appear at present as though the stone was laid up without mortar. There was likewise a poor selection of colors, which does not produce a happy effect, but is not wholly the fault of the stone. In both the above houses there is a sad lack of architectural skill, but both are evidence of the capability of the stone to withstand the disintegrating forces. The stone in both houses and in others in different localities, is now much harder than that in the quarry from which it was obtained.

Along the Wabash Railway, in Warren and Fountain counties, built in 1856, Mansfield sandstone was used in some of the bridges and culverts and was found to stand so well that in most of the new culverts constructed during the last few years the Mansfield stone has been used. The stone has been used in many wagon bridges throughout the area and where any

*The exact date could not be ascertained further than it was a number of years before the war.

care has been observed in the selection and the seasoning of the stone it has been entirely satisfactory. It might have been used with equal satisfaction at many other places where limestone has been used at greater expense, because it was thought the sandstone was too soft to stand the weather.

The writer has no hesitancy in recommending the Mansfield sandstone from the standpoint of durability alone, despite its softness, provided (1) that ordinary intelligence is used in its selection, as there is, of course, much poor stone in any formation, and (2) that it is quarried in proper season and without the use of powder or other explosives.

Adaptability of the Mansfield sandstone.—The Mansfield sandstone is adapted to rock masonry of all kinds where it will not be subject to great transverse strain, violent abrasion or require a smoothly finished or delicately carved surface. It is well adapted for use in stone buildings, either wholly or as stone fronts or for water tables, sills, cornices, pillars, etc., but if used for lintels or other purposes where it will be subject to transverse strain extra thickness should be used, or, it should be protected from cross strain by overarchng or other means. It will furnish valuable bridge stone if proper precautions are taken in construction. The ground course, if exposed above low water mark, should be protected by an external coating of cement, and where the piers or abutments are exposed to an extra rapid current or one carrying much suspended matter, it should be protected by riprap or broken stone, as in fact should be done with any stone.

Distribution of the Mansfield sandstone.—As already stated the area over which the stone extends forms a belt of varying width, running in an east-of-south direction from Warren county on the north to the Ohio river in Perry and Crawford counties in the south. The stone outcrops in Warren, Fountain, Montgomery, Parke, Putnam, Clay, Owen, Greene, Monroe (?), Martin, Orange, Crawford, Dubois, and Perry counties. In the first five of these counties and parts of Clay and Owen the outcrop has been mapped in detail and is shown on the accompanying two map sheets. The approximate location of the remainder of the area may be seen on the sketch map at the beginning of this report. No detailed work has been done on any part of this approximate area so far as known, except in Orange and a part of Martin and Dubois counties by E. M. Kindle and shown on the map sheet accompanying his report on the whetstones in this volume, and in Monroe county by Mr. C. E. Siebenthal in a map as yet unpublished.

The brown stone and the buff are not distinguished on the map. The brownstone occurs in considerable thickness at the following localities:*

1. In sections 31 and 32 (23 N., 6 W.), two miles southwest of Greenhill in Warren county, where it is more properly red than brown, and

* For particulars on each of these localities consult the index.

has been quarried for building stone and for bridges; quarry not now in operation.

2. At Fountain (Portland) in Fountain county, where it has been quarried in small quantities along with the gray and buff.

3. At Hillsboro in Fountain county, where it has been quarried to considerable extent and shipped to Chicago and elsewhere.

4. At the Narrows, on Sugar Mill creek a mile and a half southwest of Wallace, Fountain county, where no use has been made of it.

5. On Mr. Milligan's place, near Russell's old mill, in section 15 (17 N., 7 W.), in Parke county, where it has been slightly exploited, but none shipped.

6. About a mile southeast of Guion, Parke county, where a limited quantity was quarried several years ago.

7. About two miles south of Judson, where a quarry has been open on a small scale for two years, but has accomplished very little.

8. At Portland Mills, Parke and Putnam counties, a quarry was opened this year (1895) on a rather large scale and the company plans to take out stone in large quantities.

9. At Mansfield, Parke county, a quarry was in operation for several years and several hundred car loads of stone shipped away.

10. On Mr. Pruitt's place, a mile and a half northeast of Mansfield, the brownstone occurs in limited quantities and has been quarried for local use.

11. On Little Rocky Fork near Fallen Rock, about three miles southeast of Mansfield, brownstone of superior quality is exposed. It occurs over a considerable area, but of commercial value in only a few places; it has never been worked.

12. About two miles east of Bloomfield, Greene county, is a deposit of brownstone of superior quality that has not been worked, but will be important in future time.

13. Near St. Anthony, Dubois county, is a deposit of brownstone not so thick as that farther north, but of good quality and extensively worked.

14. Between Jasper and Knoxville, in Dubois county, is a more or less extensive deposit of brownstone that has not been developed. Other occurrences of similar stone are reported between this exposure and the quarry at St. Anthony.

Brownstone of inferior quality occurs a few miles southeast of French Lick, in Orange county, and at a few other points in Orange and Martin counties, and probably in other localities that were not explored.

It will be observed that the brownstone does not form a continuous bed over the whole area, but occurs in isolated areas variable in size and extent, and surrounded by the gray and buff stone with which it is sometimes interstratified.

The buff and gray sandstone occurs over the entire area designated on the maps, concealed in many places by the glacial drift in the north part of the area and by the accumulated soil in the south part of the area, but outcropping in areas of greater or less extent along nearly all the watercourses.

While it has been quarried for local use in a great many places, it has been worked in large quantities in only two localities—Williamsport and Attica. At Williamsport the quarry was opened many years ago, but the working of it on a large scale is of recent date.

In the vicinity of Attica there are several large quarry openings on both sides of the Wabash river, only two of which are now in active operation, both on the north side of the river in Warren county.

CHAPTER IV.

LOCAL DETAILS OF THE GEOLOGIC FEATURES AND THE DISTRIBUTION OF THE SANDSTONE.

EEL RIVER BASIN.*

Eel river is a tributary of the north prong of White river and with its tributaries drains nearly all of Putnam and Clay counties and parts of Owen and Greene counties. While considerable sandstone occurs in places along the lower course of the stream, only such portion of the valley as lies north of town line 12 N. was examined and is described in this report.

Jordan Creek.—Many terminal ravines of Jordan creek extend into 12 N., 4 W. and 5 W., but they are mostly in a drift-covered area, the sandstone so far as observed outcropping only in the southwest quarter of Sec. 33 (12 N., 4 W.), Owen county. Just south of the township line in a ravine in the northeast quarter of Sec. 5 and the northwest quarter of Sec. 4 (11 N., 4 W.), is an outcrop of massive sandstone, 30 to 35 feet exposed. Some of the stone is light gray, but most of it is yellow, and some variegated yellow and gray. The stone is ferruginous in places with some cross-bedding, but much of it is even-grained, comparatively free from iron and would furnish good building stone, especially bridge and foundation stone for local use. The most promising outcrop for quarrying is in a small secondary ravine from the south in the northeast quarter of Sec. 5 (11 N., 4 W.), where the water has cut

* The term Eel river is sometimes applied to what is locally known as Mill creek and sometimes to Walnut creek. In this report we follow the most common local usage, applying the name to the stream formed by the confluence of Mill creek and Walnut creek, giving the local names to the tributaries above this point.

a narrow gorge 10 to 12 feet wide through the rock in which the sandstone is exposed in a bold cliff 25 to 30 feet high on each side, with little or no covering for several yards back from the face of the cliff, thus being in an admirable position for quarrying at comparatively no expense for stripping.

The sandstone lies unconformably on a compact blue limestone, which outcrops 20 yards north of the sandstone gorge, and up the main branch from the east into the N. W. quarter of Sec. 4 (11 N., 4 W.), in which quarter there is a bright red sandstone, which appears to occur in patches of considerable extent in the yellow and gray sandstone, but not in sufficient quantities to justify quarrying it alone.

Down Jordan creek to the south and west, bluffs of yellow and gray sandstone of considerable extent are reported, but were not examined.

Eel River below Croy's Creek.—While no valuable dimension stone occurs in the Eel river basin between Croy's creek and town line 12 N., sandstone suitable for bridges and foundations outcrops in several places and has been quarried to a small extent at three different points.

A small quantity of inferior sandstone has been quarried on Mr. McIntosh's farm in 12 N., 5 W., Sec. 31, the S. E. quarter of the N. W. quarter.

On Mrs. Nancy Byer's place, in the N. W. quarter of the S. E. quarter of the same section, sandstone has been quarried for local use to a depth of six to eight feet. It has an even cleavage parallel to the bedding, and is comparatively uniform in grain and color, except where small leaf-like patches of dull brown occur in the buff to yellow body. The brown spots are spots of weakness. Stone from this place has been used in the bridge across Eel river in the S. W. quarter of Sec. 29 (12 N., 5 W.), and in smaller bridges and foundations in the neighborhood.

A ledge four to six feet thick of a similar sandstone is exposed east of the wagon road on the east side of the same 40 acres. A larger quarry is reported about half a mile south of the limits of our map, near the middle of Sec. 6 (11 N., 5 W.).

On the west side of Eel river below the Poland bridge, through the N. W. quarter of Sec. 32 (12 N., 5 W.) and the N. E. quarter of Sec. 31 is a cliff of coarse-grained yellow sandstone, 10 to 12 feet thick, containing conglomerate in places. While in some places it has a comparatively even grain and color in most places it is cross-grained and contains many iron blisters. As there is but very little covering and the rock is very durable it might be quarried to advantage for bridge stone at points where the cross-bedding is not too strongly marked.

At the bridge in the N. W. quarter of Sec. 32 (12 N., 5 W.) the sandstone is thin-bedded and associated with black and drab-colored shale. Above (north of) the bridge the shale is replaced in part by sandstone.

On W. B. Ringgo's farm in Sec. 20 (12 N., 5 W.), the south side of the section, about midway between his house and the river, is a small outcrop of sandstone which is superior in quality to any of the sandstone described above but it is limited in quantity. The stone has a medium fine grain and a light gray color dotted with small brown spots. It is overlain by three to six feet of soil and drift, which thickens rapidly back from the face of the quarry, so that only a limited supply of stone could be obtained. Northeast of Mr. Ringgo's house, near the middle of Sec. 20, is an outcrop of massive yellow and gray sandstone that has been quarried for rip-rap along the river bank. It contains too much false bedding for dimension stone.

There is a small outcrop of very pyritiferous sandstone and black shale at Carpenter's mill, in the N. E. quarter Sec. 20 (12 N., 5 W.), which has no economic value but has been dug in several places in search of silver. Pyrite is abundant in many places at this horizon (the base of the Coal Measures), and especially so at this locality where it is associated with shale, sandstone, and a complex conglomerate. The rather uncommon appearance of the rocks, along with the metallic look of the pyrite, has suggested to some the possible occurrence of gold and silver. As a result considerable capital has been spent exploiting for precious metals at this and neighboring localities.

That there is a considerable bed of sandstone in this locality is shown by the well section at Mr. Ringgo's house on the south side of Sec. 20 (12 N., 5 W.), in which, after passing through 11 feet of sand and soil, the drill penetrated 51 feet into white sandstone without going through it. Part of the stone, possibly a large part judging from the surrounding outcrops, is pyritiferous, and the water in the well is so strong with the iron sulphate from the decomposed pyrite as to be unfit for household use.

On the east side of Eel river, between the mouth of Mill creek and town line 12 N., there is very little sandstone exposed, a wide bottom bordered by gentle drift slopes extending most of the way. There is a small outcrop of yellow sandstone and intercalary shale just north of the township line in the S. E. quarter of Sec. 33 (12 N., 5 W.), a little more than half a mile west of the brick church, where the stone has been quarried to some extent for use in foundations in Poland. Another small quarry from which foundation stone has been obtained is on the north side of the road a quarter of a mile west of Poland. In both places the stone is of inferior quality and in limited quantity.

Croy's Creek.—The Mansfield sandstone outcrops in a number of places along Croy's creek, but in no place does it have more than a local value, and in many places is not even suitable for foundations, as it contains much cross bedding, many iron secretions, and in places is shaly and crumbling.

There is an outcrop of thin-bedded white sandstone in the bed of the creek at the bridge near the mouth of the creek in the S. E. quarter of Sec. 17 (12 N. 5 W., Putnam county). A shaft sunk less than a quarter of a mile west of the bridge would indicate a considerable thickness of this stone (25 feet or more).

In a small tributary ravine from the west, just above the bridge, sandstone outcrops in considerable quantities. Near the mouth of the branch, on the south side of the road, sandstone has been quarried for bridges and foundations, and was used in the abutments of the bridge across Croy's creek, mentioned above. The exposure shows from four to six feet of coarse-grained ferruginous sandstone overlain and underlain by shale. The stone contains numerous iron secretions, and is not suitable for superstructures.

About 100 yards west of the old quarry opening is an outcrop of sandstone, drab and black shale, and conglomerate, that has been worked for several years in search of silver. Up the ravine, west of this opening, considerable sandstone is exposed, which is superior in quality to that described above. In one place, about a quarter of a mile above the "silver mine," is an outcrop of four to six feet of sandstone of a light yellowish red, of rather pleasing and durable color. It has a medium fine, even grain and would work easily, but has numerous weather seams on the exposure. The stone could not be obtained in commercial quantities unless the overlying yellow stone could be worked with profit at the same time, and even then the quarrying of it would be attended with some risk, as the color is subject to sudden changes.

Near this patch of red sandstone in the rock in the bottom of the creek is a kettle hole, known locally as the "crucible," 12 to 16 inches in diameter and five or six feet deep, which is formed by the eddying currents. About 100 yards west of the red sandstone the ravine has cut a narrow passage eight to ten feet deep through a bed of massive yellow to buff colored, coarse-grained sandstone, which might be used for bridges and foundations.

Near the middle of Sec. 17 (12 N., 5 W.), on the south side of Croy's creek, on the north-south road, is an outcrop of brown stone similar in color and texture to that at Mansfield, but of a loose, shelly structure. It is doubtful if good stone in commercial quantities could be obtained here, as it would require too much stripping to reach the solid stone. The brown stone is overlain by a pink-colored sandstone and underlain by yellow sandstone and shale.

In the S. W. quarter of Sec. 17 (12 N., 5 W.) on the road northwest of Mrs. McCullough's, is an outcrop of soft, crumbling sandstone, underlain by black shale and coal.

In the S. W. quarter of Sec. 9 (12 N., 5 W.) is an outcrop of 10 to 15 feet of massive yellow, cross-bedded sandstone which is too much

cross-grained to work easily. Small exposures of sandstone along with a fissile black shale occur up this ravine farther north.

At the cross roads in the middle of the west side of Sec. 5 (12 N., 5 W.), and several places on the east side and S. E. quarter of the same section, soft, shelly sandstone is exposed, in some places yellow, in others brown, but all too shelly to have any commercial value. This sandstone belongs to a horizon above that of the Mansfield stone.

No outcrop of sandstone of even local importance was observed on Secs. 7 and 18 (12 N., 5 W.). On Mrs. Farrow's place, S. E. quarter of Sec. 1 (12 N., 6 W.), an outcrop of yellow sandstone that was quarried for local use twenty years or more ago. It is said to have been worked to a depth of eight or ten feet, but only three or four feet are exposed now. The deposit is too thin and the covering too heavy to permit an extensive use of the stone.

A small quarry of nice building stone is located on Mr. Inglehart's place, about a mile southwest of the above, in the N. E. quarter of Sec. 11 (12 N., 6 W.). It is over a low divide from Croy's creek in the Birch Creek valley. The stone is fine-grained, homogeneous, and light gray in color with faint shadowy yellow in places, and works easily to a smooth surface. It occurs in regular layers, ranging from two inches to 24 inches thick. The whole thickness that has been quarried is about four feet. It is overlain by three feet of soil and is said to be underlain by coal. This quarry has been in operation in a small way for thirty years or more. In 1895, 300 perch of stone were removed and sold at \$1 per perch. It is said to withstand fire so well that stone was hauled from here to Knightsville for use in the iron furnace in operation there years ago.

On Mr. Hadden's place in the N. W. quarter of Sec. 36 (13 N., 6 W.), on the north side of the small ravine southeast of the schoolhouse, is an outcrop of gray and yellow banded sandstone 12 to 15 feet thick. It has been quarried to some extent for local use, but the numerous irregular weather seams and the patches of iron oxide will prohibit its use in fine structures.

At the schoolhouse in the northeast corner of Sec. 35 (13 N., 6 W.) is an outcrop of sandstone somewhat similar to that on Mr. Hadden's place, but is more cross-grained and contains more iron oxide.

On the bank of Croy's creek at the section line on the north side of Sec. 35 (13 N., 6 W.) is an outcrop of argillaceous black shale containing clay ironstone concretions.

In the rock-cut on the Vandalia R. R., on the east side of Croy's creek in the N. W. quarter of Sec. 25 and the S. W. quarter of Sec. 24 (13 N., 6 W.), is an outcrop of Mansfield brownstone. The cut is eight to 15 feet deep, the rock extending to near the surface at the middle of

the cut and covered with glacial drift at either end of the cut, the excavation in no place reaching the bottom of the sandstone. The stone varies in color from yellow-brown to red-brown and purplish-brown, much of it being like the Mansfield stone in color and texture, but is of no value for building purposes as it contains iron secretions, is very cross-bedded and shelly.

There is an exposure of the same bed, mostly yellow and yellow-brown in color, thin-bedded to shaly in structure, on the National road on the west side of Croy's creek in the N. W. quarter of Sec. 26 (13 N., 6 W.).

The same bed of sandstone outcrops in a more massive form north of the National road in the N. W. quarter of Sec. 26, N. E. quarter of Sec. 27 and S. W. quarter of Sec. 23. In the S. W. quarter of Sec. 23 on the east side of the ravine east of the road is a small quarry, whose face shows eight to twelve feet of light gray, yellow-stained, shelly sandstone, which contains numerous irregular seams and irregular layers varying from one inch to two feet in thickness. Down the ravine from the quarry the stone becomes more massive and, while being more difficult to quarry, is a stronger and a more durable stone. Coal has been mined in the ravine about a quarter of a mile above (northwest of) the quarry.

There is an outcrop of the Mansfield sandstone in the northwest quarter of Sec. 24 and the S. W. quarter of Sec. 13 (13 N., 6 W.) on each side of Croy's creek and each side of the wagon road. The rock lies at the base of the hill, six to eight feet being exposed. It has been quarried a little on the east side of the creek, but the heavy stripping permitted only a small quantity of stone to be removed. On the west side of the creek the slope is so gentle that there would be little stripping for twenty-five or thirty yards back from the outcrop and some good bridge stone could be obtained here.

Most of the exposures above this on Croy's creek are shale and shaly sandstone rocks of the Coal Measures. Toward the head of the creek in about the N. E. quarter of Sec. 11 is an outcrop of heavy bedded sandstone. In the N. E. quarter of Sec. 14 (13 N., 6 W.) is an outcrop of twelve to fifteen feet of blue-black shale that may prove valuable in the future.

*Mill Creek.**—Mill creek is the large tributary of Eel river from the east, in the south part of Putnam county and the north part of Owen county. It heads in the older Paleozoic rocks east of the area mapped and flows through the Lower Carboniferous sandstone and limestone, the Mansfield sandstone capping the hills on its lower course. Between the mouth of Croy's creek and that of Mill creek the Lower Carboniferous limestone outcrops in several places. On Slate Run, in Sections 15 and 16 (12 N., 5 W.) there is an outcrop of fissile black shale which is exposed in several places and contains some cannel coal. The only outcrop

*Sometimes called Eel river.

of sandstone that might have even local value is on the east side of Sec. 16 on the south side of Slate Run, where there is a ledge fifteen to twenty feet thick, the upper part of which contains stone suitable for bridges or foundations. There is an outcrop of shelly sandstone on the east side of Sec. 10, but it is too shelly and crumbling for use.

On the lower course of Mill creek the base of the hills next to the creek is of compact blue Lower Carboniferous limestone (St. Louis) which is overlain by a bed of massive, yellow, ferruginous sandstone (Mansfield), the tops of the hills being covered with glacial drift. The gentle dip of the rocks to the west causes the limestone to appear higher on the hills in ascending the creek until the Mansfield sandstone finally disappears and the glacial drift rests directly upon the limestone. Still further east beyond the limits of the map the underlying Lower Carboniferous sandstone appears.

On each side of the creek in sections 11, 12, 13, and 14 (12 N., 5 W.) the Mansfield sandstone occurs in an exceptionally heavy, massive bed. In the bluff on the east side of the creek, about 200 yards below Crouse's mill and 150 yards back from the creek, near the middle of Sec. 11 (12 N., 5 W.), the sandstone forms a bold perpendicular bluff 40 to 50 feet high. It is yellow, coarse-grained and massive, with numerous veins and patches of iron, and much of it is cross-grained. In only a few places does it weather evenly, and in no place is the stone sufficiently homogeneous in color and texture to furnish good building stone. The limestone underlying the sandstone east of Crouse's mill contains much coarsely crystalline calcite in cavities or openings in the limestone. This calcite or "tuff" has been searched diligently for "mineral." It has no commercial value outside of the few nice cabinet specimens of calcite that might be obtained.

The largest outcrop of the Mansfield sandstone on the south side of the creek is in the northwest quarter of Sec. 13 (12 N., 5 W.), at what is known as the "Buzzards' Roost." The massive sandstone here forms a semi-circular bluff 50 to 60 feet high on a small tributary of Mill creek from the south. The stone is gray, yellow and yellow-brown in color. While much of it is cross-grained and full of iron secretions, there are considerable areas where it is even-grained and comparatively free from iron and would furnish a good building stone. The good stone lies in irregular patches, and may be located on the face of the bluff by its regular, smooth surface, the cross-bedding and the iron secretions, when present, being shown by a ridged and pitted surface. The sandstone lies unconformably on a drab-colored, lumpy shale containing ironstone nodules. In places between the drab shale and the sandstone is a layer of black, very pyritiferous shale two to four inches thick. The drab shale is underlain by a compact blue limestone, which forms a waterfall

in the ravine a few yards from Mill creek. The massive sandstone outcrops on the south side of Mill creek above and below the Buzzards' Roost, but none was observed that promised great economic value.

On the north side of Mill creek, opposite the Buzzard Roost, in the S. W. quarter of Sec. 12 (12 N., 5 W.), a section of the hill shows:

Section on Mill Creek, near Crouse's Mill.

	Feet.
Glacial drift.....	30 +
Massive yellow sandstone.....	40 to 50
Black shale, with coal	12
Gray and drab shale	10 +
Concealed.....	20
Buff sandstone.....	4
Limestone, compact blue	25

The sandstone contains too much iron and cross-bedding to make a good building stone.

In a ravine from the north in the S. E. quarter of Sec. 12 (12 N., 5 W.), the sandstone occurs in large quantities, in some places of a quality suitable for building stone, one of the best exposures being in a secondary ravine from the east, about one-quarter of a mile north of the creek, where it occurs in a ledge 20 to 25 feet thick, of homogeneous, durable, coarse-grained, buff sandstone, with but very little covering. The loose boulders of sandstone in this ravine, and there are a great many very large ones, have a very hard surface. Excellent bridge and building stone could be obtained in this ravine. In some places the sandstone is underlain by a coarse conglomerate, in other places by a light gray, soft sandy shale; in still others, by a heavy bed of blue-black shale.

In section 7 (12 N., 4 W.), along the small branch known as Brush creek, the massive sandstone outcrops in considerable quantity, and none of it was observed on the north side of the creek east of this. A soft, yellow sandstone is exposed in several places, but the exposures are small and in no place has it any economic value.

At Croy's Mill in section 28 (12 N., 4 W.), in the bottom of the creek, a light gray, nearly white, sandstone occurs in the limestone. This is probably a local deposit, as it was not observed elsewhere at the same horizon, unless perhaps it might be correlated with that at Oakalla.

Along the south side of Mill creek, through 12 N., 4 W., a soft yellow sandstone outcrops in a number of places near the top of the hill and a small quantity of brownstone was observed at one place, the S. W. quarter of Sec. 28 (12 N., 4 W.). None of it observed was of any economic value, except a prominent outcrop of the Mansfield buff sandstone in section 34 (12 N., 4 W.), the west side of the section, close to the section line, and half a mile north of Mt. Pleasant church. A small watercourse has cut

its way down 30 to 35 feet through a bed of massive yellow and buff sandstone, which is all or nearly all regularly bedded; mostly free from cross-grain, varying from fine-grained to coarse-grained, and extensive areas could be quarried with very little stripping. It is a promising opening for fine building stone and good bridge stone. This is the most eastern outcrop of the massive sandstone observed on Mill creek, but the overlying soft yellow sandstone outcrops at intervals for several miles east of Cataract, as far east as the middle of the south side of section 3 (11 N., 3 W.). The falls on Mill creek, or as they are widely known, Eel River Falls, one at the village of Cataract, in section 35 (12 N., 4 W.), and the other down the creek a mile northwest of the town, are both in the Lower Carboniferous (St. Louis) limestone, which forms heavy ledges of compact blue limestone. The hills on either side have a heavy covering of glacial drift, but no sandstone was observed.

Deer Creek.—The Deer Creek valley lies, almost wholly in the Lower Carboniferous limestone, but on the high ground back from the creek, soft yellow micaceous sandstone and shales of the Coal Measures outcrop in a number of places as far east as the Monon Railway, and in one place, (14 N., 4 W., Secs. 28 and 33) east of the railway. This sandstone in places contains thin layers of coal, but no workable beds, nor has the sandstone any commercial value. It is thought to belong to a horizon above that of the Mansfield sandstone. The only outcrop of the typical Mansfield sandstone observed in this valley is in section 2 (12 N., 5 W.) extending west into section 3 and north into section 35 (13 N., 5 W.). In the southeast quarter of section 2, on the west side of the creek, the sandstone outcrops in a ledge 10 or 12 feet thick, massive, coarse-grained, gray and yellow colored. It outcrops along the bluff west into the southeast quarter of section 3, but in no place has any economic value. North from the ford of the creek the sandstone outcrops along the west side of the creek into section 35 (13 N., 5 W.), the best exposure being in the northeast quarter of section 2 (12 N., 5 W.), where the stone has a light gray, nearly white color. The loose boulders, of which there are a great many, have a very hard surface, but the stone appears to be no harder than the average, an inch or more beneath the surface. Good stone for local use in bridges, foundations, or even superstructures, could be obtained at this place.

On the ridge between Deer creek and the Duweese branch, on each side of the National road between Manhattan and Putnamville, sandstone, shale, and coal outcrop in several places. A sandstone quarry was opened, but not worked to any extent, north of the National road about a mile east of Manhattan in section 13 (13 N., 5 W.). The sandstone is for the most part soft and shelly. Coal has been mined north of the road in section 18 (13 N., 4 W.).

On the hill south of Forest Hill Cemetery, at Greencastle, in sections 28 and 33 (14 N., 4 W.), shaly sandstone, shales, and fire-clay with traces of coal are exposed, but have no economic value.

Soft yellow sandstone outcrops on the hills west of the Monon Railway between Putnamville and Cloverdale, but there is none of value.

Limestone has been quarried in several places in the Deer Creek valley. It has been quarried for local use from the bluff underlying the sandstone bed just described above in section 2 (12 N., 5 W.). There are much larger quarries in sections 8 and 17, on the north side of the National road near Putnamville, where an excellent flagstone and good building stone has been quarried for many years. There are other quarries at Greencastle Junction, southwest of Greencastle, and at the town of Greencastle.*

Big Walnut Creek.—There is comparatively little of the Mansfield sandstone along the main Big Walnut creek, and what there is has but little commercial value. Sandstone in large quantities occurs on Snake creek and Little Walnut creek tributaries, and will be described under these headings.

Soft, shaly sandstone and shales of the Coal Measures outcrop in various places on the hills bordering Big Walnut creek between its confluence with Mill creek and its confluence with Little Walnut, in the west part of 13 N., 5 W., and the north part of 12 N., 5 W., but none of any economic value.

Mansfield sandstone of inferior quality outcrops on the west bank of Walnut creek on the east side of section 4 (12 N., 5 W.) west of the wooden bridge. About one mile above the bridge in the southeast quarter of section 33 (13 N., 5 W.) is a small outcrop of compact blue limestone in the creek bed, overlain unconformably by a sandstone shale conglomerate and a very pyritiferous sandstone.

There is a heavier ledge of the sandstone (twelve to fifteen feet) in the northeast quarter of section 32 (13 N., 5 W.) west of the wagon road and more than a quarter of a mile west of the creek. It is underlain by fire-clay and shale. The sandstone contains too much iron ore and false bedding to have any economic value. In the north part of section 32 and the south part of section 29 sandstone outcrops in a number of places, but contains much iron ore and is soft and shelly.

On Johnson's branch in the south part of Sec. 7 (13 N., 5 W.), on the small tributary from the east and above and below it is an outcrop of yellow sandstone and black shale. Small quantities of sandstone suitable for foundations could be obtained here but there is too much overlying drift material to permit the quarrying of large quantities. In the

*The limestone quarries will probably be described in detail in future volumes of the survey reports.

northeast quarter of Sec. 7 (13 N., 5 W.), the false-bedded yellow sandstone in the bottom of the valley next to the watercourse is overlain by a heavy bed of shale 25 to 30 feet thick. Small quantities of thin-bedded sandstone have been quarried for local use from a small outcrop near the head of Johnson's branch, west and southwest of the middle of Sec. 6 (13 N., 5 W.).

A section of the bluff on the south side of Big Walnut creek at Reelsville shows:

Section at Reelsville.

	Feet.
Glacial drift.....	8
Shelly, coarse-grained, yellow sandstone (Mansfield).....	14
Drab sandy shale.....	8
Hard semi-crystalline, reddish, encrinital limestone.....	3
Drab sandy shale.....	12
Shelly limestone and sandy shale.....	2
Black and gray sandy shale.....	2
Compact, blue-gray, fossil limestone.....	10
Black shale (slate).....	10
Compact blue limestone.....	20

The upper sandstone in this section belongs to the Carboniferous, while all the underlying are Lower Carboniferous. The sandstone has no value.

About three-fourths of a mile east of Pleasant Garden, on the south side of the National road, is an outcrop of the Mansfield sandstone in which a quarry was opened, but soon abandoned. The stone is exposed in the bluff 10 or 12 feet thick with but little overlying material and underlain by compact blue limestone. It is quite variegated in color, at the east end of the bluff the gray body containing many yellow and yellow-brown spots and stripes, while towards the west end of the bluff the spots are red and red-brown. There are many irregular seams, some of which may be due to the powder used in blasting it, but most of which are probably due to the action of the weather. The stone might be used for small bridges and foundations but is unfit for superstructures. A somewhat similar stone outcrops on the creek bluff south of the Vandalia Railroad in the northeast quarter of Sec. 22 (13 N., 5 W.), where the exposure is larger but with no improvement in the quality.

The town of Reelsville is located for the most part on the rocks of the Coal Measures. The Lower Carboniferous limestone outcrops at the base of the hill, 25 to 30 feet above the creek. The Vandalia Railroad west of the depot has cut into this limestone several feet. Overlying the limestone is an outcrop of soft sandstone and shale, the shale predominating, and in one place the shale is richly impregnated with iron ore. It is possible that a shale suitable for making paving brick could be obtained here.

A soft, yellow sandstone with intercalary shale outcrops in several places along the branch from the northwest just above Reelsville in sections 16, 8, and 9 (13 N., 5 W.), but so far as observed it has no economic value. The Lower Carboniferous limestone, overlain by a green shale, outcrops along the branch and base of the hill for more than a mile from its mouth.

Between Reelsville and Snake creek, along the west side of Big Walnut, the Mansfield sandstone outcrops in a number of places through sections 22, 15, 10, and 3 (13 N., 5 W.), but it contains iron secretions and much false bedding, which renders it unsuitable for building purposes, unless it be for foundations. It occurs in a massive bed ten to twenty feet thick along the creek bluff, in some places underlain by black shale containing thin layers of coal.

Along the east side of Big Walnut creek, opposite the bluff described above, is a wide bottom bordered by gentle slopes, on which are a few exposures of Lower Carboniferous limestone. The only sandstone on the east side is a thin bed of shaly sandstone and shale on the hill northeast of Hamrick station, more than a mile east of the creek, but it is too shelly to have any value. There are extensive limestone quarries at Oakalla, in the south part of Sec. 26 (14 N., 5 W.) and at Greencastle, which have been in operation for many years. In one of the quarries at Oakalla the compact blue limestone is overlain conformably by three to four feet of thin bedded light gray, nearly white, calcareous sandstone, which appears to be a local occurrence, as it was not found elsewhere in the vicinity. It may correspond stratigraphically with that occurring at Croy's mill, mentioned elsewhere.

Snake Creek, tributary of Big Walnut Creek.—Snake creek, a small tributary of Walnut creek from the west in the south part of 14 N., 5 W., cuts through considerable sandstone, the Mansfield stone being along the lower course and the overlying Coal Measures about the head waters. The sandstone lies unconformably on the limestone, as shown by the large limestone outcrop at and north and east of Fern station, and another outcrop in the east side of Sec. 32 (14 N., 5 W.), while along the south side of the creek the sandstone outcrops in large quantities, in some places down at least to the creek bed and below it.

The largest outcrop of sandstone on Snake creek is at the Fern picnic grounds on the east side of section 33 (14 N., 5 W.), where the best stone for building purposes is in the southeast quarter, section 33 (14 N., 5 W.), in a ravine from the south, about a quarter of a mile below (southeast of) the picnic ground. The sandstone outcrops in a bold bluff 60 feet high (Bar.). The color varies from light gray to yellow. It has a coarse, even grain and weathers evenly, the surface being marred only by a few weather seams. There is at this point a fine bed of building stone, adapted to bridges, foundations or superstructures. As some of

the stone is variegated in color, building stone could be profitably quarried only by having a market for the variegated stone, which is suitable for bridge work or foundations. The stone is quite soft and easily worked, but hardens on exposure. It has not been quarried, not even for local use, as it is thought to be too soft. The occurrence of these bold bluffs is proof of its durability, and the examination of the exposed surface shows that it hardens sufficiently for practical purposes. Where the color of this stone is suitable for the work in hand it can be used with perfect safety so far as strength and durability are concerned, providing the stone is quarried without heavy blasting and not too late in the season, so that it can dry out before the freezing weather.

The bluffs at the picnic ground are higher than the one described above, in one place measuring 85 feet, but the stone is more variegated in color, contains some iron secretions, and is cross-grained in places. With care in selecting, good bridge stone could be obtained from these bluffs, and a closer examination might show some sufficiently uniform in color for good dimension stone.

There is an extensive outcrop of yellow Mansfield sandstone on a small tributary of Snake creek from the south, south of Fern Station, east and southeast of the picnic grounds. A small branch of this tributary, which heads at Mr. Roger's house, in the northwest quarter of section 4 (13 N., 5 W.), and flows east through his farm, has an almost continuous bluff of yellow sandstone 10 to 25 feet high along the south side. In most places the sandstone extends to the bottom of the valley, but in a few places there is an outcrop of blue-gray and black shale underneath the sandstone. The stone resembles that described at Fern Cliffs in being yellow colored and quite soft when green, but hardening on exposure. It lies in good position for quarrying, forming low bluffs along the water-course, and having very little covering, in some places none. Near the middle of the west half of section 4 (13 N., 5 W.) two wells dug 50 to 75 yards back from the face of the bluff went through 8 feet of drift material and penetrated 30 feet into the sandstone. In a few places the rock shows cross bedding, but most of it is evenly bedded, fairly homogeneous in color and texture, and would furnish good building stone. No stone outcrops on the north side of this branch, the slopes there being covered with glacial drift.

Up Snake creek, about two hundred yards west of the cliffs, is an outcrop of three to four feet of black fissile shale or slate which is highly carbonaceous and contains much pyrite. It splits easily into sheets two or three feet across, but it is too pyritiferous to stand exposure to the weather. It is underlain by a crumbling, lumpy shale and overlain by shelly sandstone.

Sandstone is exposed at intervals to the head of Snake creek and on most of the small tributaries from the north. It outcrops in a massive ledge

on Mr. John's place on the south side of Sec. 21 (14 N., 5 W.), where it is underlain by fire-clay and shale, and on Mr. Goodman's place in the S. E. quarter of Sec. 29 (14 N., 5 W.), and in several other places along the ridge north of Snake creek. The only stone of any economic value west of the cliffs is that in a small ravine from the north, just north of the I. & St. L. Railway, in the northeast quarter Sec. 31 (14 N., 5 W.), where the stone is evenly bedded, light gray to buff in color, and is exposed 12 to 15 feet, the bottom being concealed. Some stone has been quarried here for use on the railroad and much more could be obtained. The sandstone exposed along Snake creek through Sec. 32 (14 N., 5 W.) contains much iron pyrites, false bedding and patches of shale, so that it has no economic value.

Little Walnut Creek.—Little Walnut creek has cut a channel in the Lower Carboniferous limestone close to the eastern border of the sandstone of the Coal Measures. The Lower Carboniferous limestone is exposed along the bottom of the valley and base of the bluffs; the sandstones and shales of the Coal Measures form the upper part of the hills, occurring in large quantities on the west side of the basin and in small quantities on the east side.

The largest exposures of sandstone in the Little Walnut Creek basin are those along Long Branch in the west and northwest part of 14 N., 5 W. On the hill west of the mouth of Long Branch, in Sec. 27 (14 N., 5 W.), the northeast quarter, and Sec. 22, the southeast quarter, on Mr. Stoner's place, the sandstone outcrops in a massive ledge 60 to 75 feet thick, 90 to 100 feet above the creek. The following is a section of the hill at Mr. Stoner's:

Section at Mr. Stoner's, on Little Walnut Creek.

	Feet.
Glacial drift	30+
Massive sandstone (Mansfield)	70
Black and blue shale.....	15
Compact blue limestone (Lower Carboniferous)	65+
Total	180

There are two abrupt overhanging cliffs of the sandstone 50 to 60 feet high, one in Sec. 27 and one in Sec. 22, each being horseshoe shaped and in a small ravine. Between the cliffs the stone outcrops in a few places but the slope is mostly covered with gravel. In the bluff in Sec. 27, the more southerly one, there is more stone exposed, the bluff being 10 or 12 feet higher, but the quality of the stone is inferior to that in the other bluff, having numerous iron secretions and weathering unevenly. In the more northerly cliff the stone is comparatively free from iron, except about eight or ten feet at the base which is pyritiferous. It is fine-grained homogeneous in texture and presents a smooth, clean surface on

the weathered exposure. The stone is buff to cream-colored in the upper part of the bluff, grading to a light gray near the base, the light gray having faint patches of dull yellow, that would possibly become more numerous on exposure. It is difficult to estimate the proportion of light gray, but at the face of the cliff it probably forms not less than one-fourth of the whole. It is quite probable that back from the face of the cliff in the interior of the bed the greater part of the stone is of a light gray color, the buff color being due largely to greater oxidation of the iron in the stone. It contains a considerable per cent. of the amorphous-looking chert grains.

As there is probably a thickness of 35 or 40 feet of excellent light gray and buff sandstone at this point with very little loose material on top of it, an almost inexhaustible amount of good building material could be quarried at a moderate expense. The stone in the interior is soft, by many it will be thought too soft for building stone, but it should be noticed that the exposed portions of the upper part of the bluff and the loose boulders on the hillside south of the bluff are extremely hard. It is the shaded portion under the overhanging bluff that is soft. The softness is not due wholly to its being shaded but to the fact of its being saturated with water.

Sandstone of inferior quality outcrops in a number of places west of Mr. Stoner's farm on the hill south of Long Branch. On the north side of the branch the hills are mostly covered with drift, very little rock being exposed. North of Brunerstown in the northwest quarter of Sec. 17, the southwest quarter of Sec. 8 and the east side of Sec. 7 (14 N., 5 W.), the sandstone outcrops on both sides of Long Branch, forming bold cliffs close to the creek, and extending beneath the bottom of the valley, the Lower Carboniferous limestone being below the drainage level. Much of the stone along this part of the branch contains too much segregated iron for good building stone. Good bridge and foundation stone could be obtained in a number of places by careful selection. The best stone observed in this region is a little more than a quarter of a mile southeast of Mr. Wiley's house in the northeast quarter of Sec. 7 (14 N., 5 W.), where the bluff is 30 to 40 feet high, composed of buff and light gray sandstone containing a few small specks of iron pyrites, and mica flakes and numerous chert grains. The sandstone is exposed in several places north, northeast and northwest of Brunerstown, but none of any value was observed. Along the small tributary of Long Branch from the west in the northeast quarter of Sec. 18 (14 N., 5 W.) the sandstone exposed is 20 to 25 feet thick and darker in color than at any other place along Long Branch.

On Leatherman branch in sections 4 and 5¹ (14 N., 5 W.) a heavy sandstone ledge occurs somewhat similar to that described on Long Branch. In the northeast quarter of Sec. 5 it is exposed 15 to 35 feet,

and is of a dark yellow to yellow-brown color. It is remarkably free from iron or conglomerate, the weathered face showing lines of weakness parallel with the bedding, due probably to shaly or argillaceous material. For more than a half mile southeast from this point the branch cuts its way through this bed of sandstone, which forms bold cliffs on either side.

On the other or north prong of Leatherman's branch is an outcrop of sandstone similar to that described above. In several places along this prong the Lower Carboniferous limestone is exposed. The best sandstone observed is that near the upper limit of the outcrop in the northwest quarter of Sec. 4 (14 N., 5 W.) near the township line. The bluff is 40 to 50 feet high, 10 to 12 feet at the base being concealed. The stone is mostly buff-colored, but variegated gray and brown at the base. Small streaks of iron conglomerate occur in places. Good stone for local use could be obtained here.

In Sec. 10 (14 N., 5 W.), just west of the confluence of Leatherman and Little Walnut creek, is a ledge of massive Mansfield sandstone 10 to 15 feet thick, underlain by compact blue limestone exposed 15 to 20 feet above the creek. In the northwest quarter of Sec. 10 on a small tributary of Leatherman's branch from the west is an outcrop of fine-grained gray-colored sandstone which has had considerable local use for whetstones and grindstones.

On Mr. Wright's place on the east side of Little Walnut creek, in the southeast quarter of Sec. 11 (14 N., 5 W.) is an outcrop of bituminous coal which varies from thirteen to twenty-six inches in thickness and which has been mined for local use. The coal is underlain by fire-clay and in turn by massive yellow sandstone which outcrops in massive ledges in the ravine below the road and in other ravines east and west of the coal. Less than a quarter of a mile south of the coal mine a small chalybeate spring emerges from the base of the massive sandstone which here contains thin patches of shale. In the valley south of the spring, in sections 13 and 14 (14 N., 5 W.) the Lower Carboniferous limestone which outcrops in large quantities contains much nodular chert, and both the chert and limestone contain fossils.

Sandstone outcrops further north in the Little Walnut Creek valley at the following places: Sec. 2 (14 N., 5 W.) the S. E. quarter; in Sec. 35 (15 N., 5 W.) the N. W. quarter; and Sec. 34 the N. E. quarter; Sec. 27 the N. W. quarter; Sec. 22 the S. W. quarter; Sec. 28 the N. W. quarter; and Sec. 20 the S. E. quarter and N. E. quarter. The largest outcrops are in the southeast quarter of Sec. 20 and the northwest quarter of Sec. 28, where the stone occurs in a massive bed twenty-five feet thick, but as in the other exposures mentioned, it is too variegated in color and contains too much iron pyrites for building stone.

The Lower Carboniferous limestone outcrops in many places in the vicinity of the above sandstone exposures. It has been quarried at Clinton Falls in the north part of Sec. 28 (15 N., 5 W.) at Mr. Holland's,

in the south part of Sec. 22 (15 N., 5 W.) and in the southwest quarter of Sec. 13 (15 N., 5 W.) Good building stone occurs at the last two places, and stone good for burning into lime may be obtained at almost any of the numerous exposures in this valley.

Big Walnut Creek above its confluence with Little Walnut Creek.—In the northeast part of Putnam county, east of Bainbridge and Carpentersville, sandstone similar to that at Riverside, Fountain county, has been quarried in several places. It appears to correspond in position to the formation called the Knobstone in the former State reports, but is referred to elsewhere in this paper as the Riverside sandstone.

It is a fine-grained homogeneous sandstone, blue on the interior of the bed, but drab to buff on weathered exposures. In places it contains considerable pyrite which forms a white efflorescence on the weathered surface. At a depth not affected by the weather, the stone is probably massive in most places; that it is in some places is shown by its occurring so in the abrupt cliffs along the creeks where it has not been so long exposed to the elements. On the weathered exposures, incipient bedding planes develop at more or less frequent intervals, which are in general horizontal and parallel with each other, thus greatly facilitating the quarrying of the stone where they are not numerous enough to injure it. The contact between the interior blue color and the exterior buff is shown in some places by a sharp line.

It has been quarried to considerable extent in two places and in smaller quantities at other points along Big Walnut creek in the northern part of Putnam county (not shown on the accompanying map sheet). One of the quarries, now owned by Mr. Miller, is in the south part of Sec. 29, (16 N., 3 W.), on the east side of the creek, on the south side of the wagon road from Carpentersville to New Maysville. The rock outcrops on a bold cliff on the bank of the creek, a section showing:

Section on Big Walnut Creek east of Carpentersville.

	Feet.
Soil.....	2
Sandy shale	10
Sandstone, face of quarry	25
Sandstone to bottom of creek	35
Total	72

The upper part of the quarry face shows thin-bedded stone (2 to 6 inches) merging into the overlying shale. The lower part of the quarry is in layers six inches to three feet thick. The bluff beneath the quarry is heavy bedded, two to four feet, and contains scattered pyrite nodules. The stone has had a local use for many years; possibly 5,000 cu. ft. in all have been quarried. Its principal use has been for bridge abutments and foundations the abutments of the bridge across Walnut creek at

this point being built of this stone. The bridge is said to have been constructed 15 years ago, and the stone shows no evidence of decay at the present time.

The other quarry referred to is Mr. W. H. Rice's on the west side of Sec. 8 (15 N., 3 W.), on the east side of the creek, on the north side of the Bainbridge-New Maysville wagon road. A detailed section of the quarry face shows:

Section at Mr. Rice's Quarry.

Shaly sandstone and shale.....	8 feet.
One layer buff sandstone.....	1 foot.
One layer buff sandstone.....	10 in.
One layer buff sandstone.....	9 in.
One layer buff sandstone.....	8 in.
One layer blue sandstone.....	2 feet.
One layer blue sandstone.....	10 in.
One layer blue sandstone.....	2 feet 6 in.
One layer blue sandstone.....	3 feet.
One layer blue sandstone.....	3 feet.
Total.....	22 feet 7 in.

The stone resembles that at the Miller quarry described above. The bedding planes will probably be less numerous in the interior, the beds becoming thicker but retaining an easy horizontal cleavage. None of the pyrite nodules were observed here, but there is much finely diffused pyrite, and in places small leaf-shaped soft patches which would injure the stone for fine work where they occur. There is not as much stone available at this point as at the Miller quarry, since the slope above the quarry is much steeper and the stripping would soon become too expensive. However, the supply would probably never be exhausted by the local demand. The quarry is said to have been opened two years ago and the stone used mostly in bridge abutments.

There are doubtless many exposures of this stone along Walnut creek that might be quarried to advantage, but no others were examined.

RACCOON CREEK BASIN.

The Raccoon Creek valley, which lies near the middle of the Brazil Sheet, contains a great quantity and many varieties of sandstone. The headwaters of both Big Raccoon and Little Raccoon creeks lie in the Lower Carboniferous limestones and sandstones east of the limits of the accompanying map, and both creeks cut a channel of considerable length through the Mansfield sandstone and then into the overlying Coal Measures, through which both flow for some miles above their confluence, as well as the main stream from the confluence to the Wabash river. Both

creeks have a general southwesterly course to near their confluence, where the main stream takes a sudden turn to the northwest.*

Sandstone in the greatest quantity and of the best quality occurs along that part of its course where it cuts through the Mansfield sandstone at the base of the Coal Measures. However, good building stone occurs in the lower course, in the overlying sandstone of the Coal Measures, and stone less valuable in the Lower Carboniferous rocks. Sandstone has been quarried in each of these formations in the Coal Measures at Coxville and on Stranger's Branch (14 N., 7 W.), in the Mansfield stone at Mansfield, Judson, Portland Mills and intervening points; in the Lower Carboniferous (Riverside) at Raccoon station.

Both the brownstone and the gray and buff varieties occur on both Little Raccoon and Big Raccoon creeks and on Rocky Fork, southeast of Mansfield. The most valuable stone occurs near Fallen Rock, on Little Rocky Fork, near Mansfield and Portland Mills, on Big Raccoon creek, and near Judson, on Little Raccoon creek.

The lowest exposure examined in the Raccoon Creek valley is that on the east side of the creek at Coxville, on the C. & I. C. Ry., in section 15 (14 N., 8 W.). Stone is said to occur at Mecca and other points north of Coxville, but was not examined.

The quarry at Coxville, known as the Evans quarry, has been operated more or less spasmodically for a number of years by William Evans. No figures in regard to the production could be obtained.

The stone is a coarse-grained buff sandstone, slightly variegated in places, occurring in a massive irregular deposit, having a maximum thickness of outcrop of about fifty feet. However, at few points is there a thickness of fifty feet of massive sandstone, in most places a considerable thickness of shelly sandstone, black shale and coal occurring with the sandstone. Coal has been mined near the base of the bluff at each side of the quarry.

A fair quality of bridge and building stone could be obtained here in large quantities. It would be necessary to handle considerable inferior rock to get it, and it is doubtful if the quarry could be operated profitably on a large scale unless some use could be made of the rough stone.

In the former State reports this rock is classed as conglomerate (corresponding to the Mansfield stone), but no evidence is given in support of the statement. The hasty field examination does not support such a view, yet the evidence was not sufficient to state positively that such might not be the case. It seems more probable that it is of more recent age and belongs in the Productive Coal Measures. If it were Mansfield stone the Coal Measures should rest unconformably upon or against it, which does not appear to be the case, as the sandstone spreads out over

* It is possible that at one time in its history this stream had a direct course southwest to the Wabash river instead of the big northwest bend it now has.

the coal on either side. This coal might be the so-called sub-conglomerate coal, but there is no positive evidence that such is the case.

There is a small outcrop of sandstone on the south side of the creek at and below the gristmill at Bridgeton, section 22 (14 N., 7 W.). It is variegated yellow and yellow-brown in color, very shelly and accompanied by considerable shale. It has no economic value and is apparently of the age of the Productive Coal Measures.

On Mr. Mitchell's farm, on the north side of the creek, a quarter of a mile north of the bridge at Bridgeton, is a sandstone quarry from which stone for local use has been obtained. It is a micaceous yellow and gray variegated shaly sandstone, twelve to fifteen feet thick; a few layers, two feet or more in thickness, might furnish a fair quality of stone, but most of it is too thin-bedded and shaly to have much value.

Sandstone is exposed in a number of places along Stranger's Branch northeast of Bridgeton in sections 1, 2, and 11 (14 N., 7 W.) and section 36 (15 N., 7 W.), but all of inferior quality for building stone; much of it is suitable for well curbing, foundations, or small bridges.

Mansfield.—Although not in operation at the present time, the quarry at Mansfield, 14 N., 6 W., section 5, has produced more brownstone than any other one quarry in the State. The quarry is situated on the north side of Raccoon creek a quarter of a mile north of east from the village of Mansfield on the south side of section 5 (14 N., 6 W.), on property formerly belonging to Mr. Smith.*

The quarry was first worked by M. W. Wolf, of Chicago, in 1887. Mr. Wolf operated the quarry until 1891, four years, when he sold out to the Parke County Brownstone Company, who continued the business until 1894, when it passed into a receiver's hands and work in the quarry ceased.

The company employed about forty men, about twenty being in the quarry, had two steam channeling machines, two steam-power and one horse-power derricks, and a steam saw gang. A branch railroad was built to Brazil, and stone was shipped to Evansville, Terre Haute, Fort Wayne and Indianapolis, Ind.; Owensburg, Ky.; Paynesville, O.; Chicago and Roseville, Ill.; Wymar, Neb., and for bridge stone on the C. & E. I. R. R.

The dressed stone was sold at 65c. to \$1.25 per cubic foot and the rough stone at \$2.50 to \$4 per cubic yard. During the busy season the company shipped at the rate of one car-load per day.

Plate XIII shows the Mansfield brownstone quarry about the time it was first opened and plate XIV a view of it shortly before it closed. It may be noticed that the numerous weather seams of the surface in the first view have disappeared in the interior of the bed in the second view,

*The information in regard to the owner's shipments, etc., of the stone was obtained from Mr. Smith.



MANSFIELD BROWNSTONE QUARRY, MANSFIELD, INDIANA, WHEN FIRST OPENED.

where the stone is massive. The weather-seamed surface of the outcrop, while denoting lack of perfect homogeneity in the rock, does not signify lack of durability as much as it might under other conditions. It is noticeable that in many places throughout the State, where the hillsides facing north have a bold outcrop of rock, the one facing south on the opposite side of the valley has either no rock exposed, being covered deeply with soil, or else a very much weathered, crumbling exposure. This quarry is on the south slope.

The total thickness of the stone exposed at the quarry is thirty to thirty-five feet, but the bottom is not exposed and the total thickness is not shown. About 200 yards east of the quarry opening, an opening made with a core drill showed thirty-three feet* of brownstone, underlain by fifty feet of lighter yellow colored sandstone. Not all of the stone exposed on the present quarry face is good building stone; in fact there is more worthless stone exposed than there is good stone.

The most injurious constituent of the rock is the large number of iron "kidneys" or "blisters" scattered through it. These are hollow shells and lumps of iron oxide, varying from a half inch to two or three inches in diameter, which are quite abundant in certain parts of the bed. These blisters are due in many cases to the pebbles originally in the rock, which have been changed to iron oxide by replacement by the infiltrating waters. They are not simply a surface phenomenon, but are just as liable to occur far in the interior of the bed. The patches of shale and shaly sandstone injure much of the stone, necessitating the handling of so much waste material. These are most abundant at the west end of the quarry, disappearing entirely on the bluff east. The iron blisters continue along the face of the bluff for 150 to 200 feet east of the quarry and less frequently further east. From the large amount of waste material to be handled it is doubtful if any more stone could be raised with profit from the present quarry opening. A more promising opening, so far as can be determined from the surface, is on the bluff some 200 yards north of east of the present opening, near where the core was taken out by the diamond drill. The stone at this point is not wholly free from the iron oxide, but more nearly so than at points further west. The top of the bluff at this point has been planed off by the glacier (striae S. 45° E.), being ten to twelve feet lower than it is seventy-five yards further east. Eastward the stone changes into a yellow and yellow-gray color, with segregated veins and patches of the iron oxide. At the middle and west end of the quarry there is a layer of chert conglomerate ("peanut rock") overlying the sandstone. It is made up of subangular pieces of chert from the underlying limestone, imbedded in the sand and iron oxide, and attains a thickness of four or five feet in places.

* According to the statement made by Mr. Smith.

Several different shades of brownstone occur at this quarry, but the mass of the stone is a rather dark purplish red-brown, which gives a brighter red-brown powder when crushed. The color is due to the abundance of hematite in the stone. It contains numerous small light gray specks uniformly distributed, which can only be seen on close inspection and have no other effect than to give the body of the stone a lighter shade than it would otherwise have.

There are other shades due to the mixture of the more hydrous oxides of iron; these occur in comparatively small quantities and it is only by quarrying the stone in large quantities and selecting the colors that they can be used to advantage for building stone.

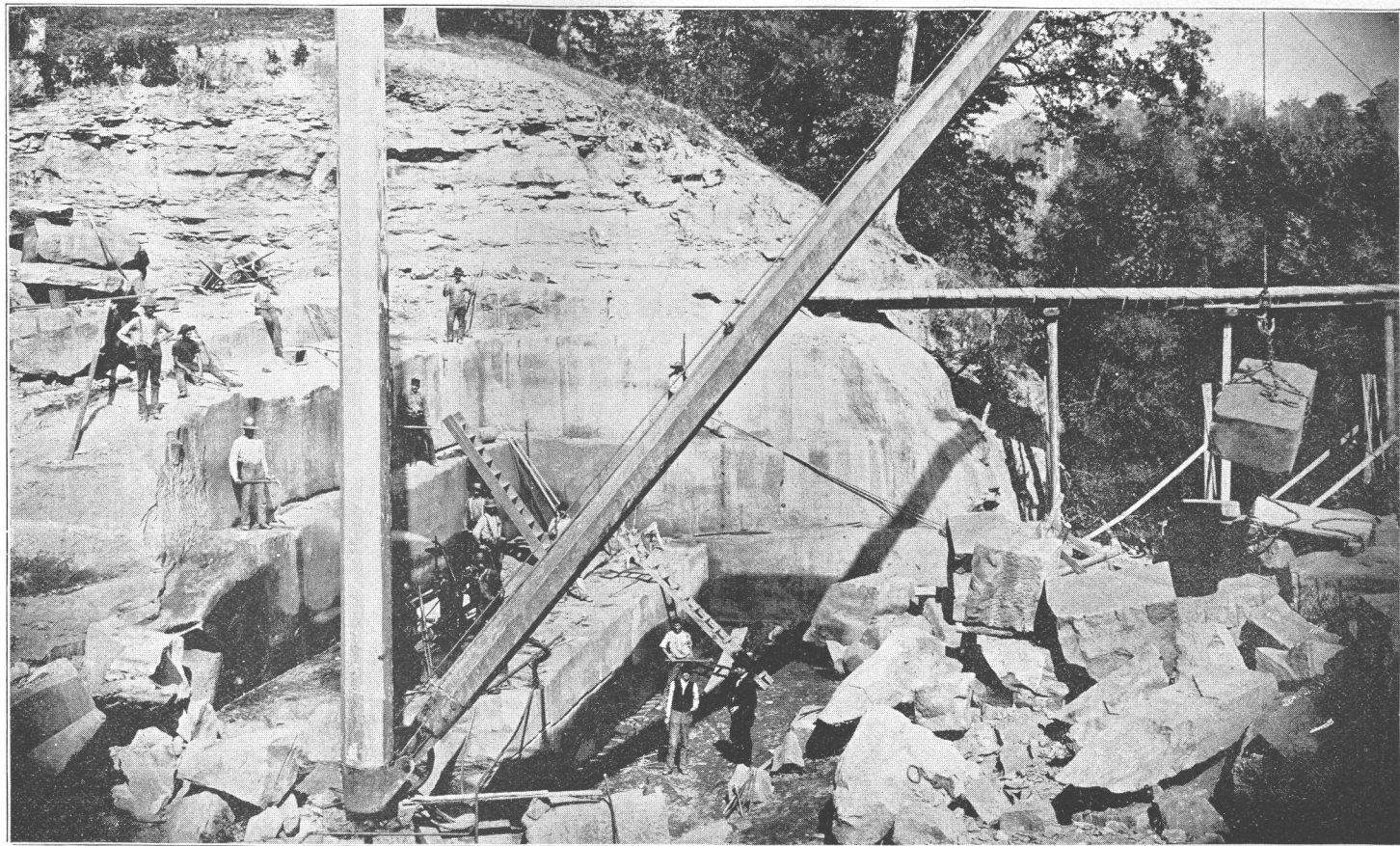
In places the stone is strikingly banded gray and dark brown, the bands about half an inch to an inch in width and inclined about 30° to the horizontal. These bands mark the lines of cross-bedding along which the iron-bearing waters have penetrated, depositing more iron in some bands than in others.

For chemical analysis, microscopic character, etc., of the Mansfield sandstone see Chapter III and plates XI and XII.

In the narrow ridge above, (southeast of) the quarry in the southeast quarter of Sec. 5 (14 N., 6 W.) buff sandstone outcrops in a number of places, but it contains too much iron and has too heavy a covering of loose material to be of value; no brownstone was observed. On the north side of this ridge on the north side of Sec. 5 (14 N., 6 W.) the buff and gray sandstone forms a precipitous bluff in several places, but is highly ferruginous in all the outcrops.

In the bluff on the south side of Raccoon creek, east of Mansfield, in the northwest quarter of Sec. 8 (14 N., 6 W.) massive sandstone is exposed and has been quarried at intervals for a distance of 200 yards along the bluff. At the south end of the bluff the stone has a red-brown color much like that in the quarry north of the creek, but there are patches of a brighter red color than any of that on the north side of the creek. At the north end of the bluff the stone is light gray to buff, and is overlain by a thin layer of the chert conglomerate similar to that across the creek, but there are very few pebbles or iron blisters in the body of the rock. In fact the stone is more uniform and freer from impurities in this bluff than in the larger quarry north of the creek, but it is unfortunately overlain by a heavy bed of drift material twenty-five to thirty feet thick.

The stone quarried from this bluff has been for local use. The stone in the bridge across Raccoon creek, at Mansfield, is said to have been taken from this place. This bridge was built in 1868-9, and the stone work is yet sound, except the bottom course in the middle pier, which is much decayed.



MANSFIELD BROWNSTONE QUARRY, MANSFIELD, INDIANA, AFTER BEING IN OPERATION A YEAR OR MORE.

W. H. Pruitt's Quarry.—On W. H. Pruitt's farm on the east side of Raccoon creek, in the N. E. quarter of Sec. 5 (14 N., 6 W.), and the N. W. quarter of Sec. 4, is a rounded hill with buff, gray and brown sandstone outcropping on the southwest and north sides. A small quantity of the stone has been quarried on the northwest side of the hill. The quarry has been opened in the brownstone, which, like that at Mansfield, consists of different shades. The prevailing color is a purplish brown with a steel gray lustre, but the general color of the stone is lighter than the Mansfield stone. There is a thickness of about ten feet of the brownstone exposed at the quarry, underlain by buff sandstone and overlain by drift material, which slopes up rapidly to a height of 25 feet or more above the sandstone exposure. How thick the brownstone may be under this drift can not be determined from the surface. No iron secretions, which proved such a serious drawback to the Mansfield stone, were observed at this place; there is a little cross-bedding. The color and texture of the stone are good, and some good stone has been taken out. Whether it can be profitably obtained in quantity depends upon the character and thickness of the brownstone under the drift and the amount of stripping that will be necessary. This could be determined by drilling a few holes on the hill above the quarry opening. The brownstone outcrops also on the south side of the hill, while on the immediate creek bluff on the west end only buff sandstone was observed.

Rocky Fork Branch of Raccoon Creek.—Rocky Fork, with its tributaries, drains nearly all of Jackson township, Parke county (14 N., 6 W.), the head branches extending into the townships north and east. It has cut a network of channels through the massive Mansfield sandstone, exposing that rock in many places. The most valuable stone in the valley is that exposed on Little Rocky Fork in the vicinity of "Fallen Rock" and on "Straight Branch" of Big Rocky in the north part of Sec. 10.

Sandstone is exposed on each side of the creek between the confluence of Big and Little Rocky Forks and that of the main stream with Raccoon creek, the largest exposures being on the west side of the creek. On the east side of the wagon road on the west side of the creek, in the northeast quarter of Sec. 8 and the northwest quarter of Sec. 9 (14 N., 6 W.), the thickness of the sandstone exposure is about 25 feet, of which the upper 12 to 15 feet have a red-brown color like the Mansfield stone. It contains much cross-bedding and many iron blisters. The bottom of the exposure is light colored and contains patches of shale. There is none of it suitable for building stone.

There is an outcrop of similar stone in the southwest quarter of section 9 (14 N., 6 W.), and at intervals between it and the above, but it has no economic value. The same is true of all the stone observed in sections 16 and 15 (14 N., 6 W.). The largest exposures are on a small tributary from the southeast in the northeast quarter of section 15 (14 N., 6 W.),

where the stone is 35 to 40 feet thick, forming perpendicular to overhanging bluffs. Most of it contains iron secretions, but there are a few small patches comparatively free from iron, from which good bridge stone might be obtained in limited quantity.

On the lower part of *Straight Branch*, in the south part of section 10 (14 N., 6 W.), the stone is ferruginous, cross-bedded, yellow and buff colored, but in the north part of section 10, above the chalybeate spring, the character of the rock is much improved.

About 50 yards north of the spring, on the west side of the branch and 20 feet above it, a sandstone ledge three to four feet thick is exposed. It is free from iron secretions and cross-bedding, has a good texture but lacks homogeneity of color, varies from gray and buff to light brown and bright red. About 100 yards above the spring is a small outcrop of lumpy limestone in the bottom of the valley.

North of the limestone, beginning at about 200 yards north of the spring and continuing almost all the way for a quarter of a mile or more along both sides of the branch, are sandstone bluffs 30 to 40 feet high, containing even-grained, evenly bedded sandstone, heavy bedded and uniform in texture. It varies in color, but is uniform through considerable thicknesses. Buff and yellow are the prevailing colors, but there are patches of considerable size of bright brick-red color. It is doubtful if the red could be obtained in large quantities, but excellent buff and yellow stone could be obtained in unlimited quantities.

The water from the chalybeate spring, near the middle of section 10 (14 N., 6 W.), is strongly charged with iron, and has formed a considerable deposit of bog iron ore around it. It is a strong flowing stream.

On the tributary of Rocky Fork, known as *Ground Hog Branch*, in sections 11 and 12 (14 N., 6 W.), the Mansfield sandstone outcrops in several places, but contains too many iron segregations and too much cross-grain to have any commercial value. On the west side of section 12 is a bed of black shale 25 feet thick overlying the massive sandstone. It contains thin seams of coal and sandstone.

Along Big Rocky Fork, above its confluence with Ground Hog Branch, in sections 2 and 11 (14 N., 6 W.), are many high rugged cliffs of sandstone, in some places 60 feet or more in height. In most places it is very false-bedded and contains intercalary patches of black shale. In a few places small areas of the sandstone occur, free from false-bedding and comparatively uniform in texture and color. Such an area which promises considerable good stone is near the middle of the north half of section 11 (14 N., 6 W.), where the evenly bedded buff-colored sandstone at the top of the cliff, varying from 30 to 50 feet in thickness, is underlain by black shale and false-bedded sandstone. Good stone for local use could be obtained here and at several points along the creek through the south

half of section 2 (14 N., 6 W.). Small outcrops of soft, shelly, yellow-colored sandstone and black shale occur along the creek in sections 35 and 36 (15 N., 6 W.), but the greater part of this area is covered deeply with glacial drift, and the rock in the few exposures has no commercial value.

East of Beech Grove church, through the south half of section 30 (15 N., 5 W.), in Putnam county, thin-bedded to shaly light-gray and yellow sandstone outcrops in several places, the largest exposure being one on the wagon road about 150 yards east of the church, and another on the south bank of the branch just north of Mr. Shonkwiler's barn, about a half mile east of the church. In both places the surface of the sandstone is marked with glacial striæ running S. 25° W. The stone at the top of the exposures is in thin layers one to three inches, but massive at the base and probably massive at the top a short distance back in the bluff. Stone for local use in rough work might be obtained here at little expense.

In the northeast quarter of the southeast quarter of Sec. 30, on the south side of the branch, is an outcrop of six feet of thinly-bedded sandstone of a bright brick red color, variegated in places. While the color is attractive the surface exposure would not indicate sufficient stone of a uniform color to be worked with profit.

There is a fine little chalybeate spring in the south part of Sec. 19 (15 N., 5 W.) on one of the terminal tributaries of Rocky Fork from the north. No rock exposures were observed in this tributary, the slopes being covered with glacial drift. The record of a drilled well in the southeast quarter of the northeast quarter of Sec. 19 (15 N., 5 W.) gives 30 feet of drift and more than 60 feet of sandstone, water having been obtained in the sandstone 90 feet from the surface and 60 feet from the top of the sandstone.

Little Rocky Fork.—The Mansfield sandstone outcrops in large quantity and fine quality on Little Rocky Fork through Sec. 22 (14 N., 6 W.) from the northwest corner to the southeast corner. It outcrops further southeast, in sections 23 and 26, but the best stone, and probably all that has any economic value is in Sec. 22. The stone through the northwest quarter of Sec. 22 is mostly concealed by overlying drift, only a few small ledges of inferior gray ferruginous sandstone being exposed. In a small ravine from the west, about a quarter of a mile south of the school-house, is an outcrop of fissile black shale underlying the sandstone.

A little more than a half mile southeast of the school-house, on the west bank of the creek, in the northwest quarter of the southwest quarter of Sec. 22 (14 N., 6 W.), is an outcrop of handsome red sandstone, probably not surpassed in quality by any in the State. A section of the bluff at this point shows:

Section near Fallen Rock on Little Rocky Fork.

	Feet.
Glacial drift.....	0 to 15
Buff sandstone.....	6 to 10
Red sandstone.....	12 to 15
Red and gray variegated sandstone.....	8
Buff sandstone.....	8

The red sandstone has a lighter and brighter shade than the Mansfield stone, is more uniform in color and texture and is free from flaws. It is exposed for a distance of 50 or 60 yards along the bluff, terminating rather abruptly to the northwest in buff and yellow sandstone containing reticulated iron veins and lumps. Along the bluff to the southeast the red stone disappears beneath loose soil and drift material. The next rock bluff in that direction is more than 100 yards distant, and it is of red and yellow variegated stone with too much iron to be of any value. On the opposite side of the creek, northeast from the red stone, the nearest stone is yellow colored and contains much segregated iron oxide. The short limits of the good stone in these three directions is more favorable than otherwise to the probability of finding a greater extent in the remaining direction, namely to the southwest or back into the hill. If the stone extends back into the hill any considerable distance without change in its uniformity, which seems probable, this would prove a valuable deposit. The six to ten feet of buff stone overlying the red ought to more than pay for its removal, and the only stripping that would be expensive would be the drift material. The surface indications are such as to fully warrant investigation.

About the middle of the south half of Sec. 22 (14 N., 6 W.), 60 yards north of the wagon road, a small quantity of red sandstone was quarried from the bottom of the valley several years ago, but the opening is now concealed by the wash from the stream.

In a ravine from the south on the south side of the wagon road in the southwest quarter of Sec. 22, at the "caves," a heavy bed of good sandstone is exposed. The small watercourse has cut a channel 60 to 75 feet deep in the rock, which in two places has yielded more readily to water than elsewhere, and has been undermined, forming a water-fall in the branch and an overhanging cliff ("the cave") on either side. The stone varies in color, buff, yellow, gray, red and variegated occurring. However, the variegated forms a small part of the whole; much gray, yellow and buff stone occurs, uniform in color for a considerable extent. The red was not observed in paying quantities. There is a little cross grain in one place and a little iron in another, and in one place it is somewhat shelly. Nevertheless, there is much good building stone at this locality that could be quarried to advantage if sufficient care was taken in selecting the quarry opening and in classifying the stone after quarrying. While the

bed is 70 or 75 feet thick, it is in most places not more than 30 or 40 feet on the face of the bluff.

At "Saltpeter Cave," on the north side of the creek, 150 yards north of east from the ravine above mentioned, is a large exposure of excellent sandstone. The massive bed 40 to 50 feet thick, the base of which contains much pyrite, is underlain by a drab-colored shale 10 feet or more in thickness. The shale and the pyritiferous layer decaying more rapidly have left the more durable massive sandstones projecting in an overhanging bluff which has been cut back by the small stream into a crescent shape. The upper ten feet of this rock has weathered shelly and shows a little cross grain, but the succeeding 30 feet appears uniform in grain and texture but varies in color, gray, buff, red, and variegated occurring with the buff predominating. It is rather coarse grained and contains some mica. The homogeneous texture and the regular bedding of this stone make it a very desirable building stone.

The only exposure of good stone observed on Little Rocky Fork above the "Saltpeter Cave" is in the bluff at the spring across the creek from Fallen Rock. The bluff here is 20 to 25 feet of homogeneous buff-colored sandstone, with smooth, moss-covered face, entirely free from weather seams. Firm rock extends to the top of the bluff, and the slope is very gentle back from the face of the bluffs, so that little stripping would be necessary in quarrying the stone.

The bluff at Fallen Rock and southeast from it on the east side of the creek contains too much iron to be used for building purposes. In this part of the valley there are numerous very large fragments that have broken off from the parent ledge and rolled into the valley. The largest of these, termed Fallen Rock, is probably 15 x 30 x 20 feet. One called Elephant Rock, from its shape, contains much iron oxide, and weathers very irregularly.

There is a small outcrop of black shale at the base of the massive sandstone on the west side of a small ravine from the north at the section line between sections 22 and 23 (14 N., 6 W.), in the southeast quarter of Sec. 22. There is another small exposure of black shale in the northwest quarter of Sec. 26. Sandstone outcrops in the southwest quarter of section 23 and the north part of section 26 (14 N., 6 W.), but the exposures are small and have no economic value. That in the first locality named resembles the Portland stone, but has too much overlying glacial material to be worked with profit.

West side of Raccoon Creek between Mansfield and Portland Mills.—Between Mansfield and Portland Mills sandstone adapted to local use outcrops in several places. In the northwest quarter Sec. 33 (15 N., 6 W.), west of the wagon road, is a low bluff of massive sandstone 15 to 20 feet high, cross-grained and ferruginous. There is a natural bridge near the southwest end of the bluff, where a small ravine has cut a channel about

five feet high and 25 to 30 feet across under the ledge of sandstone. The stone is not suitable for building purposes.

On the west side of Sec. 28 (15 N., 6 W.), in a small branching ravine from the northwest, is an outcrop of the basal chert conglomerate similar to the "peanut rock" at the Mansfield quarry. The conglomerate rests unconformably on the Lower Carboniferous limestone, and is overlain in places by a dull-brown shale. There is very little massive sandstone exposed at this locality. In the northeast quarter of Sec. 28 (15 N., 6 W.) there is considerable limestone exposed, and at intervals for several miles above this the limestone is exposed on both sides of the creek, in some places 50 feet or more in thickness.

The limestone extends up Troutman's Branch more than a mile from the mouth. Good stone for lime burning could be obtained from the bluffs along the south side of the branch in Secs. 21 and 28 (15 N., 6 W.). On a small tributary of Troutman's Branch from the west, in the S. E. quarter of Sec. 20 (15 N., 6 W.) is an outcrop of massive sandstone 30 to 40 feet thick, overlain by 10 to 20 feet of drift, and underlain by 8 to 10 feet of blue-gray shale. Several small springs, highly charged with iron, emerge on the top of the shale at the base of the sandstone, and have formed considerable deposits of iron oxide on the face of the bluff. The lower part of the sandstone contains much iron pyrites, which is probably the source of the iron in the spring water. The sandstone contains too much iron to be valuable for building stone.

Along Troutman's branch, above this, in sections 16, 9, 8, and 5 (15 N., 6 W.), there is very little sandstone exposed, but there is considerable black and drab-colored shale exposed, the largest outcrop being near the middle of the north half of Sec. 16 (15 N., 6 W.), just west of the wagon road and on the east bank of the branch. The shale is here exposed 35 to 40 feet thick, containing a few inches of sandstone and overlain by two to three feet of soil and clay. The shale at the top of the bluff has a dirty yellow color due to oxidation of the iron, while that near the base has a blue-drab color, which is presumably the color of the interior of the bed. In the northeast quarter of Sec. 8 (15 N., 6 W.) the shale, blue-black in color, has a firmer texture and has had a local use for hearths and back walls for fire-places, as it is said to withstand the fire remarkably well.

In a small ravine on the west side of Raccoon creek, in Sec. 16 (15 N., 6 W.), is a horseshoe bluff of massive, coarse-grained, ferruginous yellow and gray sandstone, underlain by 40 to 50 feet of limestone. The stone is covered too deeply by glacial drift (25 to 30 feet) to be quarried.

On a small tributary of Raccoon creek from the northeast, east of the wagon road, in the southeast quarter of Sec. 9 and the northeast quarter

of Sec. 16 (15 N., 6 W.), is a deposit of heavy-bedded gray, yellow-spotted sandstone that has been quarried for local use in bridge building. The stone is suitable for small bridges and foundations but is not sufficiently uniform in color for superstructures. It occurs in large quantities and could be quarried cheaply. Near the mouth of this tributary, in the northeast quarter of Sec. 16 (15 N., 6 W.), is a high shale bluff which shows:

Vertical Section in 15 N., 6 W., Section 16.

Yellowish brown shale (weathered)	10 to 12 feet.
Drab shale	12 to 15 feet.
Shaly sandstone.....	4 in.
Fissile black shale.....	4 feet.
Coal	4 in.
Lumpy, drab-colored shale (fire-clay).....	8 feet.
Limestone.....	12 in.

In the southwest quarter of Sec. 10, on the north side of Raccoon creek, the Lower Carboniferous limestone outcrops in large quantities and in one place has been quarried for local use.

In the southeast quarter of Sec. 3 (15 N., 6 W.) on the north side of the creek, below the mouth of Limestone branch, is a bold bluff of gray and buff colored sandstone, from which stone for use as grindstones has been obtained in years past. Bridge stone might be obtained here, but as better stone occurs near Portland Mills it will probably never be quarried.

On Limestone branch, the small tributary from the north in Sec. 3 (15 N., 6 W.), sandstone of inferior quality outcrops in several places, resting unconformably on a bed of compact, blue, cherty Lower Carboniferous limestone, which outcrops along the bottom of the valley. The limestone contains much chert and is highly fossiliferous.

Above the mouth of Limestone branch, on the north side of the creek, in Sec. 2 (15 N., 6 W.), there are rugged cliffs, 30 to 40 feet high, of coarse-grained, variegated Mansfield sandstone, which occurs in heavy layers, containing much false bedding and many iron segregations.

In the small branching ravine in the southwest quarter of Sec. 36 and the southeast quarter of Sec. 35 (16 N., 6 W.), on the land of Mr. Harbeson and Mr. Miller, there are large exposures of the Mansfield stone. The numerous small ravines have all cut narrow channels into the sandstone, which forms steep to overhanging cliffs on each side, the gullies in places being as narrow as they are deep. The stone contains much false bedding and iron oxide, but there are small areas comparatively free from either which might furnish stone for local use. Such a locality occurs in the northwest quarter of the southwest quarter of Sec. 36 (16 N., 6 W.), near the half section line on the north side of the forty acres,

where twenty to twenty-five feet of fairly good stone are exposed. In the northeast quarter of the southeast quarter of Sec. 35, in a ravine from the north, is the thickest outcrop observed on the branch, but the stone is too irregularly bedded to have any value. In the south part of the southeast quarter of Sec. 35 (16 N., 6 W.), just north of the wagon road, there is considerable blue-black shale and shale conglomerate exposed, along with thin layers of sandstone.

There is considerable sandstone of inferior quality exposed in a small ravine east of the one mentioned, and nearly parallel with it, in the southwest quarter of Sec. 36 (16 N., 6 W.). A small outcrop of limestone occurs in the southwest corner of this section (Sec. 36).

Ferndale.—On the east side of Raccoon creek no sandstone outcrops of even local importance were observed between Mr. Pruitt's quarry previously described and in the vicinity of Ferndale postoffice in the northwest quarter of Sec. 34 (15 N., 6 W.) About fifty yards south of the postoffice some sandstone has been quarried for local use from the loose boulders and exposed ledges. The stone has a comparatively uniform coarse grain, but is quite variegated in color, having patches of red-brown, yellow and gray. It is a good, durable stone, suitable for underground foundations.

Sandstone is exposed on each side of Limestone branch* for 100 yards or more below (west of) Ferndale postoffice, with occasional exposures toward the top of the hill. The Lower Carboniferous limestone is exposed along the bottom of the valley from the postoffice to Raccoon creek, and has been quarried at the east end of the bridge to build the approaches to the bridge. It is very fossiliferous about midway between the postoffice and the creek. The limestone is exposed above Ferndale in the southeast quarter of Sec. 27 (15 N., 6 W.) and again in the northwest corner of Sec. 26 and the northeast corner of Sec. 27.

On the hill on the north side of the branch, opposite Ferndale postoffice, the yellow-gray-brown variegated sandstone, ten to twelve feet, lies unconformably on the Lower Carboniferous limestone (St. Louis) and is overlaid by thirty feet or more of bluish argillaceous shale, sandy at the base.

Along Limestone branch above Ferndale, through Sec. 27 (15 N., 6 W.), are extensive outcrops of black shale and gray and variegated sandstone which seem to replace each other in part in different localities, in places the shale predominating, in places the sandstone. In the northeast corner of the section, just south of the east-west wagon road, a light gray fossiliferous sandstone rests unconformably on the Lower Carboniferous limestone and is overlain by a black shale containing coal. Some coal has been mined. The sandstone contains many fossil coal plants,

*This should not be confused with the Limestone branch on the north side of the creek, just below Portland Mills.

in one place a trunk of a *calamites* stem eight or nine inches in diameter being exposed for a length of sixteen feet, with both ends concealed in the sandstone.

No valuable sandstone for building purposes was observed in this locality, as in most places it is more or less variegated in color. In several places within three-quarters of a mile southwest from the northeast corner of Sec. 27 (15 N., 6 W.), along Limestone branch there are exposures of good, durable stone, uniform in grain and structure, but lacking uniformity of color. Good bridge and foundation stone could be obtained here.

Between Limestone branch and Bain branch there are large exposures of limestone, especially prominent near the middle of Sec. 22 (15 N., 6 W.) and the southwest quarter of Sec. 15 (15 N., 6 W.). No sandstone of even local value was observed.

Bain Branch.—On Bain branch sandstone outcrops on the lower course and again near the headwaters, but in the middle course through the north part of sections 13 and 14 (15 N., 6 W.) the slopes are covered with glacial drift and no sandstone is exposed. A small quantity of gray and buff colored sandstone has been quarried in the southeast corner of Sec. 10 (15 N., 6 W.) in the bluff on the south side of the creek, where it occurs in layers eight to sixteen inches thick and is exposed through a thickness of twenty to twenty-five feet, including thin layers of intercalary shale. Ripple-marked sandstone outcrops about 200 yards west of this bluff in the bed of the creek, and shaly sandstone and Lower Carboniferous limestone outcrop along the small tributary from the northeast in the southeast quarter of Sec. 10 and the west side of Sec. 11 (15 N., 6 W.), but there is none of any value.

In the northeast quarter of Sec. 13 and the southeast quarter of Sec. 12 (15 N., 6 W.) at the county line between Parke and Putnam counties is an outcrop of more massive yellow sandstone, which is pyritiferous at the base and underlain by blue and black shale; several small chalybeate springs emerge from this sandstone. The maximum thickness observed in the outcrop was twenty feet. Good, durable bridge stone could be obtained here; the color is not uniform nor pleasing enough for good dimension stone.

There is a low (eight to ten feet) bluff of massive sandstone along the south bank of Raccoon creek in the southwest quarter of Sec. 2 (15 N., 6 W.) which contains some good stone, but it is not so accessible as better stone nearer Portland Mills. The same may be said of similar bluffs along the south bank of the creek in the northeast quarter of Sec. 2. Some yellow ferruginous sandstone outcrops along a small tributary in the southeast quarter of Sec. 2 and the southwest quarter of Sec. 1 (15 N., 6 W.), but it has no economic value. In the northeast quarter of the

southeast quarter of Sec. 2 on this branch is one of the finest chalybeate springs observed in this region.

Nelson Branch.—On a small branch in the middle and southeast quarter of Sec. 1 (15 N., 6 W.), locally known as the Nelson branch, is one of the most promising sandstone outcrops in the Raccoon valley. The small watercourse has cut a deep gorge back into the sandstone and limestone for a half mile from the creek, and it is near the upper limit of this deep gorge, just below the upper waterfall, that the largest exposure of the sandstone occurs. The bluff is forty-five to fifty feet high, the lower twelve to fifteen feet being concealed by the huge angular blocks that have broken off and tumbled down from the top of the ledge, some of which boulders are not less than fifty feet across. The upper part of the cliff is perpendicular, smooth, seamless and moss-covered. The stone is apparently solid to the top of the cliff, with very little overlying waste material. The color of the stone as indicated by the boulders in the talus is somewhat variegated, with gray the prevailing color, streaked in places with buff and red. The perpendicular face of the cliff is not accessible and it is not possible from the base of the cliff to see how much of the stone is variegated, but the absence of iron segregations, the freedom from seams and the uniformity of texture would indicate a considerable uniformity of color, and the outcrop would indicate large quantities of good, durable building stone.

The sandstone outcrops for nearly 100 yards above the falls (southeast), and in large quantities along the branch between the upper and lower falls, the best stone occurring along the south or west side of the branch.

The lower fall, which is near the middle of the section, is about thirty feet high and in the Lower Carboniferous limestone underlying the sandstone. The limestone outcrops along the branch below the falls to Raccoon creek, but no sandstone of economic importance was observed below the lower fall.

Portland Mills.—There are quite marked local variations in the stratigraphy in the immediate vicinity of Portland Mills. Nelson's branch, described above, where not less than fifty feet of the massive Mansfield sandstone occurs, underlain by shaly and cherty Lower Carboniferous limestone, is scarcely more than a half mile southwest of the village. Immediately east of the village is a high cliff of blue-black shale ("The Blue Bluff") which is eighty feet or more in thickness. The shale underlies the town in part and extends probably a quarter of a mile west of the town, the glacial drift concealing the western limits. North of the village, on the north side of Raccoon creek, the red and gray Mansfield sandstone occurs in a bed 100 feet thick, underlain by an impure limestone. West of north from the village, about 100 yards west of the school-house, is another exposure of the blue shale (yellow and brown on

the weathered surface) fifty feet or more in thickness. East, southeast and northeast of the village are considerable exposures of compact, blue limestone of Lower Carboniferous age. Three fourths of a mile north-east are fine outcrops of the basal conglomerate between the Lower and Upper Carboniferous systems.

In the heavy sandstone deposit on the north side of the creek, opposite the village, a quarry has recently been opened in the brownstone by the Portland Mills Red Sandstone Co., but at the present writing (December, 1895) no stone has been shipped, and but little more than preliminary work has been done. The soil and waste material have been stripped from a half acre or more, and in places opened to a depth of three or four feet. The surface stone so far removed lacks uniformity of color; besides the different shades of brown there are a few irregular patches of gray. Part of the variegation is probably due to weathering influences, the leaching of the color by organic acids. In places there are scattered pebbles of shale, sandstone, and iron which, while not abundant, ruin some of the stone for mill blocks. The brownstone ranges from twenty-five to fifty feet in thickness, with no sharp line of parting between it and the underlying gray and yellow sandstone. The total thickness of the sandstone from the highest exposure, 100 yards or so north of the quarry to the underlying limestone at the creek, is 100 feet. There can be no doubt of the great quantity of stone at this locality and where it is uniform in color and free from the pebbles it is a handsome and durable stone. There will be some waste material, but the good stone, if properly selected, can be used with perfect safety. A microscopic examination shows the brownstone to consist almost wholly of white quartz grains in a cement of red iron oxide. (See fig. 2 on plate 12.) Partial chemical analysis made by Dr. Baker at Greencastle shows this stone to have a higher per cent. of iron oxide cement than that from other localities.* There are two glacial pot-holes in the new quarry opening, one about four feet and the other six feet across and six to eight feet deep.

West of the quarry and facing the mill pond is a bluff forty to fifty feet high, of massive gray and buff sandstone with a few feet of red stone in places along the top. Along the bottom of this bluff and at the west end, the stone is very much cross-grained and streaked in places with iron ore. Through a thickness of twenty feet or more at the upper part of the bluff toward the east end, the stone is uniform in texture and would furnish good building stone. Immediately north of the mill and thence west the stone has little, if any, commercial value.

East of the quarry the stone outcrops along the creek to the bluffs of Byrd branch, a distance of a quarter of a mile.

* See tables in the final chapter for analyses.

Byrd Branch.—Sandstone is exposed in several places along Byrd branch through Sec. 31 (16 N., 5 W.), but so far as observed contains too much iron and false bedding to have any commercial value. Near the middle of the north half of Sec. 31 (16 N., 5 W.), the basal conglomerate, marking the unconformity between the Lower Carboniferous limestone and the Mansfield sandstone of the Coal Measures, occurs on each side of the branch. It consists of large angular and sub-angular chert pebbles varying in size from one inch to eight or ten inches in diameter, much of it being fossiliferous and all bound together by a cement of sand, clay, and lime. The conglomerate is eight to ten feet thick and is overlain by the coarse-grained yellow Mansfield sandstone, which at the base contains many fossil coal plants and segregations of iron oxide.

In the northeast quarter of Sec. 31 (16 N., 5 W.), 100 yards south of the forks of the road, there appears to be a fault in the strata, as shown on the accompanying figure. (Fig. 1.) While there is a possibility of this being a case of unconformity by erosion, the abrupt change looks more like a misplacement of the layers.

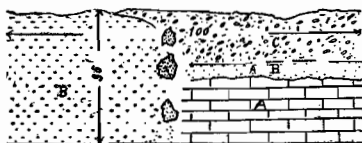


Fig. 1. Section of fault on Byrd branch near Portland Mills.

- A—Lower Carboniferous limestone.
- B—Mansfield sandstone.
- C—Glacial drift.

Along Byrd branch, underlying the sandstone, is a bed of Lower Carboniferous compact blue limestone which occurs in regular strata eight to twenty inches thick, evenly bedded and regularly jointed, weathering out in rectangular blocks two or three feet across. Good foundation stone and stone suitable for making lime could be obtained from this limestone. Similar limestone outcrops in large quantities further east along both sides of Raccoon creek through the southeast quarter of section 31, the south part of Sec. 32 (16 N., 5 W.), and the north parts of sections 5 and 6 (15 N., 5 W.).

Between Portland Mills and Ramp Creek.—There is a marked change in the strata in the ravine from the south in the northwest quarter of Sec. 6 (15 N., 5 W.); near the head of the ravine the massive sandstone occurs twenty-five feet or more in thickness underlain, as seen in passing down the ravine, by a shaly conglomerate ten feet, drab-colored shale twenty feet, and limestone twenty feet, while near the mouth of the

ravine the drab colored shale is eighty feet thick, apparently replacing all the other strata, as there is no evidence of faulting. This immense bed of shale, if it proves of proper quality for paving brick, as the outcrop would indicate, will no doubt be used when transportation facilities are afforded. The cost of mining it would be merely nominal.

Through the north central part of Sec. 6 (15 N., 5 W.) south of Raccoon creek are several ravines that have cut channels through the massive sandstone and into the underlying limestone, the latter exposed on the lower course and the largest exposure of the sandstone being around the heads of the ravines, where it is forty to fifty feet in thickness, but too variable in color and texture to have much value as a building stone. Small quantities of coal occur in the bed of shale underneath the sandstone and it has been mined for local use in the southwest quarter of Sec. 5 (15 N., 5 W.).

Large quantities of black shale, with small quantities of coal and some sandstone, occur along the Beck branch in the east side of Sec. 4 (15 N., 5 W.).

Along the south side of Raccoon creek through Sec. 33 (16 N., 5 W.), the massive Mansfield sandstone outcrops in a low cliff along the bank of the creek. In places the stone is homogeneous and exposes an even, regular weathered surface. In many places there are segregations of the iron oxide which cause the stone to weather unevenly, and which give it a variegated color. Good stone in limited quantities could be obtained in different places along the bluff.

Near the middle of the west half of Sec. 33 (16 N., 5 W.) on the north side of the creek the sandstone forms a high steep bluff on the creek bank, at the upper end of which a small branching ravine has cut numerous gullies exposing large quantities of the stone. Southwest from this point, along the bluff small quantities of sandstone have been quarried for local use.

Near the middle of the north part of Sec. 33 and the south of Sec. 28 (16 N., 5 W.) the Lower Carboniferous limestone outcrops at a higher level than the sandstone along the creek both south and east of it. Some of the limestone has been quarried. Limestone containing considerable chert outcrops along the ravine east of the wagon road in the southeast quarter of Sec. 28 (16 N., 5 W.) on the north side of the creek, and in Sec. 34 on the south side of the creek. On the south bank of the creek just east of the wagon bridge is a perpendicular cliff forty-five feet high of the massive sandstone, which is variegated in color and lacks uniformity in texture, in some places containing streaks of iron oxide, and in places patches of coarse conglomerate. There is a similar bold bluff of the sandstone one-half mile northeast of the bridge on the creek

bluff and in a small ravine from the east, where the stone is more uniform in composition and would furnish good bridge and foundation stone where the overlying drift is not too thick to prevent its use.

On the opposite or west side of the creek in the southwest quarter of Sec. 27 (16 N., 5 W.) the sandstone outcrop measures 55 to 60 feet in thickness, and is quite variable in texture. In some places it is homogeneous in color and texture with a smooth weathered exposure, and, within a few yards, it will show much false bedding, iron secretions and variegated color. Good stone could be obtained here by observing care in selecting the opening for the quarry.

Ramp Creek.—The only outcrop of sandstone of any note on Ramp creek is at Blakesburg in the northwest quarter of Sec. 25 (16 N., 5 W.), and that has very little, if any, economic value. It is interesting from a scientific standpoint in showing a marked unconformity between the sandstone and the underlying Lower Carboniferous limestone as shown on the accompanying figure (Fig. 2). The sandstone is nearly

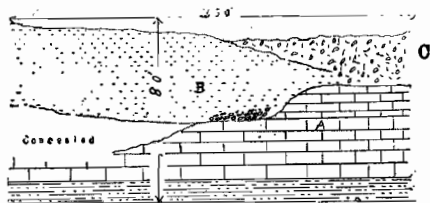


Fig. 2. Section of the bluff at Blakesburg.

- A—Lower Carboniferous limestone.
- B—Carboniferous (Mansfield) sandstone.
- C—Glacial drift.

forty feet in thickness, and contains at the base a coarse conglomerate of chert pebbles from the Lower Carboniferous limestone.

The underlying hard, durable, crystalline limestone has been quarried for local use on each side of Ramp creek 100 yards or more above the sandstone bluff.

A small outcrop of sandstone was reported near the middle of the south half of Sec. 26 (16 N., 5 W.).

Big Racoon Creek above Ramp Creek.—The only outcrop of the Mansfield sandstone of any economic value in the Racoon valley above Ramp creek is at what is known as the Snake Den, on Mr. Long's place in the northeast quarter of Sec. 15 (16 N., 5 W.), where the sandstone is 65 feet thick and overlain by glacial drift. It is gray and buff in color, and, for the most part, of uniform texture; a little cross-grained and ferruginous in a few places. There is a great deal of good building stone at this locality, but only a limited quantity could be obtained with profit owing to the heavy bed of overlying drift.

There is a small outcrop of Mansfield stone half a mile east of the Snake Den, on the south side of the creek in the north part of Sec. 14 (16 N., 5 W.), but it has no economic value.

Limestone outcrops in several places along the creek and on the tributaries in the upper part of the Raccoon Valley, some of it being of good quality, but occurring in limited quantity; it has been quarried in the north part of Sec. 2 (16 N., 5 W.).

In the north part of section 14, the west part of section 12 and the east side of section 1 (16 N., 5 W.), and elsewhere in this vicinity is a fine-grained, impure, drab-colored sandstone that is apparently the equivalent of the sandstone at Riverside and that on Big Walnut creek, east of Bainbridge. It has been quarried to some extent along the I., D. & W. R. R., one-fourth mile west of Raccoon Station, and was used in the piers of the railroad bridge on the creek, east of the station, but it has been found necessary to replace it in part, as it began to crumble badly. No resources were available for having any tests made on this stone, but an examination of the outcrops would indicate a stone fairly homogeneous in texture and color, but containing too much clay and iron pyrites to stand exposure in most places. For indoor work or for foundations of small buildings it might be used with safety.

Limestone and drab-colored sandstone outcrops are to be expected about the headwaters of Raccoon creek, but no exploration of the valley north of the I., D. & W. R. R. was made by the writer.

Little Raccoon Creek.—Little Raccoon Creek valley was not explored below Sand Creek station in Sec. 3 (15 N., 7 W.). Citizens of that vicinity report no outcrop below that point. If any does occur it is liable to be of more recent age than the Mansfield sandstone.

The lowest exposure of the Mansfield sandstone observed on the creek is that near the middle of the east half of Sec. 2 (15 N., 7 W.) where the stone has been quarried to some extent. The total thickness of the exposure varies from thirty to thirty-five feet in layers, from one inch to four feet thick. The color is variegated, brown at the base of the exposure, gray and brown banded near the top, in places pepper-and-salt appearance caused by the small black and brown specks of iron oxide in the gray stone.

The above is but one of several small quarries in this vicinity, from some of which stone has been shipped by rail to Logansport. Another quarry, and the smallest of the lot, is on the bluff a quarter of a mile east of the creek, just south of the wagon road, where the stone is gray and brown variegated, too much variegated to be of value for building stone. It would make a good bridge or foundation stone.

Another and larger quarry opening is on the small, rounded hill in the southeast quarter of Sec. 35 (16 N., 7 W.) on the east bank of the

creek and 150 yards north of the wagon road. The stone has been quarried near the top of the small, rounded hill, which covers four or five acres. The color is gray, with yellow and brown patches, and in a number of places is cross-grained. There is not sufficient uniformity of color or grain for good building stone, but excellent bridge stone might be obtained.

Another one of these quarries and the one now in operation (April, 1895), is the brownstone quarry on the east side of the creek in the northeast quarter of Sec. 35 (16 N., 7 W.). The stone is a nearly uniform brown, there being some variation in shade, as in the Mansfield quarry; in fact, the stone in grain, color, and texture is very much like the Mansfield stone. It differs in not having the numerous iron blisters and in being much more shelly on the outcrop.

A great deal of work has been done here and much material removed, most of which has been waste. A little good stone has been obtained and there is more in sight, yet at present the good stone is but a small per cent. of the waste and will continue so for some time. How far it is back in the bluff to the sound stone can not be told with certainty from the present opening. The most economical method of testing such a locality would be with the core drill, which would show whether the stone is solid or not back from the bluff, and if it should prove so, the cheapest way to work it would be from the top of the flat. If the drill would show that the rock back from the bluff continues shelly it would save all the work now being done at great expense. The face of the quarry shows thirty-seven feet of sandstone underlain by a blue shale. The lower ten feet of sandstone are very shelly. The remainder shows some good stone, a few feet at the top showing numerous gray and yellow patches, caused probably by the red iron oxide being leached out in part or reduced to the lower oxide by the infiltrating waters from the overlying soil.

The occurrence of so much shelly material on the bluff at this point might at first suggest the thought that the stone is inherently less durable in its composition and make-up, than in other more solid outcrops, such as those at Mansfield and at Portland Mills, but this is not necessarily the case, as the way the bluff faces, the amount and nature of the overlying and underlying material and the relation to the creek channel have something more to do with the nature of the outcrop than the composition of the stone. This quarry is on the south-west slope, the most trying of all, and in most places in this part of the State the slopes facing south or west will have no rock outcrops, even where the north and east slopes have many rocky bluffs.

Around the point of the hill, east from the quarry opening, the red color of the sandstone changes to a variegated and gray. There is a similar change in color in the small ravines north of the quarry.

While at the quarry there are scarcely any iron secretions, less than one hundred yards north of the quarry, along the face of the bluff there is a great deal of segregated iron oxide accompanied by much false bedding.

Ray Branch, a small tributary of Raccoon creek from the northeast just below the quarry, has a few outcrops of yellow, shelly sandstone and some shale in some of its terminal ravines in the northwest quarter of section 31 and the southeast quarter of section 30 (16 N., 8 W.), but none valuable for building stone. The lower part of the valley is wide and the slopes covered with drift, except the sandstone quarries described above.

On the *Miller or Cumberland Branch*, in Sections 1, 3, and 12 (15 N., 7 W.), and Sections 6 and 7 (15 N., 6 W.), there are some heavy sandstone ledges exposed. At the mouth of the branch, in the northeast quarter of Sec. 2 (15 N., 7 W.) the sandstone occurs in bluffs on each side of the creek, much of it false bedded and ferruginous, yet in a few places sufficiently uniform for good bridge stone. On the east side of the south prong of the branch, in the northeast quarter of section 12, and again in the southeast quarter of Sec. 12 (15 N., 7 W.) the yellow sandstone has been quarried in small quantities for local use. There is a great deal of inferior sandstone exposed in this section, and while in some places the quality is all right for an average building stone, the overlying drift material is too heavy to permit its being quarried in any great quantity. It is underlain in places by black shale and coal. The latter has been mined in small quantities in one place.

Along the east prong of *Miller Branch*, in Sec. 1 (15 N., 7 W.), and Sec. 6 (15 N., 6 W.), the sandstone ledge is twenty-five to forty feet thick, and in a few places the exposure is even-faced, sharp angled, lichen-covered and evenly bedded, indicating a good durable building stone. The color is yellow gray. There is a coal bank in this ravine in the northwest quarter of Sec. 6 (15 N., 6 W.), east of the heavy sandstone outcrop, and the black shale is exposed in several places, both east and west from the sandstone bluffs.

Southwest of Judson, on the west side of Little Raccoon creek, the yellow *Mansfield* sandstone of inferior quality outcrops in the bluff west of the wagon road, the maximum thickness measured being forty feet. In the small tributary from the north, in the northeast quarter of section 26, and the southeast quarter of Sec. 23 (16 N., 7 W.), much yellow and gray sandstone is exposed. Close to the section line between the two sections some stone has been quarried, which is soft and easily worked, but contains too much iron for suitable building stone. Black shale and coal occur underneath the sandstone.

In the small tributary from the northwest on the north side of Judson, in the northwest quarter of Sec. 24 (16 N., 7 W.), gray and yellowish

brownstone has been quarried for local use. The dull, variegated color injures its use for building stone. The face of the quarry opening is about twenty-five feet with several feet of overlying drift. The stone is free from iron secretions; but there are a few weather seams, due, in large measure, to the powder used in blasting. There is a large quantity of stone exposed in this ravine, much of it suitable for bridges and foundations.

On the east side of Little Raccoon creek, between Judson and Guion, the Mansfield sandstone outcrops in large quantities. From the wagon road, near the middle of the west side of Sec. 19 (16 N., 6 W.), to Mr. Strong's house, near the middle of Sec. 18 (16 N., 6 W.), there is a continuous ledge of sandstone, the thickness of the exposure varying from 5 to 25 feet. The most valuable building stone is about one quarter of a mile north of the wagon road in the northwest quarter of Sec. 19 (16 N., 6 W.), where the gray and buff sandstone is 15 to 20 feet thick in evenly bedded layers three to five feet thick, the surface smooth and the corners sharp and angular. There is very little covering back from the face of the bluff for 100 feet or more. Abundance of good building stone for heavy masonry could be obtained here. Further north, through Sec. 18 (16 N., 6 W.), the quality of the stone is not so good, yet good foundation or bridge stone could be obtained in a number of places.

Near the middle of the south half of Sec. 18 (16 N., 6 W.) is a small outcrop of shelly limestone at the base of the bluff on the creek bank where lime for local use was burnt several years ago.

Along the small tributary from the southeast in the southeast quarter of Sec. 18, south of Mr. Strong's home, red sandstone was quarried to some extent a few years ago. The face of the quarry is 12 to 15 feet, the upper 3 to 5 feet having a bright red color, the remainder of the bed being gray, or yellow-brown. It is underlain by 15 to 20 feet of black shale. The sandstone lacks uniformity both in color and structure, and while there is considerable nice building stone, it is doubtful if it could be quarried with profit unless the coarse rubble stone could be disposed of with profit.

The North Prong of Little Raccoon Creek.—There is no valuable sandstone on the north prong of Little Raccoon creek. The Mansfield sandstone is exposed on the east bank of the creek at the railway bridge at Guion, where it was quarried for the bridge abutment; in the railway cut, 100 yards or more east of the creek where the stone is brown in color, but too shelly to be valuable; in the small tributary from the northwest at the school-house just north of Guion; on the south and east side of the creek in the southwest and southeast quarters of Sec. 5 (16 N., 6 W.), in the small ravines from the northwest in the northwest quarter of Sec. 5, where there is a single small outcrop of yellow sandstone; in a small tributary on the west side of Sec. 34 (17 N., 6 W.),

and on both sides of the creek in the east side of Sec. 34 and the west side of Sec. 35, which is the uppermost exposure of the sandstone observed on this creek.

There is a large quantity of Lower Carboniferous limestone exposed in Sec. 34 (17 N., 6 W.) on both the main creek and the tributary from the north. On the west bank of the creek just below the mouth of this tributary is a big limestone quarry now abandoned where a great deal of lime was burned a few years ago. There is a small outcrop of limestone about half a mile west of Waveland and it probably underlies the drift in the valley above Waveland. For a distance of two miles above Waveland the slopes are covered with glacial drift, and the valley was not explored further east.

South Prong of Little Raccoon Creek.—The Mansfield sandstone outcrops in six different places in the valley of the south prong of Little Raccoon creek. The first exposure found in ascending the valley is in 16 N., 6 W., Sec. 17, the northwest quarter, about 150 yards north of the creek, where it first appears as thin-bedded, somewhat ferruginous sandstone. It occurs in heavier layers in the small ravine at the spring but weathers very irregularly. It is yellow-brown to red-brown in color and in the creek just south of the spring is a massive ledge of yellowish brown sandstone, but it is all too impure for good building stone.

On the south side of the creek in the ravine from the south in the S. W. quarter of Sec. 17 is an outcrop of sandstone from fifteen to twenty-five feet thick in the bluffs along each side of the ravine. The upper part of the bed is coffee-colored to reddish brown, the lower part of the bed a yellowish brown color. The upper part is evenly bedded, two to four feet thick in places but having weather seams, the lower part shaly and disintegrating in places. The weathered boulders are thin, angular and hard, and there are no large boulders. Mr. Strong says that stone was quarried here 24 years ago by a Chicago firm and several carloads shipped, but the industry was soon discontinued as they claimed the freight rates were so high that the stone could not be quarried with profit.

The next outcrop on the south prong of Little Raccoon creek is near the middle of the north half of Sec. 17 (16 N., 6 W.) where the rock is exposed on both sides of the creek and on the south side of the small branch from the northeast. On the branch side of the hill the rock is shaly on the outcrop but on the creek it forms a massive ledge eight to ten feet thick.

There is a larger exposure of the sandstone in the southeast quarter of Sec. 17 where it forms a precipitous bluff on the south bank of the creek; the Lower Carboniferous limestone appears on the east (north) bank a short distance (75 yards) below the sandstone cliff and forms a low retreating bluff twenty-five to thirty feet high along the east side of the creek through the southeast quarter of Sec. 17, while the sandstone forms

a perpendicular bluff along the west side for about twenty-five yards to near the point where the road crosses the creek, where the limestone outcrops on both sides of the creek. There is a short interval of a few yards at this point between the sandstone bluff and the limestone which is concealed by soil and debris so that the contact of the two formations is not shown. The discordance in bedding here is to all appearance due to unconformity by erosion. The rocks seem in no place broken or much disturbed.

The limestone has been quarried for local use on the east side of the creek in the southeast quarter of the southeast quarter of Sec. 17 (16 N., 6 W.).

On the branch from the south, west of Parkeville, 150 yards north of the gravel road at the school-house in the northeast quarter of Sec. 20 (16 N., 6 W.), there is an outcrop of brown coffee-colored sandstone with light gray spots, varying in places to a more reddish brown color. It extends along the bottom of the branch for 100 yards or more, exposed in places six or eight feet, in thin-bedded to shaly layers one to two inches thick. It contains considerable brown hematite in places, in one place in a curious chain-like form.

The wells at Parkeville are twenty to forty feet deep, and find water in a bed of gravel.

There are two outcrops of blue-gray to black shale northeast of Parkeville in Sec. 2 (16 N., 6 W.), both on the creek bank, one near the middle of the north half of the section, the other in the northeast quarter.

At the latter point the fifteen to twenty feet of the shale exposed in the bluff on the south bank of the creek is quite fissile and micaceous, near the base containing several thin layers of micaceous sandstone.

The largest outcrop of sandstone observed on this branch of Little Raccoon creek is the uppermost one which occurs in Sec. 22 (16 N., 6 W.), the southwest quarter, and extending into Sec. 27, the northwest quarter. The rock outcrops on both sides of the creek and in the creek bed, but the largest exposure is in the perpendicular bluff in the south and west side, which is known locally as the "Snake Den." The thickness of the rock exposed is forty feet, being overlain by drift and underlain by a gray to black shale. The shale outcrops in the creek bed near the lower end of the bluff and a quarter of a mile up the creek above the upper end of the bluff.

The sandstone in this bluff is very irregularly bedded and ferruginous, and weathers with a very uneven face; the cross bedding is quite pronounced in many places, and the iron in the form of limonite layers occurs in layers, sometimes along the true bedding planes, sometimes along the false bedding planes. Near the upper end of the outcrop the rock is evenly but thinly bedded and has been quarried a little for local use.

While there is abundance of sandstone in this locality, it is too imperfect to have more than a local use.

No sandstone was observed on the south prong of Little Raccoon creek above Sec. 27 (16 N., 6 W.). The only rock exposure observed above this point is a small outcrop of limestone in the southeast quarter of Sec. 8 (16 N., 5 W.), a mile and a half south of Russellville, this part of the valley being covered with glacial drift.

SUGAR CREEK BASIN.

Sugar creek, like Walnut and Raccoon creeks, heads in the older Paleozoic rocks, east of the accompanying map, and in its southwesterly course cuts successively through the Lower Carboniferous limestones, sandstones, and shales, the Mansfield sandstone, and well into the overlying Coal Measures. Large quantities of the Mansfield sandstone are exposed in north central Parke county and southeastern Fountain county, some of the exposures in this area being thicker than any observed elsewhere in the State.

Sugar Creek below Rockport.—That part of Sugar Creek valley between the Wabash river and the C. & I. C. Railway lies in the productive Coal Measures and was not explored. It is mostly bottom land and there are probably few rock exposures. Along the railway north of Sugar creek, up the Rush Creek valley, are small exposures of black shale, with a little shaly sandstone in places. At and north of Tangier the slopes of Rush creek are covered with glacial drift, and no rock exposures were observed.

Just east of the C. & I. C. Railway on the north bank of Sugar creek is an outcrop of gray and black shale, and about half a mile east of the railway is a small outcrop of soft yellow sandstone somewhat similar in quality to that in the bluffs southwest of Rockport.

Along the bluff in the west and northwest parts of Sec. 35 (17 N., 8 W.), which is a quarter to a half mile west of the creek, there is a heavy bed of yellow sandstone that varies in thickness on the outcrops from twenty to fifty feet. It is exposed in perpendicular and overhanging bluffs in all the little ravines and gullies, but in most places between the small watercourses the rock is concealed by drift material. The stone is underlain by coal, which has been mined for local use at several points. While the sandstone occurs in great quantities along this bluff, it contains too many iron secretions to have more than a local value.*

Along a small winding tributary from the west and north in the north part of Sec. 35 and the west part of Sec. 26 (17 N., 8 W.) the same bed of sandstone is exposed. In several places it is sufficiently uniform for

* The location of this sandstone bluff is shown on the map by broken lines.

good bridge stone or heavy masonry of any kind; in certain localities it contains much iron oxide and iron sulphide. The chalybeate (sulphur) spring comes from the decomposing pyrite in the sandstones and shales. In passing up the ravine the sandstone is succeeded by overlying black shale and shaly sandstone.

Rockport.—There were formerly a mill and several houses at the bridge across Sugar creek in the northeast quarter of Sec. 35 (17 N., 8 W.), and while the mill and most of the houses have disappeared the place still retains its old name, Rockport. There are large exposures of massive sandstone here on both sides of the creek. On the south side of the creek near the mouth of a small tributary from the south, near the site of the old mill, the water has cut a deep, precipitous gorge in the sandstone which is known as the Devil's Den. It is an admirable location for a quarry for rough building stone, owing to the great thickness (thirty to forty feet) of the stone and the little waste material overlying it. In point of durability and ease of working it would be suitable for any kind of work, but the rather dark buff and yellow color will not make it attractive for fine buildings. The natural face is smooth and even, the angles sharp and firm, indicating both homogeneity and durability. Like most of the massive sandstone of this region it is soft in the interior, but hardens on exposure.

No rock has been quarried at the Devil's Den, but a quarry has been opened on the north side of the creek opposite from which probably 2,000 cubic feet or more of stone have been taken. The stone is inferior in quality and in a poorer position for quarrying than that on the south side of the creek. A section of the quarry face shows:

Section of the quarry at Rockport.

	Feet.
Soil	2 to 6
Micaceous sandstone	40
Blue-gray sandy shale	25

The sandstone varies in color from a blue-gray to brown, in places variegated. The upper ten feet of the sandstone are more or less shelly, and it is cross grained in several places. The shale closely resembles that used for manufacturing paving brick.

A quarter of a mile west of the quarry on the north side of the road is a rugged crescent-shaped bluff of the sandstone underlain by coal. A small quantity of sandstone has been quarried at this locality.

The sandstone at Rockport and vicinity is thought to belong to a horizon above that of the Mansfield sandstone. The reasons for so thinking are not conclusive and could only be established by a shaft or boring extending below the bottom of the valley. It is probably the equivalent of the stone at Coxville and at Cannelton.

Between Rockport and Sugar Mill Creek.—Along the north side of Sugar creek above the quarry at Rockport are large exposures of buff and yellow sandstone and black shale. Through Sec. 25 (17 N., 8 W.) the sandstone bluff twenty to thirty feet high is almost continuous and much good homogeneous sandstone is exposed. In a few places the face of the stone is marked with veins, seams, and pockets of iron oxide, but in many places it is smooth, even, seamless, moss-covered, and indicates a good durable stone. The absence of bedding planes in large measure prohibits its local use where it is needed in only small quantities, as it could not be quarried to advantage without the use of channelers and steam drills. However there are a great many massive boulders that have fallen off the parent ledge and lie strewn along the foot of the bluff. The sharp corners and the even surface of these boulders indicate homogeneity and durability, and a good building stone for local use could be easily and cheaply obtained.

Considerable sandstone outcrops through the north part of Sec. 30 (17 N., 7 W.), some of it being more thinly stratified than that above described and containing some intercalary shale. On the east side of Sec. 30 and the west side of Sec. 29 the strata become more diversified. A section of the bluff about half a mile below the mouth of Sugar Mill creek shows:

Section near mouth of Sugar Mill Creek.

	Feet.
Yellow sandstone	5
Black shale	3
Gray and yellow striped sandstone	12 to 15
Shale brown to black containing pockets of coal	12
Cross-bedded sandstone, shale, and coal	12 to 15

The coal near the base is ten to twelve inches thick and dips west four or five degrees.

On the south side of Sugar creek between Rockport and Sugar Mill creek there is very little if any sandstone of economic importance except that along Roaring creek. On Slate Run, Sec. 25 (17 N., 8 W.) and Sec. 31 (17 N., 7 W.) there is an outcrop of black limestone in a bed of black shale. The limestone occurs in two layers which in one exposure shows a thickness of four to six inches each. In another exposure near by, these layers were eight to ten inches thick. Some nice black marble could be obtained here, but it is doubtful if it could be quarried in sufficient quantities to be profitable.

Roaring Creek.—Coal has been mined for local use at several places along Roaring creek; in the southwest quarter of Sec. 29 (17 N., 7 W.), in the southwest quarter of Sec. 32 and the southeast quarter of Sec. 31. The coal is in lenticular masses or pockets and nowhere thick enough to be mined with much profit. It is accompanied with much black shale

and gray and yellow sandstone. The sandstone varies from 20 to 40 feet in thickness, and occurs in regularly stratified layers. The bottom part next to the coal and shale in most places contains much pyrite, some conglomerate and false bedding. The upper part is regularly bedded and free from impurities, but frequently contains gray and yellow banded colors. Good bridge and foundation stone could be obtained in a number of places along Roaring creek through the south part of Sec. 32 (17 N., 7 W.) and in the tributary ravine in the southeast quarter of Sec. 31 (17 N., 7 W.).

About a quarter of a mile above Roaring creek on the south bank of Sugar creek is an outcrop of typical, false-bedded, massive, Mansfield sandstone, eight to ten feet exposed. There is another similar outcrop about a quarter of a mile below the mouth of Sugar Mill creek on the south side of the creek. In neither place is it sufficiently uniform to have any economic value.

Sugar Mill Creek.—Sugar Mill creek is a large tributary of Sugar creek from the northeast which heads in the Lower Carboniferous rocks in Montgomery county, and cuts through both Lower Carboniferous rocks and the Coal Measures in both Fountain and Parke counties. A glance at the map will show the diversified character of the rocks along its course. Near the mouth is a small outcrop of Lower Carboniferous limestone (St. Louis?) overlain by conglomerate, sandstone (Mansfield), and shale; and a short distance above, about the mouth of Greene creek, the Mansfield sandstone is below the water level and sandstones and shales of more recent age form the bluffs for two miles or more above when the Mansfield sandstone reappears and is followed by Coal Measures, Mansfield sandstone and Lower Carboniferous.

No outcrop of Mansfield sandstone was observed on Greene creek, a large tributary of Sugar Mill creek from the north, but soft sandstone belonging to a horizon above the Mansfield stone has been quarried in small quantities in the northwest quarter of Sec. 8 and the northeast quarter of Sec. 7 (17 N., 7 W.). The quality is not sufficient to merit more than a limited local usage. Coal occurs in several localities.

Along the south side of Sugar Mill creek, east from the mouth of Greene creek, is a precipitous bluff of sandstone and shale with thin seams of coal. In one of the short ravines cutting back into this bluff the coal reaches a thickness of three feet and is mined for local use. The shale here resembles that used for making paving brick. There is considerable sandstone along this bluff which might be used for building stone if it were accessible, but the heavy covering of glacial drift prohibits its use to any great extent.

On the west side of the creek on the northwest quarter of the southeast quarter of Sec. 21 (17 N., 7 W.) is a bold projecting point known as the Pinnacle, which consists of a narrow ridge of the blue-black,

brick shale 40 feet in thickness overlain by a narrow ledge of massive sandstone 10 feet thick. The sandstone might have a local value for bridge stone. The shale is in admirable position for cheap mining and may prove valuable if means of transportation are ever provided.

There is a small outcrop of false-bedded Mansfield stone in the creek bed below the iron bridge in the northeast quarter of Sec. 21 (17 N., 7 W.) and about half a mile above the iron bridge near the middle of Sec. 15 (17 N., 7 W.), on the east side of the creek is a small quarry in Mansfield sandstone. It belongs to Mr. Heath and has been worked to some extent for bridge stone; the abutments for the iron bridge a half mile below were obtained here. A section of the quarry face shows:

Section of Mr. Heath's quarry.

	Feet.
Thinly bedded sandstone	4
Massive yellow sandstone grading into drab shale.....	8
Shale and shaly sandstone	10
Massive gray and brown sandstone	20

North and northwest of Heath's quarry in the northwest quarter of section 15, the southwest quarter of section 10 and the southeast quarter of Sec. 9 (17 N., 7 W.) the Mansfield sandstone outcrops in large quantities, being 75 to 80 feet thick in places. The base of the bluffs consists of gray and yellow sandstone, the upper part is brownstone, which varies in thickness from eight to 25 feet. The colors and texture of the brownstone resemble that at Mansfield, but the structure on the outcrop is not the most promising. In some places it is in thinly stratified layers two or three inches thick, in other places it shows cross grain accompanied by variegated colors. Closer investigation may show some good stone in this locality. Some preliminary work has been done by Hunter and Hollenbach on land leased from Mr. Milligan. One or two drifts were started in the bluff, but only penetrated a few feet, none of them beyond the limits of the thinly laminated stone. There is some good even grained building stone in the gray and yellow stone underlying the red or brownstone, but it could not be quarried in large quantities profitably unless the overlying brownstone should prove valuable enough to be quarried at the same time.

There is considerable shale in and overlying the sandstone in the bluff on the south side of the creek at Russell's old mill in the northeast quarter of Sec. 16 (17 N., 7 W.). A quarter of a mile north of the mill on the east side of the creek the massive gray and buff sandstone outcrops 10 to 20 feet on the banks of the creek and is overlain by 25 to 40 feet of drift.

In the north part of township 17 N., 7 W. in sections 3 and 4 and the north half of sections 9 and 10, no Mansfield sandstone was observed,

but there are exposures of sandstone belonging to a higher horizon accompanied by much black shale and some coal. Coal has been mined in the small ravine that heads near Russell Mills postoffice (Grange Corner) and flows west through the north part of Sec. 10 and in the ravine from the northwest in the north part of Sec. 4 (17 N., 7 W.).

In the southwest quarter of Sec. 34 (18 N., 7 W.) and in Sec. 33 along the small ravine from the northwest, ferruginous yellow sandstone and black shale are exposed, but none of economic value was observed.

The best building stone in this part of the valley is at J. R. Switzer's quarry in the northwest quarter of Sec. 34 (18 N., 7 W.), where several thousand cubic feet of stone have been quarried for foundations in Wallace and vicinity. The stone is gray and yellow, in some places slightly variegated. It is micaceous and splits easily with or at right angles to the grain. A section of the quarry face shows:

Section at Switzer's quarry.

	Feet.
Soil	2 to 4
Thin shelly sandstone	2
Massive gray and yellow sandstone	10
Shelly sandstone	3 to 6

In places the stone contains iron pebbles, but the greater part of the bed is free from impurities. In some places it is underlain by black shale which decays more rapidly than the overlying sandstone, thus causing the sandstone to form overhanging ledges. This stone deserves a more extensive local usage than it has had.

On both sides of Sugar Mill creek in the southeast quarter of Sec. 34 (18 N., 7 W.) is a heavy ledge of coarse ferruginous sandstone underlain by black shale. Some bridge stone might be obtained here, but the greater part of it contains too much segregated iron oxide to have any value.

On the north side of the creek nearly opposite the mouth of Wolf creek is a small isolated exposure of yellow sandstone, known locally as the "Snake Den," from which a small quantity of inferior stone has been taken.

On Wolf creek the sandstone outcrops for nearly three-quarters of a mile from the mouth. At the Wolf creek falls, and for nearly a quarter of a mile above, the stone outcrops in the bed of the creek and in the bluffs on each side, but contains too much iron pyrites and iron oxide to have any commercial value. Near the upper limit of sandstone on Wolf creek in Sec. 2 (17 N., 7 W.) the stone contains less iron than at the falls, is more regularly bedded, and contains much intercalary shale. While there is some good building stone, but little of it is accessible on account of the shale and overlying drift.

Between the mouth of Wolf creek and the Narrows of Sugar Mill creek but very little sandstone is exposed and the little that is has no commercial value.

In a small ravine south of the wagon-road in the southwest quarter of Sec. 25 (18 N., 7 W.), red, yellow, gray, and blue, variegated sandstone has been quarried in small quantities. The record of a drilled well on the north side of the road in the same quarter section gives:

	Feet.
Blue and drab shale ("Soapstone")	35
Variegated red, yellow, and gray sandstone	66 $\frac{2}{3}$

The Narrows on Sugar Mill creek are in the east side of Sec. 25 and the west side of Sec. 26 (18 N., 7 W.) where for about a half mile the creek has cut a narrow channel into the massive sandstone which forms the bottom and sides of the channel. The smooth rock bottom and the regular perpendicular walls resemble an artificial waterway. The stone has a pinkish red color for the most part, but varies to buff and gray in a few places. In many places the stone is cross-grained as shown by a faint banding of colors, but it weathers evenly with a smooth surface and is not ridged as it is in many localities where it is cross-grained. On the east side of the creek near the lower end of the Narrows and also near the upper end a small watercourse has cut a deep channel back for some yards from the main creek exposing some nice sandstone.

While the variegation in color and the patches of cross-grain injure much of this stone, there is a great deal of good building stone and much of it suited for heavy masonry. It would require a closer investigation and some preliminary work to determine whether it could be quarried in large quantities with profit, even if transportation facilities were at hand, which is not the case at present.

On the west side of the creek, nearly a quarter of a mile above the Narrows, is a sandstone quarry where several thousand feet of stone have been extracted. A section of the quarry face shows:

	Feet.
Sand	2
Boulder clay	3
Massive yellow sandstone	12

The sandstone is micaceous and contains numerous seams, many of which are no doubt powder cracks. The stone is inferior in quality to much of that in the Narrows.

No sandstone was observed along Sugar Mill creek above the quarry just described. The valley above Wallace was not traversed, but citizens report that there are no rock outcrops above that village. A drilled well in Wallace is said to have struck rock at a depth of 66 feet. Less

than a quarter of a mile west of Wallace, on the north side of the wagon road, is a magnificent chalybeate spring which emerges from a slope of glacial drift.

Turkey Run and vicinity.—Along Sugar creek between the mouth of Sugar Mill creek and Turkey run sandstone outcrops in a number of places, but it is of inferior quality for building purposes. Through the south part of Sec. 28 (17 N., 7 W.) are some bold bluffs of Mansfield sandstone, which contains much iron oxide and false bedding.

Turkey run has cut a narrow, winding channel through the Mansfield sandstone 40 to 60 feet deep with nearly perpendicular and, in places, overhanging bluffs on either side. The stone is yellow and gray in color and contains numerous streaks and patches of iron oxide. While stone for heavy masonry might be obtained here, it is doubtful if first-class building stone could be obtained in paying quantities. The same is true of the stone along Sugar creek between Turkey run and Rock Hollow in a less degree, as in some places along the north side of the creek there are patches of considerable extent which appear to be free from the iron blotches. Mr. Hooghkerk reports that in drilling the well at the Turkey run hotel the drill passed through:

Well section at Turkey Run.

	Feet.
Gravel and sand	31
Sandstone (Mansfield)	30
Limestone	2
Sandstone, white, fine-grained (Riverside)	30
Total.....	93

The limestone is supposed to be Lower Carboniferous and the sandstone overlying it the Mansfield sandstone.

The sandstone in the vicinity of Turkey run has been deeply scored by the glacier, the sand that has been scraped off being distributed over the region to the south. Glacial striæ bearing south, 37 degrees east, are clearly shown in two places: one about a quarter mile east of the hotel, the other more than a half mile east. This glacial action has scraped off all the disintegrated material from the top of the sandstone, if any such ever existed, and the fine state of preservation of the striæ shows that there has been no disintegration of the stone at these points since that date, probably several thousand years ago, surely a strong proof of the durability of the stone.

Rocky Hollow.—Rocky Hollow, which lies mostly in the northwest quarter of Sec. 27 (17 N., 7. W.), is a deep narrow gorge cut into the massive Mansfield sandstone. The walls are so high and precipitous that the gorge can be entered only at the mouth and at the head of a few of the terminal ravines, many of which are cut down so abruptly at the

terminus as to be practically inaccessible. No part of the gorge can be traversed except in time of low water. While much of the stone along the bluffs is cross-bedded and ferruginous, in a number of places it is free from imperfections and would furnish good buff and gray building stone, should it ever be made accessible to transportation. This deep winding rocky gorge, with its precipitous overhanging moss-grown walls, is a romantic spot and attracts a great many tourists during the summer months.

On the south side of Sugar creek, opposite and above the mouth of Rocky Hollow, large quantities of buff and gray sandstone are exposed, some of which is good building stone. A promising exposure is that in the small ravine on the south side of the creek about a quarter of a mile or a little more below the bridge at the Narrows, where there is a thickness of ten feet of flagstone on the top, underlain by 30 feet or more of massive gray sandstone. Southeast from the above ravine, about 200 yards, the flagstone increases in thickness to 15 feet or more.

Flagstone quarry.—Mr. W. B. Hooghkerk opened a flagstone quarry here in 1880 and operated it for three years. Most of the product was used for flag and curb stone in Rockville, this county, and about Tuscaloosa, Ill. Probably 20,000 cubic feet or more were taken out of this quarry. The opening is about 100 feet long, 12 feet deep and quarried back 20 to 30 feet into the bluff. The stone lies in quite regular layers one to six inches thick, the upper layers being thinner than the bottom ones. The layers are in many places separated by thin films of clay or shale, which makes a separation of the flags an easy matter. The stone is not as durable as much of the Mansfield sandstone, owing to the abundance of mica and carbonaceous matter, yet the flags that have been lying in the quarry for 12 years or more show little signs of decay. If the stone was properly quarried and seasoned it would no doubt prove as durable as much of the stone in general use.

East from the quarry the flagstone grades into black shale, which outcrops in great quantities in the ravine between the quarry and the Narrows.

The Narrows of Sugar Creek.—At the Narrows in the northwest quarter of Sec. 26 and the northeast quarter of Sec. 27 (17 N., 7 W.) Sugar creek has cut a narrow channel through the Mansfield sandstone for about a quarter of a mile. The channel is twenty to thirty feet deep and sixty to one hundred feet across. The prevailing color is gray with patches of yellow. The bluffs contain many irregular hollows and rounded prominences, showing lack of homogeneity. The hard, indurated surface and the bold cliffs which have long been exposed to the rapid currents of Sugar creek rushing through this narrow channel show the stone to be very durable, and to resist abrasion much better than one would expect from its friable nature. It would make a good bridge

stone, but is not sufficiently homogeneous in either color or texture for good dimension stone. The bridge across Sugar creek is placed on the natural rock abutments.

A hundred yards or more below the bridge a thinly bedded sandstone overlies the massive sandstone. Above the bridge the massive sandstone extends only a few hundred yards, where it is replaced by the overlying shale, thin-bedded sandstone, coal, and fire clay. The black shale occurs in a bed fifty to eighty feet thick for more than a mile above the Narrows on the main Sugar creek and on Brush creek tributary from the north, and the Fullwater branch from the southeast. It contains intercalary sandstone, coal and fire-clay, the coal in some places reaching a thickness of 12 inches.

The lower course of *Brush creek* is mainly in black and drab-colored shale, which contains some sandstone and sandy layers. The middle course is mainly through drift-covered slopes with no rock exposures. The upper part of the creek was not examined, but is said to contain some shelly sandstone of no commercial importance.

The bluffs on the lower part of *Fullwater branch* for half a mile or more from Sugar creek are mostly black shale, with some coal and fire-clay. In the east side of the southeast quarter of Sec. 26 (17 N., 7 W.) the shale is in part replaced by heavy bedded sandstone. The sandstone occurs as a lenticular mass in the shale bed. It has a maximum thickness of twenty feet, is evenly bedded, somewhat micaceous, comparatively homogeneous and durable. Great massive boulders of it have tumbled into the watercourse and almost obstructed the channel. It is underlain by a thin streak of cannel coal, gray shale, and shaly sandstone. Good stone for local use could be obtained from these large boulders and exposed ledges at this locality, but the thickness of the overlying shale and drift prevent its being quarried in large quantities.

Near the upper limit of the sandstone ledge is an outcrop of black limestone three to five feet thick, in layers 10 to 20 inches thick. It occurs in the black shale, with shale both above and below it. Fine black marble might be obtained from this limestone, but it is doubtful if it could be economically quarried in large quantities.

Sugar Creek, between Keller Branch and the Shades of Death.—On the lower course of Keller branch and along Sugar creek for half a mile or more, the black shale outcrops in large quantities, underlain in places by false-bedded ferruginous sandstone. The black shale outcrops for a half mile above Keller branch where it is replaced by the Mansfield sandstone which, beginning in the northeast quarter of Sec. 24 (17 N., 7 W.), forms almost continuous bluffs on one or both sides of Sugar creek up to the Shades of Death in Sec. 11 (17 N., 6 W.), in some places at the bottom of the valley, in others near the tops of the hills.

In the southeast quarter of Sec. 13 (17 N., 7 W.) and extending into the southwest quarter of Sec. 18 (17 N., 6 W.) is a bold cliff of massive Mansfield sandstone, which is one of the thickest deposits of this stone in the State. At the sulphur spring north of Mr. Durham's house the outcrop measures 80 feet in thickness (Barometer), and a quarter of a mile northeast it measures 100 feet. In both places the stone extends below the bottom of the creek, and there are no wells nor borings to show its depth. The glacier has scraped the top of it, not telling how much, so that 80 or 100 feet marks only part of the present thickness, and a smaller part of the original thickness. Unfortunately the quality is not equal to the quantity, as it contains some false bedding and patches of segregated iron oxide with much iron pyrites near the base. However, there is much good durable building stone well adapted to heavy masonry, and no doubt much gray and buff building stone of good quality could be obtained here. Whether it could be profitably quarried in large quantities would require closer investigation. Near the base of this bluff, in the vicinity of Mr. Durham's sulphur spring, there is considerable conglomerate made up of white quartz pebbles about the size of a pea, in a matrix of yellow and gray sandstone. It varies in thickness from 2 to 20 feet. In places it is banded—layers of pebbles separated by layers of sand.

Two prominent remnants of the deep erosion in this sandstone stand on the north side of the creek opposite this high bluff, and consist of table rocks, one about 20 feet and the other 50 or 60 feet high. They have abrupt faces on the creek side, and steep but less abrupt slopes on the opposite side. The stone is too cross-grained and ferruginous to have any value.

There is evidence that in a former stage of its history Sugar creek was one-quarter to one-half mile south of these bluffs, and ran close to the southwest corner of Sec. 18 (17 N., 6 W.). East of this former channel in the northwest quarter of Sec. 19, and the S. W. quarter of Sec. 18 (17 N., 6 W.) the massive Mansfield sandstone outcrops over an area of several acres. In one place on the roadside in the N. W. quarter of Sec. 19, it shows glacial striæ running south 45 degrees west. A well drilled near the middle of the N. W. quarter of Sec. 19 is said to have passed through soil and drift 27 feet, and penetrated 46 feet into the yellow sandstone.

In the small tributary from the southeast in the south part of Sec. 18, and extending into sections 19 and 20, are extensive outcrops of shelly, and cross bedded, yellow sandstone. Where the wagon road crosses the branch in the southwest quarter of Sec. 18 (17 N., 6 W.) there are large quantities of black shale, which grades into sandstone both up and down the branch from this point.

On Sugar creek, a short distance above the mouth of the tributary mentioned, near the middle of Sec. 18 (17 N., 6 W.), the Lower Carboniferous limestone appears in the bottom of the valley and rapidly rises on the hillside in ascending the creek, within a half mile, reaching a height of 60 or 70 feet above the bottom of the valley. Most of the limestone has a blue-gray color, but in some places it is reddish-brown. Certain layers are highly fossiliferous. In a small ravine on the east side of the creek, about 100 yards east of the wagon road, near the northeast corner of Sec. 18 (17 N., 6 W.) is a nearly perpendicular bluff of limestone and drab-colored shaly sandstone. The limestone immediately overlying the fine-grained sandstone, contains great numbers of geodes, consisting of an opalized quartz crust lined with white and limpid quartz crystals.

On the west side of the creek, in the southeast quarter of Sec. 7 (17 N., 6 W.), about a quarter of a mile below the new iron bridge, a small watercourse has cut a channel back 100 yards or more from the creek, forming a deep and picturesque ravine. A section in this gorge shows the following strata:

Section on Sugar Creek, southeast quarter of Sec. 7 (17 N., 6 W.).

	Feet.
Massive Mansfield sandstone.....	40
Hard calcareous shale	10
Shelly limestone, fossiliferous	25
Geodic limestone	15
Shelly limestone	10
Blue-gray shaly sandstone.....	5

The limestone decays more rapidly than the Mansfield stone, and thus undermines the latter, until by its own weight the overhanging mass breaks off, tumbling in immense boulders into the ravine and leaving a smooth, perpendicular face. Over this perpendicular face the water rushes in time of a freshet, forming a cascade 50 feet or more in height. While good building stone occurs in these picturesque bluffs it is inaccessible.

The accompanying figure (Fig. 3) shows at the left a section across this gorge a short distance below the waterfall. The right side of the figure is a section of the bluff on the north side of Sugar creek about 200 yards above the falls.



Fig. 3. Section on Sugar creek, northeast corner of Parke county, Ind.

- b*—Lower Carboniferous limestone.
- c*—Massive Mansfield sandstone.
- f*—Glacial drift.

On Sugar creek, less than a quarter of a mile above this waterfall, the limestone horizon is beneath the creek level, and the Mansfield sandstone again forms the bottom of the valley. This disappearance of the limestone is not due to a sharp dip in the strata, but to the erosion of the limestone before the sandstone was deposited upon it.

At the iron bridge in the southwest quarter of Sec. 8 (17 N., 6 W.) the sandstone has been quarried in small quantities on each side of the creek, and also a hundred yards above the bridge on the north side. The stone is well suited for bridges and foundations, being strong, durable and easily wrought.

Large quantities of sandstone and shale are exposed in the ravine from the southeast just above the bridge, but the sandstone is of inferior quality.

Above the bridge, on the north side of the creek, through Sec. 8 (17 N., 6 W.), heavy ledges of evenly bedded, smooth faced sandstone occur in the bluffs. In some places it contains patches of conglomerate, consisting of small quartz pebbles, yet in most places this stone would furnish a good building and bridge stone. Through the middle of Sec. 8 the Lower Carboniferous limestone is exposed at the base of the bluffs for a quarter of a mile or more, and sinks below the bottom of the valley just below the mouth of the ravine from the east, in the northeast quarter of Sec. 8. It almost immediately reappears and the outcrop is then almost continuous at varying heights along the bluffs up to and beyond the Shades of Death, while the Mansfield sandstone and accompanying shale and conglomerate in a bed of variable thickness form the upper part of the bluffs, overlain in most places by more or less glacial drift. Building stone of good quality occurs at different places along this part of the creek in sections 5, 4, and 3 (17 N., 6 W.). The outcrop on the hill northeast of the mill in the southeast quarter of Sec. 5 (17 N., 6 W.) shows forty feet of Lower Carboniferous, drab-colored, shaly sandstone at the base, with two intercalated beds of limestone two to four feet thick, and overlain by twenty-five feet of massive Mansfield sandstone.

Shades of Death.—The picturesque summer resort known as the Shades of Death, in the northwest quarter of Sec. 11 (17 N., 6 W.), is very near the upper (eastern) limit of the Mansfield sandstone horizon in the Sugar creek basin. A section of the strata from the hotel to the creek, based on barometric measurements, shows:

Section at the Shades of Death.

	Feet.
Glacial drift.....	50
Massive yellow Mansfield sandstone.....	40
Lower Carboniferous shaly sandstone and limestone.....	80
Total.....	170

The prevailing color of the Mansfield sandstone is yellow to yellow-brown, being variegated with lighter and darker streaks in many places. It has a coarse-grained, open, porous texture, with considerable segregated iron oxide in many places, and much pyrite near the base.

Emerging near the base of the Mansfield sandstone in the ravine at the hotel, there are several chalybeate springs, the water from which forms a beautiful little cataract over the Lower Carboniferous rocks below the springs.

The Mansfield sandstone occurs in a massive bed 40 feet thick in this ravine above the falls, but contains much segregated iron oxide and false bedding. At the high bluff on the cliff overlooking Sugar creek it occurs as a fine conglomerate, the separate pebbles being about the size of wheat grains. It is quite durable, but the cross grain would interfere with working it, and the variegated color would spoil its value for building stone.

On the north side of Sugar creek, opposite the Shades of Death, the sandstone occurs in as heavy a deposit as on the south side, but the slopes are more retreating, and in many places the sandstone is covered with soil and drift. Stone for local use may be obtained in this locality, but the outcrops do not suggest a desirable dimension stone where uniformity of color and texture are required.

The Lower Carboniferous, drab-colored sandstone (Riverside) here is quite shelly on the surface, but in the interior is more or less massive as evidenced by the fresher exposures on the overhanging creek bluffs. It forms bold massive cliffs on Indian creek in sections 7 and 12 (17 N., 6 W.). The cliff at "Devil's Backbone," at the mouth of Indian creek, is 100 feet high (barometer), all of this being drab-colored sandstone. In many places this rock contains iron pyrites in considerable quantity, and is more or less shelly on all the exposures observed. Closer investigation might show areas of fairly good building stone in this formation, but it will in no place be as durable as the Mansfield stone. It contains two or more layers of limestone, varying from a few inches to six or eight feet in thickness.

The valley was not explored above Indian creek, and if the irregularities between the Lower and Upper Carboniferous formations are as great as they are down the creek there may be isolated exposures of the Mansfield sandstone above this point. None were reported.

COAL CREEK BASIN.

The Mansfield sandstone outcrops on all the large tributaries of Coal creek, viz, East fork, Dry run, Turkey run, and North fork, the largest and best exposures being on the East fork, but even there it is inferior in quality to stone both north and south of this valley.

The part of Coal creek below Veedersburg was not explored, as it runs through the productive Coal Measures. Sandstone is reported in several places, but none of any value for building purposes.

East Fork of Coal Creek.—The only outcrop of Mansfield sandstone on Coal creek below its confluence with the East fork is in the north part of Sec. 13 (19 N., 8 W.), a mile southwest of Veedersburg at the wagon bridge below the mill, where it is exposed in the bottom of the creek. It contains too much iron pyrites and false bedding to have any economic value, even if it were above the water-level.

There are some large beds of shale on the East fork of Coal creek in Secs. 8, 17, 15, and 16 (19 N., 7 W.). The largest bluff is on the north side of the creek in the northwest quarter of Sec. 17 (19 N., 7 W.), where there is an almost vertical bluff of 35 to 40 feet of shale overlain by 10 or 12 feet of gravel.*

The first outcrop of the Mansfield sandstone observed in ascending the East fork of Coal creek is in the east side of Sec. 17 (19 N., 7 W.) at the bridge below the old mill, where it is exposed in the bottom of the creek and in the creek bank, is very false bedded and pyritiferous, overlain by a more evenly bedded coarse-grained, buff to bluish drab-colored sandstone, with intercalary shale. This overlying sandstone has been quarried to considerable extent on the north side of the road at the mill on the property of Mr. Frank Coates. During the past five years there has been more than 40,000 cubic feet of stone taken out of this quarry. It has had a local use for many years, the foundation of the mill having been taken from it sixty years ago. The separate layers of the stone vary from one inch to 30 inches in thickness, the upper layers being thinnest. In the interior of the bed, as shown in the bottom of the quarry, the rock has a blue gray color, which weathers to a yellow gray as shown at the top of the quarry. The stone will probably never have more than a local use.

There are other small sandstone quarries on the south side of the creek a quarter of a mile west of the mill, where the stone occurs in heavier layers than at the mill, but the layers are not continuous, grading rapidly into shale. The intercalary shale at both places contains much iron pyrites, which on the weathered surface in places stains both the shale and the sandstone a yellow and yellow-brown color.

* For particulars on the shale deposits, see the accompanying report on the clays and shales by the State Geologist.

Near the middle of the east side of section 16 (19 N., 7 W.) is another small exposure of the Mansfield sandstone in the creek. There are larger exposures on Clifty creek, a small tributary from the south, in the west part of section 15 (19 N., 7 W.). Near the upper (south) limit of the sandstone on Clifty it weathers into thin, shaly layers, north of which it occurs in a massive bed, ten feet exposed, weathering very irregularly.

At the confluence of Clifty creek with the East Fork, there is an unconformity in the strata, shown by the black and drab shale resting against the sandstone and conglomerate with discordance in bedding.

There is a fine exposure of the dove-colored shale at this point, but the sandstone has no economic value. A few layers near the base of the cliff contain some good stone, but are overlain by too much waste material to have any commercial value.

In the southwest quarter of section 10 (19 N., 7 W.) are bold bluffs of sandstone 30 to 40 feet high and variegated in color, being dark brown and yellow to yellow-brown. There is some nice looking brownstone in the bluff on the south side of the creek, but it is overlain by a great quantity of loose, shaly material, so that it is practically inaccessible.

The sandstone outcrops in a small ravine on each side of the Veedersburg-Hillsboro road in the northeast quarter of section 10 (19 N., 7 W.), but has not been used.

There has been a small quantity of imperfect sandstone quarried on the south side of the wagon road in the northwest quarter of section 11 (19 N., 7 W.). The stone is brown with many gray patches and numerous iron secretions.

The outcrop of sandstone is almost continuous on both sides of the creek from the middle of Sec. 11 (19 N., 7 W.) up to and beyond Hillsboro, near the middle of section 12. It has been quarried on both sides of the creek. On the north side of the road, one-fourth mile west of Hillsboro, a section of the quarry face shows:

Section west of Hillsboro.

	Feet.
Soil	1
Shale	3
Shelly sandstone	3 to 10
Yellow-gray sandstone	12

There has been probably 8,000 cubic feet of stone taken from the lower yellow-gray sandstone.

On the south side of the creek the stone has been quarried on the face of the bluff for 200 yards or more through the west side of section 12 and the east side of section 11 (19 N., 7 W.), about half a mile west of Hillsboro, where the stone is quite variegated in color, much of it being either yellow or light gray, and containing patches of bright red and brown. It

is overlain by a heavy bed of drift, so that the quarries are confined to within a few feet of the face of the bluff.

The largest quarries at *Hillsboro*, in fact the largest in the Coal Creek basin, are south and southeast of the town, and lie along a small tributary from the southeast, which joins the main creek close to the middle of Sec. 12 (19 N., 7 W.), the quarries extending for a quarter of a mile above the confluence. There are a number of quarries along this branch which have been worked at different times, 100,000 cubic feet or more in all having been removed. They were formerly owned by Mr. L. K. Stevens, but were sold to different parties. Mr. Wineberg, Mr. Connell and Mr. N. R. Harlan took out stone at different places. Mr. Clarence W. Moore, of Chicago, Ill., now (July, 1895) is said to own the quarry on the west side of the branch, nearest the town. The others belong to the Hillsboro Brownstone Company.*

Considerable stone has been shipped from Hillsboro and from the present appearance of the openings much good stone has been obtained, but it must have been at considerable expense, owing to the amount of waste material to be handled. Besides the glacial drift overlying the sandstone there are shaly and shelly patches of worthless stone diffused through the bed, and occasionally patches of segregated iron oxide, or "iron blisters." The patches of shale and shelly stone in the body of sandstone are a more uncertain quantity than the overlying glacial drift and soil, as they are liable to occur at any time and at any place in the body of the stone. In the lower quarry, the one nearest the town, the stone is largely brownstone, but red, gray and yellow patches occur merging into one another. Where the greatest proportion of the stone is brown there the most iron kidneys occur. This opening is about 75 yards long and has been quarried back 20 or 25 feet into the bluff.

At the brickyard on the east side of the branch opposite the quarry above mentioned, the stone has been quarried a very little, and so far as exposed it is very shelly and broken. Eighty yards southeast of the brickyard on the east side of the branch some good brownstone is exposed, but it is overlain by 20 to 30 feet of shale, iron ore, fire-clay, and shelly sandstone. A well back from the face of this bluff is said to be through 20 feet of drift and loose rock to the sandstone, and to have penetrated 17 feet into the brownstone. About a quarter of a mile above (southeast of) the brickyard, on the east side of the branch, there is an exposure of four feet of handsome brownstone at the bottom of the quarry, and Mr. Harlan reports that they drilled through six feet more of the same color, thus making at least 10 feet of brownstone at this point. While it is the most uniform and best appearing stone in any of the quarries, it is unfortunately overlain by 20 feet or more of waste material

*The historical information was furnished by Mr. Nathan R. Harlan, Hillsboro, Indiana.

Along the west side of the branch above the brickyard, the stone is more variegated in color, considerable yellow and buff-colored stone occurring, and in one opening the stone is tinged with pink, approaching the color of a peach blossom. About 150 yards above the upper quarry opening is an outcrop of good yellow sandstone, four feet thick, with very little stripping.

The sandstone extends up this ravine for more than a mile, to near the middle of the east side of Sec. 13 (19 N., 7 W.), but above the quarry openings mentioned it has little or no economic value, being mostly shelly and containing streaks of shale. In the southeast of the northeast of Sec. 13 (19 N., 7 W.), is an outcrop of shale conglomerate, which is near the upper limit of the sandstone in this ravine.

Along the small ravine that flows through Hillsboro sandstone outcrops at various points from the mouth to north of the railroad in the southeast quarter of Sec. 1 (19 N., 7 W.), but none that promises to be of more than local value.

While there is much stone and much good stone in the vicinity of Hillsboro, it is unfortunately overlain by a considerable thickness of glacial drift and shelly sandstone, besides considerable waste material in the bed, such as patches of shale and stone with seams, so that it can not be worked with profit unless the overlying materials can be, in part at least, utilized at the same time. The Hillsboro Brownstone Company has attempted this by making pressed brick out of the overlying clay. While handsome brick are obtained, unfortunately the stone at this point is of inferior quality.

The sandstone outcrops in a number of places for two miles or more above (east of) Hillsboro along the bluffs of Coal creek. Where the road on the range line between Sec. 7 (19 N., 6 W.) and Sec. 12 (19 N., 7 W.) crosses the creek the sandstone outcrops on each side of the creek on both sides of the road. About fifty yards east of the road on the north side of the creek the sandstone, which is light gray in color and of inferior quality, has been quarried to a slight extent. That on the west side of the road is not so shelly nor so cross-grained, and does not have so many seams. East of the road on the south side of the creek the stone is more shelly than on the north side; but up the creek about 150 yards from the bridge, at Daniel Pickering's quarry, there are 12 to 15 feet of evenly bedded gray sandstone in layers 10 to 30 inches thick, which splits and works nicely and makes a good building stone. The upper part of the bed is a conglomerate made up of white quartz pebbles and is overlain by shale and sand. About 200 yards west of the road on the south side of the creek, just below the mouth of a small ravine from the southeast, is another quarry opening larger than either of the above, in which the stone is light gray with yellow spots and streaks and is overlain by shale and sandstone. It has been quarried for 100

yards or more along the bluff 8 to 10 feet deep and 15 to 20 feet back into the bluff where the stripping becomes too heavy to permit further work with profit.

On the east side of Sec. 7 and the northwest quarter of Sec. 8 (19 N., 6 W.) along a small ravine from east of north, considerable brownstone is exposed. This stone has a beautiful purple and brown color and good texture, but is structurally very imperfect, being thin bedded to shaly on all the exposures. If it could be obtained free from the numerous bedding seams it would make a splendid building stone. If these seams are due wholly to weathering they may disappear back from the surface of the bluff, and if so, the stone might be quarried where the drift material is not too heavy; if, however, the seams are due wholly to the character of the deposition they will extend throughout the bed. This could be determined in large measure by the diamond core drill at no great expense.

In the southwest quarter of Sec. 8 (19 N., 6 W.) on the south side of the creek, the brownstone is heavier bedded, in layers two to ten feet thick, and contains some cross-bedding and patches of shale. The most serious drawback at this point is the large quantity of glacial drift overlying, which is six to ten feet thick on the face of the bluff and thicker back from the bluff.

In the southeast quarter of the southwest quarter of Sec. 8 (19 N., 6 W.), at Jesse Brant's, the sandstone has a light gray color, medium fine grain, and can be dressed easily to a smooth even surface. It has been quarried for local use in bridges, foundations, etc., for 25 years, probably 10,000 cubic feet in all. All the loose stone has been planed off by the glacier, the upper surface of the stone being level and marked by glacial striæ running south 20° west. The same phenomenon was observed in Mr. Brant's well, 100 yards or so back from the bluff, which is 95 feet deep, passes through 12 feet of drift and penetrates 83 feet into sandstone. A well on the south side of the creek at this point 90 feet deep passes through 12 feet of drift and penetrates 78 feet into the gray and red sandstone, the bottom being red.

There is no sandstone of any economic value on this branch of Coal creek above the section line on the south side of Sec. 8 (19 N., 6 W.). There are a few exposures of shelly sandstone and shale as far as Cold Spring mill in the west part of Sec. 16 (19 N., 6 W.). The underlying Lower Carboniferous limestone outcrops on Hannah's Fork in the northeast quarter of Sec. 17 and the southeast quarter of Sec. 8 (19 N., 6 W.), where it is very fossiliferous.

Dry Run, tributary of Coal creek.—No sandstone of any value outcrops on Coal creek between the mouth of the East Fork and the mouth of

Dry Run. Small quantities occur associated with the shale beds at the brick works south of Veedersburg.*

There is only one outcrop of sandstone on Dry run, and that is southeast of Mr. Voorhees' house, at the schoolhouse in the northwest quarter of Sec. 33 (20 N., 7 W.). This stone has been quarried for local use on the north side of the creek, near the schoolhouse, where there is about 20 feet of sandstone exposed, light gray, with yellow and brown streaks, brownish-yellow and some red-brown in color. The bottom of the bed is thinly stratified, while in the upper part of the quarry it is massive and is overlain by sand and gravel. The stone outcrops for 100 yards or more, north of the quarry, along the small ravine from the north, and for nearly a quarter of a mile both up and down the creek from the quarry.

The valley and slopes of Dry run, both above and below this exposure, are covered with a variable thickness of glacial drift. A well in the south part of the northeast quarter of Sec. 28 (20 N., 7 W.) went through 100 feet of drift and penetrated 65 feet into the sandstone without passing through it.

Coal Creek above Dry Run.—Between the mouth of Dry run and Stone Bluff there are several outcrops of shale and coal. About one mile north of Veedersburg and west of the C. & I. C. Railway, on a small tributary of Coal creek from the west, in Sec. 31 (20 N., 7 W.) the shale has been quarried for use in the brick works at Veedersburg and coal has been mined at the same place.

In the southwest quarter of Sec. 19 (20 N., 7 W.) on the west side of the creek are large exposures of black shale associated with some coal, and in places containing a great many fossil coal plants, *sigillaria*, *calamites*, and fern leaves. Coal was at one time shipped from here and is now quarried to some extent for local use; the bed varies from 18 to 30 inches thick. About 200 yards southwest of the coal bank is a small outcrop of massive yellow sandstone in a small ravine from the west, which has been quarried a little for local use.

Stone has been quarried on Mr. Remster's place in the southwest quarter of Sec. 29 (20 N., 7 W.), just east of the Veedersburg-Attica road. The stone occurs in layers two to 12 inches thick and has been quarried to a depth of three feet. It is micaceous, evenly bedded, with thin streaks of blue shale between the layers.

The sandstone outcrops on both sides of the wagon road in the west side of Sec. 20 and the east side of Sec. 19 (20 N., 7 W.). West of the road the stone is exposed 15 to 20 feet, is of a light gray color, massive and has some false bedding.

*See the report of the State Geologist for description of the shale and clay deposits of this vicinity.

At the grist mill at Stone Bluff there is an outcrop of 12 to 15 feet of thinly stratified, medium grained white and yellow sandstone underlain by a blue shale. A similar stone is exposed in the creek above the mill. At the mill-dam and extending below it to where the wagon road crosses the creek is an outcrop of the Mansfield sandstone, yellow and gray, coarse-grained, false bedded, and overlain by fire-clay and thinly stratified sandstone. In a small ravine from north of west below the mill-dam the sandstone is exposed and contains a lenticular mass of blue drab shale.

About a mile north of Stone Bluff, along the railroad at the section line on the north side of Sec. 18 (20 N., 7 W.), is a small outcrop of massive yellow sandstone that was quarried for use in the abutments of the bridge at Stone Bluff.

Nearly two miles northeast of Stone Bluff, at the middle of the west half of Sec. 8 (20 N., 7 W.), sandstone has been quarried for use in bridges and foundations. The stone here is yellow-brown and light gray, the yellow predominating, and contains numerous mica scales in places. Over an area of several acres the stone has a very light covering of drift, and well sections show the rock to be of considerable thickness. A well near the quarry shows:

	Feet.
Soil and drift	7
Sandstone.....	60

A well a quarter of a mile west of the quarry shows:

	Feet.
Soil and drift	4
Sandstone	38

A well a half mile southwest of the quarry shows:

	Feet.
Soil and drift	5
Sandstone and shale	75
"Hard rock" (quartz conglomerate?)	5
Fire-clay	16
Sandstone.....	3

There is evidently an amount of from 50 to 70 feet of sandstone in this locality, and should it all or a large part of it prove suitable for building purposes it might prove to be a valuable deposit, as it is only three-quarters of a mile from the railroad; in fact the stone extends to the railroad, to the quarry mentioned above. The stripping is not heavy, being only four, five and seven feet in the well sections. A few cores taken out over the area would indicate in a general way the character of the stone through the bed. It is from surface indications one of the most promising localities in the Coal creek basin.

Soft yellow sandstone outcrops along Coal creek in the southwest quarter of Sec. 4, and along the west side of Sec. 10 (20 N., 7 W.), but it has no economic value.

On Turkey run a soft yellow sandstone outcrops in Secs. 8, 9, and 16 (20 N., 7 W.), but it has no economic value. In the northeast quarter of Sec. 16 is an outcrop of arenaceous shale, and near the half-mile line on the east side of Sec. 16 (20 N., 7 W) is an outcrop of Lower Carboniferous (Riverside) sandstone and shale.

SOUTHEAST SIDE OF THE WABASH RIVER ABOVE COAL CREEK.

On the east or south side of the Wabash river, above the mouth of Coal creek, there is a great deal of sandstone, exposed both Carboniferous and Lower Carboniferous. Extending to a few miles above Covington, the stone belongs to the Middle Coal Measures; from that point to a short distance above Attica, the base of the Coal Measures, or the Mansfield sandstone predominates, and thence to and beyond the eastern border of the map sheet the Lower Carboniferous (Riverside) sandstone and shale occur. Good building stone occurs and has been quarried in each of these three formations.

Cayuga Pressed Brick and Coal Mining Company's Quarry.—About three miles northeast of Cayuga on the east side of the Wabash river in the southwest quarter of Sec. 27 (18 N., 9 W.), is a large sandstone quarry belonging to the Cayuga Pressed Brick and Coal Mining Company. The quarry was opened in 1888 and continued in operation until the fall of 1892, during which time between 3,000 and 4,000 carloads of stone were shipped to Terre Haute, Ind., Chicago and Danville, Ill., and local points.* No stone has been quarried since 1892.

The stone belongs in the Coal Measures at a horizon above that of the Mansfield sandstone, and on the quarry face has an exposure of 35 to 40 feet of stone, overlain by 15 to 20 feet of gravel, the base being concealed. The upper four to six feet of the stone is very shelly and contains patches of shale. There are irregular streaks of shale and cross-grain structure scattered through the bed, the shale being most abundant at the south end of the quarry. There is much iron pyrites in places sufficient to give a yellow color to the stone, and many iron kidneys in places along the bedding. There is one hard calcareous layer in places near the north end of the quarry, but it is not continuous. The stone is micaceous throughout and has a blue-gray color, due in part to the diffused pyrites and in part to carbonaceous material. The present quarry face shows seven channel cuts with possibly one other concealed by the debris in the quarry. The 15 to 20 feet of gravel, which overlies the

*Information by Mr. Decker.

sandstone, is excellent ballast, and the company is now engaged in shipping it for that purpose, which will thus uncover an area of fresh stone. It is doubtful, however, if the stone can be quarried with profit after the gravel is removed, owing to the large quantity of waste rock in the body of the stone, and the lack of durability in the stone itself. The abundance of iron pyrites and the shaly streaks are objectionable features to its use for building stone.

Coal has been mined along the river bluff south of the quarry, and a new mine has recently been opened east of the quarry and west of the old canal bed. Heavy beds of shale are exposed along the river bluff between the quarry and the railroad bridge. Near the east end of the railroad bridge is an extensive gravel deposit, from which large quantities of gravel have been shipped.

Beard, Platt & Kimbrell's Quarry.—On the east side of the Wabash river, in a small ravine from the east, and one and one-half miles above Perrysville, in 19 N., 9 W., the south part of section 23, Beard, Platt & Kimbrell, of Danville, Ill., have opened a sandstone quarry, but have not shipped any stone. A section of the bluff shows:

	Feet.
Intercalated mud-colored shale and sandstone.....	12
Coarse gray sandstone, with thin streaks and flakes of coal.....	8
Clayey layer.....	$\frac{1}{2}$
Red, variegated and speckled gray sandstone.....	10
Hard calcareous layer not continuous.....	1
Gray and red-brown variegated sandstone.....	10
Light gray to bluish gray.....	12+

It will be noticed that the good stone is in the bottom of the quarry and is overlain by a great thickness of poor and worthless material that would not pay for the handling. There is a great deal of stone exposed at this point, and while much of it is imperfect some of it may prove valuable.

In the bluff to the northeast the best stone is at or near the top of the bluff, and, while the stone is not so fine in color and grain as that in the quarry opening, it possesses the merit of being accessible.

The stone down the ravine from the quarry opening contains much iron oxide and lacks homogeneity.

On Mr. Lewbetter's place, in Sec. 26 (19 N., 9 W.), south of the quarry described above, large quantities of sandstone are exposed, in places 50 to 60 feet thick, the most promising looking stone being that on top of the bluff north of the chalybeate spring, where about eight or ten feet of the top of the bluff has a soft gray color, even grain, soft in the interior and hard on the exposed surface, occurring in layers two to

three feet thick. The lower part of the bluff consists of yellow ferruginous sandstone with traces of coal.

The Glen.—Considerable sandstone has been quarried for local use at the Glen on Mr. John Rhode's place in the south part of Sec. 14 (19 N., 9 W.). A section of the quarry face at the largest quarry opening shows:

<i>Section at the Glen Quarry, South of Covington.</i>		Feet.
Soil and clay with sandstone boulders.....	2	
Shelly sandstone with many seams and patches of shale and clay.....	15	
Brownstone.....	12	
Gray sandstone with yellow-brown stripes.....	8	
Gray sandstone with patches of coal and pyrites.....	6	

The brownstone is comparatively uniform in color, but contains numerous iron kidneys, which injure it greatly for building stone.

Down the ravine (west) 75 yards from the above quarry and on the south side of the ravine is another opening in the sandstone from which gray and yellow stone has been taken. The stone is evenly bedded, uniform in grain and texture, but not in color, and would make a good bridge stone. There is a nice looking building stone on the north side of the ravine near the mouth.

Covington.—No sandstone is quarried at Covington. The quarry northwest of the town on the west side of the river is described on a subsequent page. There is an exposure of a few feet of coarse-grained shelly sandstone on the east bank of the Wabash river at Covington, between the wagon bridge and the railroad bridge, the peculiar grain and texture of which are suggestive of the Mansfield sandstone, but there is not sufficient stratigraphic evidence to so classify it at present and it is designated with the unclassified Coal Measures on the map. A finer grained ferruginous sandstone of different character outcrops near the wagon bridge.

Southwest of Portland.—Along the immediate river bluff southwest of Portland (Fountain postoffice) in section 6 (20 N., 8 W.) the massive Mansfield sandstone is exposed 15 to 20 feet thick, light brown in color and containing iron secretions. The heavy covering of drift material (15 to 20 feet) would prevent the economic production of the stone.

Along a small ravine from the southeast in the northeast quarter of section 7 and the northwest quarter of section 8 is an outcrop of buff and yellow sandstone belonging to a horizon above that of the Mansfield stone. It occurs in evenly bedded layers three to four inches thick, with some intermingled shale and shaly sandstone. The rock is soft when first quarried and contains a great quantity of mica. There are several thin layers of hard calcareous sandstone in that branch of the ravine from the southeast. The stone has been quarried for local use at the forks of the ravine

in the northeast quarter of section 7 (20 N., 8 W.). As this quarry is not more than one-fourth mile from the Covington branch of the Wabash Railway the stone might have a more extensive use for bridges, foundations, etc.

In the southeast quarter of section 5 (20 N., 8 W.), east of the wagon road, is an outcrop of black shale containing traces of coal. In the northeast quarter of section 5, on the southeast side of the wagon road, is a heavy ledge of Mansfield sandstone which has been quarried a little for local use. Along the old canal in section 12 (20 N., 9 W.) is an extensive deposit of peat that recently burned for several months before it was extinguished by heavy rains. It is said to cover several acres.

Portland (Fountain Postoffice).—There are large exposures of the Mansfield sandstone at Portland. The old Wabash and Erie Canal was cut in the solid rock at this point, and along the south side of the canal the rock wall is 12 to 15 feet high, the tow-path, on which the railway is now placed, being on the north side. Between the railway and the wagon road, running northeast from the town, there are thirty acres or more on which the stone has little or, in some places, no covering, and has been quarried to some extent. Mr. Brooks says he has shipped 500 or 600 perches to Covington in the last four years. The stone has all been quarried near the surface, none of the openings being more than five or six feet deep. The reason the stone has not been quarried to a greater depth appears to be that there are a few bedding seams near the top, while the bottom of the bed is massive and hence not so easily quarried by hand. The greatest objection to the stone, as shown on the bluff and in the small quarry openings, is the lack of uniformity in color, that in the lower part of the bluff being a light gray with occasional brown spots, while in the upper part of the bed there is much brownstone, which, in many places, is two or three feet thick, and in one place ten feet or more. Considerable nice brownstone could be obtained here, but it is not in sufficient quantities to be worked for the brownstone alone, and could only be quarried with profit by having a market for the accompanying gray and variegated stone.

The durability of this stone is shown by the hard compact surface of the natural outcrops, and the appearance of the face cut in the construction of the old Wabash and Erie Canal 50 years or more ago which is discolored and moss grown but shows no sign of disintegration and the pick marks made at that time are plainly visible.

Bear Creek.—Bear creek, which joins the Wabash river at Portland is a comparatively short tributary, yet has quite a variety of rocks in its valley. The mouth of the valley is in Mansfield sandstone at the base of the Coal Measures. Near the middle of its course is an exposure of the Lower Carboniferous limestone above which the Mansfield sandstone

occurs again followed by sandstone and shale of the overlying Coal Measures.

The Mansfield sandstone on the lower course of the creek in sections 32 and 33 (21 N., 8 W.) is somewhat similar to that at Portland. It forms bold rugged cliffs 60 to 80 feet high along the creek, the valley in places being a deep narrow canyon. In most places the stone is buff-colored, contains secretions of iron oxide and considerable false bedding, which is quite pronounced at the Arch at the picnic grounds a quarter of a mile south of Portland. "The Arch" is an opening about 15 feet wide and nearly as high through the narrow ridge of sandstone between Bear creek and one of its small tributaries. It is on the outside of one of the sharp curves of the creek, which has here cut back under the bluff until it has made an opening through into the ravine. The cliff is nearly 40 feet high, all of gray and variegated sandstone with patches of iron oxide. On the east side of the road east of the Arch is a small rounded hill of brownstone, the top of which is 40 feet above the road and about 75 feet above the creek. The stone has some false bedding and patches of iron oxide and is somewhat shelly, yet there are small areas having a good texture and color. While there is some good stone here it could not be obtained without handling considerable inferior stone. At the east end of this rounded hill is an isolated pulpit rock 20 to 25 feet high and more than 20 feet in diameter. West of the wagon road, between the small rounded hill and the Arch, some variegated sandstone has been quarried, possibly 2,000 cubic feet in all. The quarry has been abandoned for several years.

On Bear creek for a half mile or more above the Arch through the southwest quarter of Sec. 33 (21 N., 8 W.) and the northwest quarter of Sec. 4 (20 N., 8 W.) the Mansfield sandstone forms bold cliffs sixty to eighty feet in height. The stone is massive, yellow, gray and brown in color, contains much false bedding and many iron secretions. Small patches of good stone of uniform grain occur scattered through the defective rock.

Near the section line on the north side of Sec. 4 (20 N., 8 W.) Bear creek has cut quite a narrow channel through the sandstone, which is massive, yellow, even grained, almost free from iron secretions and false bedding, and could be quarried to advantage on the north side of the creek for bridge or foundation stone.

The finest building stone in this valley is just north of the middle of Sec. 4 (20 N., 8 W.) on the lower course of a small tributary known as Rattlesnake, where the stone has a light gray, nearly white color, and a medium, coarse, even grain. It outcrops on both sides of Rattlesnake just south of the small coal bank and in the horseshoe-shaped bluff across the neck between Rattlesnake and Bear creek. This is probably

one of the handsomest building stones in the county, but so far it has received no attention. A very little was quarried for local use. The rock shows bedding planes at the surface six inches to ten feet apart, which are probably due to the influence of the weather, and in the interior it is no doubt massive. On the west side of the creek (Rattlesnake) south from the coal bank, there is an acre or more of the stone with very little loose material overlying it, the stone being ten to fifteen feet thick. On the east side of the creek and on the horseshoe bluff the bed is twenty-five to thirty feet thick and is overlain by a drab-colored shale and shelly sandstone. The base of the bed in all the exposures contains much iron pyrites and in places patches of shale, from two to four feet of the stone being injured by these substances.

In a small tributary of Bear creek from the east, just over a narrow ridge north from the mouth of Rattlesnake, there is an outcrop of massive, cross-grained, ferruginous, yellow sandstone, but it contains too many imperfections to have any commercial value.

At and below the confluence of Rattlesnake branch and Bear creek there is an outcrop of impure siliceous Lower Carboniferous limestone containing many geodes and fossil bryozoa.

In the southeast quarter of the northeast quarter of Sec. 4 (20 N., 8 W.) is a fine chalybeate spring in the bed of the creek. A short distance above the spring is a small deposit of handsome yellow ochre, which occurs in a layer three to four inches thick in the creek bank. It is said to form a heavier deposit, now concealed, a short distance up the creek. The sandstone and shales of the Coal Measures outcrop in several places in the southwest quarter of Sec. 4 (20 N., 8 W.). In the northeast quarter of the southeast quarter a short distance below the iron bridge a dark colored, carbonaceous sandstone has been quarried by Mr. Gallo-way for local use in bridges and culverts. It is not a handsome stone, and is inferior to the Mansfield stone described above, yet it is better adapted to local use for rough bridge stone, as it is stratified and can be quarried more cheaply in small quantities. Shales and clays of different kinds occur on both Bear creek and Rattlesnake in the southeast quarter of Sec. 4 (20 N., 8 W.). An impure, dark colored sandstone and shale outcrops at the cross-roads in the middle of Sec. 10 (20 N., 8 W.) and an impure, yellow-red and variegated sandstone outcrops 200 yards or more southwest of the cross-roads, but it has no economic value.

Between Bear Creek and Shawnee Creek—There is an outcrop of Mansfield sandstone in a small ravine in the south part of Sec. 27 and the north part of Sec. 34 (21 N., 8 W.). The rock is exposed along both sides of the ravine for nearly half a mile, varying in thickness from five to thirty or forty feet. Much of it contains cross-bedding and streaks of iron oxide, yet small areas occur sufficiently free from these imperfections to furnish a good bridge stone for local use.

Near the middle of the west side of Sec. 27 (21 N., 8 W.) in the bottom of the old canal bed is a small outcrop of shaly Riverside sandstone.

Near the middle of the south part of Sec. 22 and the north part of Sec. 27 (21 N., 8 W.) between the railroad and the river is an outcrop of massive buff sandstone, which outcrops for nearly 200 yards along a bayou near the river with a vertical face twelve to fifteen feet high. There would be but a slight covering to remove for 100 yards or more back from the bluff. In places the rock is seamless, and so far as can be seen from the surface, perfectly uniform. In some places there are a few weather seams, along which is a thin coating of iron oxide, that has probably come from the diffused pyrite, which in some places has been in small grains which have oxidized in places, giving the stone a sort of salt and pepper appearance. Some stone has been quarried at this place, probably 8,000 cubic feet or more, said to have been quarried by Jacob Strumpf, of Williamsport, for use in Covington. It is a promising location for a quarry, as there is abundance of good, durable, buff stone that is apparently for the most part uniform in color and texture, and admirably situated for quarrying, being close to the railroad and river, and having very little stripping.

The sandstone outcrops in several places along the railroad through the southeast quarter of Sec. 22 (21 N., 8 W.) as far as the mouth of Shawnee creek.

Shawnee Creek.—Large quantities of Mansfield sandstone are exposed along the lower course of Shawnee creek between Rob Roy and the river, but there is none of any economic value for a half mile or more from the river. There is a considerable area in the south part of Sec. 23 and the north part of Sec. 26 (21 N., 8 W.) in which the Mansfield sandstone has but a very slight covering of drift and soil, being exposed in many places. There being no openings or stream channels cut through it, the character of the rock is uncertain. A drilled well just south of the section line in the northwest quarter of Sec. 26 (21 N., 8 W.) gives the section :

Well section near the mouth of Shawnee Creek.

	Feet.	Inches.
Sand and soil	4	
Sandstone, coarse (Mansfield).....	38	
Coal		14
Sandstone, fine (Riverside)	46	
Total	89	2

In and below the small ravine from the southeast in the southeast quarter of Sec. 23 (21 N., 8 W.), the northeast quarter Sec. 26 and the northwest quarter of Sec. 25, considerable quantities of black fissile shale occur, in places being 25 feet or more in thickness. No sandstone of economic importance was observed in this part of the valley. Some of the shale might be utilized for the manufacture of paving brick.

On the north side of Shawnee creek in the southwest quarter of Sec. 24 (21 N., 8 W.), about a mile from the river, there is a bold bluff of the Mansfield sandstone where a great mass (several thousand tons) of rock fell off the face of the bluff two years ago (in 1893), and now lies in large boulders on the bank of the creek. The stone has a light buff color, with faint yellow bands following false bedding in places, and a medium coarse grain, with here and there small patches of a fine conglomerate, the pebbles being no larger than wheat grains. On all the exposed surfaces, both the old moss-grown surface and that exposed by the recent fall two years ago, the rock is very hard—harder than the Mansfield stone in most of its outcrops. At the west end of the mass of debris and down stream from it the sandstone has considerable cross-grain and secretions of iron oxide. At and near the upper (east) end of the freshly exposed bluff the rock is comparatively free from the iron secretions, and almost so from the cross-grain. At this point good bridge stone and possibly good dimension stone could be obtained. The clean, solid, massive stone is twenty to twenty-five feet thick, overlain by from one to ten feet of shelly sandstone and drift soil, and is underlain by a pyritiferous black shale.

About 200 yards (about 500 by the creek) above the fallen rock referred to above, the sandstone has been quarried a little on each side of the creek, possibly 2,000 cubic feet or more. The stone is light gray and buff in color, and in a few places nearly white. In some places are small dark-colored specks of oxidized pyrites giving the stone a salt-and-pepper appearance. A few small streaks of fine conglomerate occur, but do not seriously mar the stone. Some nice stone could be obtained at these openings.

On the west side of the wagon road, 100 yards north of the iron bridge over Shawnee creek, in the southwest quarter of Sec. 24 (21 N., 8 W.) is a large deposit of calcareous tufa (locally called "marl"), which has been quarried for lime-burning. It occurs in regular stratified layers two to ten inches thick, and has been quarried to a depth of twelve to fifteen feet over an area of 600 square feet or more. The bottom is not exposed and the total thickness of the deposit is not known. The stone, while having an open, porous texture, is firm, and has a semi-metallic ring. It seems a little strange that more of this stone has not been burnt into lime, as it is easily quarried, as its porous texture renders it easily burnt and as wood is abundant. It would furnish a remarkably pure lime, and it is only a mile from the C. & I. C. Railway, and in a region almost devoid of limestone. It is said that plasterers object to its use because "the white coat mixed with it is so tough." This stone will be used with profit sometime.

Deposits of tufa similar to this but in smaller quantity occur in many places throughout the region, where small springs emerging at or near

the base of the Mansfield sandstone, deposit the lime carbonate, the deposit in many places taking place at the present time. There is at present no spring at the deposit mentioned above, but probably was at the time of the deposit of the tufa. There is a similar but smaller deposit on the north side of the creek 240 steps above the wagon bridge.

Along Shawnee creek between the wagon bridge in the southwest quarter of Sec. 24 (21 N., 8 W.) and the confluence of Big and Little Shawnee creeks in the northeast quarter of Sec. 25 (21 N., 8 W.) the light gray and buff colored Mansfield sandstone outcrops in several places, lying unconformably on the Riverside sandstone, which in some places is exposed in bluffs 20 or 25 feet high and in other places, close by, lies below the level of the valley.

The Mansfield sandstone outcrops along Big Shawnee creek for a quarter of a mile above its confluence with Little Shawnee. Black pyritiferous shale with thin layers of coal are exposed along the creek bank at the base of the sandstone for nearly 100 yards above the confluence of the two creeks. Near the upper limit of the sandstone on Big Shawnee creek in the southwest quarter of Sec. 19 (21 N., 7 W.) the stone has been quarried to some extent (possibly 500 cubic feet) for local use. The quality is sufficient to guarantee a more extensive production, as the stone is comparatively even-grained, homogeneous in texture, and nearly so in color through considerable areas; some being a light gray, some a buff color. The natural exposures show a smooth face, even grain and sharp corners. Good bridge stone and probably good building stone could be obtained here.

On Little Shawnee creek the Mansfield sandstone outcrops for nearly 100 yards above its confluence with Big Shawnee in a ledge 15 feet thick. A short distance below where the wagon road west from Rob Roy crosses the creek the Mansfield sandstone ends and the underlying shaly Riverside sandstone begins. Where the road crosses the creek the latter stone forms a bluff 40 or 50 feet high, but it has no economic value.

Through the middle of Sec. 30 (21 N., 7 W.) there is no rock exposed, the slopes being covered with drift material. In the southeast quarter of Sec. 30 is an exposure of 12 feet or more of light gray and yellow-colored Mansfield sandstone which has been quarried to some extent at what is known as the Barney Brown quarry. Some of the stone was used for bridges in the vicinity and some was used in Mr Brown's stone house in the southeast quarter of Sec. 30 (21 N., 7 W.) close to the quarry. This house is said to have been built more than 50 years ago, and the mortar has washed out from between the stones, thus giving the building a kind of dilapidated appearance, yet the stone shows no signs of decay. A little more care in selecting the colors might have produced a happier effect. The sandstone outcrops for nearly one-fourth mile south

of the quarries, but contains too much iron oxide and false bedding to have any value.

There is a small outcrop of shaly Riverside sandstone on the south side of the creek in the northwest quarter of Sec. 23 (21 N., 8 W.) near the middle of the section. Small exposures of the same stone occur at intervals through the south part of Sec. 24 and the north part of Sec. 25 (21 N., 8 W.), and there are large outcrops of it along both sides of Big Shawnee creek north of Rob Roy through the north part of Sec. 30 and the south part of Sec. 19 (21 N., 7 W.). From less than half a mile east of Rob Roy to the head of Big Shawnee creek no rock exposures were observed, the valley and bordering slopes being covered with glacial drift. The valley is very shallow, the creek appearing to flow over a gently rolling plain. On Little Shawnee creek there is a bold cliff of the Lower Carboniferous (Riverside) sandstone less than a quarter of a mile above its confluence with Big Shawnee. In the southeast quarter of Sec. 30 the Riverside sandstone outcrops underneath Mansfield sandstone and again in small quantities up the creek from the Brown quarry in the northwest quarter of Sec. 32 (21 N., 7 W.). Above this the creek was not explored, citizens reporting no rock outcrop of any kind.

Nave Branch.—The lower course of Nave branch, which runs nearly parallel with Shawnee creek, has no rock exposed. It occupies a wide, shallow, dry, valley bordered by low gravel hills. North of the branch on the east side of the Wabash ("The Towpath") Railway is a quarry in this gravel deposit from which large quantities have been shipped, having been taken from 12 acres or more to the depth of 12 to 15 feet.

The first rock observed in place in ascending Nave branch is near the middle of the north side of section 24 (21 N., 8 W.) just west of the north-south wagon road, where a coarse yellow sandstone (Mansfield) is exposed three to six feet. East of the wagon road the thickness of the exposure increases to 15 feet. About 50 yards east of the road the stone has been quarried a little for local use, but the inferior quality will never justify more than a local usage.

The sandstone outcrops at intervals for a mile and a half further up the creek into the southeast quarter of Sec. 18 (21 N., 7 W.), in places the rock being concealed and in places the sandstone being almost entirely replaced by a black shale. The shale* outcrops in large quantities in the northeast quarter of Sec. 24 (21 N., 8 W.) where it contains some coal, small quantities of which have been mined.

Just east of the C. & I. C. Railway in the northeast quarter of the northwest quarter of Sec. 19 (21 N., 7 W.) is another sandstone quarry from which probably 10,000 cubic feet of sandstone have been taken. Part of it has been used in constructing the stone culvert for the railway

*See the preceding report by the State Geologist for particulars.

across Nave branch. The stone is gray and buff in color and has a few irregular seams and has been quarried to a depth of 10 feet. The stripping is too heavy (six to ten feet) to permit much stone to be quarried here with profit. There is an exposure of Lower Carboniferous sandstone (Riverside) beginning east of this quarry and continuing for a quarter of a mile or more. More than a quarter of a mile east of the quarry in the southeast quarter of Sec. 18 (21 N., 7 W.) is a low ledge of the Mansfield stone, the most eastern exposure observed on this branch. It contains too much iron oxide and false bedding to be of any value.

No outcrop of the Mansfield stone was observed between Nave branch and Attica except a slight exposure near the middle of the west half of section 18 (21 N., 7 W.).

Between Attica and Riverside.—No sandstone was observed to outcrop in the town of Attica, but a very short distance northeast of the town in the northeast quarter of Sec. 5 (21 N., 7 W.) there is a small exposure of shelly Mansfield sandstone of no commercial importance.

Along a small branch from the south in the south half of Sec. 33 (22 N., 8 W.) large quantities of sandstone (Mansfield) have been quarried from one of the largest sandstone quarries in this part of the State. The stone has been quarried on both sides of the ravine for more than a quarter of a mile, through a thickness varying from 12 to 25 feet and back into the hill until the expense of stripping became too great to make further quarrying profitable. The abandoned quarry face shows five to 12 feet of glacial drift and a like thickness of loose shelly sandstone overlying the marketable stone, which is yellow to yellow-brown and greenish-gray in color with small dark specks of iron oxide scattered through it. It is in thin layers at the top of the bed, becoming heavier toward the base, the bedding seams apparently having been opened by the weathering agencies.

There was formerly a switch run into this quarry from the Wabash Railway which passes close to the north end of the quarry, but the switch has been removed and the quarry abandoned for many years. Nothing definite could be obtained in regard to the history of this quarry, as to when it was opened, or when closed or the amount obtained, etc.

The sandstone outcrops along this ravine for a half mile south of the quarry, but the greater part of it has no economic value. Immediately south of the south end of the quarry the sandstone is very cross-grained and ferruginous, but less than a quarter of a mile further south the cross-grain disappears and some nice even-grained sandstone occurs, suitable for building purposes. There is a small outcrop of the underlying Lower Carboniferous sandstone and limestone near the middle of the south half of Sec. 33 (22 N., 7 W.). At the mouth of a small tributary ravine from the east along this outcrop are three small chalybeate springs that emerge at the contact of the Mansfield sandstone with the Lower Carboniferous.

The base of the sandstone here contains much pyrite which probably furnishes the iron for the springs; the upper part of the bed (12 to 15 feet) contains good bridge stone.

For 150 yards or more along the Wabash Railway northeast from where it crosses the ravine above mentioned the road is cut six to ten feet into the shelly imperfect yellow Mansfield sandstone.

At the north end of this rock cut in the small ravine from the southeast is an outcrop of the Mansfield sandstone which extends only a short distance above (south of) the railway until it is replaced by the underlying rocks. As it does not occur north of the railway, it would appear as though the stone occurred at this place in an eroded channel in the Lower Carboniferous rocks.

No other outcrop of the coarse grained Mansfield sandstone was observed between the last mentioned and Turkey run above Riverside. The Lower Carboniferous, Riverside, sandstone outcrops in many places through sections 27, 26, and 25 (22 N., 7 W.), and has been quarried in several places

Riverside Postoffice (Independence Station).—At Riverside postoffice in the northeast quarter of Sec. 26 (22 N., 7 W.) are two large sandstone quarries, one of which is not in operation at present (1895). This is an entirely different rock from the Mansfield stone, both in its lithologic character and its geologic position. It belongs in the Lower Carboniferous system, and is named from this locality where there is a good, accessible, typical exposure.

It corresponds lithologically with the Knobstone group near the base of the Lower Carboniferous, and possibly belongs to that group, but not enough areal or paleontologic work was done to definitely determine its position in the geologic column further than that it is Lower Carboniferous, and lies unconformably below the Coal Measures.*

It is a very fine-grained sandstone, blue on a fresh surface, weathering buff to dark gray on long exposure. It is quite evenly stratified, in many places on natural exposures the stratification planes becoming quite abundant, even grading into shale. In the quarry there is a little shelly material at the top, below which the stone occurs in layers 16, 17, 18, 19, 20, 22, and 42 inches thick, with thinner layers near the top of the quarry. The stone works easily and splits nicely, either with the bedding or across the grain. The layers are loosened from the floor by wedges, and can then by drilling a series of holes along the desired line of break and inserting wedges (plugs and feathers) be split almost as straight and even as if sawed. A steam drill is used for making the holes, and formerly all the stone was so wedged off; but recently the Knox blasting system has been used with a little saving of labor and

* It has been referred to in former State reports as the Chester sandstone, but sufficient evidence was not found either in the reports or in the field to justify such a classification.

increased injury to the stone. The company intends using the Githens system the coming season. Owing to the homogeneous fine grain the rock will take a very smooth finish, and can be used for delicate carving and tooled work.*

The average thickness of the marketable stone is about fifteen feet, and the maximum thickness of the quarry face twenty-seven or twenty-eight feet. The quality of the stone improves as the quarry is worked further back into the hill; that is, there is more of the blue stone, which commands a better price than the buff, and there is less shelly sandstone, but the overlying glacial material increases in thickness.

A chemical analysis of this stone, made for the Survey by Dr. H. H. Ballard at Rose Polytechnic Institute, shows its composition to be as follows:

<i>Analysis of Riverside Stone.</i>		Per Cent.
Insoluble residue		93.16
Alumina (Al_2O_3)		1.60
Iron oxide (Fe_2O_3)		2.69
Lime (CaO}) .....		.13
Total		97.58

While the iron was determined as ferric oxide, as is customary, it does not exist in the stone as such, but as diffused carbonate and possibly some sulphide. It is probably this protoxide or lower oxide of iron that gives the fresh stone its blue tint, and its oxidation into the higher or sesquioxide form that gives it the buff tint. This is a partial element of weakness in the stone, but not a serious one, as the iron is present only in small quantity and is finely diffused, so that it undergoes a gradual oxidation without serious injury to the stone; in fact, where the stone is placed in a dry position, as in the walls of buildings, this oxidation is a process of centuries, simply causing the stone to "mellow" with age. The only other element of weakness in the stone is the alumina which is liable to absorb water and cause the stone to burst on freezing, but this is not present in sufficient quantities to be a serious injury to the stone, for while the percentage is higher than in the Mansfield stone it is much lower than in many sandstones famed for building stone. [See tables in final chapter for comparison.]

The microscope shows [See Plate 11] the occurrence of many angular quartz grains, which make up the bulk of the insoluble residue, some muscovite, biotite, feldspar, calcite, and limonite. The stone is much

*The workmen state that the stone has a peculiar action on the tools, viz., the smooth-edged drove and splitting chisels soon becoming toothed by use. This stone is known to some extent locally as freestone, not within the meaning commonly assigned to freestone, namely, a stone that works freely in all directions, but because it is supposed to contain many impurities.

finer grained than the Mansfield stone, the average size of the grains being 0.07 millimeters in diameter, the largest measuring 0.13 mm. (see p. 204 for comparison). The constituents are intimately mixed, making the stone homogeneous throughout.

Crushing tests made on this stone for four specimens gave a strength of 6,000, 6,090, 6,100 and 6,800 respectively.† This, as will be observed from consulting the tables in final chapter, is about the average for common sandstone.

Absorption tests on two specimens of the blue stone gave 4.8 per cent. and 6.8 per cent. respectively, and on the buff stone 5.8 per cent. and 6.1 per cent.

The homogeneity of the Riverside stone, its pleasing color, the smooth finish of which it is susceptible and its adaptability to fine carving, will no doubt cause an increasing demand for this stone as its properties become better known.

Stone in small quantities is said to have been quarried here fifty years or more ago. Quarrying on the present enlarged scale has been carried on since 1887, when the quarry now in operation came into possession of the present company, Guyer, Burchby & Co. It has been worked over an area of about three acres, yielding an average thickness of about twelve feet of sound stone.

It has been shipped to Lafayette, Indiana; Decatur and Peoria, Illinois; St. Louis, Missouri, and Detroit, Michigan, more going to Lafayette than to any other point. At Lafayette it has been used in the High School building, in the electrical building at Purdue University, in many private dwellings and in the Brown-street bridge.

There is another quarry belonging to the Riverside Stone Co., a quarter of a mile west of the Guyer, Burchby & Co. quarry in the same bed of stone, which differs little in quality, but there is much more of the loose shelly stone at the top, making much more waste material to handle, so much in fact that it is doubtful if much more stone could be lifted with profit. Considerable stone has been taken from this quarry, the excavation being larger than at the other quarry; and it has apparently been well equipped for work; the stone was sawed into trimmings and dimension stone in a mill located at the quarry. It is not in operation this year (1895).

There is a great deal of Riverside stone exposed along the Wabash Railway both east and west from the Riverside quarries, and while in

† Mr. Howe, of Rose Polytechnic Institute, who tested the stone, states that the specimens "although appearing quite true in surface were found to be quite the contrary when placed upon a steel plate. Not over 75 per cent. of the area was in contact with the plate in any case." So that the above probably represents considerably less than the maximum strength of the stone.

many places it is shelly and crumbling on the weathered surface, yet in a few places it is sufficiently sound to indicate fairly good building stone.

Turkey Creek.—Turkey creek is a small tributary of the Wabash east of Riverside in sections 19, 30, and 29 (22 N., 6 W.). Its lower course is in the Riverside sandstone, and the upper part in the Mansfield sandstone. The latter stone in this valley has no commercial value, being thin-bedded to shaly, containing much iron oxide and disintegrating on exposure. It rests unconformably on the Riverside stone, the accompanying figure (Fig. 4) showing where it has filled in an old erosion

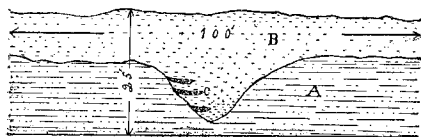


Fig. 4. Section showing the contact of the Carboniferous and Lower Carboniferous rocks on Turkey Creek.

- A—Riverside sandstone (Lower Carboniferous).
- B—Mansfield sandstone (Coal Measures).
- C—Basal conglomerate.

channel. The Riverside stone where observed in this valley is too shaly to have any value

Grindstone Creek—Grindstone creek is another small tributary of the Wabash lying east of Turkey creek and nearly parallel with it, in sections 20, 21, and 28 (22 N., 6 W.). The rock exposures are similar to those on Turkey creek, but there are larger exposures of the Mansfield sandstone. It outcrops almost continuously from the section line near the middle of the west side of the southwest quarter of Sec. 21 (22 N., 6 W.) south to within a quarter of a mile of Robert's postoffice in the middle of the south side of Sec. 28 (22 N., 6 W.). None of the stone along the creek so far as observed has any economic value. South of the wagon bridge in the northwest quarter of Sec. 28 (22 N., 6 W.) there is some fairly good stone, but it is covered by too much waste material to be quarried with profit. Some stone has been quarried on the hill west of the creek in the middle of the west half of Sec. 20 (22 N., 6 W.).

The best outcrop of sandstone in this part of the county is on the flat east of Grindstone creek in the middle of Sec. 21 (22 N., 6 W.) at Mr. Martin's stone quarry, where stone was obtained for the wagon bridge over Flint creek and where some has been quarried for foundations. It has been worked to a depth of six or eight feet, but no opening has penetrated to the bottom of the bed so that the total thickness is unknown. The prevailing color of the stone is light gray, in places stained a yellow-brown. It occurs in somewhat regular layers two to three feet thick.

There is, in places, no stripping, in some places a few inches of soil and shelly sandstone, but the cost of stripping over several acres would be very slight. If this stone should prove to retain its homogeneity through any considerable thickness it would be a promising opening for a quarry.

This deposit apparently rests unconformably on the Lower Carboniferous rocks and has a northeast-southwest trend, extending southwest probably to Grindstone creek, and outcropping only a hundred yards or so northeast of the quarry. This appears to be the eastern limit of the Mansfield sandstone on the south side of the Wabash river. Small isolated patches may occur in places along the western part of Tippecanoe county, but none were reported and the region was not traversed.

The Riverside sandstone, in some places more calcareous, in others more shaly than at Riverside, outcrops along the lower course of Flint creek. On the south bank of the Wabash river a half mile or more below the mouth of Flint creek in the Burnett reservation is a large deposit of broken chert known as the Flint quarry, which has been quarried in large quantities and shipped to Lafayette and elsewhere for road material. It was formerly loaded on flat-boats and shipped on the Wabash river. It is now (1895) shipped by rail.

THE NORTH SIDE OF THE WABASH RIVER.

The area of the Mansfield sandstone north of the Wabash river is practically limited to Warren county.* It outcrops along the river bluffs in many places from Black Rock on the eastern border of the county to the mouth of Redwood creek well to the west side of the county. There are also numerous exposures along the tributaries from the north, as Little Pine, Kickapoo, Pine, Rock and Redwood creeks. The upper limits of the deposits on some of these creeks is not clearly defined, being concealed by the heavy bed of overlying drift. This is especially true on Kickapoo creek. In the eastern part of the county the northern limit of the formations in the creek basins is near the tops of the hills, where it is replaced by the underlying Lower Carboniferous rocks; in the western part of the county the northern limit is at the base of the hills, where it disappears beneath the overlying rocks of the Coal Measures.

The irregularities of the outcrop in the eastern part of the county are largely due to unconformity by erosion at the base of the deposit, that is, previous to the deposit of Mansfield sandstone, there had been an elevation and erosion of the land followed by a depression of this area when

*Tippecanoe county was not traversed and it is possible that small exposures of the sandstone may occur in that county, but if so they are isolated from the main body. Some of the county reports mention its occurrence, but give no localities.

the Mansfield sandstone was deposited in the eroded channels and inequalities of the old land surface. Particular instances of this unconformity are mentioned on the following pages.

In Sec. 27 (20 N., 9 W.), across the river from Covington, between the I., B. & W. railway and the river, are several small quarries in the sandstone of the Coal Measures. Sandstone has been quarried here at intervals for several years, but the stone is of inferior quality and has never had more than a local use and probably never will. In most places it is very thin-bedded, grading into shale, and associated with considerable quantities of shale. East of the quarries apparently the black shale replaces the sandstone entirely, forming a very heavy bed containing much iron pyrites and some coal.

Northwest from these quarries along the railway is a heavy bed of gravel, from which large quantities have been shipped. It will no doubt continue to furnish gravel for many years yet.

Redwood Creek.—Sandstone of local value outcrops below (southwest of) Redwood creek, but it all belongs to a higher horizon than does the Mansfield sandstone, and is interspersed with productive beds of coal. In the southwest quarter of Sec. 3 (20 N., 9 W.) is a deposit of Carboniferous sandstone that has had a local use for grindstones.

The Mansfield sandstone outcrops in bold bluffs 40 to 50 feet high along the lower course of Redwood creek, in sections 1 and 2 (20 N., 9 W.) and Sec. 35 (21 N., 9 W.). It varies from light gray to yellow in color, contains much segregated iron, many lenticular shaly patches, and is in most places, more or less, cross-grained. Owing to these defects, it is doubtful if the stone will ever have more than a local use. There are small areas of good stone, strong, durable, and homogeneous, but all such occurrences grade rapidly into imperfect stone, both laterally and vertically.

Small quantities of stone have been quarried above the wagon bridge in the northwest quarter of Sec. 1 (20 N., 9 W.). Stone from the immediate vicinity was used in the abutment at the east end of the bridge above mentioned. The abutment at the west end is the rock in situ. This bridge was constructed in 1876, and the rock as yet is unaffected by the weather, except in being discolored, as it darkens on exposure.

At the "Hanging Rock," about a quarter of a mile above the bridge, the cliff is undermined by the creek, the upper part jutting out 15 or 20 feet over the water. The stone at this point contains many reticulated veins of iron; the sandstone between the veins standing out in relief gives the face of the cliff a very picturesque appearance. It has been referred to by a previous writer as the "Pictured Rocks."

The sandstone disappears beneath the creek bed near the middle of the north half of Sec. 35 (21 N., 7 W.), and is succeeded by a bed of black

limestone that would furnish a black marble of fair quality. The bed is three feet thick where exposed on the creek bluff and it is apparently solid; where exposed in the creek bed a few yards above there are two layers eight and ten inches thick respectively.

The effect of the weather on the outcrop appears to be (1) to change the coal-black color to a dull gray, due no doubt to loss of bitumen and (2) to cause the opening of the joints. Otherwise the stone withstands the weather much better than most black limestone. No use has ever been made of this stone as far as known. It is underlain by a bed of black shale 15 to 20 inches in thickness that lies unconformably on the Mansfield sandstone. The shale is very pyritiferous and contains many secretions of clay ironstone, etc.

There is a small exposure of sandstone up the creek (east) 100 yards or so from the marble, and another small exposure more than a half mile further north in the northeast quarter of Sec. 26 (21 N., 9 W.), above which the slopes are covered with glacial drift.

Rock Creek.—No exposure of the sandstone was observed between Redwood and Rock creeks, the low bluffs being covered with drift and the river bottom with alluvium.

On Rock creek the lowest outcrop observed is in the north part of Sec. 29 and the south part of Sec. 20 (21 N., 8 W.), where for nearly half a mile along the creek there are bold jutting cliffs of gray and yellow sandstone, twenty to twenty-five feet thick. At the mouth of a small tributary from the north, known as Rattlesnake, where the stone has been quarried in small quantities, the opening shows fifteen to eighteen feet of fairly good stone, which has a nearly uniform gray color, and occurs in irregular layers from three to thirty inches thick. Bridge and foundation stone might be obtained here sufficient to supply the local demand. On the south side of the creek, a hundred yards above the quarry, the base of the sandstone cliff contains a layer of coarse conglomerate and lenticular masses of coal. A similar exposure occurs on the same side of the creek 200 yards or so below the quarry, where the conglomerate occurs in irregular masses an inch to three feet thick, with streaks of coal two to three inches in thickness. At the base of the conglomerate are a number of nodular masses of clay ironstone, four to eight inches in diameter, and containing imprints of many fossil leaves remarkably well preserved.

The Mansfield sandstone outcrops more or less continuously for more than two miles above the quarry mentioned, nearly to the Wabash Railroad, in the south part of Sec. 7 (21 N., 8 W.). About the middle of the west side of Sec. 20 (21 N., 8 W.) is a considerable quantity of calcareous tufa deposited on the face of the sandstone cliff, large boulders from which have broken off and now lie scattered along the creek bank. Lime for local use might be burned from this tufa.

Through the northeast quarter of section 19 and the south part of Sec. 18 (21 N., 8 W.) there is considerable shale accompanying the sandstone, both underlying and overlying it. It apparently overlies it unconform-



Fig. 5. Section on Rock Creek, Warren County, Indiana.

- B—Mansfield Sandstone.
- C—Black Shale.
- D—Black Limestone (Marble).

ably, as shown in the accompanying figure (Fig. 5). In this overlying shale, just north of the wagon road in the southeast quarter of Sec. 18 (21 N., 8 W.), near the top of the outcrop is a bed of black limestone, somewhat similar to that mentioned on Redwood creek, but not so compact and uniform in texture. Small quantities of black marble might be obtained, but the outcrop would not promise it in commercial quantities. Sandstone of inferior quality has been quarried in small quantities in the ravine from the northeast at the upper end of the shale bluff in the southeast quarter of section 18. The sandstone above this point has but little economic value, even for local use.

Between Rock Creek and Williamsport.—For a mile or more above Rock creek, toward Williamsport, there is but little sandstone exposed, the broad river bottom merging gradually into the gentle drift-covered slopes of the highland. There are a few small exposures of shelly sandstone along the small tributaries, known as Dry branch and Clear branch, in sections 20, 21, 16 and 17 (21 N., 8 W.), but none of any economic value. Wells in that area penetrate sandstone after passing through a thickness of drift varying from eight to thirty feet or more.

Beginning on the north side of Sec. 22 (21 N., 8 W.) and continuing along the river bluff, outcropping the greater part of the way, to the town of Williamsport, is a heavy ledge of Mansfield sandstone. In the ravine in the north part of Sec. 22 and the south part of Sec. 15 (21 N., 8 W.) the stone has a brown to red-brown color, but it is very cross-bedded and more or less shelly throughout, and has little if any commercial value. North of the road, in Sec. 15, the stream has cut a channel or gully in this brownstone six to ten feet deep and three to ten feet wide for 200 yards or more. On the south side of the road the brownstone outcrops about 200 yards, beyond which the bluff is covered with gravel and sand. Through the southeast quarter of Sec. 15 (21 N., 8 W.) and the northwest quarter of Sec. 14 the gray and buff sandstone outcrops in considerable quantities between the wagon road and the river. The many small watercourses cutting back into this bluff give the sandstone ledge

a very sinuous course. The bluff was not followed through its whole length, but where observed it contained too many iron secretions and lacked the necessary homogeneity to make it valuable for building stone.

At the mineral spring in the south part of Sec. 11 (21 N., 8 W.) the bed of sandstone is 35 to 40 feet thick, and rests unconformably upon a bed of black and drab-colored shale. The base of the sandstone is very ferruginous, the iron oxide probably being oxidized iron pyrites from which the spring derives the iron with which it is charged. The ferruginized water-soaked base is soft and partially disintegrated, but the upper part is hard and firm. Between the spring and the town the massive sandstone forms a ledge near the brow of the bluff, from which massive boulders have broken away and lie strewn along the slope. Stone has been quarried in small quantities from this ledge in several places.

Williamsport Quarry—The quarry of the Williamsport Stone Co. is on the south bluff of Fall creek, at the school-house, near the middle of the town of Williamsport. The quarry has been opened for many years, said to have been first used about 1840, but it was in May, 1893, that the present company began work on a large scale with modern machinery. Previous to this date it had been worked at intervals by hand to supply the local trade. The stone at Williamsport belongs to the Mansfield formation and rests unconformably upon a bed of carbonaceous, partly conglomeratic shale. The sandstone at the quarry is 50 feet thick at one end of the quarry, being clean, solid, massive stone through the entire thickness, except two or three feet of soil and somewhat shelly rock at the top. At the other end of the quarry the shelly rock extends through two channel cuts to a depth of 10 or 12 feet. On the best face there are seven channel cuts, each about six feet thick. The natural rock face at the west end of the quarry is more even, firm and regular than the channelled face. The only markings on the 50-foot face are a few incipient weather seams parallel with the bedding, all indicating a stone of remarkable homogeneity, which, however, is local, as at the east end of the quarry there is considerable shaly material, and the natural exposure near the end shows local variations in texture. Less than 100 yards west of the quarry the outcrop in the creek bank above the fall shows several feet of shelly and very cross-grained stone.

The stone has a buff color, and when first quarried has a yellow tint, but on drying becomes much lighter, ending in a light gray or faint buff in the seasoned stone. The chemical analysis shows it to be highly siliceous.

Chemical Analysis of the Williamsport Stone.

	Per Cent.
Residue insoluble in HCl.....	98.57
Ferric oxide (Fe_2O_3)	0.65
Alumina (Al_2O_3)	0.05
Lime (CaO)	0.02
Total	99.29

The insoluble residue is white and consists mainly of quartz, but not entirely so, as the microscope shows the presence of feldspar fragments. The feldspar is mostly microcline, and while not abundant occurs in appreciable quantity. Muscovite, limonite, zircon, and rutile are also distinguishable in small quantities in the microscope.

The quartz grains are smaller than in the brownstones, the average size, being .19 millimeter in diameter, and the largest .32 millimeter. The grains are all sharply angular and in some places are bound together by a silicious cement. In some instances the silica appears to be a secondary enlargement of the quartz crystals upon which it is deposited. Possibly ten per cent. or more of the quartz shows that it has been subject to strain. This, along with the occurrence of the microcline, is suggestive of the probable derivation of at least part of this material from a region of metamorphic rocks.

The stone when green is soft, easily cut or broken, but hardens on seasoning. It is channeled one way in the quarry (using the Bryan channeler), while the blocks are separated the other way by using the Knox system of blasting. The large blocks are then lifted from the quarry and placed in the saw mill and sawed while green.

The stone is used for dimension stone, bridge stone and rubble. The product for 1894 was 111,000 cubic feet, proportioned as follows: building stone, 45,000 cubic feet, bridge stone, 11,000, and rubble, 55,000 cubic feet. The market is mostly along the Wabash Railway between Toledo, Ohio, and Taylorville, Ill. The Methodist church erected in Williamsport last summer (1895) was constructed of the Williamsport stone.

Between Williamsport and Attica no sandstone was observed on the north side of the Wabash river. In the river bluff are considerable exposures of Lower Carboniferous drab-colored sandstone and shale corresponding in position to the Riverside sandstone described above. Small quantities of limestone are associated with this sandstone in the vicinity of Williamsport, but it has no economic value. The formation is in most places too shaly to have any value, but in a few places it has been quarried for building stone, the most productive point being on the wagon road a quarter of a mile northwest of the bridge at Attica, where it has been quarried for several years by Jacob Schmidt. The product is partly used in Attica and vicinity and part shipped to points in Illinois along the Wabash Railway.

Pine Creek Valley.—The lower course of Pine creek is in the Lower Carboniferous rocks, the middle and upper course as far as Rainsville and beyond, in the Mansfield sandstone, and still further north, again in the Lower Carboniferous rocks; about the headwaters, however, the rocks are mostly concealed by the glacial drift. There is but little of the Mansfield stone in this valley of much value as building stone, yet stone of good

quality occurs in a number of places, and in many places it is adapted for local use as a bridge or foundation stone.

The Riverside, or Lower Carboniferous, sandstone forms some bold cliffs along Pine creek both above and below the mill pond in the east side of section 36 (22 N., 8 W.) about a mile from the mouth of the creek. The outcrop just below the dam is 60 feet thick, the stone lying in regular, evenly bedded layers two to four inches thick at the top and 20 or 30 inches at the base. It has a blue tint more pronounced than in most localities where this stone occurs. It has been quarried in small quantities and possibly will be in larger quantities. At this point, near the mill pond, it is overlain by a heavy bed of excellent gravel and the stone could be quarried economically only by making use of the gravel at the same time, which might well be done. The stone has been quarried in small quantities both up and down the creek from the dam. The outcrop continues for nearly two miles above the dam.

A small outcrop of the Mansfield sandstone occurs on the wagon road along the border of the French reserve in the southeast quarter of Sec. 36 (22 N., 8 W.) where it has been quarried in small quantities. The stone is too imperfect to have more than a local use.

In the northwest quarter of Sec. 35 and the southeast quarter of Sec. 27 (22 N., 8 W.) on the west side of the creek is a heavy deposit of the Mansfield sandstone 25 to 40 feet in thickness. It occurs in regular layers 8 to 30 inches thick, in some instances with a thin layer of shale or clay between the layers. In one place there is a lenticular mass of blue-black shale 10 to 15 feet thick inclosed in the sandstone. The sandstone resembles that in the Bernhart quarry described later, but is less uniform and even in texture, in places showing much cross grain. Near the upper end of this cliff in a small ravine from the west, on the land of Mr. McCabe some stone has been quarried for local use. The exposure is 18 to 20 feet thick underlain by black shale. The stone is yellow and light gray in color and comparatively uniform in texture and would be a good durable stone for buildings, foundations, or bridges. The supply that could be lifted economically is limited, but is probably sufficient to supply all the local demand.

In the immediate vicinity of the Indiana Mineral Springs in section 23 and the east side of Sec. 22 (22 N., 8 W.) the slopes are covered with glacial drift which forms very steep bluffs in places on the creek bank 75 feet or more in height.

On the lower part of Fall creek in the west side of section 22 and the east side of section 21 is a heavy deposit of the Mansfield sandstone accompanied by black shale. The stone varies in texture, and in the channel and bluffs at the "Narrows" of Fall creek the lack of homogeneity is shown by the numerous irregular cavities in the rock. This is a rather picturesque and romantic spot, with the irregular massive sandstone cliffs

almost touching each other and overshadowing the very irregular pot-holed bottom of the creek. South of the "Narrows" a coal bank has been opened in the Productive Coal Measures, but there is no sandstone of any importance.

At the mouth of Fall creek the coarse sandstone is below the bed of the creek and is overlain by a heavy bed of black shale which forms a bold cliff on Pine creek below the mouth of Fall creek. At the old mill on Pine creek just above the bridge the sandstone outcrops in the creek, but is very cross bedded and charged with iron secretions. On the east bank of the creek, about a quarter of a mile above the mill, the stone has been quarried for local use. It occurs in a massive ledge 12 feet thick with the prevailing color light gray near the south end of the quarry, becoming more yellow in passing northward along the bluff. Good stone for bridges and foundations could be obtained here. Underlying the heavy ledge of good stone is a bed of shelly, cross-grained, disintegrating sandstone.

From the quarry above mentioned to the bridge across Pine creek, in the northeast corner of Sec. 16 (22 N., 8 W.) there are heavy ledges of sandstone exposed on both sides of the creek. In most places it contains iron secretions and cross-bedding, yet interspersed through this imperfect stone are patches of even-grained homogeneous stone well suited for building purposes if properly selected, and occurring in sufficient quantities to supply all local demands. About a quarter of a mile south of the bridge is an outcrop of excellent yellow and light gray building stone which might be quarried in large quantities. The stone in the bluffs at the bridge contains too many defects to make a valuable building stone. There is a bold cliff of massive Mansfield stone at the spring less than a quarter of a mile above the bridge on the west side of the creek, but it is highly impregnated with iron. In the ravine from the west at the upper end of this cliff, in the southeast quarter of Sec. 9 (22 N., 8 W.), the stone is more homogeneous in color and texture and some good yellow sandstone occurs, the watercourse having a channel 15 to 20 feet deep cut into it. Yet it is doubtful if much good stone could be economically obtained at this locality owing to the heavy deposit of glacial drift overlying it.

Through the east and north sides of Sec. 9 and the southwest quarter of Sec. 4 (22 N., 8 W.) the sandstone is exposed in large quantities, much of which is suitable for bridge or foundation stone, but which has too much iron and cross-grain for good building stone. Less than a quarter of a mile above the mouth of Honey branch on the east side of Pine creek is a small quarry with a face of 12 to 15 feet of yellowish gray massive sandstone with considerable variegation in color. Small quantities have also been quarried on the west side of the creek at the same place. For a distance of more than a quarter of a mile in the southeast quarter of Sec.

4 (22 N., 8 W.) the slopes are covered with glacial material and no sandstone is exposed. Beginning at the middle of the south side of section 4 and continuing west for more than a quarter of a mile the sandstone forms a bold bluff and is of fair quality; while it contains considerable cross-bedding it weathers evenly and could be used for heavy masonry. In the southwest quarter of Sec. 4 (22 N., 8 W.) the sandstone bluff terminates abruptly in a bed of black shale. It is not clear whether this is simply a discordance in deposition or whether it denotes unconformity by erosion. On one side of a fairly sharp nearly vertical line is an exposure of 30 feet of black carbonaceous shale containing clay ironstone and on the other side 15 feet or more of massive sandstone overlain by glacial drift. The black shale continues for a quarter of a mile or more up the creek when it gives way to sandstone.

For a distance of nearly a mile through the north half of Sec. 4 (22 N., 8 W.) no sandstone of even local value is exposed, and in fact very little rock of any kind appears, the region being covered with drift.

Near the middle of Sec. 33 (23 N., 8 W.) the sandstone occurs in a massive ledge and thence outcrops most of the way on one or both sides of the creek to the middle of Sec. 23 (23 N., 8 W.), a distance of about four miles. Near the south end of this exposure the stone has been quarried on both sides of the creek, mostly on the west side, on property said to belong to Mr. Frye. The thickness of the ledge quarried is about five or six feet, probably about five thousand cubic feet in all having been removed. The stone has a variegated yellow color and is marked by a series of alternating gray and yellow narrow bands that are exceedingly intricate in their contortions and foldings, resembling the contortions often observable in the gneisses of metamorphic regions, but probably due to an entirely different cause.

Sandstone of a fair quality has been quarried on the north side of Sec. 33 (23 N., 8 W.) a hundred yards or so above the old mill, also a half mile further north on the east side of Sec. 23 and at various points at and on each side of Rainsville. At Rainsville the stone contains much segregated iron and much cross-bedding. The bedding surfaces where exposed in several places contain beautiful ripple marks. Some fair bridge stone occurs at a small quarry on the north side of the creek, on the east side of Sec. 22 (23 N., 8 W.). At the upper limit of the outcrop observed near the middle of Sec. 23, the stone is too friable to be of any value.

In the northwest quarter of Sec. 24 (23 N., 8 W.) is an outcrop of the underlying Lower Carboniferous shaly sandstone, above which no rock exposures were observed. The valley becomes shallow and is bordered by gentle drift-covered slopes. In the brief time at our disposal, we were unable to obtain any well sections in this vicinity and the partings shown on the map for this locality are somewhat indefinite.

The Mansfield sandstone is exposed in several places on Mud Pine creek in sections 33, 28, and 29 (23 N., 8 W.), and has been quarried for local use in bridges and foundations in Sec. 33 by Mr. Chas. A. House. The stone contains much cross-grain and is more or less variegated throughout. While it shows evidence of durability and may be used safely in bridges, it is not a desirable building stone. Shaly micaceous sandstone, black shale and coal belonging to the productive Coal Measures, outcrops in Sec. 29 at several points. The coal is mined in one place, but the sandstone has no value for building purposes.

At Mr. House's quarry in the northwest quarter of Sec. 33 (23 N., 8 W.) is a natural curiosity that has attracted many visitors. It consists of a "Table Rock" in the middle of the creek, and is an isolated remnant of the rock left by the creek which has cut a channel on either side of it. The top contains about 400 square feet and is ten to twelve feet above the bed of the creek. The surface of the rock in this locality has been scraped by the glacier and shows the glacial grooves and pot holes.

Bernhart's Quarry, Attica.—About a mile north of Attica on the C. & I. C. Railway, and east of Pine creek is one of the largest sandstone quarries in this part of the State. While the stratigraphy is not perfectly clear there is good reason for believing that this quarry is in the sandstone of the Mansfield period that rests quite unconformably on the Lower Carboniferous sandstone. It is unlike the Mansfield stone in most, though not in all, places in that it is not massive, but occurs in regular layers frequently separated by partings of black shale. The shale is more abundant in some parts of the quarry than in others. The layers vary in thickness from a few inches to six feet. The total thickness of the stone on the quarry face is about 50 feet, and in two places it has been worked 12 to 15 feet deeper. The stone has a buff color and medium coarse grain, is homogeneous in color and texture, is easily quarried and quite durable. It is nearly all used for bridges and culverts along the Wabash Railway, and small quantities in wagon bridges and foundations. It was opened about 1856, and is said to have been in almost continuous operation since that date. Mr. F. J. Bernhart has controlled the quarry since 1892, and his father for 14 years previous to that date.

Kickapoo Valley.—The stone in the Bernhart quarry appears to be isolated more or less from other outcrops of the same stone. A small exposure of stone similar to that described above occurs along the railway in the northeast quarter of Sec. 31 (22 N., 7 W.), and a larger outcrop occurs along the railway north of the Attica-Independence wagon road in sections 29 and 20 (22 N., 7 W.), but the Lower Carboniferous (Riverside) shaly sandstone outcrops on the bluff on each side of the Bernhart quarry; in the valley no rock is exposed. The largest vertical exposure of the Mansfield stone in this valley is at Kickapoo Falls, about a quarter of a mile below Kickapoo station. The little watercourse has

cut a ravine, or crescent-shaped cove back into the sandstone which surrounds it with a vertical wall 80 feet high, there being about 60 feet of massive sandstone underlain by 20 feet of black and drab colored shales. The lower 20 feet of the sandstone tends to disintegrate and ex-foliate, the upper 40 feet or more being very firm and presenting a nearly even regular face. Near the middle of the crescent and at the top of the cliff is the remnant of a large pot hole.

The outcrop of the sandstone is continuous from the falls up to the Indiana Greenstone Quarry, near Kickapoo station, where the C. & I. C. Railway has cut an opening through the sandstone about twenty-five feet deep, and it is on the side of this rock-cut that the quarry is located, and the one derrick serves to lift the stone from the quarry and place it on the cars. The stone is somewhat similar in texture to that at Bernhart's quarry, but it is not so evenly bedded, contains no shale partings, and does not have such a uniform color. At the north end of the quarry there are some iron secretions that injure the beauty of the stone. The color varies somewhat in different portions of the opening. While in general a straw yellow is the prevailing color, in some portions it has a distinct greenish tint, from which the quarry is named, and on the point next to the creek east of the railway it is nearly white. Considerable stone has been taken from this quarry and shipped to various points along the C. & I. C. Railway for bridge and foundation stone.

The sandstone occurs in large quantities in the ravine from the north and west at the upper end of the Greenstone Quarry, extending to the section line between Secs. 19 and 20 (22 N., 7 W.). At the upper limit of the stone on this branch are some picturesque rapids and falls, where the water is cutting the channel in the sandstone. On the west side of this ravine near the mouth, and not far from the Greenstone Quarry, is a quarry opening, which apparently was worked to some extent several years ago, but is not now in operation.

No outcrop of the Mansfield sandstone was observed on Kickapoo creek above Kickapoo Station. Black and blue shale are exposed at several points a mile above the station, and elsewhere, so far as observed, the region is covered with a heavy deposit of glacial material. Some well sections show ninety feet of drift.

Between Kickapoo and Little Pine Creeks.—The occurrence of the sandstone on the north side of the river over this area is even more patchy than on the south side. Three exposures occur between Kickapoo creek and Independence. At what is known as the Steadman quarry, in the southeast quarter of Sec. 29 (22 N., 7 W.), the stone has been quarried to considerable extent, but not recently. The stone occurs in the river bluff about 200 yards or less from the river channel. The total thickness of rock exposed is thirty-five feet, the base being concealed below the drainage level. There is practically no covering of drift or soil near

the edge of the bluff, but the upper eight or ten feet of the sandstone are shelly in places, the remainder of the rock exposed occurring in layers three or four feet thick, but the layers are not regular. Yellow and yellow-gray are the prevailing colors. The uncertainty of the extent of the sandstone in this locality is due not simply to the unconformity at the base, but as well to the glacial or preglacial erosion at the top. A well on the bluff back of the Steadman quarry, not a quarter of a mile from it and but forty feet above, is said to be 110 feet deep, forty-five feet in gravel and sixty-five feet in fine sand, with no solid rock.

There is another small exposure of sandstone of medium quality that has been quarried in small quantities on the McAdams property in the southwest quarter of Sec. 28 (22 N., 7 W.), and a slight outcrop in the northeast quarter of section 28, but they are of only minor local importance.

In the vicinity of Independence large quantities of the Riverside sandstone and shale (Lower Carboniferous) are exposed, but it is all too shelly apparently to have any value.

On each side of the river at Independence there are a great many large crystalline glacial boulders, that are so abundant in places as to prevent the tilling of the soil. The largest of these boulders, known locally as College Rock, occurs at the school-house on the west side of Sec. 22 (22 N., 7 W.), and is approximately 12 x 14 x 10 feet above the surface; the dimensions beneath the surface are not known. So far as known this is the largest glacial boulder in the State.

At Independence are deposits of good potter's clay that were used many years ago. A pottery was in operation here in 1870-71, and one two miles north of town from 1855-65.*

The only exposure of Mansfield sandstone observed between Independence and Little Pine creek is on the east side of a small tributary known as Dry branch. A coarse yellow sandstone of no commercial importance and containing patches of quartz conglomerate, forms a bold cliff along the east side of the ravine, the slope on the west side being covered with drift.

Little Pine Creek.—On Little Pine creek the yellow Mansfield sandstone outcrops through the northwest quarter of Sec. 17 (22 N., 6 W.), through Secs. 8 and 5 (22 N., 6 W.), and a small area of the red in Sec. 32 (23 N., 6 W.). The outcrop is observed to rest unconformably on the drab-colored shaly Riverside sandstone, which outcrops in a number of places. The outcrops show conspicuously in the bluff on the west side of the creek on the north side of Sec. 8 (22 N., 6 W.), where the relation of the shale and sandstone is as shown on the accompanying figure

* See Report on Clays by the State Geologist in this volume.

(Fig. 6), the underlying drab shale having been eroded before the overlying sandstone was deposited on the irregular surface.

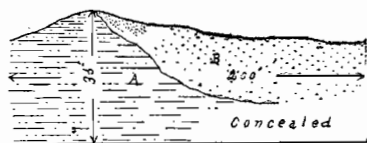


Fig. 6. Section on Little Pine Creek showing unconformity between the Lower and Upper Carboniferous rocks.

A—Lower Carboniferous (Riverside).

B—Upper Carboniferous (Mansfield).

At "Falling Rock" in the southeast quarter of Sec. 5 (22 N., 6 W.) is a bold outcrop of the sandstone in a small ravine where the sandstone 30 feet in thickness forms a perpendicular bluff which is kept so by the more rapid disintegration of the underlying shale and softer sandstone at the base of the deposit. The stream washing this away more rapidly in its channel than elsewhere gives the bluff its crescent shape. There are numerous occurrences similar to this throughout the sandstone area. A very similar one and one given the same name ("Falling Rock") occurs about two miles northeast in the northeast corner of Sec. 4 (22 N., 6 W.). Small quantities of medium quality yellow and gray sandstone have been quarried for local use on the slope north of Falling Rock in the southwest quarter of Sec. 5 (22 N., 6 W.) and other ledges equally as good occur in the northwest quarter of the same section.

Greenhill Red Sandstone Quarry.—Probably the most important sandstone from a commercial standpoint in this part of the county is the red sandstone in the west part of Sec. 32 and the east side of Sec. 31 (23 N., 6 W.). The stone outcrops along the south side of a small branch from the west, and so far as known is not exposed on the north side of the branch, the slopes being covered with glacial material. The stone has been quarried for use in building and bridges; the principal quarry opening being on the east side of the road a short distance north of the half section corner between sections 31 and 32. The face of the quarry is 20 feet, the total thickness of the bed is not shown, but is not less than 30 feet and may be much more. There is a little shelly rock at the top, but in no place more than one or two feet and the overlying drift is very light, being from zero to two or three feet. The stone on the quarry face is somewhat friable, much more so than that in the natural exposures or in the bridge abutments where it has been used. It has a light red color, a much lighter, brighter, warmer red than any other red sandstone of the State. The lighter color is apparently due to the presence of less iron than in the brownstones rather than a different state of hydration, the brighter color being due probably to the absence of the hydrous oxide.

The small quantity of iron is shown both in the chemical analysis and in the microscopic examination. The percentage of iron is lower than that in any other sandstone of the State that has been analyzed (see final chapter for comparison).

Chemical Analysis of Greenhill Red Sandstone.

Digested in concentrated hydrochloric acid (HCl).	
Residue (white) insoluble in HCl.....	98.73
Alumina (Al_2O_3) .....	.28
Iron Oxide (Fe_2O_3) .....	.36
Lime (CaO).....	.03
Carbonic acid (CO_2) (by computation).....	.02
Total.....	99.41

The stone is remarkable, not only for the low percentage of iron, but of the alumina and lime as well, the percentage of all the soluble material being less than one per cent., so that the question naturally arise whether there is sufficient cement to make the stone of any value. In favor of its strength might be stated (1) that the grains are closely interlocked and there is probably some silicious cement, as a fragment of the stone digested in dilute acid for several days, still retained much of its tenacity, and (2) the stone where it has been used shows an indurated surface much harder than the fresh stone, and this despite the fact that the stone was quarried by blasting with powder and dynamite. The Martindale house, about four miles southeast of Pine Village, was constructed of stone from this quarry more than 35 years ago.* It shows no effect of disintegration yet, in fact is not even discolored. Examination with the core drill is said to have been made by Chicago parties in this locality several years ago, but nothing definite about the results could be obtained. Despite the fact of the friability of the stone in the quarry and the low percentage of cement, the evidence from the weathered face and the use in buildings and bridges is sufficient to warrant further exploitation of this stone when transportation facilities are offered.

Black Rock and vicinity.—At Black Rock, in the southeast quarter of Sec. 9 (22 N., 6 W.), is an isolated outcrop of yellow Mansfield sandstone and conglomerate, capping a high promontory overlooking the Wabash river. A section at this point shows 30 feet of massive Mansfield sandstone underlain by 75 feet of Lower Carboniferous shaly sandstone, thus making the top of the sandstone 105 feet above the river.†

*The actual date could not be ascertained further than that it was long before the war.

†The old county map gives it 140 feet, but careful measurements made by the writer on two different days with a good aneroid showed only 105 feet.

The Mansfield stone lies unconformably on the underlying shaly sandstone as shown on the accompanying figure (Fig. 7) and 30 feet denotes the

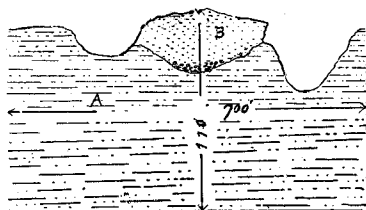


Fig. 7. Section of the bluff at Black Rock.

A—Riversidesandstone and shale.

B—Mansfield sandstone.

maximum thickness. The rock is very ferruginous and has little or no economic value. The conglomerate at the base contains pebbles of chert, quartz, and the underlying shaly sandstone. On top of this rock 50 to 75 yards back from the face of the cliff and 10 feet below the highest point is a chalybeate spring, which is heavily charged with iron and has formed a considerable deposit of iron oxide around it.

Sandstone and conglomerate outcrops at several places indicated on the map in the south part of Sec. 4 (22 N., 6 W.) and in the northeast corner of section 4 at "Falling Rock," but none of it has any value as a building stone. There is much conglomerate in this vicinity, and much of it is made up of geode fragments; in one place on a space of two or three square feet 24 geode fragments were counted. In some places the conglomerate is fine, the separate pebbles being about the size of wheat grains, while in other localities they are coarse, being about the size of hickory nuts. No Mansfield sandstone was observed east of the county line in Tippecanoe county, but the region was not explored and it is possible that small isolated spots of it may occur.

CHAPTER V.

NOTES ON THE SANDSTONE QUARRIES OF INDIANA, OUTSIDE OF THE AREA MAPPED.

The following notes are made from a more or less hasty examination of the different localities, and mainly on the commercial features of the stone with little reference to the stratigraphy, and are given here only as a preliminary report on these localities. Many of the quarries are more important commercially than many of those in the area mapped and are deserving of a more thorough investigation, in the absence of which these notes are given.

THE PORTLAND STONE, VERMILLION COUNTY, IND.

The Carboniferous sandstone quarried at Worthy, Vermillion county, is known in the market as Portland stone. The quarry is situated in a small ravine about 150 yards west of the main line of the C. & E. I. railway from Terre Haute to Chicago, on the west side of the Wabash river about four miles north of Hillsdale, in section 14 (Tp. 16, N. R., 9 W.)

The stone at the quarry of the Portland Stone Co. belongs to the age of the Coal Measures at a horizon above that of the Mansfield stone.* It is thought to be correlative with somewhat similar deposits of sandstone as yet undeveloped on the Little Vermillion river at Francis Davis' about three miles west of Newport, and on Big Vermillion river about six miles northwest of Cayuga, both in Vermillion county.†

Chemical Composition of the Portland Stone.—The following analysis of the Portland stone was taken from an article in the "National Builder," January 19, 1895, furnished by S. S. Gorby, State Geologist, but the analyst is not given nor any particulars in regard to the analysis:

Analysis of Portland Stone.

	Per cent.
Silica (Si O_2)	91.182
Lime carbonate (CaCO_3) .....	.864
Magnesia (MgO)	1.413
Ferric oxide ($\text{Fe}_2 \text{O}_3$)	1.120
Alumina ($\text{Al}_2 \text{O}_3$)	2.134
Moisture and loss	3.287
Total	100.

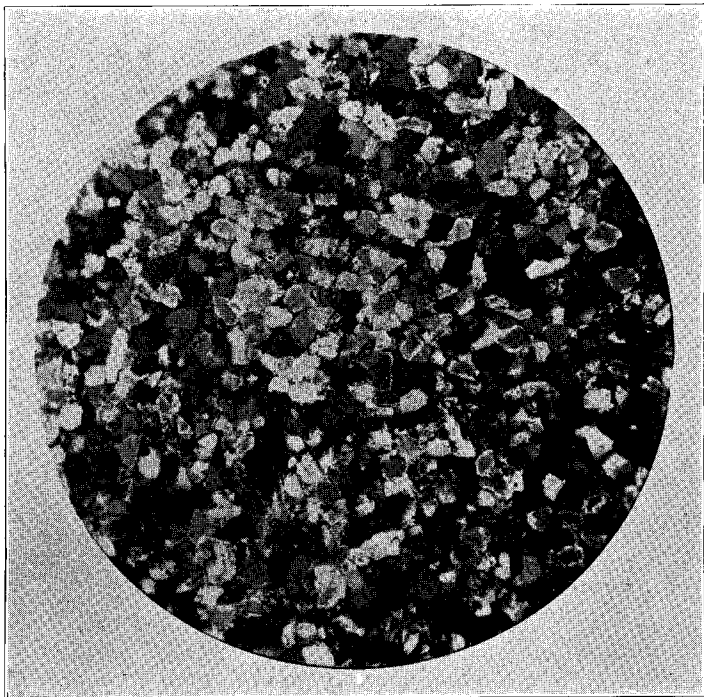
The crushing strength of Portland stone is given in the "National Builder" ‡ as 27,300 pounds per two inch cube, which would equal 6,825 pounds per square inch, providing it was a perfect two inch cube. This is about the average strength of good sandstones. See tables in final chapter of this report for comparison.

Microscopic and Mineralogic Character of the Portland (Ind.) Stone.—The Portland stone is finer grained and more complex in its mineralogic composition than the Mansfield stone. The stone contains about the same percentage of quartz as the Mansfield brownstone, but a lower percentage than the Mansfield gray or buff stone. The quartz is all angular

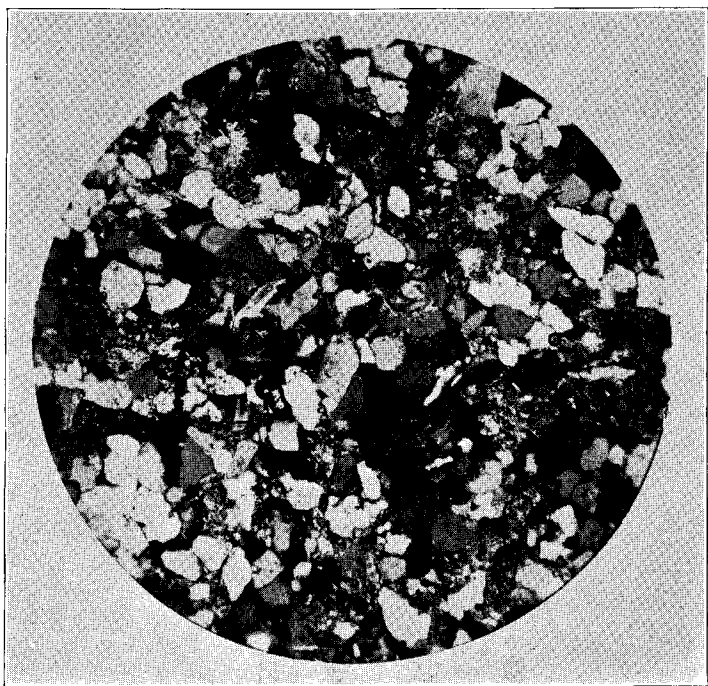
* Its more precise location in the Coal Measures, with its relation to the different coal beds, will no doubt be given in the economic report on the coal.

† Both these localities were visited and notes made on the outcrops and samples collected for examination, but lack of time has prevented laboratory examination and the preparation of the notes for publication.

‡ The "National Builder," January 19, 1895. The test was made by J. D. Kramer, Cincinnati, Ohio.



No. 1.



No. 2.

MICROPHOTOGRAPHS.

No. 1. CANNELTON SANDSTONE, CANNELTON, INDIANA.

No. 2. PORTLAND SANDSTONE, WORTHY, INDIANA.

as shown in the microphotograph, Fig. 2, Plate 15. The grains are comparatively uniform in size, averaging 0.214 millimeter or .0082 of an inch in diameter. The largest grain measured was 0.3 millimeter or .0118 inches in diameter. It will be noticed on comparison that in the size of the grains the stone resembles the buff colored Mansfield stone at Williamsport, and is finer grained than the brownstones. A few of the grains show they have been subject to strain, but the greater number of them are free from such appearance, so that while part of the grains may have come from an area of distorted strata much of it evidently did not. The grains are enclosed in a complex cement of clay, mica, granular and crystalline quartz, fragments of decaying feldspar, carbonates and iron oxide. The clay evidently comes, in part at least, from the decaying feldspar with which it is closely associated, along with granular quartz and calcite.

The mica is muscovite and occurs in small, ragged flakes, much of it intimately twisted among the grains, thus serving as an elastic bond of strength, and indicating a deposit simultaneous with the sand. The carbonates occur in minute, scattered, microscopic patches through the rock; they are thought to be in part calcite and in part dolomite, or siderite, or both. These minerals in minute quantities are not readily differentiated. The rock digested in cold dilute acid gave some effervescence, which, having ceased and the acid being heated, was renewed with even greater vigor than at first, thus indicating the occurrence of both the calcite and one or both of the other carbonates. The chemical analysis would indicate that all three might be present. The carbonates are unequally diffused through the rock, some areas being free from them, others containing not less than three or four per cent.

Some of the quartz grains are bound together by a quartz cement so firmly as to be differentiated only between crossed nicols. Whether the quartz has been deposited on the grains in their present position, or whether such areas are but fragments of quartzite from some other region does not in all cases appear. Yet the evidence appears to support the former view, as some of the areas are large enough to form a conglomerate if they were deposited as quartzite. In any case the quartz cement hardens and strengthens the rock.

The iron oxide occurs in very finely diffused grains that are possibly derived from oxidized iron pyrites or carbonate. None of the original sulphide was discovered, but not a sufficient number of fresh specimens were examined to prove its absence further than to prove that if it occurs, it is in minute quantities.

There is some finely diffused carbonaceous matter that aids in giving the deep bluish tint to the stone. In one place a fragment of fossil plant was found under the microscope that still retains its cellular structure.

The quartz grains contain some fluid inclusions and some microlites of zircon, anatite and rutile, but the inclusions are few and all minute.

The rock occurs in a massive bed, which in the quarry shows a working face of 51 feet, and it is said that a core from the diamond drill was taken out to the depth of 69 feet without reaching the bottom of the stone or a change in its character. However, the present face extends to the bottom of the ravine and to carry it any deeper would require pumping especially in wet weather. Should the stone prove to be of good quality to a considerable lower depth the pumping would not be a serious hindrance as there is no permanent stream in the ravine in dry seasons, and it could be done cheaper than to strip the overlying waste material. On the present quarry face there is overlying the quarry stone a thickness of 25 feet or more of shale, fire-clay, coal and boulder clay. The fire-clay and coal are said to be utilized and probably more than pay for their removal. If the shale could also be utilized for paving brick it would add greatly to the profits of the quarry. Plate 16 shows a view of the quarry in operation.

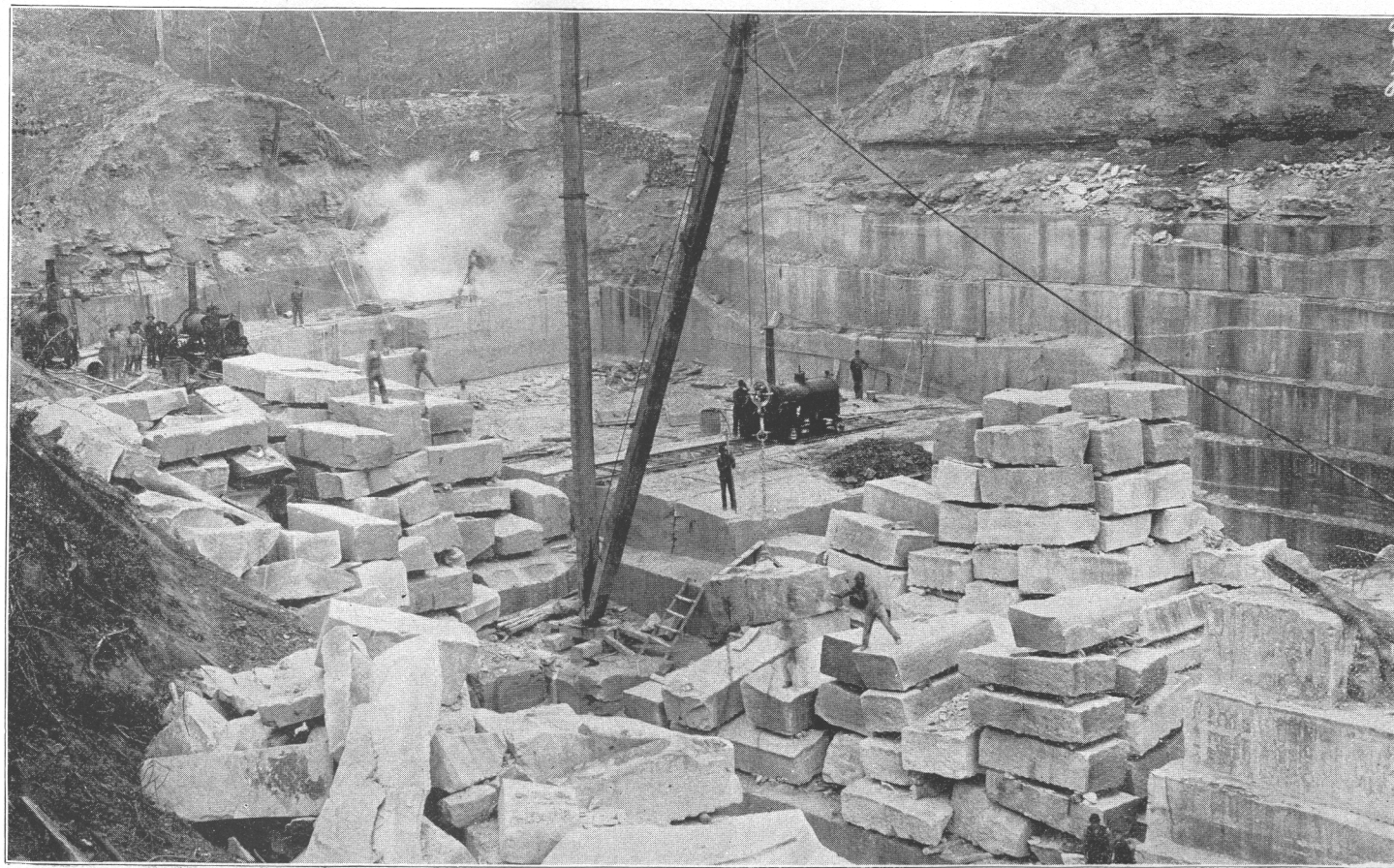
The quarry was opened in 1894 by the Portland Stone Co., with offices at the quarry and in Chicago, and representing a capital of \$40,000. The production of the quarry for the first year (1894) was 200,000 cu. ft.; for the past year (1895) 200,000 cu. ft.

The quarry is well equipped for work; the company employs from 30 to 60 men, and has besides its own railway engine for shifting cars, two steam power derricks, two horse derricks, three channelers (two in operation, 1895), one steam drill and two gangs of saws. They contemplate putting in a six gang mill.

The principal shipping points for the stone are Chicago, Ill., Milwaukee, Sheboygan, and Portage, Wisconsin; Detroit, Mich., and Terre Haute, Ind. Some stone has been shipped to each of the following points: Charleston, Homer, Muncie, Indianola, Rossville, Sadoris, Seymour, Danville and St. Joe, Ill.; Cayuga, Newport, Montezuma, and Dana, Ind.

Some of the stone is used for bridges and some for buildings. There are probably more than 200 buildings in Chicago which contain the Portland stone, either for entire fronts or as trimmings. Nearly all the brick houses and flats in Chicago have stone trimmings, such as cornices, lintels, water tables, etc., or else the entire front of stone and the side walls of brick. The Portland stone appears to give good satisfaction for such uses and is a growing rival of the Bedford and Joliet stone. The court house and church at Charleston, Ill., are built of Portland stone. It has had considerable use along the C. & E. I. railway for bridge stone, both on the main line and the C. & I. C. division. It was used in the bridge over the Calumet river in Chicago, built during the past summer, 1895.

The thickness of the deposit of the Portland stone, its massive structure, its homogeneity of texture, composition and color, the ease with



PORTLAND SANDSTONE QUARRY, WORTHY, INDIANA,

which it can be quarried and dressed, its location near the railway, its proximity to important markets, all combine to give it great commercial importance and the industry, which has so quickly risen to prominence, will no doubt continue to increase for some years to come, or until the expense of stripping the overlying waste material prohibits the further profitable production of the stone.

CLAY COUNTY.

Brazil.—Sandstone has been quarried in limited quantities in several places in the vicinity of Brazil. The stone is of inferior quality and never had more than a local usage. The quarries are nearly all abandoned at the present time and will probably never again be worked to any extent, as the large brick works can supply a better and cheaper building material than can be obtained from the sandstone.

On the Pierce farm on the hill north of Newburg (Turner), two and a half miles west of Brazil, a soft, micaceous sandstone was quarried for foundation stone in Brazil. The quarry was in operation for ten or twelve years, but has been abandoned now for three or four years and the overlying soil and drift have crumbled in, almost entirely concealing the stone.

Stone has been quarried in small quantities at several localities along Otter creek, north of Brazil. At the high trestle on the C. & I. C. railway, stone has been quarried on each side of the creek. It is a very light gray sandstone, slightly variegated with yellow and more or less shelly on the exposed surfaces. It is both overlain and underlain by coal. Stone has been obtained here within the last two years, but the quarry is not now (1895) in operation.

On Otter creek in Sec. 18 (13 N., 6 W.), near the little town of Cardonia, gray, buff, and banded sandstone has been quarried for local use. The gray and yellow banded stone is very handsome in hand specimens, but is only of medium value for building material. The stone occurs in a bed 15 to 18 feet thick and has been quarried at several points along the Midland railway in this section. The sandstone at all the localities above mentioned in the vicinity of Brazil occurs in the Coal Measures at a higher horizon than the Mansfield sandstone.

ORANGE COUNTY.

Sandstone adapted for local use in foundations, bridges, curbing, etc., occurs in many places in Orange county. The best stone is that interstratified with the Lower Carboniferous limestones, and designated the Paoli sandstone by Mr. Kindle in his report on the whetstones of this region. [See the following paper in this volume.]

Notes were made on the occurrence of this stone at several different localities, and samples taken, but lack of time has prevented an examination of the latter and a proper arrangement of the former. The stone has been quarried for local use at West Baden, Paoli, Orleans and elsewhere, and will no doubt be used more in the future than in the past when the people realize the ease with which it can be quarried and dressed. Here, as in most other limestone regions, the citizens have the impression that because it is much softer than limestone that it will not stand the weather.

The Mansfield sandstone of this region is for the most part too imperfect for good building stone, as it contains much conglomerate, cross-bedding and many iron secretions.

GREENE COUNTY.

Bloomfield.—A mile and a quarter northeast of Bloomfield in the southwest quarter of Sec. 13, (7 N., 5 W.,) is one of the most promising exposures of red or brown sandstone in the State of Indiana. It outcrops on each side of a small tributary of Richland creek, known locally as Warren branch, the largest and most promising exposure being on the west side. The thickness of the exposure is 35 feet, but as the bottom is concealed by the debris of the valley the total thickness of the deposit is unknown. The length of the exposure is about 200 yards, being concealed at each end by loose soil and debris. It occurs at the base of the hill which rises to a height of 50 feet or more but with a very gentle slope, and the stripping would probably not exceed 10 feet, 25 or 30 yards back from the face of the bluff.

The stone is remarkably uniform in texture and more uniform in color than is customary for the brownstone on the surface. It is coarse to medium in grain as shown on the drawing (see No. 5, on plate 12) and weathers evenly, showing a firm, even, hard, indurated surface, in some places moss-grown. The base of the bluff is strewn with many large boulders, some 10 to 20 feet in diameter, some sharply angular and some rounded. Trees two feet or more in diameter are growing behind some of these boulders, indicating that they have been separated for many years from the parent ledge, yet as a rule there is but very little sand or debris about them, indicating that there has been very little disintegration; on the contrary they are harder on the surface than in the interior.

The stone varies in color, but is comparatively uniform at any one place. The prevailing color is reddish brown, somewhat brighter than the Connecticut brownstone and not unlike the stone at Mansfield and St. Anthony in color.

The chemical analysis shows it to have a high percentage of iron oxide, higher than most of the brownstone of Indiana. The microscope shows this iron to be partly crystalline, crystal faces measuring 0.032 millimeter in length occurring. The percentage of alumina and lime is remarkably low.

Chemical analysis of brownstone from Bloomfield.

	Per cent.
Residue (white) insoluble in hydrochloric acid	85.29
Ferric oxide (Fe_2O_3)	11.83
Alumina (Al_2O_3 ) .....	.19
Lime (Ca O} ) .....	.06
Carbonic acid (CO_2), (computed) .....	.05
Water and loss, by difference	2.58
Total	100.00

As shown by the microscope the insoluble residue is practically all quartz, the grains averaging 0.28 millimeter in diameter.

This stone has not been developed, not even for local use except a small quantity taken out this year (1895) by Mr. Joseph Shryer for the foundation of his house in Bloomfield, and that was taken from the loose boulders and not from the parent ledge. The location is in the little valley that leads to the Bedford-Switz City division of the Louisville & New Albany Railway about two miles distant, so the lack of transportation facilities ought not to be a serious drawback to the development of this stone.

Rockwood.—At Rockwood, about five miles south of east from Bloomfield, buff and gray sandstone has been quarried to some extent by Mr. J. Hassler and brother. The stone has been taken from two different openings. On the south side of Plummer creek, about a quarter of a mile south of the railroad, is a ledge of light gray sandstone, six to eight feet thick, that is an exceptionally fine building stone. It has such a smooth easy cleavage that it can be readily split in sizes of any dimensions. A slab twelve feet long, four feet wide and six inches thick, lying at the quarry, looks as regular as though it had come from the saw mill. The ease with which it can be quarried and its agreeable color should give this stone an extensive local use. It would make good whetstones or grindstones.

The stone at the railroad, on the north side of Plummer creek, near Mr. Hassler's house, is buff-colored and somewhat variegated in places. It is not as uniform, valuable, or desirable stone as that on the south side of the creek, yet is suitable for foundations and heavy masonry and has been quarried in considerable quantities.

DUBOIS COUNTY.

St. Anthony.—J. B. Lyne & Son operate a brownstone quarry about one mile west of St. Anthony, Dubois county, Indiana, near the middle of Sec. 27 (2 S, 4 W.). The quarry was opened in 1887 and operated on a small scale for two years when it was shut down. It was reopened in 1894 by Lyne & Son with improved machinery and is now doing an extensive business. They have built a switch from the quarry to the Louisville, Evansville & St. Louis ("Air Line") railway, and ship stone to Louisville, Evansville, St. Louis, Terre Haute and intermediate points.

The stone occurs in a massive bed varying from 10 to 16 feet in thickness. It is overlain and underlain by shale. The underlying shale is light gray with streaks of black, said to be accompanied by coal and fire-clay in places, but none is exposed at present. Near the north end of the quarry the shale is impregnated with considerable iron, which also occurs in small quantities in the base of the sandstone at this point. The overlying shale has a blue-gray color and contains some intercalary sandstone. One or two incipient bedding planes appear on the exposed surface of the sandstone, but disappear in the back part of the quarry. There are a few indistinct joint planes with a general east-west trend.

The chemical analysis of the stone shows it to have a lower percentage of silica and a higher per cent. of iron than the stone at Mansfield, closely resembling the Bloomfield stone in this respect.

*Analysis of St. Anthony Sandstone.**

	Per cent.
Residue (white) insoluble in concentrated HCl.....	88.41
Iron oxide (Fe_2O_3).....	8.40
Alumina (Al_2O_3).....	.63
Lime (CaO} ) .....	.13

The insoluble residue is practically all quartz as shown by microscopic examination. In the specimens examined the grains range in size from 0.09 mm. to 0.48 millimeters in diameter, the average of 20 contiguous grains being 0.32 mm. or 0.0126 inches. The quartz grains are angular, subangular and rounded and contain many fluid inclusions and a few microscopic apatite crystals. (See No. 4 on plate 12.) The only other mineral present in any appreciable quantity is the iron oxide, apparently a mixture of the red and brown hematites with probably a minute quantity of clay. See Chapter III, for physical tests on the St. Anthony stone.

The length of the quarry floor is about 800 feet. The stone has been stripped back from the face a distance of 10 to 30 feet, a small portion of

*See table in final chapter for comparison with other sandstones.

which has been removed and much of it channeled ready for removal. In most places two channel cuts of about six feet each are removed. The large area uncovered and the removal of the stone in large mill blocks in quantity enable the owners to select the colors in a more satisfactory way than can be done in a small quarry. Here as at Mansfield and elsewhere the stone is not uniform in color throughout. There are several distinct shades which, while partially grading into each other in places, can with care be separated by proper sawing of the stone, thus giving an opportunity to bring all the stone into groups of uniform color. As one shade may predominate more in one part of the quarry than in another, the advantage of having a large face to select from and a large stock in the yard will readily appear. The quarry is well equipped with channelers, drills, good derricks and a good mill, and apparently the only limit to the supply of good brownstone is when the expense of stripping the overlying shale and soil will prevent a profit on the stone. If arrangements can be made to utilize part or all of this now waste material for brick making or other purpose so as to wholly or in part pay for its removal this time may be indefinitely postponed.

Northwest of St. Anthony.—No other outcrops of brown stone are reported in the immediate vicinity of St. Anthony. A buff stone has been quarried near the town for use in building the Catholic Church and in some of the foundations. In the region west of north from the brownstone quarry the brownstone is said to outcrop at different points. The region was not traversed except the road from Jasper to Knoxville, along which the brownstone is exposed in a number of places. The largest and best exposures observed are at Herrman Brelage's, in sections 21 and 28 (1 S., 4 W.). The stone varies in color through several shades of brownish red, and in certain spots is impregnated with "iron blisters." At some of the exposures the color and texture are fairly uniform. How far the uniformity extends cannot be predicted definitely from the examination of the surface exposure. The largest single exposure observed was not more than twelve feet thick, but an outcrop eight feet thick near the top of the hill and another twelve feet thick at the base of the hill, thirty or forty feet below the first, would indicate that there is a bed of considerable thickness, possibly not less than forty feet. However, the intervening concealed interval may consist largely of buff sandstone or shale.

Jasper.—Gray and buff sandstone has been quarried for local use at several points in the immediate vicinity of Jasper. The Catholic Church at that place is constructed of stone from different quarries in the vicinity. The only quarry in operation in 1895 is operated by James Schroeder and one assistant, in the south part of Sec. 25 (1 S., 5 W.), a mile or more northeast of Jasper. The stone is gray and buff in color, and harder than the average Mansfield stone. The product is mainly used for

foundations. Small quantities have been shipped to Huntingburgh for flagstone and curbstone. The Jacob Eckert quarry, on the east side of Patoka creek, about half a mile east of Jasper, has been abandoned for some years, as has the Fisher quarry, a mile north of the town.

PERRY COUNTY.

Cannelton.—Some of the largest and oldest sandstone quarries in Indiana are those near Cannelton, Perry county. Sandstone is exposed in the Ohio River bluffs in many places in Perry county, and has been quarried at and below Cannelton, but the most valuable stone, and that which has been quarried most extensively, occurs on the bluff two to four miles above (east of) Cannelton at and below Rock Island, in sections 12, 13, and 14 (7 S., 3 W.).

The Mansfield sandstone and conglomerate occurs at the base of the bluff at Rock Island, but is not quarried, except in small quantities for rip-rap. The dimension stone is all taken from the overlying Coal Measures. Part of the Mansfield formation is coarse conglomerate composed of pebbles a quarter to a half inch in diameter, in places the pebbles forming a closely compact mass, with little sand, in other places loosely scattered through the sandstone, and occasionally occurring in layers, following the false bedding of the stone.

The dimension stone has been taken from beds overlying the Mansfield stone, and in most places separated from it by a bed of black shale. It is finer grained than the average Mansfield sandstone, the average diameter of the grains being 0.14 millimeter, the largest being 0.2 mm. (See Nos. 1 on Plate 15 and 6 on Plate 12.) The chemical analysis shows a higher percentage of insoluble residue than the average sandstone, but this residue is not all quartz, as in much of the Mansfield stone, but mica, both muscovite and biotite, occurs; the quartz contains zircon, apatite and rutile crystals.

Chemical analysis of Cannelton Sandstone.

	Per cent.
Residue, insoluble in hydrochloric acid.....	96.18
Ferric oxide (Fe_2O_3)	1.56
Alumina (Al_2O_3) .....	.54
Lime (Ca O}) .....	.15
Total	98.43

The color varies from a lemon-yellow to a light or dark gray. In general, however, the color is comparatively uniform at any one quarry opening, varying from place to place. The color is in no place an attractive one for fine buildings, owing to the rusty yellow tint of the iron oxide that always occurs. It is better adapted to heavy masonry, where economy is subordinated to ease of working and durability.

The stone occurs in a massive bed, which only rarely shows open bedding planes, but nearly always has an easy cleavage parallel to the bedding, so that it can be readily split into any thickness desired. This greatly facilitates the working of the stone, which is all done by hand. A channeler was used for a while in one of the quarries, but is idle at present (1895), the apparent reason for its idleness being that the stone at the point where it has been used is of inferior quality. In many of the openings there is not sufficient quarry floor to use a channeler to advantage. The stone occurs on the face of a steep bluff and is overlain by black shale, overlain in turn by other sandstone. The stone is quarried back in the bluff until the thickness of the overlying shale becomes too great to remove and permit any profit on the stone.

As the shale is not, in physical appearance at least, unlike that used elsewhere for paving bricks, it is possible that it might be so used here. The appearance of the shale is sufficient at least to warrant an investigation in that line. In some places it would be possible to run an incline track or chute from the shale bed to the river bank, and the loading of it on barges would be a slight expense. Even though it would but partially pay for its removal it would uncover large quantities of valuable stone, the profits on which would help pay for removal of the shale.

The large cotton mill and the Catholic church at Cannelton, are constructed of stone from these quarries. There are a dozen or more smaller buildings in Cannelton, store rooms, dwelling houses, etc., which are built of it; also many foundations, retaining walls, etc. It was used in the locks on the canal at Louisville, Ky., and for a similar purpose on the Green river, Ky. It has been used in a number of places along the Ohio river for rip-rap, retaining walls, wharves, etc.; some shipped as far down as Memphis.

The quarrying of sandstone at this locality will no doubt prove to be an important industry for many years to come, as the stone occurs in a heavy deposit, easily worked, and well adapted to heavy masonry.

CHAPTER VI.

SUMMARY.

The investigation shows that sandstone of good quality and in commercial quantities occurs at several different horizons in the Carboniferous system in western Indiana. It also shows that along with the good stone in each of these beds there is much that is inferior and that care is necessary in selecting the product. In the chapter on local details, as far as possible, all the points where good stone for local use occurs are designated, and in a less degree the defective stone is described and the defects pointed out, that it may be avoided.

The most important bed of sandstone is that termed the Mansfield, which lies at the base of the Coal Measures, unconformably on the Lower Carboniferous limestones, and is supposed to be the equivalent of the Millstone grit of adjoining States and extends in a strip varying from two to ten miles or more in width, from the north part of Warren county in an east of south direction to and beyond the Ohio river, a distance of more than 175 miles in the State of Indiana. Over all the north part of this area, all that is shown on the two accompanying map sheets, is a belt of glacial drift material, varying in thickness from zero to 200 feet or more. The great mass, probably nine-tenths, of the formation is made up of a medium to coarse-grained massive sandstone, which is associated with (1) patches of conglomerate, varying from a few inches to several feet in thickness and from a few feet to hundreds of yards in lateral extent, (2) shaly sandstone, (3) shale, (4) coal and (5) fire-clay.

The source of part of the coarse material of the conglomerates and the sandstone is shown to be from the cherts and geodes of the underlying limestones. The remainder is probably from the crystalline areas of the lake regions.

While the Mansfield sandstone is soft, friable, and easily worked, it is at the same time one of the most durable rocks in the State. This is proven by its topographic features and its use in buildings and bridges. It consists essentially of quartz grains in a cement of iron oxide, with some silica and minute quantities of clay; it is locally micaceous and contains small quantities of feldspar and other minerals in places. The tendency of the iron oxide to segregate injures much otherwise good stone. The grains are mostly angular, but in the coarser varieties some of them are rounded and subangular.

The many varieties in color are grouped under the two general heads of: (1) Brownstone, including the red-brown, purplish-brown and chocolate-brown, and (2) buff and gray stone, variegated stone, occurring in each class. Commercial stone is obtained in both classes, but is less abundant and more valuable in the first than in the second class.

The greatest drawbacks to the more rapid development of this stone are: (1) The absence of railway facilities at some of the best deposits; (2) the occurrence of the so-called iron "blisters" or "kidneys" that injure the brownstone in many localities; (3) the presence of much cross-grain or false-bedding; (4) lack of uniformity in color; (5) inferior stone having been quarried and put on the market, thus injuring the reputation of the good stone. Throughout a large portion of the area much of the stone is injured by one or more of these causes, yet in many places the stone is so far free from these defects that it could be worked with profit as is done in a few places. The stone is deserving of a more extended use than it has at present, yet the poorer stone that will be put

on the market from time to time by careless quarrymen will always be a drawback to the development of the stone.

Quarries in the Mansfield stone are in active operation at St. Anthony (brownstone), Williamsport (buff), Attica and Kickapoo (buff), Fountain (brown and buff), and numerous small quarries throughout the area. One brownstone quarry has been opened this year (1895) at Portland Mills. There are idle quarries at Mansfield, Hillsboro, Attica, Greenhill and elsewhere throughout the area. Undeveloped deposits occur at different points, the most promising being in Parke and Greene counties.

Sandstones in the Coal Measures.—Interstratified with beds of coal and shale, sandstone of good quality occurs in a number of places in the Coal Measures at a horizon above that of the Mansfield stone. These were not examined in detail, but notes made at a number of different points show much valuable stone.

The so-called Portland stone at Worthy, Vermillion county, is one of the best building stones of the State and is taken from one of the most productive quarries. The stone has a gray-blue color varying to light buff near the surface. It occurs in a massive bed more than fifty feet in thickness overlain by shale coal and glacial drift. It is highly silicious, consisting largely of quartz grains in a complex cement of clay, silica, and iron and lime carbonates. It is not so durable as the Mansfield stone, but judging from the outcrop and the composition it is equal to the average in this respect.

At Cannelton, on the Ohio river, are extensive quarries of Carboniferous sandstone immediately overlying the Mansfield stone. It is not so attractive in color as the Portland stone and will not command as high a price for building purposes, but it is accessible in larger quantities, is equally as durable, possibly more so, is easily worked and is well adapted to use in heavy masonry. These quarries have been productive for many years.

Sandstone of Carboniferous age has been quarried at Jasper, Brazil, Coxville, and points west of Newport, northwest and northeast of Cayuga, south and west of Covington, and elsewhere.

Riverside Sandstone.—At Riverside, Fountain county, are two large quarries (one in operation in 1895) in sandstone of Lower Carboniferous age. The stone varies from a light blue color on the interior to a drab or buff on the exterior. It is evenly stratified in layers from two inches to more than three feet in thickness, the thinner layers being on the exterior, and the thicker ones in the interior. It is very fine grained, takes a smooth finish and is adapted to delicate carving and ornamentation. It is not so highly silicious as the sandstones of the Coal Measures, and has a greater variety of mineral constituents. While the Riverside sandstone is not so durable as the Mansfield stone and not so well adapted

to heavy masonry, yet it is better adapted to trimming or carved work. The bulk of the stone is used at Lafayette and neighboring towns, yet some of it has been shipped to more distant points.

Similar stone to that at Riverside has been quarried near Attica at Raccoon Station on the I., D. & W. railway and on Big Walnut creek east of Bainbridge, Putnam county, and other points in the State.

In the southern part of the area there are at least two beds of sandstone in the Lower Carboniferous limestones, a much coarser grained stone than the Riverside stone, and resembling the buff-colored Mansfield stone. It is thought to occur at a horizon between the Riverside and the Mansfield (the Chester?). It has been quarried for local use at several places in Orange county.

The crushing tests of the Indiana sandstones indicate a stone about equal in strength to stones of similar character elsewhere, but below the average for all sandstones if the quartzitic varieties are included. The fire tests would indicate a stone that would not stand a fierce conflagration without more or less serious injury. However, the reports from its use in fire places, chimneys, sugar furnaces, and blast furnaces indicate a fire-resisting stone of some merit, from certain localities at least.

The experimental and statistical information is tabulated in the following pages. The value of the annual production varies from \$80,000 to nearly \$200,000.

TABLE I.

Statistics of sandstone production in Indiana for 1891, 1894 and 1895.

Location of quarry.	Kind of stone.	Capital invested.	1891.		1894.		1895.	
			Cu. Ft.	Value.	Cu. Ft.	Value.	Cu. Ft.	Value.
Williamsport..	Buff.	\$25,000	105,000	\$10,500	210,000	\$23,000	200,000	\$22,000
Kickapoo.....	Buff.		.....	.....	35,000	2,600	40,500	2,100
Attica.....	{ Buff and Drab.	{	231,600	23,160	61,600	6,100	60, 00	6,000
Riverside.....	{ Blue and Gray.	{ 19,000	128,000	34,400	67,500	9,500	81,000	12,000
Worthy.....	Gray.	50,000	(1)	(1)	200,000	20,000	200,000	20,000
Cannelton.....	Buff.	5,000	61,000	6,100	54,000	12,000	283,000	38,000
St. Anthony....	Brown.	30,000	(1)	(1)	12,000	5,000	50,000	15,000
Jasper.....	Buff.	3,500	13,500	1,755	1,500	200	1,500	200
Silverwood.....	{ Blue and Gray.	{ 250,000	206,250	57,750	(1)	(1)	(1)	(1)
Mansfield.....	Brown.	150,000	41,250	30,100	(1)	.....	(1)	.....
Other Points...	{ Brown, Buff and Gray.	{ 77,000	77,400	5,600	20,000	2,000	25,000	2,500
Total.....		\$609,500	864,000	\$169,365	661,000	\$79,800	1,140,000	\$117,800

(1) Not in operation.

At Riverside in 1891 there were two quarries in operation; in 1894 and 1895 there was only one.

A rough estimate, based on the dimensions of the different quarry openings throughout the area traversed, shows a total production of about 3,750,000 cubic feet, of which 2,000,000 feet would come from the Wabash valley above Coal creek. This estimate includes the product for local use from the many small quarries. It is possibly far within the limit of the actual output.

TABLE II.

General statistics of the sandstone industry in Indiana in the years 1891, 1894, 1895.

ITEM.	1891.	1894.	1895.
Whole number of men employed.....	307	410	414
Average wages.....	\$1.50	\$1.75	\$1.75
Number of quarries in operation.....	21	13	15
Number of derricks.....	40	36	46
Number of steam drills.....	9	6	7
Number of channeling machines.....	10	5	5
Number of saw gangs.....	3	4	6
Average price per cu. ft.....	\$0.20	\$0.14	\$0.14
Highest price per cu. ft.....	73	65	60
Lowest price per cu. ft.....	10	4	4

TABLE III.

*Statistics of the Sandstone Production in 1891.**

Number.	Locality.	Number of quarries.	Capital invested.	Number of employees.	Average wages.	Number of cubic feet.	Price per cubic foot.	Number of steam drills.	Number of channelers.	Number of derricks.	Number of saw gangs.	Value of product.
1	St. Anthony...	2	\$5,000	.....	.....	.....	.....	1	.....	.....	.....	†
2	Jasper	2	3,500	7	\$1.50	13,500	\$0.13	.....	.....	2	.....	\$1,755
3	Cannelton	3	2,400	58	1.35 2.25	61,000	10	.....	.....	9	.....	6,100
4	Fountain	1	300	3	1.25	5,400	11	.....	.....	.....	.....	600
5	Silverwood	1	259,000	60	1.50	206,250	28	.....	4	.....	3	57,750
6	Pottsville	1	1,500	12	1.25	72,000	7	.....	.....	.....	.....	5,000
7	Mansfield	1	150,000	20	1.50	41,250	73	.....	2	3	.....	30,100
8	Attica	2	40,500	39	1.50	231,600	10	.....	.....	7	.....	23,160
9	Williamsport	6	6,000	73	1.25 1.50	105,000	10	.....	.....	13	.....	10,500
10	Riverside	2	15,000	35	1.50 1.75	20,000 108,000	10 30	8	4	6	.....	34,400
	Totals.....	21	\$523,900	307	\$1.50	864,000	\$0.20	9	10	40	3	\$169,365

* Collected and tabulated from the report by Mr. A. C. Benedict to the State Geologist, and published in the Seventeenth Annual Report of the State Geologist of Indiana, 1891.

† Not in operation in 1891.

Sandstone product in Indiana for 1889.—The sandstone product for 1889, valued at \$43,983, is as follows: Warren county, \$19,163; Fountain county, \$14,500; smaller amounts in Orange and Putnam counties, in all 11 quarries. Of the total, the amount of \$16,033 was used for building purposes, \$18,080 for bridge work, etc. All of Orange county's product was used for abrasives.—*Mineral resources of the United States*, 1889-90, p. 393.

List of companies and individuals operating sandstone quarries in Indiana, with dates.

1. Williamsport Stone Co., Williamsport; quarry opened in 1840; worked by the present company since 1893.
2. F. J. Bernhart, Attica; since 1892 run by F. J. Bernhart; quarry first opened by his father in 1856.
3. Jacob Schmidt, Attica; since 1892; operated other small quarries in previous years.
4. Guyer, Burchby & Co., Riverside; since 1887. Riverside Stone Co. has a quarry close by the above, opened many years previous, but not in operation in 1895.
5. J. B. Lyne & Son, St. Anthony; since 1894; first opened in 1887.
6. F. F. Paulin & Co., Cannelton; since 1884; first opened at Cannelton, many years previous.
7. American Cannel Coal Co., Cannelton; since 1895.
8. Parke County Brownstone Co., Mansfield; from 1891 to 1894; now in the hands of receiver; operated by M. W. Wolf, 1887-1891.
9. Portland Stone Co., Worthy; date of opening not at hand, but only a few years ago; has been in vigorous operation ever since.
10. Joseph Marlowe, operating Indiana Greenstone quarry at Kickapoo, near Attica, since 1892; quarry was opened many years previously.
11. Charles A. House, Rainsville, has operated small quarries for local use for several years.
12. Louis F. Inglehart, Harmony, with his father has operated a small quarry for 30 years.
13. John Jones, Paoli, has operated local quarries since 1885.
14. Hamilton Tigert has operated small quarry since 1892.
15. Portland Mills Brownstone Company opened a large quarry at Portland Mills in 1895.
16. Hillsboro Brownstone Co. and L. K. Stevens operated brownstone quarries at Hillsboro for several years; only small quarries for local use in operation in 1895. The Stevens quarry now owned by C. W. Moore.
17. Mr. Brooks, at Fountain, operates a small quarry for local demand.

18. J. Hassler has operated quarries in gray and buff stone at different times at Rockwood, near Bloomfield, Greene county.

19. Jas. Schroeder has operated a small quarry near Jasper since 1887. Other quarries, known as the Eckert quarry and the Fisher quarry, have been worked until recently in the same locality.

Quarries were opened this year (1895) by the Condon Bros., at English, in Crawford county; others at West Baden, Orange county.

There are a number of quarries that were at one time large producers, but are now idle, the largest of such being owned by the Cayuga Pressed Brick and Coal mining Co., near Silverwood, that was in operation from 1888 to 1892 and shipped between 3,000 and 4,000 carloads of stone. Smaller quarries now idle are those near Covington, Coxville and Brazil.

TABLE IV.

*Value of sandstone production in the United States, by States, from 1890 to 1894 **

STATES.	1890.	1891.	1892.	1893.	1894.
Alabama	\$43,965	\$30,000	\$32,000	\$5,400	\$18,100
Arizona	9,146	1,000	35,000	46,400	.....
Arkansas	25,074	20,000	18,000	3,292	2,365
California	175,598	100,000	50,000	26,314	10,087
Colorado	1,224,098	750,000	550,000	126,077	69,105
Connecticut	920,061	750,000	650,000	570,346	322,934
Florida	(a)	.....	.....	.....	.....
Georgia	(a)	.....	2,000	.....	11,300
Idaho	2,490	.....	3,000	2,005	10,529
Illinois	17,896	10,000	7,500	16,859	10,732
Indiana	43,983	90,000	80,000	20,000	22,120
Iowa	80,251	50,000	25,000	18,347	11,639
Kansas	149,289	80,000	70,000	24,761	30,285
Kentucky	117,940	80,000	65,000	18,000	27,868
Maryland	10,605	10,000	5,000	360	3,450
Massachusetts	649,097	400,000	400,000	223,348	150,231
Michigan	240,570	275,000	500,000	75,547	34,066
Minnesota	131,979	290,000	175,000	80,296	8,415
Missouri	155,557	100,000	125,000	75,701	131,687
Montana	31,648	35,000	35,000	42,300	16,500
Nevada	(a)	.....	.....	.....	.....
New Hampshire	3,750	.....	.....	.....	.....
New Jersey	597,309	400,000	350,000	267,514	217,941
New Mexico	186,804	50,000	20,000	4,922	300
New York	702,419	500,000	450,000	415,318	450,992
North Carolina	12,000	15,000	.....	.....	.....
Ohio	3,046,656	3,200,000	3,300,000	2,201,932	1,777,024
Oregon	8,424	.....	35,000	.....	.....
Pennsylvania	1,609,159	750,000	650,000	622,552	349,787
Rhode Island	(a)	.....	.....	.....	.....
South Dakota	93,570	25,000	20,000	36,165	9,000
Tennessee	2,722	.....	.....	.....	.....
Texas	14,651	6,000	48,000	77,675	62,350
Utah	48,306	36,000	40,000	136,462	15,428
Vermont	(a)	.....	.....	.....	.....
Virginia	11,500	40,000	.....	3,830	2,258
Washington	75,936	75,000	75,000	15,000	6,611
West Virginia	140,687	90,000	85,000	46,135	63,865
Wisconsin	183,958	417,000	400,000	92,193	94,888
Wyoming	16,760	25,000	15,000	100	4,000
Total	\$14,464,095	\$8,700,000	\$8,285,500	\$5,195,151	\$3,945,847

(a) Sandstone valued at \$26,199 was produced by Rhode Island, Nevada, Vermont, Florida and Georgia together, and this sum is included in the total.

* From Mineral Resources of the United States, Part IV, 16th An. Rep. U. S. G. S., 1894.

TABLE V.

*Value of different kinds of stone produced in the United States during the years 1893 and 1894.**

KINDS.	1893.	1894.
Sandstone	\$5,195,151	\$3,945,847
Granite	8,808,934	10,029,156
Marble	2,411,092	3,199,585
Slate	2,523,173	2,790,324
Limestone	13,947,223	16,512,904
Bluestone	a1,000,000	a900,000
Total	\$33,885,573	\$37,377,816

* Mineral Resources of the United States. Part IV., 16th An. Rep. U. S. G. S., 1894.

a Estimated.

TABLE VI.

Table showing chemical composition of sandstones.

Number.	Locality	Insoluble residue.	Alumina.	Iron oxide.	Lime.	Magnesia.	Water and loss.	Total.
1	Mansfield	92.16	.....	6.29	.05	.....	.....	98.59
2	Judson	93.21	51	4.91	.12	.....	.....	98.75
3	Hillsboro	91.65	56	6.60	.12	.....	.....	98.33
4	Fountain	91.66	50	6.41	.05	.....	.....	98.72
5	Bloomfield	85.29	19	11.83	.06	.....	.....	97.43
6	St. Anthony	88.41	53	8.40	.13	.....	.....	97.57
7	Riverside	93.16	1.60	2.69	.13	.....	.....	97.53
8	Williamsport	98.57	.05	.65	.02	.....	.....	99.29
9	Greenhill	98.73	.28	.36	.03	.....	.....	99.40
10	Cannelton	96.18	54	1.56	.15	.....	.....	98.43
11	Worthy (Portland Stone)	91.18	2.13	1.12	.86	1.41	3.29	100.00
12	Fern .....	.....	47	1.43	.....	tr.	.....	.....
13	Portland Mills .....	.....	2.87	19.34	.....	tr.	.....	.....
14	Portland, Conn.	69.94	13.15	2.48	3.09	tr.	1.01	†100.00
15	Dakota, Minn.	81.55	10.00	1.41	1.15	0.30	.....	100.00
16	Waverly, Ohio	91.00	5.20	1.47	tr.	0.28	1.80	100.00
17	Cleveland, Ohio	91.67	6.92	tr.	0.28	0.34	1.17	100.00
18	Cromwell, Conn	70.84	13.15	2.48	3.09	tr.	1.01	†100.00

* Includes .09 per cent. alkalis.

† Includes 3.3 per cent. potash, 5.43 per cent. soda, and .7 per cent. manganese oxide.

‡ Includes 1.76 per cent. potash, 1.03 per cent. soda.

Nos. 1 to 10 analyzed for the survey by H. H. Ballard, Rose Polytechnic Institute, Terre Haute, Indiana. No. 11, from the "National Builder," January 19, 1896, by S. S. Gorby. Nos. 12 and 13, made for the survey by Dr. P. S. Baker, De Pauw University. Nos. 14 to 17, from Stones for Building and Decoration, by G. P. Merrill, p. 420. No. 18, furnished by the New England Brownstone Co. In Nos. 14 to 18 the insoluble residue is silica.

TABLE VII.

Table showing specific gravity, crushing strength and ratio of absorption of sandstones.

Number	Locality.	Specific gravity.	Weight per cubic foot.	Ratio of absorption.	Crushing strength per square inch.
			Pounds.		Pounds.
1	St. Anthony, Ind.			$\frac{3}{20}$	3,000
2	Riverside, Ind.			$\frac{20}{20}$	6,045
3	Riverside, Ind.			$\frac{20}{20}$	6,100
4	Riverside, Ind.			$\frac{20}{20}$	6,800
5	Worthy, Ind.			$\frac{20}{20}$	6,825
6	Berea, Ohio.	2.11	132	$\frac{20}{20}$	11,213
7	Hummelstown, Pa.				12,810
8	Cromwell, Conn.	2.5	156	$\frac{20}{20}$	16,894
9	Middletown, Conn.	2.36	149	$\frac{20}{20}$	6,950
10	Gunnison, Col.	2.20	137.49	$\frac{09}{20}$	5,250
11	Coal Creek, Col.	2.03	126.82	.167	2,879
12	Portland, Conn.				4,945
13	Marquette, Mich.	2.23	142.8	$\frac{20}{20}$	6,165
14	Jordan, Minn.	1.90	118.3	$\frac{20}{20}$	4,750
15	Medina, N. Y.	2.41	150.6	$\frac{20}{20}$	17,250
16	Cleveland, Ohio.	2.24	140	$\frac{20}{20}$	6,800
17	N. Amherst, Ohio.	2.14	133.7	$\frac{20}{20}$	5,450
18	Angel Island, Cal.	2.73	170.6	$\frac{20}{20}$	4,574
19	San Jose, Cal.	2.64	165	$\frac{20}{20}$	2,400
20	Bass Island, Wis.	2.04	127.5	$\frac{20}{20}$	4,850

NOTE.—Tests on Nos. 1 to 4 made for the Survey by M. A. Howe, Rose Polytechnic Institute, Terre Haute, Indiana. No. 5 from the National Builder, Jan. 1, 1895, by S. S. Gorbey. No. 6 made by Mr. Howe at Terre Haute. Tests on the same given by G. P. Merrill, Building and Ornamental Stones equal 10,250 and 8,222.

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The following bibliography does not aim at completeness, but as it contains probably the references to the most important literature on the subject it may be of value to those desirous of looking up the subject further. Very little has been written on the sandstones of Indiana, outside of a casual mention of their occurrence in the different county reports on the counties in the Carboniferous area.

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BENEDICT, A. C. Quarries in Indiana, in 17th Annual Report Department of Geology and Natural Resources of Indiana, 1891, pages 106-113, gives statistics of the sandstone quarries in 1891.

COLLETT, JOHN. (1.) Geology of Dubois county in 3d and 4th Annual Report Geological Survey of Indiana, 1872, page 236.

(2.) Same volume, page 298, says the sandrock near the county seat of Jasper county is of excellent quality, equal to any in the State for foundations and heavy masonry.

(3.) Geology of Warren county, pages 191-246 in the 5th Annual Report Geological Survey of Indiana, Indianapolis, 1874, in several places calls attention to the sandstone in the county as suitable for building stone.

(4.) Geology of Lawrence county, same volume, pages 260-314, mentions the sandstone of that county as weather and fire-proof sandstone.

COX, E. T. (1.) 2d Geological Report of the Geological Survey of Indiana made during the year 1870; Indianapolis, 1871, page 77, the massive sandstone in the hills north of Washington in Daviess county will make a durable building stone. Pages 82 and 105, the conglomerate sandstone occurs in large quantities, and where free from iron and pebbles is a handsome and durable stone. Pages 119 and 120, mention the occurrence of sandstone in western Indiana. On pages 204 and 205 he describes the sandstone and conglomerates of Dubois county, saying they are fire-proof.

(2.) 3d and 4th Annual Reports of Geological Survey of Indiana, Indianapolis, 1872, pages 83 and 138, mentions the sandstone on the bluffs at and above Cannelton as excellent building stone, enumerates the buildings and government works in which it was used.

(3.) Geology of Pike County, in same volume. Page 284 states that the "massive member of the subcarboniferous sandstone" about Pikesville furnishes the best quality of building stone; also that good Coal Measures sandstone occurs in other parts of the county.

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THOMPSON, MAURICE. Indiana sandstone, in 17th Annual Report of Department of Geology and Natural Resources of Indiana, 1891, pages 30-40, gives in outline descriptions of some of the sandstones and the counties in which they occur.

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