

1891

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Recommended Citation

Sardeson, F. W. (1891). The Lower Silurian Formations of Wisconsin and Minnesota Compared. *Journal of the Minnesota Academy of Science*, Vol. 3 No.3, 319-326.

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The fossils are for the most part, marked out by discoloration (brown or red), but a *few* by cleavage only. They are quite numerous and are easily found when one once knows how and where to look for them.

They occur fifty or more feet below the top of the formation.

I have assigned the specimens found, to the genera and species to which I think they belong. 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 Saint Peter sandstone. And it may be, as has been suggested, that the Saint Peter is of the Silurian rather than that of the Cambrian formation.

As soon as spring opens, I shall spend some days in a more thorough search, in order to find out as far as possible, the true nature and horizon of these fossils in the Saint Peter sandstone.

February 3, 1891.

THE LOWER SILURIAN FORMATIONS OF WISCONSIN AND MINNESOTA
COMPARED.—*F. W. Sardeson.*

It is the purpose of this paper to give some observations on the Silurian of Minnesota, and the Trenton group in particular; and to compare it with the same of Wisconsin.

There are some difficulties in undertaking such a comparison. For example, the Trenton group in Wisconsin is nearly all limestone, while in Minnesota it is largely composed of shales. This lithological difference is accompanied by some differences in the fauna and in the outward appearance of the fossils. Then, too, four beds are recognized in the Trenton of Wisconsin, the Lower Buff, Lower Blue, Upper Buff and Upper Blue beds, while in Minnesota two are usually spoken of—Trenton limestone, or shell beds, and Trenton shales, or green shales. These difficulties I shall aim to avoid in part and in part explain.

I shall take up one by one the beds as seen in Minnesota and compare them with the same in Wisconsin, so far as I can.

The lower Trenton limestone, or Trenton limestone of Minnesota, consists of three beds differing somewhat in lithological character and fauna; most strongly so in the area around the "Twin Cities," *i. e.*, Minneapolis and Saint Paul. The first of these, next to and conformable with the Saint Peter sandstone, is the same bed as the Lower Buff limestone of Wisconsin, judg-

ing from its fauna, a variety of *Orthis suboequata* Con., *O. deflecta* Con., *Rhynchonella orientalis* Bill., *Strophomena minnesotensis* Winchell (varieties), *Ambonychia attenuata* Hall, etc.

At Janesville, Wis., this bed is about eighteen feet in thickness, in Jefferson county, Wis., about fourteen feet; in LaFayette Co., ten feet; at Dodgeville and Platteville, Wis., nearly twenty feet. In Fillmore Co., Minnesota, it is about twelve feet; at Rochester, Olmsted Co., the same; at Minneapolis, fifteen feet; at Faribault, Rice Co., it is either represented by four and one-half feet of green (apparently unfossiliferous) shale, or it is absent.

The second of the three limestone beds at Minneapolis (seven feet of carbonaceous limestone) preserves few fossils well. In nearly all other respects it is like the bed above rather than the one below it. But I am not so sure that this is the case elsewhere. At Faribault the seven feet immediately on the green shale mentioned above has characteristics of this bed. In southeastern Minnesota it is less easily distinguishable from the bed below. In southwestern Wisconsin I could not find it at all, unless it is there more fossiliferous, and hence confused with the strata above. But at other points in Wisconsin, these strata seem to be distinguishable though in every case less distinctly than at Minneapolis.

The five feet three inches at the top of the limestone at Minneapolis is the fossiliferous bed of the three. The species that occur in it are essentially the same forms as those common in the Lower Blue bed of Wisconsin. *Orthis pervaeta* Con., *Trochonema beloitense* Whitf., *Cypricardites rectirostris* H., are abundant forms.

At Faribault this bed is of about the usual depth for Minnesota, but is darker and more carbonaceous than usual and brachiopod shells are well preserved. In Wisconsin, at Platteville, Mineral Point and Dodgeville, it seemed to be from ten to fifteen feet thick and perhaps the same thickness at Janesville.

The rest of the Lower Trenton in Minnesota is shale which is supposed to be mainly the equivalent of the Upper Buff and Upper Blue limestone of Wisconsin. But the lithological differences, together with the scarcity of fauna in Wisconsin make this more difficult to decide. All the evidence met with, however, is in favor of the supposition that the lower Trenton shales in Min-

nesota are the equivalents of the Upper Buff and Blue beds in Wisconsin, with the exception of the first ten feet of our shales. These last are, doubtless, a part of the Lower Blue bed in Wisconsin.

I came to the conclusion, some time ago, that the first strata of the shales could be classed with the limestone below, as easily as with the shales above. They form here a transitional bed, which for convenience I wish to distinguish as the *Stictoporella* bed. The limestone strata, which constitutes part of it, though crystalline like the slabs in the true shales above, are the result of sedimentation like the limestones below. The fauna, too, is as much that of the preceding as of the succeeding strata.

The *Stictoporella* bed, in ascending order, is as follows: Limestone 6 in., limestone 1 ft. 1 in., limestone 2 ft., shale 1 ft. 6 in., limestone 7 in., shale 5 ft., limestone 1 ft. 6 in. (measurements taken at Saint Paul.)

The shaly parts are not unmixed clay, but have numerous thin hard calcareous laminæ in them. The stone and shale vary locally in thickness and alternation, but are of about the same proportion, as seen in Goodhue, Olmsted and Fillmore counties, Minnesota.

There is a bed of dark colored limestone upon the Lower Blue bed at Platteville, Wis., which appears to be the same as the *Stictoporella* bed in Minnesota. It consists of, first, about four feet of solid strata, with thinner cleavable strata of the same color; second, three to four feet of green shale such as commonly occurs in Minnesota; and third, four feet of dark colored stone, apparently the transitional back to the ordinary limestone. The fossils were most of them characteristic forms of the *Stictoporella* bed in Minnesota.

At Dodgeville, Wis., the same strata, so far as I could judge, occur as a light brown bed about ten feet thick, but quite unfossiliferous. At the time this place was examined, I was very much puzzled as to whether this bed belonged to the Lower Blue or Upper Buff limestone, but upon reading over the Geology of Wisconsin, Vol. I, I became quite satisfied that it would be classified as equivalent to part of the Lower Blue limestone of the Rock river valley.

Along the Illinois Central railroad near Dodgeville, nearly every stratum from the Saint Peter to the middle of the Galena is clearly exposed. There can be recognized the Lower Buff,

Lower Blue including the bed mentioned above, the Upper Buff and Upper Blue beds. But neither there nor in the Rock river valley do any strong evidences appear to prove that the Upper Buff and Upper Blue beds are equivalent to the Trenton shales of Minnesota. Only their position suggests that they are very probably equivalents.

The Trenton shales are about eighty feet thick at Saint Paul. In Goodhue county they are about the same. In Fillmore county they are much thinner mainly on account of the upper strata, as exposed in Saint Paul, being here represented by fifteen or twenty feet of limestone. So far as known the beds of the shales were co-extensive in deposition in Minnesota.

The first ten feet of Trenton shales has been described above as the *Stictoporella* bed. It is very fossiliferous; *Orthis subaequata* var., *gibbosa* Bill., *Anoloteichia impolita* Ulr., *Pachydictya foliata* Ulr., and *Stictoporella frondifera* Ulr., occur in masses. The last named is unknown except in this bed and is very widely distributed; and for that reason the name *Stictoporella* has been proposed for this ten feet of shale.

The next thirty feet is of uniform dark green unctuous shale with numerous fossils, but many of them poor on account of the nature of the matrix. But here and there, especially toward the top of the bed, are reefs of bryozoa and brachiopoda, as well as scattering individuals of mollusca, molluscoidea and cœlenterata throughout.

These reefs occur as crystalline slabs from one to four inches thick and of various extent; from their appearance they are easily taken for sedimentary strata. But they have probably been formed by the infiltration of calcium carbonate into lenticular beds of fossils, as shown by the irregular cementing together of the fossils and more particularly by being made up almost entirely of animal remains. Also where a large shell lies horizontally near the under surface of a slab there will usually be a shaly spot or core under the shell as if it had shed off the infiltration from above. Mollusca are preserved as blue calcareous casts.

I could scarcely characterize this bed by enumerating the species which occur in it. An undescribed rhynchonella, which is essentially *R. increbescens* Hall without the concentric lines, occurs from the top of this bed downwards. *R. ainsliei* Winchell has a like distribution, but is more local. Only three species of orthis, *O. subaequata* Con., *O. testudinaria* Dalman (variety) and

Q. tricenaria Con., are known to occur, *Stictopora mutabilis* Ulr., though perhaps not confined to these strata, yet occurs in such numbers here that the name *Stictopora* seemed appropriate in designating this bed.

The next twenty feet is the *Fucoid* bed. The shale is made up largely of fucoidal masses and of calcareous laminæ somewhat irregularly distributed.

At Saint Paul there is, first, 15 feet of shale; then 5 in. limestone; 18 in. shale; 3 ft. of hard crystalline strata that weather reddish brown. This bed will be recognized at once in Ramsey, Dakota and Goodhue counties, by the quantity of fucoidal remains or by the occurrence of *Phylloporina corticosa* Ulr. In Fillmore county I have found the evidences of this bed but never the bed itself exposed. *Orthis pectinella* Con. occurs for the first time at this horizon and also *Rhynchonella increbescens* Hall.

The strata that lie upon the *Fucoid* bed are without fucoidal remains but are much more fossiliferous upon the whole. *Zygospira recurvirostris* Hall, *Rhynchonella increbescens* Hall, are extremely abundant. This bed is characterized by the absence of certain species that occur above or below. The name *Zygospira* bed is proposed from the most numerous species. There is in this bed three feet of hard shale, four feet of ordinary shale, and one foot of shaly limestone—eight feet in all.

At the upper limit of the *Zygospira* bed a new fauna appears. *Receptaculites*, *Platystrophia*, *Orthisina*—which are unknown below. *Orthisina* [*Hemipronites*] *americana* Whitf., has not been found except in this bed and hence the name *Orthisina* is proposed.

Lithologically the *Zygospira* and *Orthisina* beds are difficult to distinguish, and later searching may succeed in merging the former into the latter. In both, there are peculiar calcareous lumps, irregular in shape, rounded in the latter bed and of lighter color than the other parts of the shale, and alternating in strata, with thin smooth surfaced limestone layers. At Saint Paul only part of the *Orthisina* bed remains. At Kenyon, Goodhue county, there is over fifteen feet of this bed exposed. In Olmsted and Fillmore counties the exposures of this bed are rare, and these do not show more than ten feet thickness. In the last named county the bed consists rather of shaly limestone than a shale.

Just where the division between the Trenton and Galena should be drawn so as to agree with the division in Wisconsin is

not determined. I saw the lowest strata of the Galena at Evansville, Dodgeville, etc., in Wisconsin, and formed the opinion that the corresponding line in Minnesota, should be drawn at the top of the *Orthisina* bed: but the fauna here seems to demand a division at the top of the *Zygospira* bed or below it.

From the top of the *Orthisina* bed to the upper limit of the Trenton group is fully 100 ft. in Minnesota, and in many places the rock is exposed in vertical walls, for part or all its thickness.

The fauna in the Galena formation is much more meager than in Trenton, and for that reason close division into beds is less easily made and with less certainty. Three subdivisions however have been noted in Minnesota.

1. The first of these is a somewhat carbonaceous limestone, about thirty feet thick, that crumbles more or less in weathering. The name *Camarella* bed seems appropriate on account of several species of that genus, which occur here and have not been found in other beds.

2. The next twenty feet is of a firm, very durable limestone with few fossils of several species. Inarticulate brachiopods are well preserved. From the occurrence here of *Lingulasma schucherti*(?) Ulr., the name *Lingulasma* bed has suggested itself.

3. The last fifty feet of the Galena formation, which I shall call the *Maclurea* bed, is characterized by large gastropoda—*Murchisonia major* Hall, *Fusispira elongata* Hall, *Maclurea cuneata* Whitf., *Raphistoma lenticularis* (large variety).

This *Maclurea* bed I feel safe in correlating with the last deposited strata of the Galena formation in Wisconsin, both on lithologic and palæontologic grounds. And indeed no reason is known to me for supposing that the strata composing the Trenton group in Minnesota and Wisconsin were not in every case continuously and contemporaneously deposited. As to the first and the last bed, identical fossil forms and similarity in structure, together with nearly continuous exposures, furnish sufficient evidence of their relation on both sides of the Mississippi valley.

The succession of strata through the Trenton group in Minnesota forms a gradual transition from limestone to typical shale and again back to limestone. In Wisconsin this transition is less and less marked in proportion to the distance from the northwestern extension of the strata in Minnesota, *i. e.* from the line of the advancing and retreating shore of the sea in which the Trenton sediments were deposited.

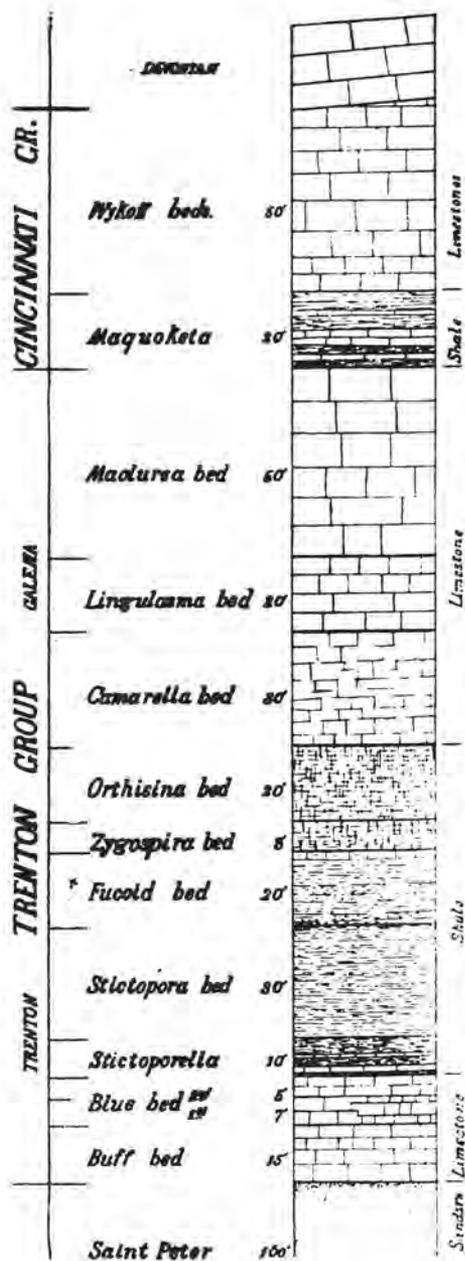


FIGURE 8.

Figure 8 is a diagrammatic section of the Lower Silurian (Ordovician) rocks of southeastern Minnesota, showing the position of the beds just described, their thickness and their lithologic characters so far as practicable.

The Saint Peter is included in the Lower Silurian but is partly excluded from the diagram for lack of space.

Various combinations of the words Trenton etc., (on the extreme left) and limestone etc., (on the right of the diagram) have been and are still in use in Minnesota. But such names are based mainly on lithologic character and conjecture and are scarcely more than provisional. The division between GALENA and TRENTON is indefinite. Trenton group and Galena group are synonyms. So also are Cincinnati group and Hudson River group.

In Fillmore county the Galena is surmounted by twenty, or more, feet of shales, the Maquoketa. These shales in Minnesota consist of alternating strata of shale and crystalline limestone, and are continuous with the Maquoketa of Iowa. But the fossils consist of numerous specimens of a few species of brachiopoda and bryozoa almost wholly different species from what I was able to find in the Maquoketa near Dubuque, Iowa; yet they are not forms that indicate a difference in the age of the strata exposed near Dubuque, and those exposed in Fillmore county.

Lastly there is upon the Maquoketa shales from fifty to seventy feet of limestone that is very fossiliferous—*O. subquadrata* Hall, *O. testudinaria* (three varieties, *O. whitfieldi* Winchell (*O. kankakensis* McChesney,) *Rhynchonella capax* Con., *Streptorhynchus wisconsensis* Whitf., etc. The fauna appears to belong to the Cincinnati group. But this limestone appears to be continuous with that identified in Iowa as belonging to the Niagara group, though perhaps only in part. In order to avoid confusion in subsequent work, I would propose a new name for this limestone—*Wykoff* beds—from the town near which the best exposure known occurs.

I have never seen any exposures nor any fossils of the Upper Silurian in Minnesota. The Devonian lies unconformably upon the Wykoff beds. Indeed if the Devonian limestone, as is probable, extended much further north than it now does, and in the same manner, it rested unconformably upon the Galena or even the Lower Trenton formations within thirty to fifty miles of its present northern limit. As it now lies there it is much less than fifty feet between the top of the Maquoketa shales, and the base of the Devonian at Spring Valley, while only fifteen miles further south near the boundary of Iowa and Minnesota, at least seventy-five feet of limestone intervenes.

October 6, 1891.

THE RANGE AND DISTRIBUTION OF THE LOWER SILURIAN FAUNA OF MINNESOTA WITH DESCRIPTIONS OF SOME NEW SPECIES.—

F. W. Sardeson.

My first intention was to make out a list of Palæozoic fossils found in Minnesota, with notes on their distribution and vertical range as revealed by thirty or forty exposures. But during prep-