AGE OF THE SHAWANGUNK CONGLOMERATE OF EASTERN NEW YORK.

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The Shawangunk conglomerate was named by Mather in 1840[1] from its typical exposures in the Shawangunk Mountains of southeastern New York, where its massive ledges form bold mountain ridges.

Early students of the geology of New York correlated it with the Medina sandstone of western New York, basing their correlation on the lithology and on the supposed Niagaran age of the fauna in an overlying limestone. Hartnagel later showed that the overlying limestone is Cobleskill, not Niagaran.[2]

A rich and varied Eurypterid fauna was subsequently discovered in the Shawangunk conglomerate of Otisville, New York, and described by Clarke and Ruedemann in their important monograph on the Eurypterids of New York.[3] These authors correlated the Shawangunk with the Salina of western New York, basing their views in part upon Hartnagel's work on the Cobleskill and in part upon the occurrence of Eurypterids in the Salina of western New York.[4] No species, however, are common to the two horizons.

The view of Clarke and Ruedemann has been followed in general by later workers, though with dissenting voices.

Van Ingen made the Shawangunk of Medina-Clinton-Niagaran age,[5] but unhappily did not publish his investigations. Schuchert correlated the conglomeratic phase of the Shawangunk with the Medina, basing his conclusions largely upon the occurrence in it of *Arthrophycus alleghaniensis* at Otisville, New York. He referred some of the overlying shale possibly to the Clinton.[6] Willard also regarded it as Medinan and the overlying red beds as Clinton.[7] Ulrich made

[1] Mather, W. W., New York Geol. Survey, Fourth Ann. Rept., pp. 246-255.
[2] Hartnagel, C. A., N. Y. State Museum, Bull. **69**, p. 1109 et seq., 1903.
[3] Clarke, J. M., and Ruedemann, R., N. Y. State Museum, Memoir **14**, 1912.
[4] Clarke, J. M., and Ruedemann, R., N. Y. State Museum, Bull. **107**, pp. 295 et seq., 1907.
[5] Science, June 9, 1911, p. 905. See also New York State Museum, Memoir **14**, pp. 418-419, 1912.
[6] Bull. Geol. Soc. of Amer., **27**, 531-554, 1916.
[7] Jour. Paleontology, Vol. **1**, 255-258, 1928.

the New York Shawangunk Clinton.[8] Others have, in general, made it Salinan,[9] or Cayugan.[9]

Clear evidence has, it is believed, been secured during the past summer showing that the Shawangunk is of Medinan and Clinton age. A preliminary report only of the results is made at this place, awaiting a more detailed publication elsewhere. The evidence is both palaeontologic and stratigraphic.

I. PALAEONTOLOGIC EVIDENCE.

The late Dr. Van Ingen first called attention to the intertonguing of beds holding Eurypterids and marine faunas at Swatara Gap, Pennsylvania.[10] It is evident that if the age of these marine faunas could be definitely ascertained, the horizon of the Eurypterids could be determined. This is the method used in this work.

Clarke and Ruedemann determined the Eurypterids collected by Van Ingen and published a list of them in their memoir on the Eurypterids of New York.[11] Dr. Van Ingen, unfortunately, did not describe the section studied by him at Swatara Gap, or cite the marine species found there, the horizons at which the Eurypterids were collected being designated in the memoir only by his field numbers.

The section at Swatara Gap was studied by the authors in connection with earlier investigations.[12] In the summer of 1929 they discovered ostracods and other diagnostic marine species that, they believe, fix the age of the beds containing them and permit definite correlation of these beds with formations of Maryland and western New York. The authors were permitted subsequently, by the courtesy of Dr. B. F. Howell of Princeton, to consult the field notes of Dr. Van Ingen and thus ascertain the horizons at which the Eurypterids determined by Clarke and Ruedemann were found by him at Swatara Gap. This was felt desirable since these Eurypterids were identified by the investigators who first named them in their monographic work on the Eurypterids of New York.

The authors wish to express their great indebtedness to the

[8] Maryland Geol. Surv., Silurian, p. 267, 1923.
[9] U. S. Geol. Surv. Tentative Correlation of the Named Geological Units of Pennsylvania, April 5, 1928.
[10] N. Y. State Museum, Memoir **14**, p. 418, 1912.
[11] Ibid., pp. 418-419.
[12] Bull. Geol. Soc. Amer., **35**, 104-105, 1924.

late Dr. Van Ingen whose discovery of the Eurypterids made this work possible.

The section at Swatara Gap will first be briefly described and afterwards the age of the Shawangunk Eurypterids will be considered.

Section at Swatara Gap, Pennsylvania.

Two sections are exposed at this place, one west and one east of Swatara Creek. The section first described is exposed along the state highway north of Inwood Station, west of the creek.

Martinsburg shale. The base of the section studied is the Martinsburg shale. The contact of the Martinsburg with the overlying Tuscarora is well shown on the north side of a small quarry in the shale, west of Swatara Creek. Its upper beds consist of dark clay shale, typical of the Martinsburg. They contain an abundant fauna, including *Cryptolithus recurvus* (Ulrich), *Isotelus stegops* (Green), *Triarthus becki* Green, *Calymene granulosa* (Foerste), *Plectambonites rugosus* (Meek), etc. All of these species are diagnostic of the Eden member of the Martinsburg shale. The Maysville member of the Martinsburg shale is lacking.

Tuscarora sandstone. Immediately overlying the Martinsburg shale is the Tuscarora sandstone. Its base is made of coarse conglomerate containing pebbles up to several inches in diameter, above which are massive gray sandstones characteristic of the Tuscarora. An abundant talus covers the mountain side north of the exposed sandstone.

At a stone crusher, formerly located on the road 600 to 900 feet north of the base of the Tuscarora[13] and operating in the Tuscarora talus, Dr. Van Ingen collected, in the talus, the Eurypterids listed from his locality "182c4k." The following species were identified from this horizon by Clarke and Ruedemann: *Dolichopterus* cf. *otisius, Eurypterus maria, Hughmilleria shawangunk, Pterygotus* cf. *globiceps, Stylonurus myops.*[14] The species were found in a peculiar dark arenaceous shale occurring between gray sandstone blocks and closely resembling the beds containing the same species of Eurypterids at Otisville, New York.

[13] Location given by older residents in the vicinity.
[14] N. Y. State Museum Memoir **14**, p. 419, 1912.

Associated with the Eurypterids were numerous trails of *Arthrophycus alleghaniensis* (*A. harlani,* Hall). The only materials observed by the authors in the talus were Martinsburg shale and Tuscarora sandstone. The strata dip toward the south so that no beds younger than the lower Clinton beds underlie the slopes yielding the talus. It seems impossible, therefore, to question the Tuscarora age of the Eurypterids.

The chief section at this locality is exposed along the county road leading north from the east end of the bridge over Swatara Creek. It is as follows:

Tuscarora sandstone. The basal conglomerate of the Tuscarora sandstone is seen a short distance north of the bridge over the creek. The overlying beds are largely concealed at the level of the road, but are well exposed on the hillside above the road. The thickness of the Tuscarora exposed here is about 330 feet.

Clinton formation.[15] Above the Tuscarora and beneath the Bloomsburg Red Beds are 1,080 feet of interbedded shale and argillaceous sandstone which may be divided into two members, the Rose Hill below and the Rochester above.

Rose Hill member. The shale of this division is prevailingly gray and arenaceous, though some beds are argillaceous and fissile and a few are pink. It contains in addition numerous hard brown "iron" sandstones so characteristic of the Rose Hill elsewhere. This division is 832 feet thick.[16]

The following marine fossils were collected by the authors in this division:

460 feet above the base, loose, *Camarotoechia neglecta, Dalmanella elegantula, Homoeospira* n. sp. aff. *evax.*

About 715 feet above base *Zygosella* sp. a Rose Hill type.

830 feet above base, in iron-rich sandstone, *Atrypa reticularis, Camarotoechia neglecta, Dalmanella elegantula, Homoeospira* n. sp. aff. *H. evax,* cf. *Orthis tenuidans, Whitfieldella intermedia* c, *Modiolopsis subalatus, Pterinea* n. sp., aff. *flintstonensis* but anterior wing constricted, plications finer; *Orthoceras* sp., *Cornulites* n. sp. c, cf. *Drepanellina* sp. Bryozoa indeterminate.

[15] In the Silurian monograph of the Maryland Geological Survey the Clinton group is made to include both the Rochester and the pre-Rochester Clinton, the latter division being named the Rose Hill formation. (Md. Geol. Surv., Silurian, p. 27, 1923.)

[16] The lower 500 feet are largely concealed but the talus indicates that these beds are essentially like those exposed above them.

In addition to the preceding Van Ingen collected the following Eurypterids 720 to 730 feet above the base of this member (in his "182B16h"), according to the identification of Clarke and Ruedemann: *Eurypterus maria, Hughmilleria shawangunk, Pterygotus globiceps, Stylonurus* cf. *myops.*[17]

Rochester member. The overlying beds consist largely of gray sandstones and some arenaceous shale. The authors collected the following fossils in them:

847 feet above base, *Camarotoechia neglecta* a, *Dalmanella elegantula, Pterinea emacerata* c, *Posidonomya rhomboidea.*

955 feet above base *Camarotoechia neglecta* ?, *Whitfieldella marylandica* c, *Goniophora speciosa, Liopteria* n. sp., *Liopteria subplana,* small var. a, *Pyrenomoeus* n. sp. aa, and the ostracoda: *Beyrichia veronica* a, *Dizygopleura pricei* c, *Drepanellina ventralis* a, *Paraechmina* cf. *postica.*

970 to 1,060 feet above base Van Ingen also collected (in his "182B23"), according to the identification of Clarke and Ruedemann,[18] *Eurypterus maria.*

Correlation. The marine species found in the above named beds show clearly that they are Rose Hill and Rochester respectively. But three of the formerly described species occurring in them (including *Atrypa reticularis*) are known to range above the Rochester, the remainder being restricted to the Rochester or older beds. All of the formerly described species are found in the Rose Hill and Rochester of Maryland and Pennsylvania, save *Goniophora speciosa* which occurs in the Waldron of Indiana.

Rose Hill faunas. The species found loose at 460 feet above the base, while not diagnostic, are common in the Rose Hill.[19]

The fauna at 830 feet is either uppermost Rose Hill or basal Rochester. *Whitfieldella intermedia* which occurs there is found immediately below the Keefer sandstone at Mount Union, Pennsylvania. It is also a characteristic species of the Irondequoit, occurring just below the Rochester in New York. *Atrypa reticularis* is also abundant at a similar horizon at Danville, Pennsylvania, the nearest locality to this point at

[17] N. Y. State Museum Memoir 14, pp. 418-419, 1912. The individuals are described as "closely related to or identical with the species named."

[18] Ibid., p. 419.

[19] Van Ingen reports in his notes, 400 to 500 feet above base, loose, *Liocalymmene clintoni,* a highly characteristic species of the Rose Hill and lower Rochester to which it is restricted.

which these beds are richly fossiliferous. *Modiolopsis subalatus* is of the Rochester type.

Rochester faunas. The marine species above the foregoing are all Rochester forms. The fauna at 847 feet is not critical but at 854 feet occur *Rhipidomella hybrida* and *Pterinea emacerata,* both of which are restricted to the Rochester fauna.

The fauna found 955 feet above the base of the Clinton is very significant. Ostracods were shown by Ulrich to be among the most diagnostic forms for the correlation of the Silurian of the Appalachian province because of the sharp restriction of the species, in many cases, to limited zones. Among the best characterized is the zone of *Drepanellina ventralis.* This zone, found at the top of the Rochester, is distinguished by containing a great profusion of the brachiopod *Whitfieldella marylandica,* if the sediments are limy, associated with numerous *Drepanellina ventralis, Beyrichia veronica,* and other ostracods. These species are found at this horizon at points as remote as Rose Hill, Maryland; Loysville and Danville, Pennsylvania; the latter two localities being the nearest places where these strata are richly fossiliferous.

These species are found here 955 feet above the base of the Clinton. In addition to *Whitfieldella marylandica* and *Drepanellina ventralis* it contains also *Liopteria subplana,* small variety, and three species of ostracoda: *Beyrichia veronica, Dizygoplura pricei,* and *Paraechmina* cf. *postica,* all of which are restricted to the Rochester. The diagnostic character of this zone and the presence of other Rochester species beneath it establishes its Rochester age.

One hundred and twenty-five feet of gray sandstone and some shale lie above the beds last described but are without marine faunas. This unit may be McKenzie, which holds a similar position westward, or Rochester. Its age is undetermined. Van Ingen reports *Eurypterus maria* in it.[20]

Bloomsburg red beds. Red sandstones and shales, 1,586 feet thick, by measurement, lie above the last named beds. The lower 35 feet contain interbedded red and greenish-gray sandstone and are partially concealed. *Leperditia* sp. is very abundant 342 feet above base of this unit.

Age of the Shawangunk Eurypterids.

Van Ingen collected numerous Eurypterids at two horizons in the above described section, one in the Tuscarora and the

[20] Ibid., p. 419.

second in the Rose Hill, 721 to 732 feet above the base of the Clinton, as measured. In the Tuscarora Clarke and Ruedemann identified the following species: *Dolichopterus* cf. *otisius, Eurypterus maria, Hughmilleria shawangunk, Pterygotus* cf. *globiceps, Stylonurus* cf. *myops.* In the Clinton they identified *Eurypterus maria, Hughmilleria shawangunk, Pterygotus globiceps, Stylonurus* cf. *myops.*[21] All these species are characteristic Shawangunk forms and are represented by carapaces. Those in the Tuscarora are in materials similar in lithology to the beds containing the same species at Otisville, New York.

Their relations establish their early Silurian age. Those in the Clinton are found far below the *Drepanellina ventralis* zone of the upper Rochester fauna. Those in the Tuscarora are beneath the Clinton. The marine faunas show that none can be as late as the Salina.

The same species of Eurypterids, embracing all the species common at Otisville, New York, are found in the corresponding beds at the Delaware Water Gap, according to the identifications of Clarke and Ruedemann.[22] The species were collected by Van Ingen.

It would seem inevitable to conclude that the Shawangunk is early Silurian[23] unless the Eurypterids are without significance for correlation.

II. STRATIGRAPHIC EVIDENCE.

The senior author read a paper before the Geological Society of America in 1923[24] in which he showed that the Tuscarora sandstone of Maryland can be traced continuously from Maryland eastward to the Delaware Water Gap in Pennsylvania, where it merges with the lower beds of the Shawangunk conglomerate exposed there. That the latter is the Shawangunk has long been recognized by the New Jersey State Geologists.[25] It bears the same fauna, is continuous with the Shawangunk of eastern New York, and is like it in lithology and stratigraphic position.

[21] Ibid., pp. 418-419. While the identifications are not in all cases without question they are, according to Clarke and Ruedemann, "identical or closely related species."

[22] New York State Museum, Memoir **14**, pp. 87-88, 418, 1812. The species are described as "identical or very closely related to the forms named."

[23] Van Ingen was evidently also led to the same conclusion though unhappily he did not publish the data upon which he based his results.

[24] Bull. Geol. Soc. Amer., **35**, 104-105, 1924.

[25] Weller, S., N. J. Geol. Survey, Paleontology, **3**, 54, 1903.

It was also shown that the Bloomsburg red beds, lying above the Clinton, can be traced eastward to merge with the High Falls red beds above the Shawangunk.

The relations of the Clinton were not clear when the former paper was presented. The Clinton was traced east, above the Tuscarora, to Lehigh Gap, but east of the latter point rapid changes in lithology obscured the section. Since that time the authors have traced the Clinton eastward to the Delaware Water Gap and find that it merges with the upper part of the Shawangunk at the latter place, in conformity with the palaeontologic evidence described above. The full presentation of the stratigraphic evidence must be given elsewhere.

Both palaeontologic and stratigraphic evidence concur in making the Shawangunk conglomerate of early Silurian age, representing the Medina and Clinton of Maryland and western New York. Its relations to the McKenzie are unknown.

The Shawangunk was manifestly referred to the Salina upon insecure evidence. The presence in it and in the Salina of Eurypterids, none of which are of the same species, is manifestly not sufficient to establish their correlation, especially as against the occurrence of identical species in the Shawangunk at Otisville, New York, and in the Tuscarora and Clinton of eastern Pennsylvania discussed above.

CONCLUSIONS.

The foregoing discussion leads to the following conclusions:

1. The Shawangunk fauna of Otisville, New York, is present in the section at Swatara Gap, Pennsylvania.

2. This fauna is found beneath the top of the Rochester, both occurring in the Tuscarora and intertonguing with clearly defined Clinton at Swatara Gap.

3. The Tuscarora and Clinton beds that contain this fauna can be traced eastward to merge with the Shawangunk conglomerate at the Delaware Water Gap and thence, uninterruptedly, to Otisville, New York, all the species common in the Shawangunk of Otisville being found also in the beds at Swatara Gap and Delaware Water Gap.

4. The Shawangunk conglomerate is, hence, early Silurian and essentially of Tuscarora and Clinton age.

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