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The St. Peter's Sandstone.

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THE ST. PETER'S SANDSTONE.

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INTRODUCTION.

In all geological investigations, rocks of any particular formation are noticed long previous to their differentiation under a distinct name. The reason is that observations are made by explorers and travelers in different portions of the country before the adoption of any definite system of nomenclature, and facts are recorded without a reference of the rocks to any special horizon. Therefore, although the St. Peter's sandstone is unknown as a formation with a distinct name in the geological column prior to 1847, references were made to it years previously.

The first reference to, and description of, rocks now known as the St. Peter's sandstone is given by Captain Jonathan Carver, in his travels through the interior parts of North America, in 1766–67–68. In this volume (p. 63) he gives an account of a cave visited by him, now known by the name of Carver's Cave. It is situated about thirty miles below the Falls of St. Anthony, and is an excavation in the St. Peter's sandstone. Carver found the stone so soft that it could be cut with a knife, and the walls of the cave were carved with Indian hieroglyphics. He also states that a little way from the mouth of the St. Peter's River is a hill composed entirely of white stone, the outer part of which crumbles into heaps of sand through the action of the weather.* This, also, is St. Peter's sandstone.

In 1817, Major Stephen H. Long visited the Falls of St. Anthony, and in his book he gives an account of the formations observed by him in Minnesota. One of these was a white or yellowish sandstone, which crumbled so easily as to deserve the name of sandbank rather than that of sandstone.

*Ibid, pp. 100, 101.

It is stated to underlie the limestone that forms the brink of the Falls. "It is of various depths, from ten to seventy-five feet."*

In 1820, H. R. Schoolcraft was sent by the general government on an expedition to the sources of the Mississippi River, and he submitted a report of his observations in 1821. This was republished in 1855,† and in this volume he refers to the geological features of St. Anthony's Falls, where the river is precipitated, at one leap, over "strata of white sandstone, overlaid by the metalliferous limestone. * * This sandstone is composed of grains of pure and nearly limpid quartz, held together by the cohesion of aggregation. If my observations were well taken it embraces, sparingly, orbicular masses of hornblende. It is horizontal, and constitutes, in some places, walls of stratification, which are remarkable for their whiteness and purity."‡ This is, undoubtedly, the St. Peter's sandstone.

In 1824, Professor Keating‖ gave a section of the strata as observed by him at Fort Snelling. In this a sandstone is mentioned as occurring beneath from twenty-five to thirty feet of limestone, and which constituted the principal mass of the bluff. He says: "This is friable, but every fragment, examined with care, seems *to be a regular crystal.*" Keating inclined to the opinion that it must have been a chemical precipitate, and not a mere mechanical deposit. He says: "The process of its formation may have been a rapid one, such as is obtained in the manufacture of fine salt; and to this may be attributed the circumstance of its fine texture. The color is white, sometimes a little grayish, when it resembles the finer varieties of Muscovado sugar."§

In the report of Dr. John Locke, made in 1839,¶ in describ-

* Voyage in a six-oared skiff to the Falls of St. Anthony, in 1817. Minn. Hist. Soc. Coll., Vol. II, p. 36 (pub. 1860).

† Summary narrative of an exploring expedition to the sources of the Mississippi. Appendix VII, pp. 303-362. Philadelphia, 1855.

‡ Ibid, p. 330.

‖ Narrative of an expedition to the source of the St. Peter's River, etc., performed in the year 1823, under command of Major Stephen H. Long. 2 vols, 1824.

§ Quoted in Vol. I of Final Report of Geology of Minnesota, 1884, p. 35.

¶ [Comparison of the geological formations of the lead regions of Iowa and Wisconsin, and the cliff formation of Ohio, Indiana, and Kentucky, with various sections.] Rept. of Geol. Expl. of part of Iowa, Wisconsin, and Illinois, by D. D. Owen, pp. 116-126. 26th Cong., 1st Sess., H. R. Ex. Doc., No 239, 1840.

ing a section as observed at Prairie du Chien, he notes the presence of a sandstone underlying a buff-colored limestone and called "soft saccharoid sandstone." It is stated to be made up of sharp, angular fragments of quartz, scarcely cemented together. It may be white or colored, and when so colored it is often strongly cemented. It is compared to coarse, common, unrefined sugar, and, though it is difficult to break off a piece without its crumbling to pieces in the hand, yet, in places, it crops out extensively, and seems to stand the weather as well as other strata which are used for building stone. It is here given a thickness of forty feet, although Dr. Locke says he did not see the base of the formation. In the section accompanying the paper this sandstone is represented as lying between a blue limestone (now recognized as Trenton) and the Lower Magnesian limestone.* In the description of the strata from the Blue Mounds to the Wisconsin River, this sandstone is again referred to as the same as seen at Prairie du Chien. "It is remarkable for having its upper surface at an exact and even plane, very nearly level. In an excavated area, where several ravines meet in the same valley, and with the eye at any point of the upper surface of this sandstone, all other points appear at the same plane, like an emptied lake, leaving a line of ice to mark its original height; even where the rock is covered by earth, the vegetation changes so abruptly in sort and color, at the surface of the sandstone, that the line may still be distinctly traced."†

On November 2, 1842, a paper by Dr. D. D. Owen‡ was read before the Geological Society of London. It was read in April of the following year before the American Association of Naturalists and Geologists. Dr. Owen notices the presence of a sandstone underlying conformably a blue fossiliferous limestone. The sandstone is "sometimes of a deep red and sometimes of a white color, and resembling loaf sugar. Beneath this succeeds a magnesian limestone." He also says he has never found any fossils in the sandstones.|| This for-

*Ibid, p. 123.

†Ibid, p. 124.

‡On the Geology of the Western States of North America. Am. Jour. Sci., Vol. XLV., pp. 151–152, 163–165; Quart. Jour. Geol. Soc. London, Vol. II, pp. 443–447, 1846.

||Ibid, p. 446.

mation he afterward described under the name of St. Peter's sandstone.

The first mention of the term St. Peter's, as applied to a geological formation, was made by Dr. D. D. Owen, in 1847.*

After referring to the formations of the Upper Mississippi, it is stated that in some high situations, as near Lake St. Croix, the strata are surmounted "by soft white sandstone, capped with shell limestones, such as form the upper portions of the hills on the Wisconsin River, near Prairie du Chien, and constitute the whole of the escarpment of the St. Peter's falls, as well as the bluffs on both sides of the Mississippi, from thence to Carver's Cave and St. Pauls; and, therefore, sometimes alluded to by us under the local name of the St. Peter's formation."† Thus, no specific description of the formation is given in this, the first place of reference. That this is the formation in question, however, there can be no doubt, inasmuch as in the following year the strata were described, and in 1852 the name St. Peter's was definitely adopted.

In the report of Dr. Owen, published in 1848,‡ this formation is called "F. 2 c." It is superimposed on the Lower Magnesian limestone, and is the rock which forms the base of the bluffs at St. Peter's, and likewise the lower nineteen feet of the Falls of St. Anthony, It is said to be remarkable for its whiteness, and to be made up of grains of limpid and colorless quartz. "It appears to be destitute of organic remains; at least none have as yet come to light. In the absence of these, it is difficult to say whether it ought to be considered as the terminating member of F. 2, or the inferior member of F. 3. Since, however, it appears to have been produced by a repetition of sedimentary action, similar to that which occurred just at the commencement of F. 2, I have thought it best to place it, for the present, as the terminating mass of that formation." || In the series of sections

* Preliminary report of Progress of the Geological Survey of Wisconsin and Iowa up to October 11th, 1847. U. S. Land Office Report for 1847, pp. 160–173. 30th Cong., 1st Sess., S. Ex. Doc., No. 2.

† Ibid, p. 169.

‡ On a geological reconnoissance of the Chippewa land district of Wisconsin, and the northern part of Iowa, 1848.

|| Ibid, p. 28.

accompanying the report, the sandstone is represented as "F. 2? c," and as occupying a position beneath the lower shell limestone, and above the Lower Magnesian limestone.

In 1852, Dr. D. D. Owen* described the St. Peter's sandstone in almost the identical language used in the report of 1848, referred to above.

Having in this brief historical review given an account of the observations made upon the rocks previous to its receiving the name which it now bears, let us examine the formation somewhat more minutely as to its distribution, lithological characters, stratigraphic position and fossils.

DISTRIBUTION.

The St. Peter's sandstone is confined to a limited district in the upper Mississippi valley. It is found in the States of Minnesota, Wisconsin, Illinois, Iowa and Missouri, and possibly in the northern peninsula of Michigan.

In Minnesota it outcrops in an irregular line in the south-eastern part of the State, extending north-west from the southern boundary to above Minneapolis, and south-west again to Martin and Jackson counties.

In Wisconsin it is found in a narrow strip running from the Menominee River, at the north-eastern boundary, to the southern boundary, occurring in patches wherever the rivers have cut into the superincumbent formations to a depth sufficient to reach it. It also outcrops to a limited extent in St. Croix and Pierce counties in the north-western corner.

In Illinois it is found in two isolated patches; one of these is on Rock River, near Grand de Tour; the other on the Illinois River, in La Salle County. It also probably underlies a part of the State, being only known by deep-well borings.

In Iowa it is found exposed only in the north-east corner, though its presence has been revealed in other localities by deep wells at from 1,100 to 1,200 feet beneath the surface.

*[Protozoic rocks in the northwest.] Geol. Survey Wisconsin, Iowa and Minnesota; and incidentally of a portion of Nebraska Territory. Philadelphia, 1852, pp. 69-71.

In Missouri the "Saccharoidal sandstone" has been correlated with the St. Peter's. It is known in several places along the Mississippi River. There has been considerable dispute as to the exact age of the Saccharoidal sandstone, but the latest examination of it by Dr. F. L. Nason* led to the conclusion that the division which has been made of first, or saccharoidal, second and third sandstones, and first, second, third and fourth magnesian limestones can not be maintained. He says the evidence is not sufficient to make more than one sandstone and one limestone formation. For the first he proposed the name of Roubidoux sandstone, and for the second the name of Gasconade limestone. It seems probable that the strata that have been referred to the St. Peter's in Missouri are Cambrain rather than Silurian.

Finally, in Michigan, it apparently occurs in a narrow strip running from the Menominee River to the Sault Ste. Marie, the Lake Superior sandstone having been considered by some authors to belong to this period also.

LITHOLOGICAL CHARACTERS.

In all its typical outcrops the St. Peter's sandstone presents the same characteristics, being a friable, coarse-grained sandstone, the grains cohering but slightly, except when permeated by carbonate of lime or various oxides of iron. It then becomes hard and indurated. In color it varies greatly, being white, red, brown, yellow, gray, pink, green, lilac, and also being frequently banded in an irregular manner. It occasionally shows stratification planes, and ebb and flow structure, and rarely, ripple marks. In thickness it varies from a thin layer to a stratum over two hundred feet thick, though the latter is infrequent. Its peculiar character and the supposed entire absence of organic remains have caused it to be regarded by some authors as a chemical precipitate rather than as of mechanical origin. We have already seen that Keating, in 1824, considered it to be the former. The same idea was advanced in 1858 by Prof. J. D. Whitney,†

*Geol. Sur. of Missouri, Vol. III, Dec., 1892.

†Geological Sur. Iowa, Vol. I, Part 1, 1858, p. 341.

who says that if this quantity of quartzose sand be the result of the mechanical attrition of azoic rocks, that it is difficult to understand the absence of detritus which would come from the destruction of schistose, feldspathic and trappean rocks which make up so large a portion of the azoic series. "The uniform size of the grains of which the sandstone is composed, and the tendency to the development of crystalline facets in them, are additional facts which suggest the idea of chemical precipitation rather than of mechanical accumulation."

The later discovery of fossils, although in limited numbers, has now caused it to be generally regarded as of mechanical origin. Upon this point Prof. Chamberlin* says that "the existence of the remains of marine life demonstrates that the fossiliferous portions at least are submarine deposits, while the well-rounded character of the grains, the ebb and flow structure, the shaly laminations, the conglomeritic portions, and its relations to the adjacent formations, leave no doubt that it belongs to the common class of oceanic sand deposits."

ECONOMIC VALUE.

The purity of the sandstone and its peculiar character have rendered it of value in the manufacture of glass in certain localities. The fact of its being generally overlain by a heavy stratum of limestone, has given it even more value to mankind, inasmuch as it is the cause of many waterfalls which are utilized for manufacturing purposes. It is the cause, for example, of St. Anthony's Falls, which has been to Minneapolis a source of immense wealth. Prof. N. H. Winchell, in the first annual report of the Geological and Natural History Survey of Minnesota for 1872 (1873), page 92, says, that at present the "sandstone is not known to be used for any purpose within the State except for mortar for the local markets and as an engraving board for idle boys. Sometimes beer vaults are made in it along the river bluffs, and sewers for the drainage of the cities of St. Paul and Minneapolis are excavated through it, the overlying limestone affording a secure roof."

*Geol. of Wisconsin, Vol. II, 1878, p. 288.

THE BASE.

The base of the formation has been but seldom observed. Professor Winchell has recorded one observation upon it. This was in Nicollet County, Minnesota, and he says about two feet of white sandstone with a thin strip of shale overlay the Magnesian limestone below. It frequently retains its arenaceous character to its contact with the underlying rock.* Professor Hall has also noticed the junction, and says that sometimes there is a finely laminated clay with stripes of green,† and the sandstone is often similarly colored. The irregular surface of the Lower Magnesian limestone is frequently the cause of great variations in its thickness, as it fills up hollows and covers ridges which exist there. In Missouri this feature is especially remarkable. Mention is made of one locality where the formation thickens so rapidly as to present the appearance of a dyke cutting off the sandstone both above and below.‡ In another place it forms a bed 240 feet long and sixty feet deep, filling a cavity in the limestone of this extent.‖

In 1877, Professor Chamberlin refers to the St. Peter's sandstone in eastern Wisconsin.§ He notes the unequal deposition of the sandstone on the Lower Magnesian limestone, stating that, instead of being of uniform thickness, as has been often asserted, it ranges from a thickness of 212 feet down to a single layer of sand grains. It sometimes varies from 100 feet to zero in the course of a quarter of a mile. Instances are known of its entire disappearance, and the consequent resting of the Trenton limestone on the upper surface of the Lower Magnesian, while in the near vicinity a thickness of from fifty-four to 100 feet has been noted.

THE TOP.

Its junction with the overlying limestone has been more frequently observed. Sometimes the transition is abrupt, but

*Second annual report of the Geological and Natural History Survey of Minnesota, for 1874, 1875, p. 132.

†Report on the Geology of Wisconsin, Vol. I, 1862, p. 29.

‡First and Second Annual Reports of Geological Survey of Missouri, 1855, p. 119.

‖Reports on the Geological Survey of Missouri, 1855-1871, 1873, pp. 142-143.

§Geology of Wisconsin. Survey of 1873-1877. Vol. 2, pp. 285-290.

again there occur certain transition beds, of which it is difficult to say whether they should be referred to one or the other formation.

At Seward's quarry, about two miles from Ripon, Wisconsin, the junction between the St. Peter's and the overlying Trenton is well shown. It is here a very friable sandstone, varying in color from yellow to brown. The upper layers, just beneath the limestone, contain concretions or nodules varying in size from half an inch to six inches in diameter. The sand is irregularly stratified. In places it is white, but it is generally more or less stained. The separation between the limestone and the sandstone is distinct. The lower layers of the former contain more or less sand, and are in thin courses one-half to one and one-half inches thick. Above they become heavier, from four to six inches, but do not seem to be fossiliferous. About fifteen feet of the sandstone is exposed. A short distance from this quarry is another exposure of the sandstone about twenty feet high. No limestone capping is present. The sand is often banded with red, while white and brown streaks sometimes alternate. It contains a few concretions near the top, below the junction with the limestone.

At Mitchell's Glen, about four miles from Ripon and a mile from Green Lake, both the Trenton and the St. Peter's occur. The limestone is separated from the sandstone by transition beds about two feet thick. The upper one of these is quite sandy, as is also the lower, but the intermediate stratum, about a foot thick, is a solid, more or less calcareous mass. The St. Peter's proper is more or less friable, and white, yellow or brown in color, more generally one of the latter. The outer surface hardens on exposure, but in places it can be taken out with a spade. At one point in the Glen is a perpendicular fall of about fifty feet, at the bottom of which is a pool of water. The sandstone is here exposed in vertical walls on either side of the Glen to a height of seventy feet, capped by layers of Trenton limestone. The bedding of the sandstone is very irregular, dipping at various angles and in different directions. Numerous large springs of clear, cold water gush out from the sandstone walls. They probably mark the approximate place of junction with the Lower Magnesian. No fossils were observed by the writer.

At another point, also near Ripon, and the evident base of the Trenton, there is an intimate mixture of sandstone and calcareous material. In this occur large specimens of Orthoceras, which are of Trenton rather than of St. Peter's age.

At Pomeroy's quarry, near River Falls, Wisconsin, at the top of a high hill, is an exposure of the Trenton limestone in heavy layers, and containing quantities of brachiopods. Beneath this exposure is an outcrop of the St. Peter's, with a vertical height of about fourteen feet. The sand is dazzlingly white, easily disintegrating on exposure. It forms a conspicuous feature in the landscape, the white line of outcrop appearing in numerous places along the face of the hill. No fossils were observed.

On the bluffs east of Prairie du Chien the sandstone occurs above the Lower Magnesian limestone. It is mostly covered, and has an estimated thickness of eighty feet. In the bed of a stream that comes down the hill, several gigantic steps have been formed, each from five to eight feet high and with "treads" two or three feet wide. No fossils were observed.

Professor Chamberlin has also noted passage bed as seen in Rock County, Wisconsin. He says "At several points in Rock County *the passage* of the St. Peter's to the formation above is attended by an alteration of sandstone and calcareous rock. The sandstone just below the calcareous bed is marked with fucoidal impressions, and the base of the calcareous layer contains abundant Scolithus tubes. The calcareous bed is of a greenish-gray cast, containing a large percentage of insoluble, argillo-arenaceous material, in addition to the evident quartzose grains that are more or less freely scattered through portions of it. This has not been observed to attain a thickness of more than four or five feet. The upper portion is usually shaly, and appears at some points to have been eroded before the deposition of the stratum of sandstone above. This latter is thin and mixed with argillaceous material on which sometimes supervenes a thin seam of carbonaceous matter followed by the fossiliferous Trenton limestone. At the most northern point at which the junction was seen, the sand mingles freely with the calcareous layers of the Trenton, for several feet above their base. At most other points the usual abrupt transition was observed."*

*Geol. of Wisconsin, Vol. II, p. 287.

It is also discussed by Professor Swezy, who mentions* the occurrence of the St. Peter's sandstone at Beloit, immediately beneath the Trenton. The author says: "Between the St. Peter's sandstone and the Trenton limestone are eight feet, or perhaps more, of transitional layers; they include, at the bottom, a foot or so of sandstone, more coarse and impure than is usual with the St. Peter's; above this five feet of impure limestone and shale, and at the top two feet more of coarse sandstone." Above this series comes the typical Trenton limestone. In a diagram, presented on page 199, these transitional layers are not referred to either the St. Peter's or the Trenton.

Another excellent exposure, showing transition beds between the Trenton and St. Peter's, occurs at Fountain, Minn. This was first described by Prof. N. H. Winchell, in 1876.† His section is as follows:

SECTION NEAR FOUNTAIN; QUARRY OF JOSEPH TAYLOR.

	FT.
No. 1. Green shale mixed with fragments of limestone that are eminently fossiliferous, ... seen,	3
No. 2. Limestone, of a bluish-gray color, in beds from four to six inches thick, free from shale, though the layers are sometimes thinly separated by shaly partings, ...	10
No. 3. Arenaceous and ferruginous shale, alternating horizontally with firmly cemented patches of sandstone, .	2
No. 4. Massive coarse sand; white, except where iron-stained, containing irony quartzite pebbles, and fragile remains of bivalves, ...	6
No. 5. Green shale, with some arenaceous and calcareous laminations, ...	3
No. 6. Cemented sandstone, the cement being shale and lime, forming, where the bluff is weathered, the floor of a bench, ...	1
No. 7. White sand, in beds that are about one foot thick and horizontal, ...	6
No. 8. A course in the sandstone more firmly cemented, forming another table, but less persistent than No. 6, . . .	1
No. 8 [9]. Massive sandstone, in some places showing an oblique lamination, ... seen,	6
Total, ...	38

* On some points in the geology of the region about Beloit. Wisconsin Acad. Sci. Trans., Vol. V, p. 194.

† Fourth Rept. Geol. and Nat. Hist. Sur. Minn., for 1875, 1876, pp. 40–42.

A species of *Lingulepis* is found in No. 4 of the foregoing section. Prof. W. says: "The remains are exceedingly fragile, and as the grains of sand in which they are embraced are feebly cemented together, it is nearly impossible to transport, or even to handle them without their falling to pieces. These fragments, for no entire specimens were obtained, are arranged promiscuously in the coarse sand, and are all confined within three feet of the top of No. 4. They seem to have suffered the attrition and friction incident to coarse sedimentary transportation. They dispel the idea, which has been suggested, of the possible chemical origin of the St. Peter's sandstone, as an oceanic precipitate."

This same locality was visited by the writer in 1889, and the following section was observed:

	FT.
No. 1. Trenton limestone in thin courses, ...	—
No. 2. Layers of coarse-grained, hard sandstone, formed of grains of rounded quartz, of nearly uniform size, with occasional fragments of Linguloid shells, ...	1
No. 3. Loose sand, with yellow and brown streaks and greenish spots, ...	6
No. 4. Greenish shale and sandstone, mostly shale, . . The upper portion of this bed is a white sandstone, formed of rounded grains of quartz, cemented by carbonate of lime, and containing fragments of fossils. The interstices of the sandstone are filled with fine particles of sand. Below this the shale is a mixture of clay, lime, and sand, the former green, the latter white, and formed of rounded quartz grains. The green shale contains what appear to be worm burrows (Planolites), and fragments of *Lingulepis morsensis* Winchell.	5
No. 5. White sandstone of St. Peter's,. . . . . covered,	—
Total observed, ...	12

About half a mile further down the railroad another exposure occurs. Here the typical St. Peter's sandstone is well exposed, and it is overlaid by the same succession of shale, loose sand, hard sandstone and limestone, as that in the previous section. In the upper portion of the shale are certain iron-stained layers, in which brachiopods of the genus Orthis are found. These are also seen in the sandstone, together with fragments and impressions of *Lingulepis morsensis*.

In the twelve feet of sand and shale given in the above section, we have transition beds between the true Trenton limestone and the typical St. Peter's sandstone below. It would appear that after the deposition of the white sandstone there came a period of muddy seas, during which the greenish shales were laid down. Then followed a period of elevation to near the surface, when the loose sand and the harder beds below were deposited. The latter were probably cemented together by lime from the layers of limestone above, which were in their turn laid down in a deepening sea, that soon swarmed with life.

In a late paper by Messrs. Hall and Sardeson* a similar conclusion is reached. These authors say that they nowhere found in Minnesota any indication of an uncomformity between the Trenton and St. Peter's. "The transition zone of a green shaly calcareous sandstone shows the steady oncoming of that Lower Silurian sea which, if it did not submerge the whole Northwest, at least extended so far that the dry land was reduced to islands, or narrow peninsular stretches of very uncertain connection with a mainland lying somewhere."

STRATIGRAPHIC POSITION.

The position of the formation in the stratigraphical column is unequivocal. It lies between the Lower Magnesian limestone and the Trenton limestone, but its limited area in the country, and its practical isolation from eastern localities, renders its correlation with formations elsewhere a matter of difficulty. In addition to this the almost total absence of fossils adds to the perplexity, as it is by means of the organic forms that rocks are most accurately correlated. The only point where direct stratigraphic continuity with any eastern North American formation can be looked for is on the Canadian side of the Sault Ste. Marie. Its presence here is shown on the geological map of Canada by Hall and Logan,† though it is present to only a limited extent. It does not occur again, in outcrop at least, until the Ottawa River is reached.

* Bull. Geol. Soc. America, Vol. III, p. 355.

† Atlas accompanying Geology of Canada from commencement to 1863. 1865.

some 350 miles to the eastward. Even in Canada and the eastern States, where it is known as the Chazy, it occupies scattered patches, which are limited in area. On the map referred to above, the sandstone on the south shore of Lake Superior, and the outcrops of St. Peter's in Wisconsin and Minnesota, are colored as Chazy; and in another map in the same atlas, showing the distribution of the Huronian rocks, by Sir W. E. Logan, the distribution of the sandstone is given in more detail, and it is designated in the legend as "Chazy (St. Peter's Sandstone)."

The reference of the St. Peter's to the horizon of the Chazy has been made by various writers, solely, it would appear, upon stratigraphic evidence. Hall, in 1863,* considered it as the equivalent of the Chazy. He says: "So long since as 1845, I had myself observed that the sandstones of the St. Mary's River come out from beneath the Black River and Birdseye limestones; but the Calciferous sandstone was nowhere visible in the immediate neighborhood. The later and more complete investigations of the Canada Geological Survey have proved the absence of the Calciferous sandstone, and of the Potsdam sandstone, on the north shore of Lake Huron; and, also, that this sandstone of St. Mary's River (which is now regarded as identical with that of the south shore of Lake Superior), rises from beneath the Black River and Birdseye limestone, and there is no evidence of the Calciferous sandstone in that region. It is the opinion of Sir William Logan, that this sandstone represents the Upper sandstone, or fills the place of the Chazy formation in the East, the limestone being absent; and that it is this arenaceous deposit, greatly augmented, which gives the sandstone formation of the south shore of Lake Superior (Geology of Canada, 1863, pp. 83-86)."

After giving the sequence of the formations as found in the Mississippi valley, as Buff-limestone-Birdseye and Black River; St. Peter's sandstone; Lower Magnesian limestone, he says: "In assigning a position to the sandstone of the south shore of Lake Superior, to the south and east of Keweena point, from the evidence before us, and in the absence of any fossils which may aid the decision, we are

*Sixteenth Ann. Rept. N. Y. State Cab. Nat. Hist., pp. 214-215.

forced to conclude that this formation is a greatly augmented development of the St. Peter's sandstone; or, that the Lower Magnesian limestone ("Calciferous sandrock") has thinned out, so as to leave the St. Peter's sandstone and the Potsdam below (as developed in the Mississippi valley) to go on as one mass to the northward."

"It is scarcely possible to suppose that the lower sandstone of the upper Mississippi Valley has not, at some time or in some form extended as far as Lake Superior; but it is far from being proved that the sandstone now so largely developed on the south shore is that sandstone, as we have shown. If this sandstone consist of both that above and that below the Calciferous, or of the St. Peter's and the Potsdam proper, then at some point we should expect to find a change of character, or nonconformity between the beds, to indicate the lapse of time in the deposition of the Lower Magnesian limestone of more southern localities; and this view is sustained by the observed want of conformity between the sandstone and Magnesian limestone near Dead River just cited."*

The question is here left in an unsatisfactory condition; but if the later conclusions,† that the Lake Superior sandstones are Potsdam or pre-Potsdam in age be sustained, it is probable that the St. Peter's formation will be confined to a narrow strip through the northern peninsula from the Menominee to St. Mary's River.

Hall asserted the same again in 1869,‡ as did also Logan‖ in the map of Canada in 1865.

In referring to the sandstone east of Keweenaw Point, sometimes called the Eastern sandstone, Dr. Alex. Winchell§ considered it as the probable equivalent of the Calciferous and Chazy formations of New York. He says, in regard to the Lake Superior sandstone as a whole: "The portion west of the Point is thought by some to be of the same age [Calciferous and Chazy], while others regard it as the equiva-

*Ibid, pp. 215–216.

†Irving, R. D.: Copper-bearing rocks of Lake Superior. Monographs U. S. Geological Survey, Vol. V, 1883.

‡Am. Phil. Soc. Trans., new ser., Vol. XIII, p. 329.

‖Atlas accompanying the Geology of Canada from the commencement to 1863. 1865.

§Sketches of Topography, Climate and Geology of Michigan. Walling's Atlas of Michigan, 1873, p. 46.

lent of the sandstones in Wisconsin and Minnesota, which are generally ranged in the horizon of the Potsdam of New York. As the uplift of Keweenaw Point has tilted the sandstones on the west, while those on the east have retained their horizontality, there is reason for supposing that the eastern strata are of more recent origin. It may, nevertheless, be true that the sandstones on both sides of the Point are of the same age, though those on the eastern side were not permanently tilted by the convulsion which upheaved the others. As we find apparently superincumbent strata, which answer to the Calciferous, we shall continue to parallelize the Lake Superior sandstone, presumptively, with the Potsdam."

Dr. Rominger, in 1873,† also considers the Chazy and Calciferous under one head. In his description he says: "Below the well-characterized Trenton strata, and reposing on the Lake Superior sandstones, we find over the whole extent of the Peninsula a series of calcareous or arenaceo-calcareous beds which hold the place of the Chazy limestone and the calciferous formation of the Eastern States. We can not distinguish two different formations with different faunas in the West, where all the fossils ever found are three or four species of shells, and those generally in imperfect condition. But we can see a plainly expressed typical similarity between the fossils of the eastern and western localities. Also the lithological characters of the compared rocks are in perfect general correspondence, so that we can safely consider our western strata as the equivalents of the two named groups of the New York system. The greatest observed thickness of the formation within the district is near 100 feet, but usually it is not found in so large a development." Worthen, in 1866,‡ considered the St. Peter's to form the upper portion of the Calciferous series of New York, while in 1874, Broadhead|| makes the Saccharoidal sandstone equal to the St. Peter's and also to the Calciferous.

In 1883 Prof. Chamberlin§ gave a résumé of the knowledge of the formation. It is stated to repose on the billowy sur-

*Ibid, pp. 43-44.

†Michigan Geological Survey. Palæozoic Rocks, 1873, p. 71.

‡Geological Survey of Illinois, Vol. I, 1866, p. 149.

||Report of the Geological Survey of Missouri; field work, 1873-1874; 1874, chart oppo. p. 18, and p. 29.

§Geology of Wisconsin, Survey of 1873-1879, Vol. I. 1883, pp. 145-150.

face of the Lower Magnesian, and to be an almost pure quartzose sandstone. The greatest thickness observed was 212 feet, but its average is hardly over eighty. Traces of life are rare. The method of formation is considered due to mechanical action, rather than to chemical solution. In discussing its history it is stated that the sand was probably derived from the Archean nucleus or the Potsdam sandstone toward the north, which was then exposed above the surface, or at least subject to the mechanical action of the waves. The distribution is given, the Saccharoidal sandstone in Missouri and the Chazy limestone of New York being considered its equivalents. He says: "We have felt somewhat inclined to refer its main deposition to the closing Calciferous or early Quebec, and to suppose that it was rewrought by the advancing sea in the Chazy or early Trenton epoch, the remainder of the interval between the Calciferous and the Trenton being unrepresented in our series, because the water had retired."*

As known in New York, the Chazy formation is essentially a limestone, and therefore differs greatly in lithological features from the St. Peter's. But in Canada the limestone is associated with sandstones and shales. At Greenville the calcareous strata are succeeded by about fifty feet of whitish sandstone, in beds from two or three to twelve inches, interstratified with bands of green shale, holding great numbers of fucoids.† A sandstone, in beds of from four to twelve inches thick, interstratified with green arenaceous shales is found resting on the Laurentian, and immediately underlying the Trenton. This is found near the mouth of the Coldwater on Lake Huron.‡

The beds of sandstone here mentioned form, however, only a small portion of the formation, while in the west the calcareous feature is almost entirely absent. This difference in lithological features, and the scarcity of fossils combined, has made it difficult to say positively, but the facts all point to the conclusion that in the St. Peter's sandstone we have the western equivalent of the Chazy limestone of the New York system. The correlation rests almost entirely upon the stratigraphic position.

*Ibid, p. 150.
†Geology of Canada, from the commencement to 1863. 1863, pp. 123-124.
‡Ibid, p. 192.

FOSSILS.

The organic remains found in the St. Peter's are but few. The following list is believed to include all that have been noticed as occurring.

BRACHIOPODA.

Lingulepis morsensis Winchell. Prof. N. H. Winchell, in 1876, described this species as follows: "Shell conical or elongate-conical, with anterior angles rounded; depressed; the apical angle not seen perfect; the front margin gently convex; sides nearly straight, but converging at an angle of about 26 degrees; greatest width is near the front, and at a distance from the anterior margin of one third the greatest width. The surface is smooth and shining, marked with very fine concentric striæ, visible especially in the anterior portion, and with more distant, dim undulations of growth. Entire length of the larger specimen seen about .85 inch; width, .52 inch; length of the smaller, .78 inch; width, .45 inch. Color of the shell light brown, with spots of brown. The smaller specimen has flattened, or slightly concave margins, for nearly two-thirds the length from the apex. The species in general contour resembles *Lingulepis briseis*, of Billings (Palæozoic Fossils, Vol. I, p. 48), but differs from it in not having its sides parallel."*

This species is found at Fountain, Minnesota, in a sandy shale, in transition beds between the Trenton and the typical St. Peter's, and it is really questionable if it belong to the latter period. It has, however, been placed there by Winchell, and is therefore inserted here.

Orthis sp. cf. *testudinaria* Dalman. A species of Orthis resembling in size and marking *O. testudinaria*, occurs in the sandstone and shale beds at Fountain, Minnesota, in association with *Lingulepis morsensis*. A similar form is found in the Trenton, which overlies the St. Peter's at Ripon, Wisconsin.

*Fourth Annual Report of the Geological and Natural History Survey of Minnesota for 1875. 1876, p. 41.

GASTEROPODA.

Specimens of the genus *Murchisonia* are referred to by Meek as occurring in Monteau County, Missouri.* Crinoid columns were also found associated.

Fragments of the internal casts of *Straparollus* and *Chemnitzia* were stated by Shumard to be found in the sandstone in Ozark County, Missouri.† They were too imperfect for accurate determination.

Maclurea (?). This is recorded by F. W. Sardeson‡ as occurring in the St. Peter's formation, near St. Paul, Minnesota, together with the species mentioned below. From the uncertainty felt in the identifications, it seems evident that the fossils are not in a very good state of preservation. Mr. Sardeson states that they occur about fifty feet below the top of the formation, and that "they are remarkably like species found in the lower part of the Trenton shales and in the Trenton limestone, which here rests conformably on the St. Peter sandstone."

Murchisonia gracilis Hall. *Murchisonia* (?) *tricarinata* (?) Hall.

LAMELLIBRANCHIATA.

Cypricardites rectirostris Hall. *Cypricardites*, 2 sp. undeter. *Modiolopsis?* (Mentioned by Sardeson.)

ANNELIDA.

Arenicolites; Scolithus sp. A species of *Arenicolites* is referred to by Winchell‖ as occurring in the sandstone at Faribault, in Rice County, Minnesota. He says: "The sandstone here is pitted with circular holes, such as have

*First and Second Annual Reports of Geological Survey of Missouri, Part II, 1855, p. 106. There is considerable doubt in regard to the exact position of all the fossils here recorded from Missouri. As already noted the Saccharoidal sandstone in which they are stated to occur, is referred by Nason to the Cambrian.

†Reports of the Geological Survey of Missouri, 1855–1871. 1873, p. 192.

‡Fossils in the St. Peter Sandstone. Bull. Minn. Acad. Nat. Sci., Vol. III, p. 318.

‖Geological Survey of Minnesota. Volume I of the final report. 1884, pp. 656–657.

been seen in a number of places in the State.* They are brought to view distinctly in the weathered and hardened surfaces, since the homogeneous sand on fresh fractures seems to constitute the entire rock, and no trace of these fossils is visible to the eye. They appear at this place on a lower bench, where the rock is hardened and reddened. They always run perpendicular, and can be traced to a depth of two and a half feet by the little furrows they cause on the face of the rock after the breaking and sliding down of masses of the bluff. This structure was first seen in this sandrock at the base of Dayton's bluff, at St. Paul, and was ascribed to Cretaceous lithodomous shells, but it is more likely to be due to some marine vegetable, or to worm-burrowing, of Cambrian age. By examining areas that have suffered different degrees of exposure, there can be traced a connection from the actually empty porous openings, through different degrees of exposure and induration, including a simple annular spottedness, to an innate internal structure in the mass of the rock itself. It would be the same as if a multitude of horse-tail rushes, or others, were growing in the bottom of the sea when the sand was accumulating, and became gradually buried under the sand, and then were imprisoned and fossilized, their presence only being evinced now by the cementation of the sand-grains about their exterior, or by a looseness of the same in their interior, thus not only forming a rude cast of each stem within the rock, but also providing for the more rapid erosion and removal of the grains that may have reached within their cases. The spots are only seen on upper surfaces, and if they be not due to imprisoned rushes or stems of some sort, or to worm-burrowing, they are at present inexplicable. They are generally from an eighth to a quarter of an inch in diameter."

This species the present writer has proposed to call *Scolithus minnesotensis.*†

Similar tubes are noticed as occurring at Waterloo and Beloit, Wisconsin.‡ In Illinois, in LaSalle County,‖ a peculiar feature of the sandstone is noticed. It is stated to contain

* "They are conspicuous at Castle Rock, in Dakota County."

† Bull. Geol. Soc. America, Vol. III, 1891, p. 41.

‡ Chamberlin, T. C. Geology of Wisconsin, Survey of 1873-77, Vol. II, 1877, p. 288; also, Vol. I, 1883, p. 147.

‖ Geological Survey of Illinois, Vol. III, 1868, p. 280.

an infinite number of minute vertical holes, about the size of knitting needles. These are, perhaps, *Scolithus* tubes. In Missouri, there is found a sandstone formed of columns perpendicular to the plane of deposit,* and these may also be *Scolithus* tubes.

Planolites sp.—A species of *Planotites* was found by the writer in 1889 at Fountain, Minnesota, in strata referred to the St. Peter's. It is associated with *Lingulepis morsensis* and *Orthis* sp., already noted, but it has not been referred to any species.

CEPHALOPODA.

Orthoceras.—Fragments of *Orthoceras*, some of large size, are noted as occurring in this sandstone in Missouri.† One locality is in Maries County,‡ the specimen stated to be five and one-half inches in diameter, while other specimens thirty inches in diameter and ten feet long are found near the line between Gasconade and Franklin Counties. In the roof of a cave near Marthasville, circular rings, supposed to be cross sections of *Orthoceras*, are noted.‖ It is possible that these specimens really belong to the overlying Trenton. The writer has collected large specimens of the genus from the Trenton at Ripon, Wisconsin, in strata which were more arenaceous than calcareous, and which might readily have been referred to as a sandstone.

The smalless of the number of species found in the sandstone is thus seen. Their occasional presence, however, may be considered a proof that the formation is of mechanical origin and not a chemical precipitate.

* Reports on the Geological Survey of Missouri, 1855–1871. 1873, p. 55.

† Swallow, G. C. Explanations of the Geological Map of Missouri, etc. Am. Asso. Adv. Sci. Proc., Vol. XI, Part 2, 1858, p. 17.

‡ Reports of Geological Survey of Missouri, 1855–1871. 1873, p. 10.

‖ Ibid, p. 55.