

INDIANA BUILDING STONE.

I.

LIMESTONES IN GENERAL.

Limestones of a fair quality for rough masonry, bridge abutments, culverts, basements, underground foundations, etc., may be found here and there throughout most of the area in which the Silurian rocks outcrop, and some of the Devonian blue limestone is much used; but it is in the Carboniferous formations that Indiana's wealth of incomparable quarrystone lies.

Beginning in the Sub-Carboniferous and running up through the Coal-Measures, there is in Western Indiana an inexhaustible supply of the finest building stones yet discovered in the world. Such an assertion may have the ring of vain boasting, or, at least, of over-enthusiasm; but upon calm investigation it will be found simply true. Nor is the richness of our State in this direction dreamed of by the general public. Our quarries, though extensive from a local point of view, are mere beginnings of a development which it would be useless to try to foresay. Geologists were laughed at when first they began to assert that Indiana possessed a grand field of workable coal; but the geologists were right and they laughed last. So when it was claimed that we had practically inexhaustible beds of fine kaolin, there was another laugh. Nevertheless the kaolin was found. A few years hence, when all the quarries of our incomparably beautiful and durable limestones and sandstones shall be acknowledged, the world will be convinced that geologists have again triumphed.

Viewed from a geological standpoint, every condition exists in Indiana for the presence of the finest quality of building stone. All our rock strata, at least over the southern half of the State, are evenly and conformably deposited one upon another. Throughout the area of the Carboniferous rocks there is no sign of more than the merest trivialities in the way of chance disturbances, with perhaps one or two local exceptions not yet fully understood. In a general way the rocks of Indiana, from as far north as Lafayette southward to the Ohio River, lie just as they were

originally deposited, saving such changes as are observable along the so-called Cincinnati Arch. This, taken in connection with the fact that most of the animal remains found in our rocks are of a deep-sea fauna, would lead us to expect to find just what we do find, that our limestones and sandstones must be, in a large degree, evenly bedded, smooth-grained, homogeneous and easily worked. But I dare say the most acute geologist never could have foreseen how exceedingly strong, durable, beautiful and easily worked much of this stone would prove to be. Practical demonstration must always supplement the assertions of science, and it is the province and function of the quarryman at last to disclose the true value of the hillside outcrops.

It would be impossible to enumerate the places in Indiana where good limestone for building purposes exists. If a line should be drawn across the State east and west through the city of Huntington all the area south of the line would, wherever denuded of the Drift, present at intervals exposures of limestone of more or less value for one or another sort of masonry. As a rule, the Silurian limestones of Indiana are not building stones of a high grade, though they are successfully used in many places; nor do our Devonian strata furnish our best stone. The oölitic limestone of the Sub-Carboniferous is the limestone of our State which may safely be said to have no equal in the world. It is found in many of the southwestern counties, and is well worth careful study, and its great value should have energetic development in every way. Its character and position are discussed from both the geological and economic standpoints in another chapter.

Limestone takes its name from the presence of calcium or lime carbonate in its substance, and, as a rule, the greater the percentage of carbonate of lime in the stone, the better it will be for building purposes. From one extreme to the other, our limestones pass through almost every possible grade between nearly pure carbonate of lime (as in the case of the best oölitic variety) and an aluminous lime shale. Carbonates other than that of lime are often present in the stone. Magnesia, iron, manganese, silica and alumina frequently appear in various proportions and in different states of chemical combination. As a rule, the presence of magnesia in a clean limestone may be discovered by testing with a half and half mixture of water and hydrochloric acid; if there be no appreciable effervescence the stone is largely magnesian. Iron, on account of its ready and swift oxidation, is a bad element in a building stone, as it colors it and also disintegrates it, so magnesia blackens and dissolves more or less in an atmosphere charged with sulphurous fumes, and, consequently, a magnesian limestone will not last well in a city where soft, sulphur-bearing coals are much used.

While the purer forms of limestones appear to have been formed at the bottom of deep, calm seas, from the destruction of calcareous shells,

magnesian limestone (dolomite) has long been a bone of contention among geologists; but without entering into the discussion here, it is sufficient to say that some of the most beautiful stones in the world, including the far-famed Parian marble, are magnesian limestone (dolomite). The carbonate of magnesia and the carbonate of lime, combined in practically equal parts, form the stone from which some of the oldest and most celebrated buildings of modern times are made. Indiana dolomite is often found to be excellent stone to endure exposure to cold, moisture and winds, but, as I have said, it blackens and disintegrates in the atmosphere of cities where much coal is burned.

As a rule, limestones of a dark blue color found in Indiana are more or less iron-bearing, and readily weather to a buff, brown or reddish tinge when exposed. Most of them gradually crumble, as the oxidation of the iron destroys their particular integrity. This is not true, however, of the blue Devonian limestone, which has been found excellent for bridge abutments and strong foundations.

The North Vernon blue limestone has been extensively used from quarries in Jennings and Jefferson counties, and some of the hard magnesian limestones of the Upper Silurian are good for rough works. Quarries of the Lower Silurian have been opened in the following counties: Dearborn, Ohio, Switzerland, Wayne, Fayette, Union, Franklin; and of the Upper Silurian in Carroll, Wabash, Miami, Cass and Huntington, and others.

Besides the oölitic, which is treated in a separate chapter, the Sub-Carboniferous deposits have strata of fine limestone, especially in the Keokuk group.

II.

THE OÖLITIC LIMESTONE OF INDIANA.

Much has been written of late, in a generalizing way, about the Oölitic limestone of Indiana, but the fact that practical builders, engaged in works of magnificent proportions, have chosen it for their purposes from New Orleans to the lakes, and from New York City to the Mississippi, and far beyond, speaks, in a language better understood than that of the scientist, its just praise. State Geologists of Indiana have, from the discovery of this surpassingly fine stone down to the present day, allowed no opportunity to go by without a word in its favor. In each report since the date when it was first examined by this Department, my able and energetic predecessors have had their say, and yet not enough is known regarding what has the just right to be named the best building stone in the world. Not only the best in point of durability, but best in every sense of the word, this stone may challenge all manner of tests. It is

flexible, elastic, resonant, uniform in its grain, equally strong in every direction, perfectly homogeneous in fact. These qualities give it the best possible power of resistance to strain or crushing force. A bar of this stone may be bent very perceptibly, and when the force is removed it will spring back to its normal state with the promptness and energy of steel. Its tone when struck is a clear, musical bell-note, indicative of thorough metallic sympathy throughout the mass. This quality of perfect resonance, taken in connection with the fact that the stone cleaves nowhere save directly in a line with the cleaving force, gives the best evidence of an evenness of grain and a smoothly distributed cohesiveness of particles throughout the mass. When first quarried it cuts like a sandstone, yielding readily to tools of all kinds. It is then soft, and yet tough enough to hold well the finest figures of carving. It comes from the quarry cut by a steam channeler into blocks or quadrangular columns six by ten feet, and a hundred feet long if desired. Its color at first is a pale brownish, which gradually lightens to a soft cream or grayish white.

Chemically speaking, the oölitic limestone is, practically, a pure carbonate of lime, the amount of matter other than this carbonate being less than 4 per cent. In other words, the carbonate of lime constitutes nearly 97 per cent. of the stone. This purity insures absolute integrity on exposure to the fumes of coal, while the perfect elasticity and flexibility of the mass render it invulnerable to the forces of cold and heat, air and moisture. Cliffs of this limestone exposed to our variable climate for unknown centuries show no sign of disintegration, the finest angles standing out as sharp now as when first the mass was fractured.

Physically the oölitic limestone is in fact a calcareous sandstone composed in chief of small grains of lime carbonate. It occurs in massive bodies, often forty feet thick, without any lines of cleavage or parting, perfectly bedded, homogeneous throughout, a solid single stone, in fact, from which a flawless block of any size possibly manageable may be cut. It takes up a very small amount of moisture, which is so distributed that no degree of cold will work injury. When we consider to what awful and prolonged frigidity of temperature this rock was exposed during the Glacial age without in the least affecting its integrity, we may safely trust it in our buildings. Other limestones were cracked, shivered, crushed under the compressions and expansions of the arctic period, while this massive deposit was scarcely changed in any part of its great body.

The area of the oölitic limestone deposits of Indiana lies principally within the following counties: Crawford, Harrison, Lawrence, Monroe, Owen and Washington. Geologically it belongs to the St. Louis group of the Sub-Carboniferous rocks, and owes its existence in a large degree, I think, to the destruction of older rocks by the action of water and a chemical and physical rearrangement of both soluble and finely-divided insoluble matter resulting from such destruction. We find in the Keokuk

limestones, immediately below those of the St. Louis group, geologically, a vast amount of crushed and ground up shells. Indeed, many of the rocks are almost wholly formed of pulverized remains of various marine forms, such as brachiopods, radiates, crustaceans, etc., all pressed together in a mass, often quite loosely cemented. In places this formation has been reduced to a marly clay, in others to a loose, rotten silicious shale, owing to the vicissitudes attendant upon the great changes constantly taking place in the depth and currents of the sea during and after their deposition. So the rocks of the St. Louis group are not infrequently vast beds of fossiliferous clays and shale, showing decomposition and re-arrangement, to a great extent, owing to causes arising subsequent to their original formation.

The area of the oölitic limestone is peculiarly limited, showing in many ways that the rock has been deposited at the bottom of a deep sea by precipitation (chemically) and sedimentation, generally of calcareous matter, in a free state partly, and partly in combination. The insoluble fragmentary matter represents calcareous fossils, whose shells are very minute or are in a fine state of mechanical division, and these particles have been evenly cemented throughout the body of the stone by infinitesimal concretions of almost pure carbonate of lime. While its process of formation has been analogous to that of chalk, it has nothing of the porousness characteristic of the Cretaceous foraminiferous deposits, and under the microscope it shows a compact structure, closely resembling the finest and closest-grained sandstone, saving that the particles are largely fragmentary, angular, and clearly show their derivation from shells. If we look about us for a present instance of the precipitation of calcium carbonate from water, we shall find it in some of the small lakes in the northern part of our State, where a soft white "chalk" is constantly being deposited. This lime precipitate is equivalent to the cementing matter of our oölitic limestone, and both materials are due to the same chemical action. In the Cretaceous chalk, formed so largely of foraminifera, the mass is loosely deposited and feebly cemented, as a rule, but the oölitic limestone, though coming comparatively soft from the quarry, has a peculiar toughness and density, and withal a dryness, which render it a puzzle at first to every examiner. These features are due to the semi-concretionary nature of the structure, resulting from the coöperation of affinity and gravitation in the arrangement of the matter. The stone is granulated, rather than crystalline, in every particular, and yet, under the microscope, the grains show a nicety of correspondence—a perfect fitting, so to call it, which is the secret of resonance, elasticity, flexibility and non-cleavage. The following analysis is a fair average for the true oölitic limestone:

Specific gravity	2.72.
Lime	53.55 per cent.
Carbonic acid.	43.33 per cent.
Water56 per cent.

With a trace of magnesia, iron, alumina, manganese, phosphoric acid, silica, and possibly another mineral not distinguishable, all in practically equal parts, amounting together to 2.56 per cent. of the whole. The iron oxide is barely perceptible, amounting to less than one-tenth of one per cent., and in many specimens it can not be discovered at all by the ordinary tests. It must be stated here that the above analysis was of stone quite recently quarried.

The St. Louis group of rocks has been a puzzle to geologists on account of its many eccentricities of deposit, and nowhere are these eccentricities more exaggerated than in Indiana. The tendency of the strata to dissolve and reform is very marked. Clastic masses of argillaceous fragments cemented by carbonate of lime are found throughout the area, and in fact a large part of the formation (especially the lower strata) is evidently the result of the destruction and re-arrangement of fossiliferous rocks of the same or an older group. The massive oölitic limestone rarely contains well-preserved fossils, while around its periphery (where it gives place to shale, marly strata and cherty deposits), rich beds of finely preserved organic remains exist. Indeed, everything connected with this fine building-stone formation appears to be evidence of the fact that the oölitic limestone has been laid down in a deep trough at the bottom of a sea, and that this has been surrounded by shallower, and therefore, more boisterous waters. The agitation of the shoal part of the sea caused the water to take up in solution the soluble substance of calcareous shells and limestone, and to hold in suspension a great amount of insoluble matter in a fine state of pulverization, a large part of which was precipitated as soon as it was carried by the sea-currents out to the calmer deep-water area. Thus slowly the massive, homogeneous limestone gradually formed in the deep trough or hollow surrounded by shales, chert and marly deposits, as the silting and chemical precipitation went on together. When, with the filling of the trough and other causes, the sea grew shallower, strata of impure rock were formed above the oölitic deposit similar to those already laid down around it.

The oölitic is the surface rock over a considerable part of its area, owing, no doubt, to the fact that the overlying strata being argillaceous and iron-bearing have been easily removed by water or reduced to clay in place.

In Washington County the oölitic limestone is found underlying a varying deposit of blue, coarse, refractory, iron-bearing limestone, which, in many places, has disintegrated and formed a red clay, in which characteristic St. Louis fossils are preserved. Along the periphery of the oölitic

deposit the stone becomes coarser in its texture and is often a mass of minute, well-preserved shells and fragments of shells rather loosely cemented.

III.

SANDSTONES OF INDIANA.

The Lower Coal-Measures of Indiana are rich in sandstones perfectly adapted to building purposes, though at this time their great value appears to be in a large degree overlooked. The Conglomerate or "Millstone grit" is a deposit pretty evenly and uniformly distributed throughout the base of the Coal-Measures proper, and wherever its grain is fine it is usually a brown, buff, pinkish or gray massive sandstone, homogeneous, non-cleaving and exceedingly strong in all directions. It comes very soft from the quarry, which makes it remarkably easy to cut; afterward it dries quickly, takes on a lively glow and holds its color perfectly. In the court-house walls at Rockville, in Parke County, may be seen some fine blocks of a pinkish-colored sandstone, whose quality is equal to the best in the world. In the southwestern part of Montgomery County, near Williamsport, in Warren County, and in Fountain County, are inexhaustible quarries of this beautiful stone. Indeed, it may be looked for, and as a rule has been found in nearly every county in the State where the Lower Coal-Measure rocks are outcropping. Along the line between the areas of the coal-fields and the Sub-Carboniferous deposits the Conglomerate will usually be found forming the bluffs of the streams and the escarpments of the hills. It is not always a building stone, however, as in many places it takes the form of a coarse, pebbly, highly ferruginous mass which weathers badly.

The best sandstones are composed of quartz particles of nearly uniform size, compactly cemented. They break with a smooth fracture in the direction of the force applied, and present a surface which, although beautifully even, has a finely cutting grit or "tooth," somewhat coarser than that of fine grindstone grit. They are perfectly fire-proof and capable of withstanding all the changes of atmospheric temperature.

The resistance to crushing weight is very great in some of our sandstones, remarkably great, indeed, considering their softness when first quarried. Blocks hewn into any desired shape, as may be done readily with a common ax, will harden upon exposure to the air for a few days, to such a degree that, upon being struck with a hammer, they will give forth a clear metallic sound, and emit sparks, like flint. Bridges and culverts built of Indiana sandstone have stood for years without the least sign of weathering. It is only a question of time as regards the development of magnificent quarrying interests in this stone throughout the en-

tire Coal-Measure area of Indiana. Next to the coal itself, the building stones of our State are of the highest importance in connection with our future mineral wealth.

Geologically speaking, the lower sandstone rock of our Coal-Measures is the equivalent of the "millstone grit," and, although seams of coal are sometimes found below it, it usually lies directly upon the Sub-Carboniferous or Mountain Limestone formation, and is in many places hardly distinguishable from the sandstone of the Chester group. It appears, at a large number of its exposures, to mark a varying shore-line where vegetable drift was cast up and buried in the sand. Fragments of *calamites* are the chief organic remains, and these are usually found in the coarsest-grained and most loosely cemented deposits.

Good sandstone for bridges, culverts, foundations and fire-proof structures may be found in all the following counties: Warren, Montgomery, Parke, Fountain, Vermillion, Vigo, Putnam and Clay, and thence throughout the Coal-Measures to the Ohio River. They are to be seen in place wherever, along the eastern limit of the area, the Conglomerate comes to the surface. So the Chester sandstone is of most excellent quality, in many places, notably in Crawford County, where, near the mouth of Blue River, and at Indian Hollow, it crops out in massive beds of fine-grained grindstone grit; and in Owen, Greene, Dubois, Martin, Pike, Orange, Perry and Harrison counties sandstones of the best quality are to be found.

Although the quarrying of sandstone is an industry as yet scarcely begun in Indiana, the annual output of this fine building material for all purposes is probably nearly a million and a half cubic yards. Considering the great value as building stone placed upon the equivalent strata of Europe by the best of modern architects, it is safe to predict that Indiana's wealth of Conglomerate sandstone will soon become as widely famous as her magnificent deposits of matchless limestone.