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The State Quarry Limestone

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the great field of science itself the results may seem small; measured by the standard of individual achievement the outcome is stupendous. In the special department of knowledge which he represented no one person has done more to raise it to the high place that it now occupies.

Wachsmuth belonged to that illustrious school of naturalists which Louis Agassiz founded in this country. His main efforts were entirely along the lines of inquiry pointed out by the Swiss savant. It was the establishment, upon a morphological basis, of a rational classification of a group of organisms. The group chosen was the crinoids, or sea lilies, a class of animals which is now all but extinct, but which in ages past was one of the most abundant forms of life. Most of the material was fossil and the difficulties surrounding the investigation were such as to students of living animals would be insurmountable. Although the work was far from finished at the time of his demise the main and most important features of the scheme were fully established and the Wachsmuth classification of crinoids has been adopted the world over.

In the Monograph of the Fossil Crinoids, which is a huge quarto of 800 pages in two parts and an atlas of eighty plates, is contained the mature reflections of thirty years' continuous thought and reflection. Twenty years ago, when at Cambridge with Agassiz, the foundations of his life's work were laid. In a little paper "On the Internal and External Structures of Paleozoic Crinoids," published in 1877, was stated the essential propositions on which rested all subsequent work. The ancient crinoids were divided into three primary groups, the separation being based chiefly upon the structure of the tegmen.

The effects of Wachsmuth's work has been completely to revolutionize the ideas which prevailed concerning the crinoids and to place the whole systematic arrangement of the groups upon an enduring basis. The stages in the development of those changes are easily traced in the various publications which were issued from time to time and culminated in the monumental monograph.

THE STATE QUARRY LIMESTONE.

BY SAMUEL CALVIN.

At the state quarries, or North Bend quarries, in sections 5 and 8 of Penn township, Johnson county, Iowa, there is a body of limestone of Devonian age, possessing marked characteristics which set it off sharply from the rest of the Devonian in the upper Mississippi valley. The formation has a thickness of about forty feet. At present there is some uncertainty as to its exact taxonomic relations.

On fresh fracture the state quarry rock is light gray in color. In texture it varies somewhat in different beds, but

near the middle of the formation it is composed of coarse, imperfectly comminuted fragments of brachiopod shells cemented together, the spaces being filled with interstitial calcite. Among the recognizable species of shells *Atrypa reticularis* is the most common, but some beds contain very large numbers of *Terebratula (Crancæna) iowensis*. At some horizons shells of an *Orthothetes* are common. *Orthis impressa* is not rare, and *Rynchonella pugnax (Pugnax pugnax)* occurs occasionally. The shells, or fragments of shells, making up the limestone are not embedded in a matrix. They are simply piled on each other and cemented together in a manner illustrated by the formation of the modern coquina along the east coast of Florida. The rocks near the middle of the state quarry beds are a brachiopod coquina having the interstices completely filled with crystalline calcite.

Near the middle of the formation the rock consists of thick ledges which, some years ago, were worked extensively. From these beds came the large limestone blocks used in the foundation of the new state capitol. Although the ledges show no definite lamination, and split as readily in one direction as another, the weathered surfaces on opposite sides of the numerous joints often show obscure signs of oblique bedding. The material was evidently swept into place by moderately strong currents.

The ledges worked in connection with the building of the new capitol are the heaviest afforded by the formation. The lowest one is four feet in thickness. It is made up of rather finely triturated brachiopod shells, the most common species being *Atrypa reticularis*. This bed, it seems, did not furnish satisfactory material for it was quarried only to a limited extent. The ledge furnishing the greater number of available blocks lies directly above the first. It is five feet in thickness, and is intersected by numerous joints. Among the great multitude of unrecognizable fragments of which it is chiefly composed it contains large numbers of entire detached valves of *Atrypa* and *Orthothetes*. The next ledge in ascending order to furnish usable stone is separated from the last by a talus-covered space of two or three feet. It also is five feet thick, and in it *Atrypa* and *Terebratula* are the prevailing brachiopods. In a fourth ledge, four feet in thickness, the rock is fine grained, the materials are very perfectly comminuted, species cannot be recognized, but it is evident that the bed is composed of debris from brachiopod shells mingled with triturated fragments of crinoids. Above the fourth ledge the layers vary

from six inches to two feet in thickness, and toward the upper part of the exposure the rock is made up almost wholly of the remains of crinoids.

Below the first ledge noted above the beds vary from a few inches to a foot or more in thickness, the thinner beds prevailing near the base of the formation. Brachiopod shells constitute the major part of the material of which they are composed.

Among the waste material of the main quarry there are many large blocks, eighteen inches thick, through which masses of chert are irregularly distributed. The position of the bed from which the chert-bearing blocks were obtained was not determined, though it is probable that it lies in the talus-covered space between ledges two and three of the main workable portion of the quarry. Whatever its position, it is a bed of remarkable interest, for it is in places crowded with fish teeth that lie embedded in the chert or among triturated brachiopod shells in the calcareous portions of the layer. It looks as if an entire fish fauna had suffered death at once. Such general fatality may have been produced by any one of several probable causes; and, furthermore, the cause was doubtless in some way related to the crustal movements recorded in the region, and to be noted further on. Changes in oceanic currents attended by rapid elevation or depression of temperature, earthquake shocks even, or concentration of sea water in an isolated basin, would be competent to produce the observed result. Whatever the cause, it was effective, and every square yard of sea bottom received its quota of dead fishes.

Several genera and species are indicated amid the profusion of fish remains interred in this old cemetery. One of the most common forms is the well known Devonian type, *Ptyctodus*. Teeth of this genus are sometimes literally crowded together to form a sort of fish tooth conglomerate. These teeth, or triturators, vary in size and shape and in the degree of wear to which they were subjected before the death of their owners; but in the opinion of experts to whom they have been submitted, they probably all belong to the single species, *Ptyctodus calceotus*. Along with *Ptyctodus* are remains of one or more species of Devonian Placoderms, as indicated by great numbers of imperfect dermal plates. The Dipnoan genus, *Dipterus*, is represented by a number of the interesting wing shaped teeth characteristic of this very old but persistent type; and there are

teeth evidently related to Dipterus, but so different as probably to make generic separation necessary.

But more interesting than all the rest, and far outnumbering the teeth that could at first sight be referred to Dipterus or to related genera, is a vast assemblage of teeth of varying shapes and dimensions, that bear a striking external resemblance to the crushing teeth of certain genera of sharks. In the opinion of Dr. C. R. Eastman, however, it is doubtful if there are any Selachian teeth in the entire lot. He finds that, microscopically, they all, so far as sections have been made, are identical in structure with the teeth of Lung fishes, or Dipnoans. They seem, indeed, to be primitive Dipnoans exhibiting a stage of evolution not far removed from the point whence the Dipnoan and Elasmobranch types diverged; and their careful study will doubtless throw much light on the nature of the relationships existing between these two groups of fishes. Dipterine fishes have long been known from the Devonian of eastern Europe, but it is only recently that this type has been found in the Devonian of America. Until the discovery of the State quarry fish bed, our Devonian Dipterines all belonged to a single genus and came from the upper Devonian formations of Pennsylvania. Now we find the type in the Mississippi valley, and here it is represented by several genera, and is connected by intergradations with exceedingly primitive Dipnoan forms. The material has been placed in the hands of Dr. Eastman, whose full report on the subject will be awaited with much interest.

Distribution.—At present the state quarry limestone is known only in Johnson county, Iowa, though it doubtless occurs at other points in Iowa and adjacent states. The main body occurs in sections 5 and 8 of Penn township (T. 80 N., R. 6 W.). It is found in the bluffs on the west side of the Iowa river from the north line of section 5 to a little more than one-fourth of a mile below the north line of section 8, the principal development occurring near the south side of the first named section. The width of the area occupied by the formation in this region is less than half a mile. In fact in following up the small tributary valleys the state quarry stone is in most cases found to disappear in less than one-fourth of a mile.

A second body of state quarry limestone is found near the southwest corner of section 20, of Graham township, at which point the formation is almost exclusively crinoidal as to composition; a third body of this limestone, but of no great thickness,

is seen near the top of the hill southeast of the bridge over Turkey creek in section 23, Newport township; and another body of the same stone occurs in rather puzzling relations to the Megistocrinus beds in section 23, Big Grove township, southwest of Solon. At the last named locality Rynchonella, or Pugnax, is the prevailing fossil. The very fossiliferous limestone seen near the base of the quarry south of Shueyville is of a very different character and belongs to a different horizon.*

Taxonomic Relations.—As already intimated, the taxonomic relations of the state quarry stone are not very clear. At first it seemed that it might possibly represent local deposits made contemporaneously with the Cedar valley beds, but later investigations indicate that it is younger than the Cedar valley and was laid down on a deeply eroded surface. In support of this view it may be noted that at the mouth of the ravine below the south quarries in section 5 of Penn township, the state quarry stone rests on the Megistocrinus beds of the Cedar valley stage. In following up the ravine the quarry stone rises higher and higher in the bluffs and soon disappears, while the members of the normal Cedar valley section appear successively in the bottom of the creek. The contact of the two formations cannot, however, be definitely traced. On Rapid creek, in section 20 of Graham township, the relations are nearly the same. The state quarry stone occurs only a short distance above the Megistocrinus beds. At Solon the equivalent of the quarry stone occurs on the west side of a small ravine, while on the east side of the ravine, only four or five rods distant, the typical Megistocrinus beds, wholly different in character and with an entirely different fauna, occur at the same level. The quarry beds at the last named locality are composed largely of shells of Pugnax (Rynchonella). They extend westward along the north side of the valley of a small creek for about one-eighth of a mile and then suddenly disappear, their place in the low bluff being taken by the normal Megistocrinus beds of the Cedar valley section.

In the bluffs above the bridge over Turkey creek, at the point already noted, in section 23 of Newport township, these beds occur above the white limestone at the top of the Cedar valley formation. No Devonian beds of any kind have so far been

*McGee: Tenth Census Rept. Vol. X, Quarries and Building Stone, p. 262.

found above the state quarry stone. The anomalous relations of this formation, the limited areas to which it is confined, the abrupt manner in which it appears and disappears, sometimes at the level of one member of the Cedar valley section and sometimes at the level of another, all lead to the conclusion that it was deposited unconformably on the Cedar valley limestone after the lapse of a considerable erosion interval. The same view is even more strongly suggested by the fact that in certain respects the fauna of the state quarry beds is unique. The deposit near Solon furnishes *Pugnax pugnus* Martin, *Melocrinus calvini* Wachsmuth, and a very peculiar Stromatoporoid, none of which are found in the other Devonian formations. Of other species that have a greater vertical range, as for example *Atrypa reticularis*, there is sufficient variation to distinguish them from individuals of the same species found at other horizons. The *Orthothetes*, so common in the beds in section 5 of Penn township, is associated with *Pugnax*, and like it is limited to the state quarry stage. The great mass of cemented crinoidal debris composing the beds in Graham township and the upper ten or fifteen feet of the formation at the state quarries has no parallel in any other stage of the Iowa Devonian. The presence of *Dipterus*, which elsewhere occurs only in the Upper Devonian, is likewise indicative of an interval between this stage and the Cedar valley beds below. In this connection it may be noted that the affinities of *Pugnax pugnus* is with the Carboniferous rather than the Devonian. These facts, coupled with the evidence of unconformity, would seem to place the formation near the closing stage of the Upper Devonian system, while the faunas of the Cedar valley stage correlate it with the Middle Devonian. The known phenomena concerning the state quarry limestone and its interesting fauna evidently require for their interpretation a number of crustal movements and a long period of erosion in the Iowa Devonian heretofore unsuspected.