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New York State Museum Bulletin

Published by The University of the State of New York

No. 327

ALBANY, N. Y.

April 1942

NEW YORK STATE MUSEUM
CHARLES C. ADAMS, *Director*

PALEONTOLOGY AND GEOLOGY

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OLDHAMIA AND THE RENSSELAER GRIT PROBLEM¹

BY RUDOLF RUEDEMANN PH.D.

Former State Paleontologist, New York State Museum

INTRODUCTION

The purpose of this paper is a double one, first to discuss the supposed occurrence of *Oldhamia* in the Rensselaer grit and second to elaborate on the nature of *Oldhamia*.

The writer in a previous paper (1929) described specimens of *Oldhamia occidentis* (Walcott) that were thought to indicate by their articulated structure, the dichotomous branching, the club-shaped appendages, representing possible sexual conceptacles and the mode of preservation (casts of substantial bodies), their probable (coralline) algal nature [see figure 2 (1 and 2)]. These and Walcott's types all came from the Nassau beds, our basal division of the Lower Cambrian.

Oldhamia occidentis as a Lower Cambrian index fossil has recently received some notice through the paper by Henry Vaughan and T. Yates Wilson (1934). In this article, the authors note the occurrence of specimens of supposed *Oldhamia* cf. *occidentis* (Walcott) in three localities in the Brainard-Old Chatham outlier of Rensselaer graywacke, situated south of the main body. Because of the diversity of views that exists as to the age of the Rensselaer grit, this discovery of "*Oldhamia*" was of considerable importance. As is known, the author ('30) has claimed a Devonian age for the Rensselaer grit while Prindle and Knopf (1932) would assign it Lower Cambrian age. In the absence of any fossils the problem has thus far been one of purely tectonic and lithologic conclusions. The finding of "*Oldhamia*" in the outlier has therefore considerable significance and invites close scrutiny of the fossils. A recent visit to the exposure at Old Chatham in company with Professors C. E. Decker, B. F. Howell and E. S. C. Smith, the last two of whom have been collecting and studying *Oldhamias* of New York and Maine for some time, has afforded new evidence. A gratifying result of the combined search has been a collection of splendid specimens in all forms of preservation. Unfortunately the first material

¹ This and the following papers were submitted April 12, 1938.

obtained by Vaughan and Wilson was not so representative and the writer declared it to be "*Oldhamia*" rather carelessly.

DESCRIPTION OF CHATHAM MATERIAL

New material obtained leaves no doubt that the so-called *Oldhamia* of the Old Chatham outlier is not the *Oldhamia occidens* of the Nassau beds, nor an *Oldhamia* at all if the genus is restricted to organic remains and if those species or occurrences that are merely minute wrinkles due to pressure and slipping of the shale are excluded.

The "*Oldhamia*" of the Rensselaer grit occurs only in red shale, intercalated between beds of heavy grit. Such shale beds are always much affected by slickensides and minute wrinkles due to the slipping of the shale which acts as a lubricating horizon between the heavier beds. The red shale shows on nearly all surfaces a system of very straight, strictly parallel, fine wrinkles, running in the same direction in overlying layers and seen on cracks to enter into the rock structure for one-eighth of an inch. These wrinkles are rarely symmetric, but mostly overturned to one side. They show various grades of distinctness and in some places fade into flat, wavy and overlapping irregularities of the surface. In other places two systems of such wrinkles intersect, producing a wavy system [see figure 1 (6)]. There are variations in size, in a few places leading up to very coarse folds, several millimeters wide and one or two high [see figure 1 (1)] that are superimposed on the delicate wrinkles. All these facts leave no doubt that this system of wrinkles and folds is the result of slipping of the shale under compression.

Similar very fine parallel rippling between numerous small slip faults was observed by the writer in the Bomoseen grit overlying the great Logan's fault in the Bald Mountain quarry in Washington county (see Bul. 169, pl. 16).

All these finely wrinkled areas of the red shale show a singularly smooth, shiny or oily surface such as is seen on slickensides or other flowage and slip planes. In short the entire system of wrinkles on closer inspection leaves "no doubt that it is the result of lateral pressure and flowage of the shale."

The parallel lines now show along cracks that are more or less perpendicular to the system of fine wrinkles, bundles of such wrinkles radiating in both directions [see figure 2 (3, 4)] sometimes almost forming a circle, from the crack. These bundles clearly

recall the bundles of fine cracks sometimes forming at pressure points along the edges of glass plates. It is these bundles of wrinkles that imitate *Oldhamia*. Farther away from the crack the wrinkles pass again into parallelism, and where small slanting cleavage cracks are seen the fine wrinkles pass over them at a different angle than on the main bedding plane [see figure 2 (3)]. The wrinkles were therefore formed after the cleavage and other cracks were formed or in a late stage of the tectonic molding of the rocks and they are much younger than the Rensselaer grit sediment.

In some cases, as the one reproduced on figure 1 (7) the pressure wrinkles assume the character of minute mountain folds. They arrange themselves in virgation (on right), intersect in systems with raised intersection nodes (on lower right), abut against each other in parallel systems (lower left) and increase by intercalation and branching; repeating on a small scale the folding of the earth in such diagrammatic clearness that it would have pleased the heart of Edward Suess.

OLDHAMIA OCCIDENS OF NASSAU BEDS AND THE CHATHAM FORM COMPARED

The Chatham form is entirely different from the true *Oldhamia*, as represented by *O. occidens* (Walcott) and *O. antiqua* Forbes. In *O. occidens* as described by Walcott and Ruedemann from the Nassau shale and quartzite the bundles or whorls of filaments (or their impressions) are not lined up along cracks, opposing each other but follow one another in tandem-series. The filaments or their impressions are distinctly symmetric and evenly rounded and not sharply angular or evenly keeled as those of the supposed Rensselaer grit *Oldhamia*. Another significant difference is that the branching of the true *Oldhamias* (*O. occidens* and *O. antiqua*) is strictly dichotomous while in the structures simulating *Oldhamia* new wrinkles appear mostly by intercalation.

While the Rensselaer grit "*Oldhamias*" are found lined up along cracks and the whole surface of the shale is covered with fine parallel lines, the *O. occidens* of the Nassau shale and quartzite is found in more or less orderly arrangement in series on otherwise smooth surfaces [see figure 2 (1); figure 3 (4)].

RESULT OF COMPARISON FOR CORRELATION OF RENSSELAER GRIT

It is therefore apparent that the *Oldhamia occidens* of the Nassau beds and the supposed *Oldhamia* of the Rensselaer grit are of en-

tirely different nature and origin and the Rensselaer grit "*Oldhamia*" can not be used for correlation of the Rensselaer grit with the Nassau beds or any other Cambrian formation.

REVISION OF OLDHAMIA

In the light of the criterions here brought forward it may be of interest to survey briefly in this connection the other remains that have been ascribed to *Oldhamia* and used more or less for correlation of Cambrian formations.

We have before us topotypes of the Irish species *Oldhamia antiqua* Forbes, figure 3 (1), and *O. radiata* Forbes, figure 3 (2), kindly sent us by Doctor Resser who also furnished us photographs, topotypes and casts of the type of *O. occidentis* (Walcott), figure 3 (4). We also have received from Professor Howell specimens of "*Oldhamia antiqua*" from the Weymouth formation of Weymouth, Mass., figure 1 (2), and from Professor E. S. C. Smith fine examples of the "*Oldhamia* cf. *occidentis*"¹ described by him from Penobscot county, Maine (1928), figure 1 (3).

A comparison of all these forms leaves no doubt that they are all of the same origin, whatever that may be. In a former paper (1929) we have followed Walcott in describing *O. occidentis* as a coralline alga from its general outline and distinct preservation suggesting a substantial original organism. The total lack of traces of organic matter in all *Oldhamias* is distinctly hostile to this conclusion and has led British authors (Sollas and Seward) to deny the organic origin of *O. antiqua* and *O. radiata*.

¹As the form from Penobscot, Maine, is distinctive in its characters from both *O. antiqua* and *O. occidentis* it is preferable to distinguish it by a separate name, for which we propose

Oldhamia smithi sp. nov. figure 1 (3, 5); figure 3 (5)

It is characterized by fan-shaped trails connected by a continuous tube, the trails frequently bifurcating, rounded, somewhat undulating or filamentous. The fans are 8 to 15 mm long and become 14 mm wide. The feeding trails or ribs of the fans number 10 to 16 and are 0 to .4 mm wide. The trails show distinct constrictions and end in round knobs.

From *O. occidentis*, the nearest form, it is distinguished by its thinner and longer and more numerous ribs or branches of the fanlike trails, from the similar *O. antiqua* by the longer and less crowded ribs.

Locality and horizon. Red (Cambrian) slate along the east branch of the Penobscot river (township 8, Penobscot county, Maine, E. S. C. Smith collector).

RELATION OF OLDHAMIA TO WORM-TRAILS

Fortunately the fundamental work of R. Richter on the recent and fossil trails of worms (1927) furnishes us conclusive criterions that permit the reference of the *Oldhamias* to worm-trails.

While the Rensselaer grit "*Oldhamias*" are definitely excluded from consideration of possibly being worm-trails or tracks by their obviously mechanical origin the others are similar in many features to recent and fossil worm-trails formed by the feeding of the animals either on the richly organic surface layer of the bottom sediment or within that sediment. Richter (1927, p. 198, figs. 2a-d) figures radiating and bifurcating groups of recent feeding trails on the bottom of the "Watten" (tide zone) of the North sea that are very similar in general aspect to *Oldhamia antiqua* and *occidens* but form circular instead of semicircular radiating groups, that is such as *Oldhamia radiata* has. The worm may feed off a circular area by radiating advances from a central burrow or hiding place or may form long furrows from which he produces groups of radiating feeding trails at random. These various trails have misled many early authors and have been described as a variety of fossils. H. Weyland and E. Buddle (1932) have recently described such radiating trails, strongly simulating algae, from the Middle Devonian of Elberfeld, Germany. Some of these radiating trails (see *ibid.* figs. 4 and 5, p. 261) are arranged in successive stories from a vertical central tube. Richter especially states (p. 199) that the feeding trails proceeding from the longer superficial furrow may be complete with starlike shape or incomplete.

A comparison of the *Oldhamias* with these feeding trails, both recent and fossil (*Chondrites*), surficial and subterranean, leads to the conclusion that *Oldhamia antiqua*, *O. occidens* and the Maine form are feeding trails of horizontally moving worms, those of *O. radiata* are the trails of worms with vertical burrows.

We figure here, figure 3 (1), a topotype of *O. antiqua* from Bray Head, Ireland, showing well the tandem-series of flabellate feeding trails, arranged somewhat in zig-zag fashion and connected by the central trail of the advancing worm. The somewhat nodular ends of the trails are clearly seen. *Oldhamia occidens* and *O. smithi* are of the same pattern. Figure 3 (4) is a photograph of Walcott's type. This clearly exhibits again the central tube or furrow and the fanlike feeding trails. Figure 2 (1 and 2) are photographs of the *O. occidens* described in a former paper by the author from the

Nassau beds at Nassau lake. They also show the central trail and the diverging, rather coarse feeding trails. Figures 1 (3) and 3 (5) represent *O. smithi*. Figure 1 (3) shows the general character of the fanlike trails; figure 3 (5) shows a typical fan with the basal tube coming out of the rock. The basal or connecting tube of *O. occidentis* is still more distinctly shown in figure 1 (4) where a central mudfilling of the tube is preserved. This form was clearly of the burrowing kind. However, figure 1 (5) shows also feeding trails of *O. occidentis* on ripple marks. Numbers 2 and 3 of figure 3 picture topotypes of *Oldhamia radiata* from County Wicklow, Ireland. It leaves no doubt that this form was living in vertical burrows from which it fed in radiating trails. The central burrows are clearly seen in the centers of the starlike fossils; one is especially well shown in the smaller figure (3) along the lower margin. There can be but little question that all these forms are the feeding trails of animals. Also the *Oldhamia howclaquei*, described and beautifully figured with photograph by Barrois in 1888 from Paleozoic rocks of the Pyrenees, is in our view one of the forms with characteristic flabellate groups of tubes, these groups proceeding from long burrows. It has the features of the group of burrows assigned by Richter to *Chondrites*.

A feature which would seem to argue against a reference of these fossils to worm-trails is the fact that they overlap freely, while as Richter has well shown the feeding trails never cross each other. This careful avoidance of crossing of the feeding trails by worms is a most characteristic feature (Richter, p. 201) comparable to the care with which the wood-boring mollusks (*Teredo*) and beetles avoid entering or penetrating other burrows, thereby producing neat complete patterns. The worms according to Richter are guided in this by the stimulus-reaction of a phobotaxis.

As Richter has shown (op. cit. p. 218), these many-branched "*Chondrites*" from the Flysch and Jurassic rocks of Europe originally described as algae take their origin in worm borings that markedly show the phobotactic sensitivity of the animals in avoiding contact and thereby producing wonderful mosaic patterns.

A glance at the photographs of *Oldhamia antiqua*, *O. radiata* and *O. smithi* would suggest that these animals did not avoid each other as the phobotaxis of the worms forces them to do. A closer study of the relations of the trails or borings indicates, however, that they belong to different thin sheets of sediment that have been compressed together until the burrows appear to coincide and cross. The

figures of the fossil "*Chondrites*" often exhibit the same secondary displacement and resulting overlapping.

We have here referred all the *Oldhamia* trails without qualification to worms. It is, however, necessary to take notice of the fact that similar trails are today produced on the sea bottom by various animals (see Häntzschel, 1935), among them shellfish, crustaceans and even a little fish; the worms, however, prevailing strongly as the authors of the trails. Considering the Cambrian age of the *Oldhamia* trails the assumption that worms must have produced the trails is unavoidable, only the crustaceans being available as improbable alternatives.

It is further a most astonishing fact (see Häntzschel, 1935) that ice crystals on the moist muddy bottoms of the North seacoast produce strikingly similar flabellate-like groups of impressions when melted out.

The presence of connecting tubes and the knoblike terminations would seem to serve to rule out the probability of the origin of the markings from ice crystals; the possibility of such an unorganic cause must, however, be considered.

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Explanation of Figures

Figure 1

- 1 "*Oldhamia occident* (Walcott)" Vaughan and Wilson. Natural size. Rensselaer grit. Old Chatham, Columbia county, N. Y. C. E. Decker coll. Shows the coarsest form of the wrinkling, proceeding from cracks. Transitions are found between these and the smallest wrinkles (no. 7).
- 2 "*Oldhamia (Murchisonites) antiqua* (Forbes)" Howell, x2. Lower Cambrian Weymouth formation at Weymouth, Mass. B. F. Howell coll.
- 3 "*Oldhamia (Murchisonites)* cf. *occident* (Walcott)" Smith=*Oldhamia smithi* sp. nov. Holotype, x2. Cambrian shale. East branch of Penobscot river, township 5, range 8, Penobscot county, Maine. E. S. C. Smith coll.
- 4 *Oldhamia occident* (Walcott). Topotype, x2. Lower Cambrian Nassau quartzite and shale. Poestenkill gorge near Troy, N. Y. C. D. Walcott coll. This specimen shows the filling of the worm burrow or tube, leading to the flabellate group of feeding burrows.
- 5 *Oldhamia occident* (Walcott). Rensselaer county, N. Y. Feeding trails on ripple marks. R. Ruedemann coll.
- 6 Intersecting systems of pressure wrinkles on "*Oldhamia*" slabs, x2. Rensselaer grit. Old Chatham, Columbia county, N. Y. R. Ruedemann coll.
- 7 "*Oldhamia occident* (Walcott)" Vaughan and Wilson, x2. Rensselaer grit at Old Chatham, Columbia county, N. Y. T. Y. Wilson coll. This photograph shows the arrangement of the pressure wrinkles in virgation (on right), intersection of two systems of wrinkles with raised intersection knobs (on lower right), abutment of parallel system of wrinkles against each other (lower left) and intercalation of wrinkles (upper right) and intercalation and branching of wrinkles (on upper left). The originals of this plate are in the N. Y. State Museum with the exception of that of no. 4, which is in the U. S. National Museum, no. 33669.

Figure 2

- 1 "*Oldhamia occident* (Walcott)" Ruedemann. Photograph of Ruedemann's original (text—figure 2), shows a succession of four whorls with cuplike bases arranged in tandem, x2. Lower Cambrian Nassau quartzite at Nassau, N. Y. R. Ruedemann coll.
- 2 Two whorls of "*Oldhamia occident* (Walcott)" Ruedemann, one, the larger in middle with basal stem, other, smaller on top with basal stem overlying the larger specimen, x2. Lower Cambrian Nassau quartzite at Nassau, N. Y. R. Ruedemann coll.
- 3 and 4 "*Oldhamia occident* (Walcott)" Vaughan and Wilson. From the Rensselaer grit at Old Chatham, N. Y., x2. C. E. Decker coll. Both photos show semi-circular opposite groups of wrinkles proceeding from cleavage cracks. No. 3 shows also the wrinkles proceeding across a crack, and both photographs show in the upper part the "*Oldhamia*" wrinkles merging into fine general wrinkling of the bedding plane. Originals in the New York State Museum.

Figure 3

- 1 *Oldhamia antiqua* Forbes. Topotype, x2. Lower Cambrian slate. Bray Head, Ireland.
- 2 and 3 *Oldhamia radiata* Forbes. Topotype, x2. County Wicklow, Ireland. U. S. Nat. Mus. no. 25003.
- 4 *Oldhamia occident* (Walcott). Holotype, x2. Lower Cambrian Nassau quartzite. Poestenkill gorge at Troy.
- 5 *Oldhamia smithi* nov. Paratype, x2. Specimen showing a finely developed fan of feeding trails proceeding from a basal track. Cambrian quartzite and shale. Penobscot river, Maine, E. S. C. Smith coll.

The originals of numbers 1 to 4 are in the U. S. National Museum, that of number 5 in the New York State Museum.

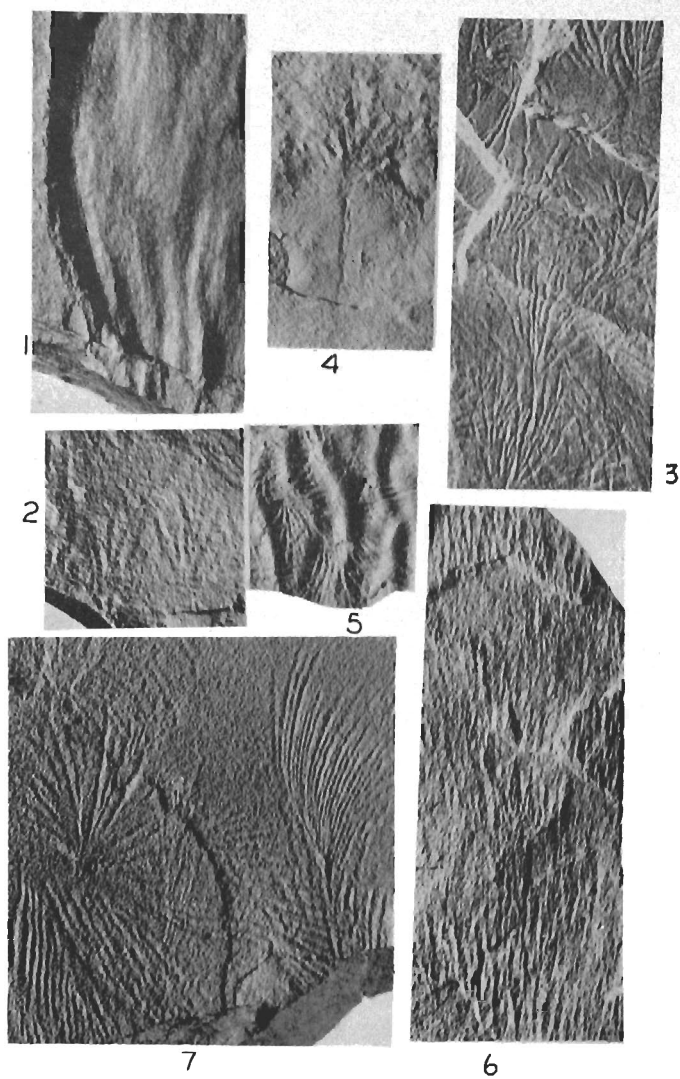


Figure 1

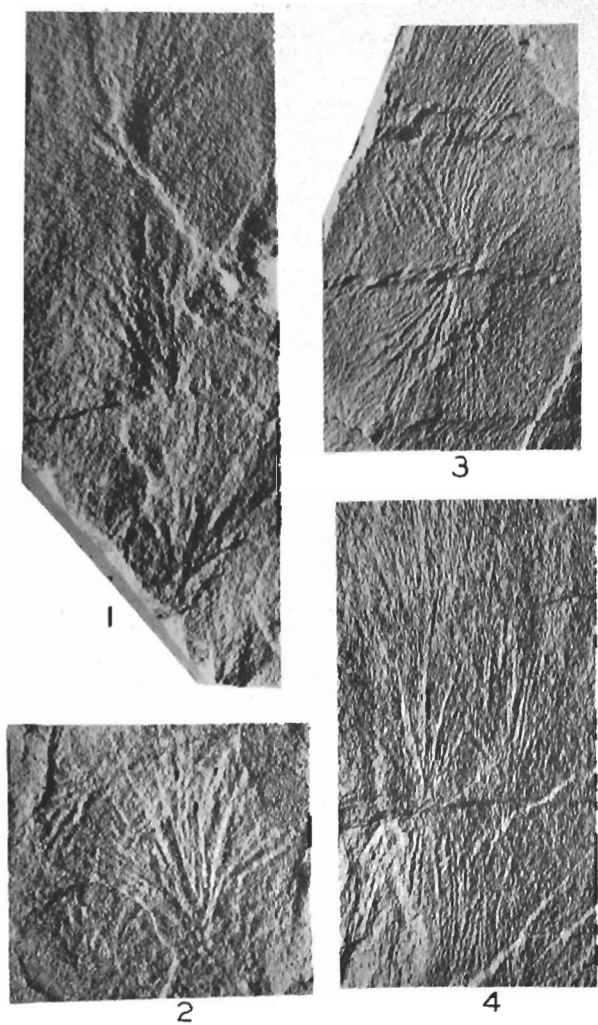


Figure 2

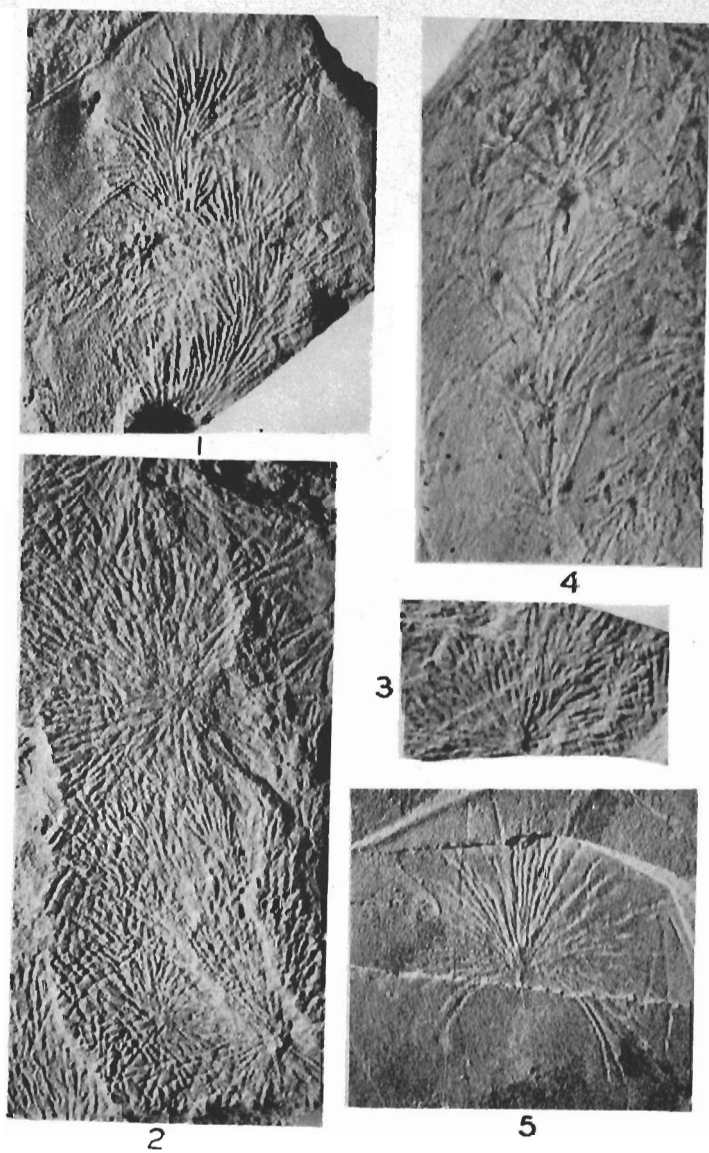


Figure 3

CAMBRIAN AND ORDOVICIAN FOSSILS

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AN ORDOVICIAN OLDHAMIA, *Oldhamia keithi* sp. nov.

Figure 5 (1, 2)

In the preceding article *Oldhamia* with its various species is described as formed by the radiating feeding trails of an unknown animal, supposedly a worm. The different species of *Oldhamia* have hitherto been found only in Lower Cambrian beds and the genus has therefore been considered as a guide-fossil of the Lower Cambrian. When the *Oldhamia* trails were recognized as feeding trails of animals, it became *a priori* probable that they would also be found in later formations. We wish here to describe a typical trail [figure 5 (1, 2)] of this kind from Ordovician rocks that was last summer collected by Dr Arthur Keith with graptolites on the north shore of the Gaspé peninsula.

Description. Vertical circular tube about 3 mm in diameter, piercing a shale stratum, 10 mm thick. Upon the upper and lower bedding planes appear radiating groups of dark straight club to wedge-shaped feeding trails extending about 14 mm from the central tube (some of the shorter trails in the photograph were later traced farther out). The feeding trails are black to dark brown in color upon a black to dark gray rock, weathered whitish on the bedding plane; nearly flat and without visible structure. There are 10 well-separated feeding trails on the upper bedding plane and at least 18, a number of them overlapping, on the lower bedding plane. The edges of the feeding trails are remarkably straight, where well-preserved and diverging more or less outward. The outer edge is more or less jagged. The wall of the inner tube is not very distinct and the material of the tube weathering whitish as the surrounding matrix.

Horizon and locality. Ordovician graptolite shale at Méchins Point

Collector. Dr Arthur Keith, 1937

Remarks. The most interesting feature of this single specimen of *Oldhamia* is the distinct appearance of the feeding trail on both the upper and lower bedding planes of the stratum, leaving no doubt that the animal which inhabited the tube was in the habit of feeding by radiating advances upon the new layers of mud that formed around it. The stratum with a thickness of 10 mm consists of a lower lighter gray varve, 6 mm thick, with a distinct black seam not more than .1 mm thick and 1 mm below the top. The upper varve is dark gray, almost black in color but weathers whitish. The mud rock is slightly calcareous, hence the whitish weathering.

It is an intriguing question whether this interesting specimen could not be used to obtain an approximate estimate of the rate of deposition of the fine-grained mud shale in two distinct layers. It is safe to assume that the tube was formed during the lifetime of a single individual, according to Dr Dayton Stoner, State Zoologist, State Museum, in not more than a year, if the animal was a worm. As the tube is clearly only a fraction of a much longer tube, this occurrence would indicate a fairly rapid deposition of the fine mud and, as the sharp boundary between the dark and light shale indicates, a deposition interrupted by intervals of nondeposition and by abrupt changes in composition of the detritus. It thus appears that this graptolite shale was deposited by sudden temporary short incursions of fine mud with probably longer intervals of nondeposition.

A CAMBRIAN ALGA, *Schodackia* gen. nov.

This trivial name is here proposed for a group of very simple and very old fossils that give little indication of their true nature, being nothing but smooth oval carbonaceous bodies connected when in their original position by thin filaments. In the genotype these bodies have been found in a biserial arrangement, in another species in apparent spiral arrangement.

The genotype was found in black slate of Lower Cambrian age (Schodack slate), the other species in Ordovician graptolite shale.

The nature of the fossils is very uncertain. We have here placed them with the algae, an assignment that can not be proved and is merely based on the habitus.

While the thallus lobes of *S. biserialis* are retained as carbonaceous film, distinctly weaker or thinner than those of graptolites, those of *S. novae terrae* possess a stout glossy test, which is even much stronger than that of the near-by graptolites and distinctly points to an originally thick periderm such as would hardly be found in such small seaweeds and is rather suggestive of egg cases of some unknown animal. One might in this connection think of eurypterids, as these merostomes are often found associated with graptolites, either by original habitat or by secondary *post mortem* drift, as some believe.

It may be mentioned here that similar, though usually larger circular carbonaceous bodies of the Upper Silurian or Lower Devonian (the Downtonian series of the Ludlow district) of Britain, *Parka decipiens* Fleming, were originally described as eggs of merostomes but later (see Seward, 1931, p. 120) have been recognized as groups of spores embedded in a thin carbonaceous layer. It is thought that these were early primitive reproductive cells fitted for dispersal in air rather than in water by the resistant nature of the spore wall. The much older age of species of *Schodackia* and their occurrence in distinctly marine beds is not favorable to the assumption of a similar function but the occurrence in the late Silurian of such very primitive algae, composed of groups of spores contained in a single globular spore case makes it proper to assume the presence of similar very primitive marine algae in the Cambrian and Ordovician seas.

Schodackia biserialis sp. nov.

Figure 5 (3-7)

Description. Thallus consisting of a filamentous thallus axis and biserial suboval thallus lobes, attached to short filamentous bases

The holotype shows eight thallus lobes, four on either side of the very thin thallus axis. It is 12 to 13 mm long; the thallus lobes are 4 to 5.5 mm long and 3 mm wide. Most of the latter are oval to elliptical, some are bluntly pointed at the distal extremity and rounded or slightly emarginate at the proximal end. Some show a flat disk at the distal end, suggesting a compressed air bladder. The lobes are carbonaceous films, showing neither structure nor sculpturing.

Horizon and locality. Schodack shaly limestone at Hudson Cemetery extension, at north end of Becraft mountain, R. Ruedemann and T. Y. Wilson collectors, 1934

Remarks. This fossil was already observed by the writer nearly 40 years ago in the black Lower Cambrian calcareous slate at the Mattawee river in Washington county, N. Y., but no clue to its nature obtained, as only the detached thallus lobes were found scattered on the bedding planes. Also at the Becraft mountain locality the surface of the shale shows mostly only numerous small scattered oval carbonaceous bodies, the thallus lobes. Only the finding of more complete specimens such as the holotype gave a clue to the probable nature of the organism.

As no organs of reproduction, sexual or asexual, could be clearly observed and only the habitus of the seaweed is available, it would be futile to attempt a classification of the form. All that could be said, is that it reminds in its filamentous axis and separate thallus lobes of some brown algae (Phaeophyceae) such as the recent gigantic *Macrocystis*, or perhaps of Chlorophyceae like *Caulerpa* that has a creeping thallus axis with rhizoids, and from which rise separate thallus leaves as in *Schodackia*.

Schodackia novae terrae sp. nov.

Figure 6 (4-7)

Description. Thallus consisting of suboval thallus lobes arranged spirally around a filamentous thallus axis

The holotype consists of four thallus lobes that are arranged radially at four different levels in the rock around a central axis. The filamentous thallus axis is not preserved but the position of the lobes leaves little doubt of the former arrangement of the lobes. The group of lobes is about 11 mm in diameter, the lobes are 6 mm long and attain a width of 5 mm. Detached lobes show a distinctly oval outline with one rounded or strongly emarginate extremity and a more or less pointed opposite distal extremity. The carbonaceous films are strong, glossy and smooth, lacking all sculpture.

Horizon and locality. Black shale of Normanskill age from Rowsell Island, Heyl collection A-162, Newfoundland. Types in collection of Newfoundland Geological Survey

Remarks. The fossils here described are associated with graptolites in black shale. While they agree in general outline and to some degree in arrangement with the genotype, they differ in a much stronger, glossy test.

AN EPIPLANKTONIC SPONGE, *Teganium merino* sp. nov.

Figure 5 (10)

Description. Sponge broadly conical, small, approximately three-fourths as wide as long (holotype 10 mm long and 7 mm wide), rapidly expanding from base to middle, then contracting moderately and expanding again towards osculum. The latter relatively small, about 3 mm wide, surrounded by a very broad rim. Paragaster and ostia not observed. Only traces of thin straight spicules (dermalia)

Horizon and locality. Ordovician. Lower Normanskill shale (Mount Merino member) at Mount Merino quarry. C. Kilfoyle coll. 1937

Remarks. The only warrant for describing this small sponge is its occurrence in the graptolite shale. It is the first found in the Normanskill shale and was undoubtedly a member of the epiplankton that is found associated with the graptolites. It differs from *T. minutum* Rued. from the Snake Hill shale by its broader form, broader margin and relatively smaller osculum.

A NORMANSKILL MEDUSAEGRAPTUS (?), *M. (?) wilsoni* sp. nov.

Figure 5 (8, 9)

Recent field work has afforded the writer material from the Ordovician Normanskill shale that apparently represents a type hitherto only observed in the Silurian.

Description. The fossil consists of a more or less cylindrical body composed of successive whorls of thick short fibers, the whorls closely arranged in cup-in-cup fashion. Where the fibers are crowded they are subparallel, where more loosely spaced they are diverging. They all possess a thick carbonaceous film indicating an original substantial structure and the latter is further attested by the presence of numerous impressions of *Spirorbis* shells visible only under the microscope. The whole body seems to be divided into two groups of filaments that face in opposite direction and suggest an original dichotomy of the rhabdosome.

The whole fossil measures 58 mm in length and 8 mm in greatest width. The fibers numbering up to 20 or more in each whorl attain about 8 mm in length and are .5 to 1.5 mm wide, averaging fairly uniformly 1 mm in width. They were apparently of cylindrical form

originally and possess well-rounded distal extremities, many of which show small circular apertures (.4-.8 mm wide). The test lacks traces of sculpturing.

Horizon and locality. Normanskill shale (Mount Merino member). Stuyvesant Falls, Columbia county, N. Y., 600-700 feet below falls. T. Y. Wilson and H. Dill coll. 1934

Remarks. This fossil is difficult to place. While suggesting a seaweed in its habit, the strong substantial tubes composing it and the presence of apertures at the distal extremities indicate its nature of a colonial stock. Its occurrence in the Normanskill (Mount Merino) beds will then at once suggest a graptolite. It is, however, to be noted in this connection that the fossils do not occur in the black graptolite shales, but in the otherwise entirely barren (save worm tubes) greenish gray shales.

If a graptolite, it is comparable to the Silurian *Aledusacgraptus* (Ruedemann, 1925), the species of which possess rhabdosomes that consist of simple stipes covered with crowded unbranched filaments, probably the thecae.

SOME NEW ORDOVICIAN EURYPTERIDS FROM NEW YORK

The eurypterids became first known from the Silurian and Devonian of both America and Europe. The first indication of their presence in the Ordovician was given by Walcott in 1882, when he described as *Echinognathus clevelandi* the robust walking leg and a body segment from the Utica shale at Holland Patent, N. Y. Similar remains of walking legs and body segments had already in 1874 been discovered by S. A. Miller in the Richmond group of Ohio but referred as *Megalograptus welchi* to the graptolites (see Clarke and Ruedemann, 1912, p. 325). The first larger Ordovician faunas were discovered by the writer in the Normanskill shale (Chazy age) and Schenectady formation (Trenton age) and described in Memoir 14. The Normanskill shale afforded six species of the genera *Eurypterus*, *Eusarcus*, *Dolichopterus*, *Stylonurus* and *Pterygotus*, the Schenectady beds even 11 species of the same genera and *Hughmilleria*. To these were added by the writer (1926) five from the Utica shale and in 1934 one species from the Deepkill shale, two more from the Normanskill shale at Kenwood, N. Y., and three from the Snake Hill shale.

The most remarkable feature of these Ordovician eurypterids is their association with the graptolites at times, as in the Normanskill shale, in typical graptolite shales lacking other fossils. The bearing of this strange association on the moot problems of the habitats of the graptolites and eurypterids has been fully discussed by the writer (1934, p. 382-85) and will not be considered again here.

We merely wish to add three more forms to the eurypterid faunules. Two are from the Deepkill shale, which hitherto has afforded only one species that was overlooked in the original study of the Deepkill graptolite fauna and later discovered accidentally. To this single species there can now be added:

Dolichopterus antiquus sp. nov.

Pterygotus (?) *priscus* sp. nov.

These Deepkill species, represented only by scattered remains of the prosoma are principally interesting as the oldest true eurypterid remains known and the oldest Merostomata save the Cambrian suborder Limulava Walcott. The minute carapaces with very thin tests of the two eurypterids *Dolichopterus antiquus* and *Pterygotus* (?) *priscus* associated with the graptolites suggest the probability that they led an epiplanktonic life on the Sargasso weeds, as many of the graptolites did. The third addition is a new species from the Normanskill grit: *Eurypterus decipiens* sp. nov.

This brings the list of eurypterids known from the Ordovician rocks of America up to 32 species. To our knowledge, none are so far reported from foreign Ordovician beds. All of these Ordovician eurypterids save the Richmond species from Ohio were collected in New York rocks, the great majority in graptolite shales, some in Normanskill grit.

The complete list of Ordovician eurypterids follows:

- | | |
|--------------------|--|
| Deepkill shale: | <i>Pterygotus deepkillensis</i> Rued. |
| | <i>P.</i> (?) <i>priscus</i> Rued. |
| | <i>Dolichopterus antiquus</i> Rued. |
| Normanskill shale: | |
| a Catskill: | <i>Eurypterus chadwicki</i> Clarke and Rued. |
| | <i>Eusarcus linguatus</i> C. and R. |
| | <i>Dolichopterus breviceps</i> C. and R. |
| | <i>Stylonurus modestus</i> C. and R. |
| | <i>Pterygotus?</i> (<i>Eusarcus?</i>) <i>nasutus</i> C. and R. |
| | <i>P. normanskillensis</i> C. and R. |
| b Kenwood: | <i>Hughmilleria prisca</i> Rued. |
| | <i>P. normanskillensis</i> C. and R. |
| c South Bethlehem: | <i>Eurypterus decipiens</i> Rued. |
| Snake Hill shale: | <i>Eurypterus hudsonicus</i> Rued. |
| | <i>Hughmilleria kilfoylei</i> Rued. |
| | <i>Eusarcus triangulatus</i> C. and R. |

- Schenectady beds: *Eurypterus?* (*Dolichopterus?*) *stellatus* C. and R.
E. pristinus C. and R.
E. megalops C. and R.
E. ? sp.
Dolichopterus frankfortensis C. and R.
D. latifrons C. and R.
Eusarcus longiceps C. and R.
E. triangulatus C. and R.
Stylonurus? *limbatus* C. and R.
Hughmilleria magna C. and R.
Pterygotus prolificus C. and R.
P. nasutus C. and R.
- Utica shale: *Echinognathus clevelandi* Walcott
Eurypterus rusti Rued.
Eusarcus breviceps Rued.
Dolichopterus insolitus Rued.
Stylonurus sp.
Hughmilleria uticana Rued.
Pterygotus walcotti Rued.
- Richmond group: *Megalopterus welchi* Miller

Dolichopterus antiquus sp. nov.

Figure 6 (2)

Description. Carapace subquadrate in outline; length shorter than width by about one-eighth (length, 3.4 mm, width 3.9 mm). Frontal margin nearly straight, antero-lateral corners slightly rounded to subtruncate; lateral margins convex in frontal two-thirds and contracted in posterior third. Posterior margin straight. Posterior and lateral margins with distinct, fairly broad border (.3 mm wide), possibly originating from doublure of underside.

Compound eyes elongate, kidney-shaped; about one-sixth as long as carapace, (.6 mm long); situated approximately midway between the base and the anterior margin and less than one-seventh the width from the lateral margin. Median eyes not seen.

Distal portion (three segments) of a short stubby walking leg is exposed. A subtriangular, pointed appendage projects from below the carapace, either a genital appendage attached to an operculum that has been pushed under the carapace, or a telson spine. It is 2 mm long and .7 mm wide.

Horizon and locality. Upper Deepkill shale (*Diplograptus dentatus* zone) along New York road at southeast base of Mount Merino below Hudson, N. Y. The specimen is associated on the same slab with *Phyllograptus angustifolius*.

Remarks. The presence of a distinct thickened frontal and lateral border as well as the contraction of the posterior half of the carapace strongly suggest reference to *Dolichopterus*. However,

Dolichopterus has the compound eyes as a rule located in or near the antero-lateral corner. The form before us has the eyes nearer the central-line, as in *Eurypterus*; at least that on the right side, while the left one is secondarily pushed farther forward as indicated by the numerous wrinkles especially on the left side and the somewhat oblique outline of the carapace.

The appendage, if a genital appendage, is not indicative of that of *Dolichopterus* but rather resembles that of *Hughmilleria*; if a telson spine, it may well be that of a *Dolichopterus* or *Eurypterus*. It is obvious that as long as the appendages and the abdomen are missing, there remains some doubt as to the proper generic position of this form.

There are a great number of macerated remains of eurypterids scattered on the bedding plane that afforded the two carapaces. All are finely wrinkled giving the impression that the eurypterid exoskeleton at the time of imbedding was composed of thin leathery tests rather than solid plates.

Pterygotus (?) *priscus* sp. nov.

Figure 6 (3)

Description. Carapace subrectangular, length to width as 7:9 (length, 2.8 mm, width, 3.6 mm); frontal margin gently convex, antero-lateral corners sharp, occupied by the compound eyes, lateral margins slightly convex, diverging somewhat posteriorly, giving the carapace a slightly smaller width in front than at the base (3.3 mm and 3.8 mm respectively). Posterior margin straight transverse. Compound eyes, small, bean-shaped, prominent, about .7 mm long. Median eyes not observed. Surface smooth.

Fragments of two appendages present. The frontal one is quite strong, suggesting the powerful chelicerae of a *Pterygotus*, the posterior one indicative of a strong swimming leg, also as in *Pterygotus*.

Horizon and locality. Upper Deepkill shale (zone of *Diplograptus dentatus*), along New York road at southeast base of Mount Merino, south of Hudson, N. Y. On same slab with holotype of *Dolichopterus antiquus*.

Remarks. While the outline of the carapace, the form and position of the eyes, as well as the fragments of appendages agree well with the corresponding features of *Pterygotus*, the characters determined seem not quite sufficient to make the reference to *Pterygotus* conclusive.

Eurypterus decipiens sp. nov.

Figure 4; figure 6 (1)

Description. Carapace broadly semielliptic, length to width as 4:5 (44+ mm wide at base and 36 mm long). Frontal margin (anterior half) evenly rounded, lateral margin nearly straight. Posterior margin straight. Lateral eyes small (5 mm long, 3.5 mm wide), approximately semielliptic, with straight inner margin, far apart, situated 13 mm from the lateral margin and 15 mm apart, slightly in front of the transversal middle line of carapace (20 mm from base). Median eyes between frontal portions of lateral eyes. Fragment of leg on left side of carapace. Three tergites are preserved in part; the first is 45+ mm wide and 12 mm long, the second 10.5 mm long near the margin and 35+ mm wide, the third is 10 mm long. The surface is covered with numerous droplike projections (preserved as depressions), indicating the presence of scales especially on the tergites, and with oblique lines near the posterior margins of the tergites.

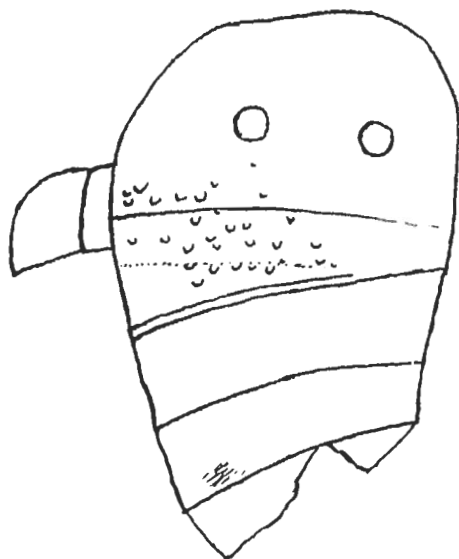


Figure 4 *Eurypterus decipiens* Rued. Outline of holotype [see figure 6, (1)]

Horizon and locality. Normanskill grit (Austin Glen member), along Onesquethaw creek near base of Callanans quarry, South Bethlehem, Albany county, N. Y. R. Ruedemann coll. 1920

Remarks. This eurypterid is notable for its size, which is large for an Ordovician form. It is distinguished from the other Ordovician forms by the evenly rounded head and the subcentral position of the eyes.

As the right margin is crushed or partly turned under, it is probable that the carapace was slightly wider and the tergites longer than shown in the figure.

Owing to its peculiar preservation, as cast, and the poor outline of the right side, the fossil was long considered by the writer as a seaweed of the *Sphenophycus* type.

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Explanation of Figures

Figure 5

- 1 to 2 *Oldhamia keithi* sp. nov. Natural size. No. 1 upper side of slab; no. 2 underside. Ordovician graptolite shale at Méchins Point, Quebec. A. Keith coll. 1937
- 3 to 7 *Schodackia biserialis* sp. nov. No. 3, holotype, x4; no. 4, same natural size. Nos. 5 to 7 detached thallus-lobes, x4; paratypes. Schodack shaly limestone at Hudson cemetery; R. Ruedemann & T. Y. Wilson coll. 1934
- 8 to 9 *Medusaeograptus (?) wilsoni* sp. nov. No. 8, holotype, x4; no. 9, natural size. Ordovician Normanskill shale (Mount Merino member), Stuyvesant Falls, Columbia county, N. Y. T. Y. Wilson and H. Dill coll. 1934
- 10 *Teganium merino* sp. nov. Holotype, natural size. Ordovician Normanskill shale (Mount Merino member) at Mount Merino quarry near Hudson, New York. C. Kilfoyle coll. 1937

Originals of numbers 1 and 2 in Canadian Survey Collection at Ottawa, those of numbers 3 to 10 in New York State Museum

Figure 6

- 1 *Eurypteris decipiens* Rued. Holotype, xl. Ordovician Normanskill grit, South Bethlehem, Albany county, N. Y. R. Ruedemann coll. 1920
- 2 *Dolichopterus antiquus* Rued. Holotype, x6. Lower Ordovician Deepkill shale, south end of Mount Merino near Hudson, Columbia county, N. Y. R. Ruedemann and T. Y. Wilson coll. 1934
- 3 *Pterygotus (?) priscus* Rued. Holotype, x8. Lower Ordovician Deepkill shale, south end of Mount Merino near Hudson, Columbia county, N. Y. R. Ruedemann and T. Y. Wilson, coll. 1934
- 4 to 7 *Schodackia terrae novae* sp. nov. No. 4, Holotype, x4; nos. 5-7, paratypes, detached lobes. Black Normanskill shale at Rowsell Island, Newfoundland, Heyl collection A-162

Originals of numbers 1 to 3 in New York State Museum; of numbers 4 to 7 in collection of Newfoundland Geological Survey

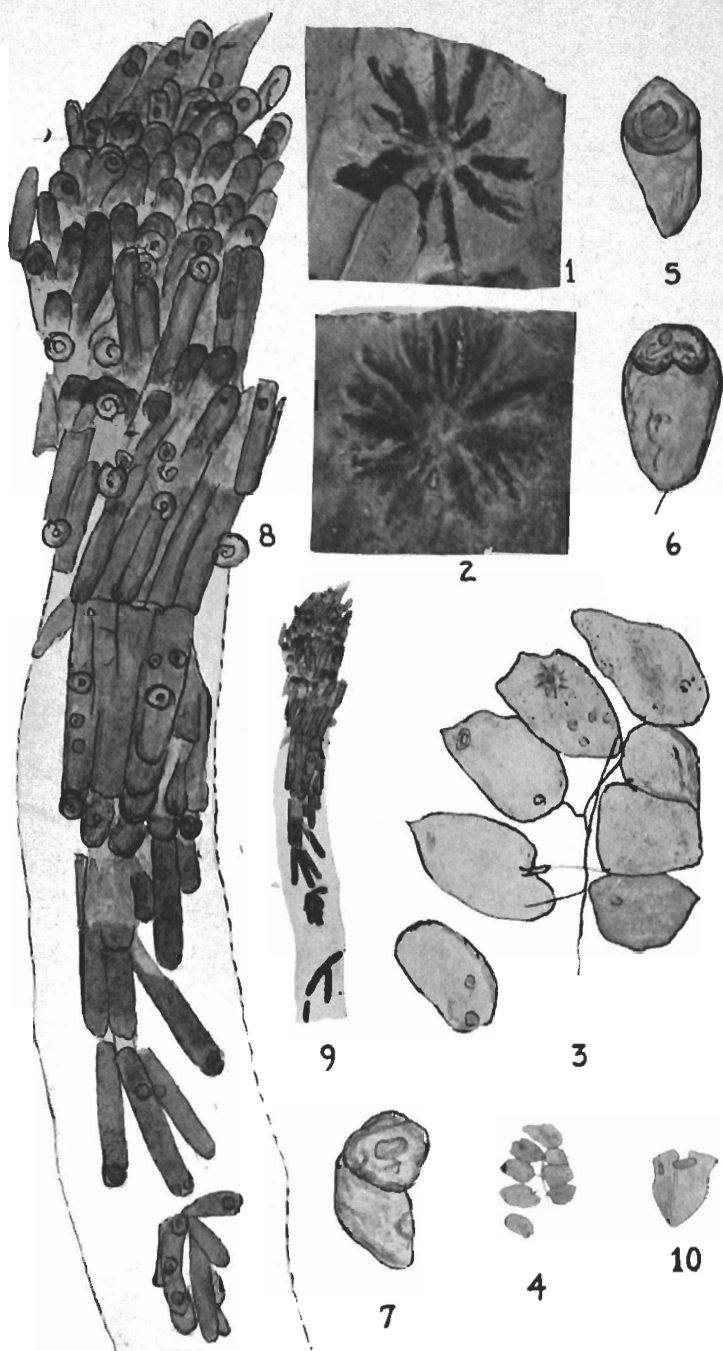


Figure 5



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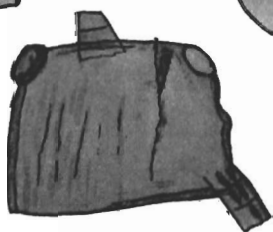


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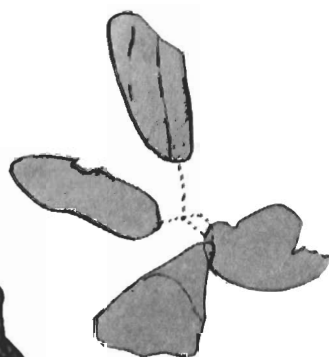


Figure 6

NOTES ON ORDOVICIAN MACHAERIDIA OF NEW YORK

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The finding of a complete shell of a species of *Plumulites*, described below, has led to a revision of the other genera and species from the Ordovician of New York described by the writer and formerly considered as belonging to the Cirripedia but now assembled by T. H. Withers in a new class Machaeridia that is placed with the echinoderms.

In 1914 Bather stated the position of the Paleozoic so-called Cirripedia *Lepidocoleus*, *Turrilepas* and *Plumulites* to be uncertain, adding: "Up to the present the main reason for referring them to the Cirripedia seems to be the difficulty of placing them anywhere else."

On a visit to the State Museum he told me the reasons why he and T. H. Withers had begun to consider them as related to the echinoderms.

In 1924 in his paper on The Phylogeny of the Cirripedia, Withers positively asserted that the three so-called Paleozoic cirriped genera could not be retained there, partly because of the great gap in range, the first definitely identifiable Cirripedia occurring not until the late Triassic and partly because by careful cleaning he was able to expose subcircular muscle scars on median plates of *Turrilepas* and on both series of plates in *Lepidocoleus*. Such scars occur in pedunculate Cirripedia only on the scutum and the Paleozoic fossils here referred to would have to be and were compared with the pedunculate Cirripedia on account of the great number of plates running up to sixty.

Finally in 1926 Withers brought out the Catalogue of the Machaeridia in which this group was created for the reception of the Lepidocoleidae (genus *Lepidocoleus*) and the Turrilepadidae (genera *Turrilepas*, *Deltacoleus* and *Plumulites*). This new class Machaeridia is in the catalog definitely arrayed with the echinoderms, largely on negative evidence namely that they can not be brought into agreement with chitons, annelids and cirripedes on one hand, and on the other because of the observation of a crystalline cleavage in plates of *Lepidocoleus succicus* and *L. squamatula*.

The Machaeridia now known from the Ordovician of New York are:

Plumulites trentonensis Withers. Snake Hill shale. Indian Ladder beds, Pulaski shale

Deltacoleus filiosus (Ruedemann). Snake Hill shale

Deltacoleus multistriatus Ruedemann. Trenton limestone and Rysedorph conglomerate

Lophocoleus siluricus (Ruedemann). Snake Hill shale

AN AMERICAN PLUMULITES WITH COMPLETE SHELL

Figure 7 (1-6)

Karl A. Pauly from Schenectady sent to the State Museum in March 1937 for identification a specimen that he had collected in the Canajoharie shale between Palatine Bridge and Stone Arabia in Montgomery county, New York. It was recognized as a complete shell of *Plumulites*, the first of its kind thus far found in America. A second, less complete but larger shell was later added but most industrious search of more shale material from the locality kindly collected by Mr Pauly afforded only detached plates.

The genus *Plumulites* was originally described by Barrande (1872, p. 565) and considered by him as belonging to the Cirripedia. He described two species with complete shells, viz. *P. bohemicus* and *P. folliculum*, both from the lower Ordovician of Bohemia. To this beautiful material can be added a third species with complete shell, found in Scotland, *P. peachi* (Nicholson & Etheridge jun.), originally described as *Turrilepas*. The plates of the two genera *Plumulites* and *Turrilepas* are similar enough to have caused confusion and the reference of various species of *Plumulites* to the genus *Turrilepas*, erected by Woodward and Salter in 1865 (p. 486). With *P. peachi* the number of species which have afforded complete shells is exhausted, although T. H. Withers in his excellent Catalogue of the Machaeridia (British Museum, 1926) cites 25 species of *Plumulites* from Europe, America and Australia.

The writer, on discovering detached plates similar to those of *Plumulites* and *Turrilepas* in the Ordovician shale of New York identified them somewhat loosely with the only supposed Ordovician cirripede known at that time in America, viz. *Lepidocoleus jamesi* (Hall and Whitfield) from the Cincinnati beds. Among those figured (1901) is also one from the Middle Trenton (Snake Hill shale) at Port Schuyler near Albany, N. Y. (*ibid.*, pl. 2, fig. 11).

This has been recognized from the figure as a species of *Plumulites* by Withers and described as *P. trentonensis* (op. cit. p. 60).

The original description of this new New York species is as follows:

Diagnosis. Kiteshaped plates short and broad, the apical part not attenuated, and with the proximal angles widely and almost equally truncated.

Distribution. Middle Ordovician, Middle Trenton beds: Port Schuyler, Albany Co., N. Y.

Holotype. The single kiteshaped plate in the New York State Museum, figured Ruedemann, 1901, pl. 2, fig. 11 [here reproduced figure 8(2)].

Description. This plate is a typical kiteshaped plate of *Plumulites*. It is comparatively short and broad, the breadth being three-quarters the length, the apical half is not attenuated, the longitudinal fold comparatively wide and straight, and the proximal angles widely and almost equally truncated. Growth lines comparatively widespaced, sharply upturned near the distal and outer margins, corresponding to the width of the truncated proximal angles.

Comparison with other species. This plate appears to resemble most closely the species *Plumulites fraternus* (Barraude), from the Ordovician (d3) of Trubin, Bohemia, but more especially the plate figured (1872, pl. 20, fig. 9). *P. fraternus*, however, has the inner proximal angle more rounded but proportionately much wider.

The material from the Canajoharie shale, both complete shells and plates, agrees in the kiteshaped plates with the holotype of *Plumulites trentonensis* and the Canajoharie shale containing the new material is equivalent in age to the Snake Hill shale.

The complete specimen affords the following description:

Shell of oboval outline, 53 mm long and 37 mm wide and triangular cross section, according to Withers; composed of two rows of small median keeled heartshaped plates and two rows of larger kiteshaped plates. In the complete shell seven plates can be counted in each of the two kiteshaped series and as many were present in the two median series. Another complete shell, unfortunately partly destroyed by the breaking rock, figure 7 (3, 4) was about twice as large as the perfect specimen before us and possessed near the base also kiteshaped lateral and heartshaped median plates of nearly twice the size of those in the smaller specimen. While the largest lateral plate in the complete specimen is 4 mm long, one of the lower plates in the second specimen measures 7 mm in length and half the length in basal width. It is also obvious that these larger kite-shaped plates become more slender and pointed towards the extremity and that the latter is more sharply turned sideways or upwards. There were also more plates in each series in the larger specimen, probably twice the number.

The plate which the writer described and figured and which was made by Withers the holotype of *Plumulites trentonensis* is a smaller lateral plate, measuring 3.3 mm in length and is therefore relatively broader and straighter than the larger plates, especially of a larger specimen. There are about 7 growth lines to a millimeter in the middlesized plates. We add camera drawings of the holotype, figure 8 (3, 4), because the original drawing is slightly diagrammatic and is too straight. The median fold also is more curved than figured; it is high and very distinct and .24 mm wide. An outer narrower fold near the distal margin is very faint.

The median plates are smaller, only about 3 mm long, more asymmetric than the lateral plates, relatively broader (approximately as broad as long), subtriangular to heartshaped and provided with a median keel which, however, is not so prominent as the fold of the lateral plates and sometimes hardly noticeable. It appears also that the figure 12 of my paper [see figure 8 (1)] represents a heart-shaped median plate of this species. It came from the Snake Hill beds at Mechanicville and is therefore of the same age as the holotype. Figure 7 (6) represents a fragmentary median plate with a broad keel.

The relation of the plates in *Plumulites* has been carefully described by Withers, from whom we quote:

The apices of the keeled plates forming the two median columns lie next the broad back, and along the back the admedian portions of the plates of one column alternate and intersect with those of the opposing column. Each plate overlaps the plate in front for at least one-third of its length. At the sides the keeled plates are intersected by the kiteshaped plates which meet in loose apposition, their outer margins forming the free margin along which the shell opened. The kiteshaped plates tend to alternate with those of the opposing series, and their apices do not project freely, but because of the alternation serve to form a continuous margin.

Our specimens do not afford any additional data on these relations. The shell, according to Withers, was bladeshaped and closed where the dorsal side of the plates is seen and open on the opposite side. The plates according to Withers numbered at least 20 in each series in *Plumulites*. Our specimens are therefore probably but young individuals.

Withers has pointed out that the shells of *Plumulites* were exceptionally thin and calcareous. In the Canajoharie shale only the impressions of the dorsal and ventral sides are found as all calcareous shells are dissolved in the shale. Fossils are rare in the beds containing the shells, only scattered graptolites (*Glossograptus quadrimucronatus*), brachiopods (*Lingula curta*) and ostracods (*Ulrichia*

bivertex) being found. The Plumulites plates are common enough to make the species a normal member of the impoverished bottom faunule.

Plumulites, together with *Lepidocoleus* and *Turrilepas*, all of which were after considerable confusion considered by authors, the present one included, as Cirripedia, have been, together with the new genus *Deltacoleus*, placed into a new group Machaeridia, which is brought under the echinoderms, partly because the forms can not be reconciled in their structure, with that of the other classes to which they have been referred, notably annelids, chitons, cystids and barnacles, and partly because of a crystalline cleavage such as we find in echinoderms, was seen in plates of a species of *Lepidocoleus* and one of *Turrilepas*. Whatever the future taxonomic position of this interesting group may become, it is certain that it should receive a distinctive group name. Several had been proposed before, namely Palaeothoracica (Stromer v. Reichenbach, 1909), Turrilepado-morpha (Pilsbry, 1916) and Protocirripedia (Jouleaud, 1916).

The range of *Plumulites trentonensis* is greater than the occurrence in the Canajoharie shale would indicate, for detached plates have also been described and figured by the writer (1926, p. 145-46, pl. 25, figs. 1-3) as *Lepidocoleus jamesi* from the Lorraine section, where they are found as "a fairly regular component of the shale faunas" in the Pulaski beds at Worthville, N. Y. It is stated there that the form ranges up to the top of the Lorraine. Before it had already been reported by the writer (1912, p. 48) from the Indian Ladder beds. It is hence safe to assume that this species ranges from Middle Trenton age to the end of Lorraine age.

Deltacoleus filusus (Ruedemann)

Figure 8 (13-16)

Turrilepas (?) *filusus* Ruedemann. N. Y. State Mus. Bul. 42, 1901, p. 577, pl. 2, figs. 13-15

Original description. Plates obliquely subtriangular, comparable in outline to an isosceles triangle with the apex pushed to one side; the nucleus falling into the apex, and the two legs standing nearly vertical on the slightly convex base; the lengthened side strongly convex, the shortened nearly straight; surface marked by strongly elevated, very regular concentric lines, which have multiplied more rapidly on the posterior side.

Dimensions. The smaller specimen measures 4 mm along the base, and 4.5 mm along the vertical side; the larger 7 mm and 9 mm in the same direction.

Horizon and locality. Snake Hill shale at Mechanicville, Saratoga county, N. Y.

Remarks. The two plates which were referred to *Turrilepas*, as a new species with doubt on account of their different outline, were collected at Mechanicville in the black shale which formerly was part of the "Hudson River shale," later was correlated with the Utica shale by the writer (1901), and is now known to be an eastern correlative of the Middle Trenton in the Appalachian geosyncline and named the Snake Hill shale.

The plates can be properly placed with the new Machaerid genus *Deltacoleus*, proposed by Withers (1926, p. 43) for forms with "shells of triangular cross section, the median plates subtriangular, keeled or angularly bent along a submedian line from the apex and rectangularly produced below, the outer plates almost flat, without a median longitudinal ridge, approaching in shape an acute-angled isosceles triangle, and with the outer proximal angle broadly rounded."

It will be seen that this generic diagnosis closely fits the two plates here figured, the smaller the median plate that is angularly bent along a submedian line, and the larger, the lateral plate, which is nearly flat save for a faint median depression, and approaches an asymmetric isosceles triangle in outline.

There is so far described only one other species, the genotype, *D. crassus* Withers from the Middle and Upper Ordovician (Llandeilian and Caradocian) of Girvan, Ayrshire, Scotland.

Deltacoleus multistriatus sp. nov.

Figure 8 (5-7)

Lepidocoleus jamesi (Ruedemann). N. Y. State Mus. Bul. 42, 1901, pl. 2, fig. 10
Lepidocoleus jamesi (Ruedemann). N. Y. State Mus. Bul. 49, 1901, p. 87-89,
pl. 4, figs. 16-19

The writer has described plates from the Trenton limestone at Trenton Falls (1901, pl. 2, fig. 10) and from the black limestone pebbles of the Rysedorph Hill conglomerate with Trenton fossils (1901a, pl. 4, figs. 16-19) as *Lepidocoleus jamesi* (Hall and Whitfield) stating that Hall and Whitfield had already reported (1875) that they had observed their *Plumulites jamesi* in the Trenton limestone.

In a restudy of these plates it is seen that they fully agree with *Deltacoleus filiosus* in the flat surface of the plates which are preserved as thick calcareous bodies, but differ markedly in size reach-

ing only one-third the size of those of *D. filusus* and possessing much finer growth lines which number 10 to 12 in 1 mm as against 6 to 7 in *D. filusus*. Differences in age or position on the complete shell would not suffice to explain these differences. We will therefore distinguish this well-marked form as *D. multistriatus*.

Description. Entire shell small, median plate broadly triangular, flat, about as wide as high, without distinct keel and gently convex base. Outer or kiteshaped plates, twice as long as wide, flat with rounded base. Growth lines sharply bent forward on the outer side, sharp, raised

Dimensions. Holotype 2.2 mm long and 2.1+ mm wide. Other median plate 1.9 mm long; kiteshaped plate 2.1+- mm long and 1.3 mm wide.

Horizon and locality. Holotype from Trenton limestone at Trenton Falls, N. Y., paratypes from Rysedorph conglomerate, Rensselaer, N. Y. R. Ruedemann coll. 1900

REVISION OF POLLICIPES

When the writer discovered in the black Snake Hill shales at Mechanicville, Saratoga county, (1899) and Green Island, Albany county, (1900) a number of plates that suggested in their form the various plates of the capitulum of a barnacle, he did not hesitate (1901) to refer these to the genus *Pollicipes* as *P. siluricus* (in reference to the "Lower Silurian," now Ordovician), pointing, however, to the "enormous gap existing between the appearance of the Lower Siluric type and the next Upper Triassic (Rhaetic) representatives of these genera."

F. A. Bather shortly after (1901) in a review of my paper (1901) pointed out that the gap is not so great as I surmised as a Silurian species, *P. signatus* was described by Aurivillius from Sweden in 1892.

Since that time the cirripede-nature of all Paleozoic fossils referred there has been placed in doubt by Withers, and it has been stated by him (1926, p. 72) that *Pollicipes aurivillii* (Moberg) [formerly *P. validus* Aurivillius] is "certainly not a scutum of a *Pollicipes*." While that author, not having seen the specimens of *P. siluricus*, cautiously leaves this form out of the discussion, it is obvious that the generic term *Pollicipes* can not be retained for the group of plates united by the writer under *P. siluricus* by comparison with the capitulum of a *Pollicipes*.

A restudy of the plates leads to the inference that the larger number, viz. figures 16-23, may well be considered as belonging to one form, probably also a Machaeridian. One of these plates shows even distinctly the two muscle scars, observed by Withers on median plates of *Turrilepas* and both series of plates of *Lepidocoleus*. As the form can not be placed into one of the genera so far described, we propose to erect for it the genus *Lophocoleus*.

Lophocoleus gen. nov.

(*lophos*, keel; *koleos*, sheath)

Diagnosis. Shell of triangular cross section, the median plates short, subtriangular, keeled and sharply angularly bent along a sub-median line from the apex and rectangularly produced below, the outer plates highly arched, with a strong median keel and lateral folds, with a long angular base and the outer proximal angle obtuse.

Genotype: *Lophocoleus siluricus* (Ruedemann)

This genus is principally distinguished from the others by the strong median keel; the relatively smooth surface, lacking the strong growth lines, and the horn-shaped lateral plates, the sides of which approach inward producing a strongly angular base.

Lophocoleus siluricus (Ruedemann)

Figure 8 (8-12)

Pollicipes siluricus Ruedemann. N. Y. State Mus. Bul. 42, 1901, pl. 2, figs. 16-25

Description. Kiteshaped plates short and broad, the apical part turned inward; with a broad high keel, a curved fold near each of the proximal angles, extending towards the beak. Proximal angles subrectangular, basal angle obtuse, basal margins gently convex. Surface fairly smooth, with very fine growth lines and faint traces of lines running parallel to the keel

Median plate subrhomboidal in outline, with a strong median keel and two accessory depressed lines or folds on each side. Outer margins straight, forming a nearly right angle at the beak, inner margins convex, together approaching a semicircle. Surface smooth, but with indications of strong growth lines at the outer margin (ended too abruptly in drawing)

Horizon and locality. Ordovician Snake Hill shale at Green Island, Albany county, N. Y., and Mechanicville, Saratoga county, N. Y. R. Ruedemann coll. 1900

Remarks. We consider the originals of nos. 8, 9, 10 as the types of this species, with no. 9 as the holotype. The majority of the specimens (nos. 8, 11 of our figures) were taken out of a little nest of fossils, a few square yards in size, on the bank of a branch of the Mohawk river. This peculiar nest of fossils contained a variety of small fossils in an otherwise rather barren shale and the *Lophocoleus* plates were all found in close proximity. The plates are all preserved as impressions only, mostly of inner surfaces, as notably the specimen with the muscle scars, figure 8 (10). It is therefore possible that the outer surfaces were not as smooth as is suggested by the impressions. The single supposed median plate, figure 8 (12) is an impression of the outer surface, and it retains traces of stronger growth lines.

It appears that the younger kiteshaped plates were broad and short, and that the plates became increasingly slender with growth; figure 11 would indicate that the very largest plates were relatively narrow and possessed a long straight inner margin.

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Explanation of Figures

Figure 7

- 1 to 6 *Phumulites trentonensis* Withers
- 1 Photograph of complete shell, x6
- 2 Camera drawing of same, x6
- 3 Photograph of larger, but incomplete shell, x6
- 4 Camera drawing of same, x6
- 5 Median plate. Camera drawing, x5
- 6 Median plate. Photograph, x5

All specimens are from the Ordovician Canajoharie shale near Broadalbin, Montgomery county and were collected by Karl A. Pauly, 1937. The types are in the New York State Museum.

Figure 8

- 1, 2, 3, 4 *Phumulites trentonensis* Withers
- 1, 2 Copies of Ruedemann's original drawings (1901, pl. 2). No. 2. Withers' holotype
- 3, 4 Camera drawings of cast and mold of the holotype, x5

Ordovician Snake Hill shale at Port Schuyler near Albany, N. Y. R. Ruedemann coll. 1900

- 5, 6, 7 *Deltacoleus multistriatus* sp. nov.

5 Holotype, x7. Median plate. (same as Ruedemann 1901, pl. 2, fig. 10). Trenton limestone, Trenton Falls, N. Y.

6, 7 Kiteshaped, outer plates. Paratypes, x12. Rysedorph conglomerate, Rysedorph Hill, Rensselaer county, New York. R. Ruedemann coll. 1900

8, 9, 10, 11, 12 *Lophocoleus siluricus* (Ruedemann)

8, 9, 10, 11 Kiteshaped plates. No. 9, holotype; Nos. 8, 10, 11, Paratypes. No. 12 Median plate, paratype. All x10

13, 14, 15, 16 *Deltacoleus filiosus* (Ruedemann). Nos. 13, 15, original drawings of cotypes, x10; Nos. 14, 16, camera drawings of same (number 14 opposite side), x12

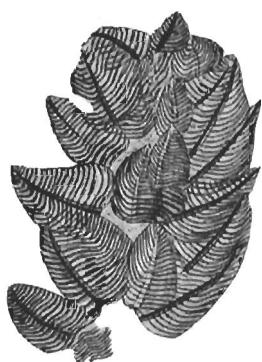
Ordovician Snake Hill shale, Mechanicville, Saratoga county, N. Y. R. Ruedemann coll. 1900. All originals are in the New York State Museum



1



3



2



5



6



4

Figure 7

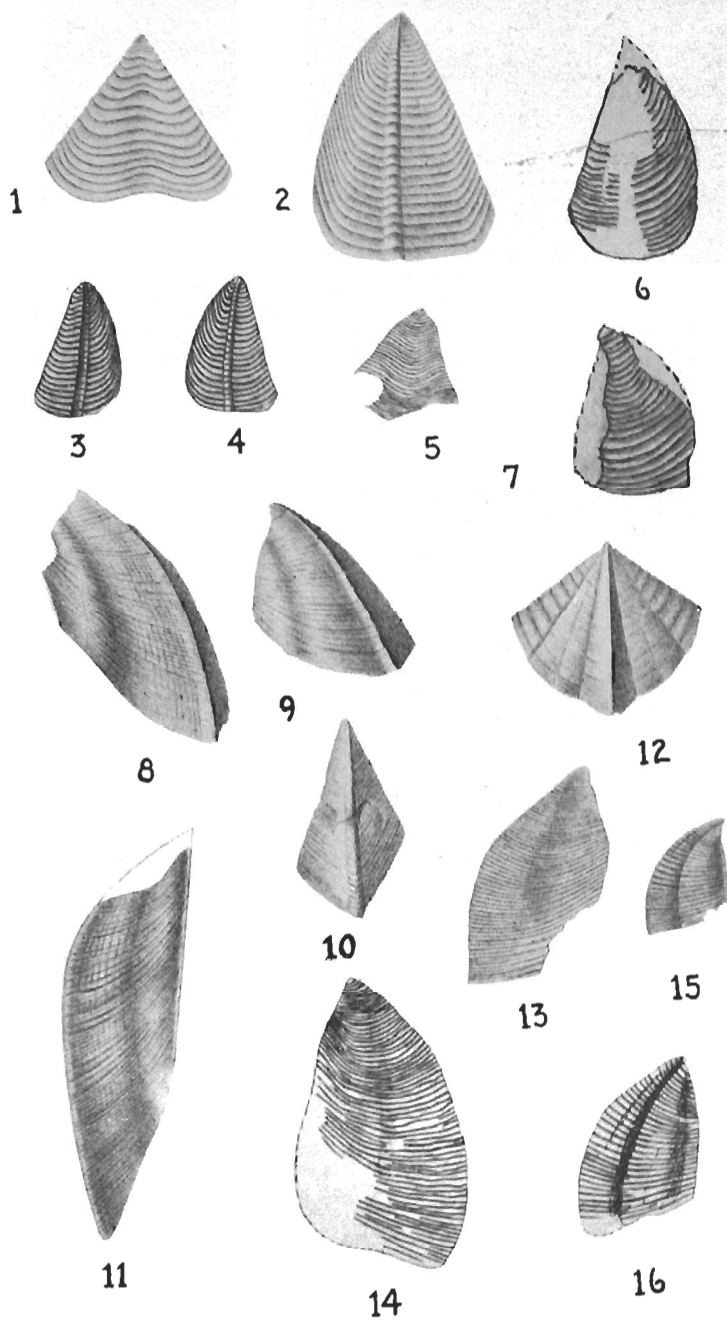


Figure 8

NOTES ON ORDOVICIAN PLANKTON AND RADIOLARIAN CHERT OF NEW YORK

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The writer has published investigations of the Paleozoic plankton of North America (1934) and of the radiolarian cherts (see figures 9-14) of the New York Ordovician (1936). The continuation of the studies in our Ordovician rocks, as well as the appearance of correlated literature, makes it desirable to publish further notes on these two moot problems and their relation to the Appalachian geosyncline.

ORDOVICIAN PLANKTON OF NEW YORK

The flora and fauna of the Ordovician plankton of New York as described before consists of seaweeds (2 genera, 4 species), sponges (4 genera, 4 species), cnidarians (1 genus, 1 species), brachiopods (11 genera, 14 species), annelids (7 genera, 7 species), mollusks (2 genera, 2 species), crustaceans (5 genera, 8 species), eurypterids (6 genera, 8 species).

It must not be forgotten that the fauna here cited as "plankton" comprises true plankton as well as epiplankton. This fact has been overlooked both in written and conversational criticisms and led to statements that such classes as sponges, brachiopods and mollusks could not be listed with the plankton. If one, however, considers the epiplanktonic forms, attached to the Sargassum of the present time, one will not hesitate to admit the possibility or even probability of sponges, brachiopods and mollusks having been attached and floating with these seaweeds.

The relatively numerous species of eurypterids occurring in the pure graptolite shales were not described in the writer's memoir on the Paleozoic plankton faunas, but merely mentioned (p. 40) as they were considered foreign elements in the graptolite fauna and the associated plankton, having come down from the littoral regions by a different route from the planktonic and epiplanktonic forms of the graptolite shale. This view was apparently supported by the general belief that the habitat of the eurypterids was the coastal lagoons and embayments, if not the rivers, rather than the open sea. This view seems further strengthened by the fact that all the eurypterids described from the graptolite shales (see Clarke and Ruedemann,

1912 and Ruedemann, 1934) are of relatively small size, only a few inches long at the most and usually preserved only in fragments.

There are, however, described in this bulletin (pages 25-27) eurypterids from the Deepkill shale that astonish by their minute size and yet apparently mature growth stage, as indicated by their relatively small eyes (the immature forms possessing large eyes in the eurypterids). Rousseau Flower has discovered other new species of small eurypterids in the Deepkill shale at the Deepkill section, to be described by him separately. These minute forms have delicate tests that, contrasting with the glossy thick tests of the graptolites, prevented their earlier observation when graptolites were the leading subjects of search. In viewing these diminutive eurypterids (*Dolichopterus antiquus*, and *Pterygotus* (?) *priscus*) among the graptolites one can hardly escape the suggestion that they may well have lived with the graptolites and the crustaceans of the *Caryocaris*-type in the Sargasso Sea.

Trilobites, while present in the impure graptolite shales in small bottom forms as the species of *Triarthrus* occur only as unica in the pure graptolite shales, as the specimen of *Niobe? huberi* found by Roy in our Normanskill or that of *Shumardia pusilla* (Sars) found by the writer in the Deepkill shale. However, the minute carapaces of species of *Boeckia jarensis* and *Parabolinella limitis* occur in limestone concretions in the Dictyonema shale of Norway. Störmer (1921; see Ruedemann 1934, p. 38) has expressed the conviction, previously urged by Strand, that these extremely minute trilobites, with their long broad spines on the pygidium and eyes directed horizontally outward, were pelagic forms.

A still more significant observation is that of the occurrence of *Aeglina binodosa* in pure graptolite shale, by G. Ubaghs, University of Liège, in Belgian Monograptus-shales (correspondence 1938).

We have already in the Memoir on the Paleozoic Plankton of North America (1934, p. 39) pointed out *Cyclopygus* (*Aeglina*), *prisca* (Barrande) as a typical nektonic to planktonic form of the neritic region on account of its large swollen glabella and immense eyes, extending to the underside.

ORDOVICIAN RADIOLARIAN FAUNA

Figures 10-14

To the plankton may now be added the radiolarian fauna of the Normanskill chert, described in 1936, which consists of 19 genera and 33 species.

The Radiolaria were found to comprise a number of genera that today are found only at depths greater than 12,000 feet. It was concluded therefore that the radiolarian chert of the lower Norman-skill beds may have been deposited in abyssal depths such as still today receive the radiolarian ooze at the bottom of the ocean. It was further inferred that the chert was syngenetic and had been formed at the time of the deposition of the ooze as silica gel under the influence of submarine volcanic eruptions, as the source of the silica.

The suggestion of the deep-sea habitat of the radiolarians in the chert was not new, as such had been already claimed for the radiolarite of the Alps and of other regions such as Borneo, and also strongly disputed. In none of these cases, however, had the radiolarians been studied as to their present habitats. Furthermore, the writer was not the first in this field as he thought, for Albert Schwarz had already in 1928 published a paper unfortunately overlooked by the writer in which he claimed that the radiolarians of the Mississippian (Culm) chert of Germany have their closest relationship with deep-sea forms of the present oceans.

Since the publication of the paper on the New York radiolarian chert, a brief but important paper by L. G. Henbest has appeared (1936) on Radiolaria in Arkansas novaculite, Caballos novaculite and Bigfork chert. C. L. Baker and W. F. Bowman already in 1917 had reported the occurrence of radiolarians in the Caballos novaculite of the trans-Pecos region of Texas and figured some specimens. Henbest found abundant radiolarians, forming as much as 25 per cent+ of some beds also in the Arkansas novaculite and Bigfork chert. It is much to be desired, as Henbest suggests, that the thorough and comprehensive study of the silica-fixing faunas of the novaculite and the detailed study of radiolarian material of Arkansas and Oklahoma be carried out. It can not fail to furnish important data on the origin of the chert. Baker had already suggested (1917, 1918) that the Caballos novaculite is radiolarian in origin and extended this conclusion to the Arkansas novaculite. Henbest infers that the beds representing the novaculite contained some silica originally and that the view of Miser and Purdue (1929, p. 57) of the absence of any extensive surficial replacement of the original limestone beds finds support.

It is important that Henbest (*ibid.* p. 77) recognizes the radiolarians as belonging to the class Spumellaria. All species in the writer's collection were Spumellaria except four Nassellaria. Also Hinde (1890, 1893, 1895) in Great Britain and Rüst (1885, 1892)

in Germany record only Spumellaria from the Paleozoic rocks, save some doubtful Nassellaria. The Spumellaria with their simple structure contrast with the bewildering variety of forms of the later Radiolaria. It is therefore natural that this primitive class or legion should appear first and prevail in the Paleozoic rocks. Although today some Spumellaria live at the surface, most of them are restricted to great depths; a perusal of the Challenger reports indicates that most live below 2000 fathoms, a significant fact in connection with the chert problem. As the writer has pointed out before (1936), on account of glacial periods in Precambrian and Paleozoic times, there is a strong possibility that the radiolarians then had already found a sufficient vertical aerating circulation reaching to abyssal depths and making life possible there for them.

It is in this connection of interest to note the well-known biologic principle that the most primitive forms of a class are usually found farthest away from the metropolis of origin of the class and on the periphery of its dispersal area while the latest and most advanced forms hold the center. On this principle the Spumellaria and Nassellaria advanced to deeper and deeper oceanic waters as the other radiolarian orders developed, a process that must have taken place very gradually and considering the great age of the radiolarians (Spumellaria and Nassellaria according to Barrois and Cayeux in Precambrian!) been initiated very early in geologic history, giving the radiolarians abundant time to reach the abyssal depths in early Ordovician age or even earlier. It is also a significant fact that the radiolarian chert is utterly barren of other fossils.

That deep-sea radiolarian earths are beginning to be found also in later eras is evidenced in a paper by Bruce L. Clark and Arthur S. Campbell (1937) on Radiolarian Earths in the Eocene series of the Mount Diablo area, Middle California. As radiolarians are also common in some littoral deposits and may form radiolarian chert in shallow seas, as is known by Davis' study of the Franciscan cherts, it is essential to study the radiolarians themselves as to their generic relations for conclusive evidence.

Radiolarian cherts are probably much more widely distributed than hitherto suspected. The occurrences in Texas, Oklahoma and Arkansas point to this conclusion. E. F. Davis (1918), as we have fully stated before (1936), has elaborately described and discussed the thick and widely spread radiolarian cherts of the Franciscan group in California; Molengraff (1902) has described the Mesozoic radiolarian cherts of Borneo—the Danau formation—which are 300

feet thick and cover an area of 40,000 square kilometers (15,500 square miles). The great thickness and enormous areal distribution forced Molengraff to the conclusion that the Danau cherts were the equivalent of the radiolarian oozes and red clays of abyssal depths. The Jurassic radiolarian chert of the Alps, the original "radiolarite" of Neumayr and Steinmann, who considered it as derived from radiolarian ooze, is still under discussion and doubt.

Also in Australia thick and extensive beds of radiolarian cherts have been found, as is evidenced by the publications of H. C. Richards (1924) and Richards and Bryan (1925), who describe *radiolarian jaspers* of Lower Devonian age from Queensland and give pictures of chert filled with radiolarians. They concluded (1925, p. 311) that "the radiolarian cherts are supposed to be the result of submarine volcanic activity in clear, warm, shallow coastal seas, raising the silica content to the optimum condition for the existence of Radiolaria, which have subsequently been preserved in a deposit of gelatinous silica interbedded with numerous layers of fine volcanic ash." In this case also, as in all others of radiolarian cherts, the study of the radiolarian genera will be necessary to solve the question of the depth of deposition.

PLANKTON AND SARGASSO SEA

The writer (1934) described the plankton of the graptolite shales as derived from the Sargasso sea of the North Atlantic, because the composition of the black shale fauna in aspect of forms and in variety of classes represented corresponds closely to that of the Sargasso sea of today. It was known before that the geosynclines which are the principal loci of the graptolite shales were open on both ends to allow free circulation of the ocean through them, as the Appalachian geosyncline was at the time when the graptolite shales were deposited; or they formed deep embayments narrowing from a wide mouth as those of Great Britain described by Marr (see Ruedemann, 1934, p. 8).

It was a further and apparently logical step, when radiolarian cherts were discovered in the graptolite shale that contained genera now living in abyssal depths, to conclude that in Ordovician time large portions of the Appalachian geosyncline were able to sink to abyssal depths that at times extended out to the open ocean and were able to receive deposits of radiolarian ooze containing deep-sea radiolaria.

It was to be expected that such unorthodox views would be challenged, as indeed they already were before the paper on the plankton was printed. Constructive criticism is welcome and helpful in the final solution of such moot problems. Such has been furnished among others by Dr Charles Schuchert in his discussion, Paleozoic Plankton of North America (1935).

The writer had stated that the typical graptolite shales are restricted in America to the geosynclines. Schuchert doubts this statement, pointing to the occurrence of graptolites in a variety of rocks, such as limestones, and to the occurrence in the interior of America (Ordovician in Cincinnati region, Maquoketa formation of Iowa and Illinois) as well as in western New York (Silurian Rochester formation) and would rather assume that graptolites occur principally where foul bottoms lacking scavengers allowed them to be preserved. The writer has repeatedly (1935) pointed to the fundamental difference between impure and pure graptolite shales.

The former, like the Utica shale, contain besides the graptolites a bottom fauna, usually impoverished, and the graptolite fauna is in that case always restricted to a few species, as in the Utica shale, where only four species of the planktonic Graptoloidea (not counting the Dendroidea, which were mostly sessile to the bottom) occur. The same is true of the scattered western occurrences, except those of the southwest which are found in a geosyncline and of that in the Rochester shale, where only two species are found in the Williamson member which is only four feet thick.

It is true these few species of graptolites may be found in large numbers and through great thicknesses as *Climacograptus typicalis* in the Utica shale in New York. But precisely in this case the writer (Ruedemann, 1897) has been able to show that a current coming into the interior from the northeast and out of the geosyncline swept around the Adirondack uplift and out into the Cincinnati basin where the fauna is lost with the disappearance of the black shale. It was the broken off branches of graptolites, besides cephalopods etc. which by their parallel arrangement indicated the direction of the westward current.

It seems an important fact that this parallel arrangement of the graptolites is found only in the impure graptolite shale, in New York in Canajoharie and Utica shales of the Mohawk valley, but is entirely absent in the pure graptolite shales of the Schaghticoke-Deerpkill-Normanskill series. Kraft (p. 240), who also observed strictly parallel arrangement of monograptids in glacial boulders, states that

in such cases only one species is found on the bedding plane [he observed the parallelism in *Monograptus priodon*, *M. nilssoni* and *Pristiograptus frequens* Jackel]. He attributes the death of the swarm of planktonic or pseudoplanktonic organisms to its being carried into a cold current, a great probability in the case of the Utica and Canajoharie shales, which were exposed to currents sweeping down from the northeast.

The parallel arrangement of the graptolites, according to Kraft, must have taken place in the deeper or more quiet reaches of the continental shelf, still accessible to the shore currents produced by wave action. This action is known to reach to depths of 50 meters or more, and in the case of tide currents to 200 meters and more. Kraft considers it possible that swarms of single species existed both as plankton and as pseudo or epiplankton in sargasso fields, and thus came to be buried together in case of sudden death.

It is likewise true that macerated graptolites are sometimes found in a condition suggesting their fading out through decomposition, but this is so relatively rare and in such contrast to the usual perfect preservation of the graptolites, owing to their durable chitinous test, as compared with other fossils, that it does not seem necessary to make a strong allowance for the imperfection of preservation in rocks where graptolites are absent or rare, as Schuchert suggests.

In contrast to the impure graptolite shales, the pure graptolite shales, such as the Schaghticoke, Deepkill and Normanskill shales in New York, and the Levis shale in Quebec and most of the shale formation of Great Britain, Australia etc. from continuous series of shales that are barren of fossils save the graptolites and their few plankton associates. Pure graptolite shale carries the most distinctive facies of fossils which fact can only point to an equally distinctive habitat, and which should not be confused or associated with the scattered occurrences of a few graptolites in various rocks outside the geosynclines. This is certainly a most important general fact, not to be lost sight of, that the continuous graptolite series in America as in Great Britain are strictly bound to geosynclines. The same is true of Australia where there is a continuous series of graptolite shales in the Ordovician, so well described by T. S. Hall, W. S. Dun, W. J. Harris, R. A. Keble, F. Chapman, K. Sherrard and others. The Ordovician geosyncline, as figured by E. C. Andrews (1938, p. 148), extends from Tasmania north through Victoria and New South Wales to the Queensland border and then swings northwest and continues through Central Australia.

**GRAPTOLITES FOUND WITH OTHER PLANKTON
ASSOCIATED AS PLANKTON AND EPIPLANKTON WITH
SARGASSO SEA**

It was the writer's opinion that the similarity of the associated plankton fauna in the pure graptolite beds by its similarity to the present epiplanktonic fauna of the Sargasso sea indicates a like habitat of that portion of the graptolites that lived as epiplankton attached to floating seaweeds. Professor Schuchert "can not believe that the graptolite faunas in themselves prove the existence of an oceanic sargassum." Nor is this claimed by the writer. His conviction arises from the aspect of the associated fauna, the forms of *Caryocaris*, minute brachiopods, sponges, worms etc. that are always found associated in the pure graptolite shale. It is certainly significant when species of *Caryocaris* are collected with the graptolites in east and west America, in Norway (Störmer, 1937), South America (Bulman, 1931) and Australia (Sherrard, 1930) and further that that type of phyllopod crustaceans has never been found outside the pure graptolite shales. Moreover the seaweeds themselves occur with the graptolites (see Ruedemann, 1934, p. 67) and the organic material, that colors the black shales originates undoubtedly from vegetable fouling as it does today (see Ruedemann, 1934, p. 46).

It may be mentioned in this connection that Kraft (op. cit. 239) observed that graptolite tests, both of *Diplograptus* and *Monograptus* which he dissolved out of limestone were still translucent with a yellowish brown coloring and the more transparent the better preserved they were. He therefore came to the conclusion that they were originally altogether transparent and thereby had acquired a biologic protection that is highly characteristic of planktonic organisms or had a yellowish brown translucent coloring that well agrees with the tints one observes while diving in the sea.

As stated before, the graptolites in the pure graptolite shales, as typically the Deepkill shales, lack the parallel arrangement. They must therefore be assumed to have, as a rule, been deposited in depths beyond the reach of wave-action, a view which fully agrees with the conclusion that they were deposited in foul bottoms not accessible to aerating currents.

A Sargasso sea presupposes a large Paleozoic Atlantic ocean. The existence of such (the Poseidon) is conceded by Schuchert and it is worth while to point out that that ocean, according to the current paleogeographic charts, was closed in the north in contrast to the present Northern Atlantic. If today, when the Atlantic is wide open

into the Arctic ocean between Scandinavia and Greenland and allows a strong branch of the Florida current to proceed into the Arctic ocean, a large Sargasso sea still forms in the eddy in the southern North Atlantic, it is much more probable that a perfect Sargasso sea formed in the center eddy of that Paleozoic ocean that was closed in the north.

Doctor Schuchert implies that the writer considers the planktonic and epiplanktonic faunas of the Sargasso sea as having originated in that sea and thence having been carried into the geosynclines. He would prefer to have the originally bottom-attached seaweeds and their fauna derived from the surrounding shallow tropical waters. This, undoubtedly is the case with the Sargasso flora and fauna of today and was, in the writer's opinion, also the case with the Paleozoic Sargasso flora and fauna. All that the writer claimed was that this originally littoral fauna became so adapted to the Sargasso sea habitat that it continued to live there as it does today, together with the Sargasso seaweed which also perpetuates itself by continual growth in the Sargasso sea. That is the reason why that peculiar fauna, as the *Caryocaris*, are never found in any beds other than the pure graptolite shale.

It is generally conceded now that the majority of the graptolite faunas as we see them in the pure graptolite shales, and in the impure ones as well, are wreckage resulting from storms, for whole rhabdosomes are always the exception; and it is further recognized that this wreckage was dropped into foul bottoms where the black shale was forming and scavengers lacking. Störmer has recently (1937, p. 276 and 1938, p. 173) added some significant observations anent the foul bottom character of the graptolite shale. He could transfer the observation made by Ström (1937) in the Norwegian fjords that the black shales formed under anaerobic conditions are followed or may alternate with gray shales which are formed whenever the bottom becomes ventilated by currents and observe successions of black graptolite shales with light gray benthonic (trilobite) shales. He could further strengthen the conclusion of the deposition of the pure graptolite shale under anaerobic condition by the observation of ringlike masses of fragments of *Clonograptus* (?) massed by currents around bare circular spots caused by gas bubbles.

POSSIBILITY OF ABYSSAL DEPTHS IN GEOSYNCLINES

We have already in the discussion of the radiolarian cherts and the pure graptolite shales asserted that they may have been deposited in

abyssal depths of geosynclines, in our case, in the Appalachian geosyncline. This statement is in conflict with the statement, often made by Schuchert (see 1936, p. 296), the leading authority on geosynclines, and others as well that all geosynclines remain shallow. According to Schuchert abyssal depths may only occur in mediterraneans but not in geosynclines. The majority of authors do not as yet distinguish between the two forms of elongate basins. Schuchert claims a principal and fundamental difference between geosynclines and mediterraneans (which however at first he also comprised under geosynclines as mesogeosynclines), consisting in the position of geosynclines *within* continents and of mediterraneans *between* continents. He considers the former as remaining shallow and rapidly filling with great thicknesses of clastic sediments coming from the geanticline (borderland) with which the geosyncline is always coupled, while the latter (mediterraneans) remain open ocean, often sink to abyssal depths and receive less clastic deposits. Making this fundamental distinction, Schuchert is forced to reject the view of the access of Sargasso-bearing currents into the geosyncline and of the possibility of abyssal depths within the geosyncline.

We fail to see that there is such a fundamental difference save by artificial definition. Our view is well illustrated by a recent review by Schuchert (1936) of a paper by P. H. Kuenen (1935) on a geologic interpretation of the bathymetrical results of the Snellius expedition in the eastern part of the Netherlands East Indies. In this review Schuchert criticizes Kuenen for calling the intricate system of deep basins divided by island arcs and shallow ridges geosynclines, stating that geosynclines are characterized "by universal coarse marine deposits, all of which were laid down in very shallow troughs, situated within the continent" etc., adding that "geosynclines have no shelf seas and no deep sea deposits" and that "both geosynclines and geanticlines are parts of a continent." "Structurally, geosynclines are relatively simple crustal affairs when compared to mediterraneans." "A mediterranean, on the other hand, is a far greater and a much deeper oceanic region which is also far more active dynamically."

Schuchert holds that "the East Indian archipelago, with its several abyssal intermediate basins and its island festoons with troughs on either side of lands, makes a highly variable morphologic complex that was wrought out of the East Indian mediterranean chiefly through its inherent periodic dynamic action, assisted by the pressures generated by the approaching continents of Asia and Australia.

The result is a tangle of linear and criss-cross arcs, conditioned by the multiplicity of subsiding and interfering basins and troughs, whereas the mountains that result from geosynclines have long and sweeping lines of conformity with the grain of the continents, like the narrow and simple Appalachians or the wider and more complex Cordilleras of western North America."

This excellent exposition of the differences between geosynclines and mediterraneans and the character of the East Indian archipelago seas would seem to be supported by the enormous Mesozoic radiolarite deposits described from Borneo by Molengraff (1902), which speak for the presence of abyssal depths in the middle of this supposed continental area. It is, however, on the other hand probable that the process of foundering of the old continent Melanesia was already in full swing in Jurassic time when the thousands of square miles of radiolarian ooze were formed in the Borneo sea.

The problem is: Are the East Indian deep troughs now within a continent and geosynclines or between two continents and parts of a mediterranean, because a perusal of the literature shows that there is no agreement on this point. Schuchert (op. cit. p. 296) considers the East Indian troughs as a mediterranean forming between the continents of old Asia (Cathaysia) and Australasia while Kuenen postulates that the Asiatic and Australian continents formed a more or less continuous mass, to which Schuchert adds: "surely not since the Paleozoic." However, recent geologists, as Chubb (1934) and Umbgrove (1937) consider the East Indian archipelago as the remaining western part of the so-called Melanesian continent that "was gradually folded, fractured and submerged in Mesozoic and Tertiary times."

It is therefore seen that there is still a very wide divergence of opinion as to the origin of the East Indian archipelago seas and that those seas may well have formed *within* a continent by folding and fracturing, instead of *between* continents. It is therefore possible that troughs may hold an intermediate position between the two and that the line can not be drawn so sharply as Schuchert would wish to.

Indeed, Bucher (1933, p. 267) rejects the differentiation between geosynclines and mediterraneans (mesogeosynclines) altogether, as being made on purely geographical basis. To him, the Appalachian geosyncline as well as the Alpine mediterranean, part of the great Tethys, are geosynclines, all partaking of the decisive tectonic character of "mobile belts."

It is therefore *a priori* to be postulated that geosynclines may partake of the character of mediterraneans to the extent that they may attain the size and depth of mediterraneans, at times at least, when situated within a continent. This seems to us to have been the case with the Appalachian geosyncline in Ordovician time. We have before pointed to the fact that this sea, stretching two thousand miles from Newfoundland to Alabama was 400 if not 500 miles wide. The recent works by Prindle and Knopf (1932) and Kay (1937) have been helpful in indicating the enormous contraction that has taken place by folding (100 miles in the Taconic region according to Prindle). Keyes has for many years asserted that the Cretaceous middle American sea was a true "ocean" in size and function, thereby placing it even above a mediterranean. The same could be said of this gigantic Appalachian sea. And there is no reason why a sea of such dimensions could not have sunk at times to abyssal depth in its central trough, even when as a rule it persisted as a shallow sea. The numerous disconformities and sharp lithologic breaks clearly testify to the dynamic mobility of this geosyncline.

The Appalachian geosyncline evolved out of the Proterozoic "eastern primary geosyncline" of Schuchert which according to that authority extended from Newfoundland at least to the Gulf of Mexico and perhaps through it. It became separated in its northern part, by the arising of the New Brunswick geanticline, into two troughs, the broader St Lawrence trough and the narrower Acadian geosyncline farther to the east. How far south this geanticline extended, is not definitely known. Schuchert would extend it to eastern Massachusetts and southeastern New York. We are here interested only in the broad St Lawrence trough through which the graptolite shales and radiolarian cherts extend. As graptolite shales are being discovered throughout the whole width of Maine, it becomes doubtful whether the New Brunswick geanticline was functioning as a barrier in early Ordovician time.

If we consider the St Lawrence geosyncline as a single trough, we find in the west, in the Chazy trough of Ulrich and Schuchert (1902), the Potsdam-Beekmantown-Chazy-Trenton series of sandstone, limestone and finally black shale (Canajoharie); in the middle (the Levis trough of Ulrich and Schuchert) the Lower Cambrian series of prevailing shales with interbedded quartzites and limestones (Nassau-Schodack etc. series) overlain by the great graptolite shale series of greatly prevailing shale with some limestone, chert and grit, the Schaghticoke, Deepkill, Normanskill and Snake

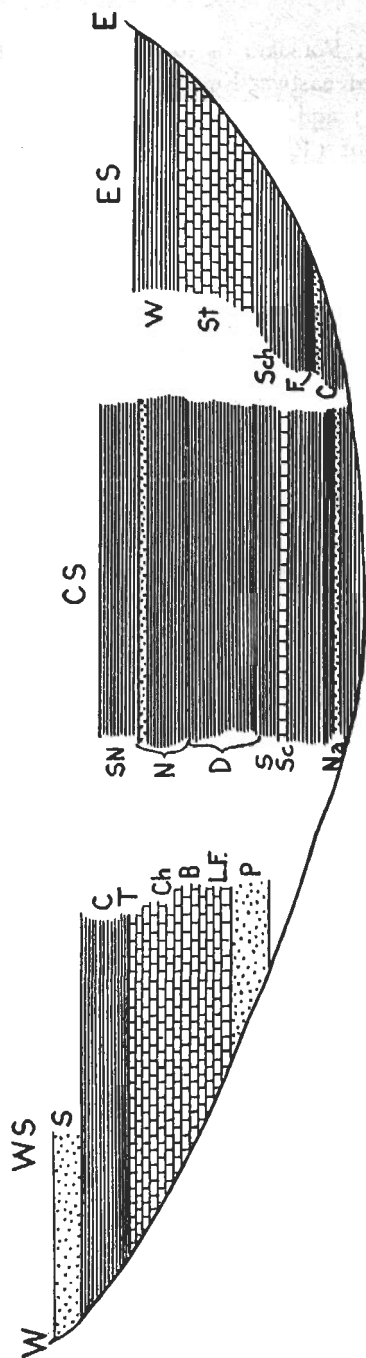


Figure 9 Diagrammatic section through St Lawrence geosyncline in middle Hudson River valley. WS western sequence ("Chazy trough"); CS central sequence ("Levis trough"); ES eastern sequence. P Potsdam sandstone, LF Little Falls dolomite; B Beekmantown limestone and dolomite; Ch Chazy Limestone; T Lowville, Black River and lower Trenton limestones; C Canajoharie shale (Trenton); S Schenectady beds; Na Nassau shale and quartzite; Sc Schodack shale and limestone; S Schaghticoke shale; D Deepkill shale; N Normanskill shale and grit (Upper Normanskill); SN Snake Hill shale; C Cheshire quartzite and shale; F (black) iron-horizon; Sch schists; St "Stockbridge limestone"; W Wallsmsac shale

Hill shales, ranging in age from Potsdam or lowest Beekmantown into the Trenton. If we proceed eastward we find in the eastern series, described by Dale (1899) and more recently with different correlations by Prindle and Knopf (1932), another series of shales, quartzites and limestones, all more or less metamorphosed, the lowest portion corresponding to the Lower Cambrian and the rest, mostly quartzite and limestone (Stockbridge limestone and dolomite of authors), to the Potsdam to Trenton series of the western or Chazy series.

Some years ago, while engaged with Doctor Newland, in a study of the ancient iron mines along the New York-Massachusetts line at the foot of the Taconic mountains, the writer was at all times able to recognize the formations of the central series, as notably the Lower Cambrian Nassau and Schodack beds, in the metamorphosed and variously named formations; thus distinctly recognizing the essential unity of all three series of formations. This unity becomes still more apparent farther south where around Stissing mountain Doctor Newland, T. Y. Wilson and the writer had no difficulty in recognizing the Nassau and Schodack beds. The fossiliferous Beekmantown-Trenton series has long been known there by the work of Dwight, and more recently (1927) by the work of Dr Eleanor Bliss Knopf. The eastern limestone and dolomite series has here moved far enough southwest to leave the highly metamorphosed belt. Doctor Knopf distinguishes here the basal ("Poughquag") quartzite of Lower Cambrian age, the Stissing dolomite (Lower and Middle (?) Cambrian) and in the "Wappinger limestone," the Upper Cambrian Hoyt limestone, the Rochdale and Copake limestones of Beekmantown age and above these unnamed limestones with Lowville, Black River and early Trenton fossils. All these formations are highly fossiliferous in their unmetamorphosed condition and they present in their faunas and lithology an amazing repetition of the western or Chazy series, thereby suggesting the littoral series of the same basin. The Lower Cambrian series extends even south to the Dover and Clove valleys back of the Hudson Highlands, as Doctor Goldring and the writer observed in the spring of 1937 at the time of the meeting of the New England Inter-Collegiate Geological Society.

Considering all three series as deposited in one geosyncline one recognizes in the western and eastern series the littoral deposits of the broad basin, in the central Lower Cambrian and Ordovician graptolite shale series the deeper water sediments of the central and deep-

est portion of the long geosynclinal basin. Also this basin was probably subject to sometimes abrupt dynamic changes producing upheaval of the bottom, as in upper Normanskill time, when the Normanskill grit beds were deposited. It is generally recognized that the fine-grained shales are mainly found at the lower levels, at the base and beyond the foot of the continental shelves, although irregularities may occur on the continental shelves, especially through the influence of the glacial periods.

BURDEN IRON ORE AND THE APPALACHIAN GEOSYNCLINE

In the course of the mapping of the Catskill quadrangle the writer was able to place the Burden iron ore as a definite horizon between the Nassau beds and the Schodack beds. As that iron ore horizon will be fully described in the bulletin on the Catskill quadrangle, it suffices here to discuss the relation of this iron ore horizon to the Appalachian geosyncline.

The Burden iron ore consists of limonite which has been mined for a long time in a belt south of Hudson and of siderite, from which the limonite has originated through weathering. The same combination of iron ores forms a long belt at the foot of the Taconic range, where many mines were operated, in the last century and some during the World War. Also these mines were found by Doctor Newland and the writer to be associated with metamorphosed rocks comparable to the unmetamorphosed Nassau and Schodack beds farther west and it is an interesting fact that the belt of Burden iron ore extending from the old Burden mines north for about seven miles to the Pless Hill mine corresponds to a break of iron mines and ore beds in the eastern belt, strongly suggesting that the Burden ore belt has been torn out of the eastern belt and carried by about 15 miles farther west than the rest of the iron belt by one of the overthrusts which pervade the whole region.

It is then to be concluded that the iron ore was deposited at the bottom of the geosyncline at the beginning of Lower Cambrian Schodack time, mainly in the eastern part of the trough, for in the middle sequence, save for the Hudson region, the iron ore is only represented by the iron-stained weakly ferruginous Bomoseen grit and ferruginous quartzite of the Schodack beds.

This asymmetric position of the iron-horizon (see figure 9) is very significant. Doctor Newland (1936) considers the siderite as a primary deposit in shore lagoons, into which iron solutions were brought from the land. The beds point therefore to a near-by shore

and continental land in the east, and as a corollary to deeper water in the middle of the geosyncline, where the Schodack shales were forming.

It is further very probable that the appearance of the iron ore in the Nassau quartzite and Schodack limestone interval has a much greater significance than would appear from the mere local occurrence in eastern New York. It has been found, in conversation with such authorities as Doctors Buddington, Newland and Resser, that they have observed the occurrence of iron ore beds in their respective districts of research between the basal quartzites, whatever the name of these may be in the region, and the overlying limestones and shales of Lower Cambrian age, with various names. It is important to note here that the Nassau quartzite, as well as the basal quartzites of other areas in the Appalachian geosyncline, is unfossiliferous; the Nassau beds have yielded nothing but the *Oldhamia*, a worm-trail. It is now probable, as Doctor Resser holds, that the Nassau quartzite and all the basal quartzites throughout the Appalachian geosyncline are Precambrian south from the Random quartzite in Newfoundland which was considered already by Walcott and is still held to be the last stage of the Precambrian, because connected with undoubted Precambrian by transitional beds and completely unfossiliferous.

If this correlation is true, the iron ores which seem to appear throughout the Appalachian geosyncline above the basal quartzite and thereby above the terminal Precambrian mark the long period of continental emergence and erosion, the Lipalian period of Walcott. It is worth while to remember in this connection that widely spread iron ore deposits are beginning to be considered as evidence of long periods of continental erosion which furnished the iron solutions to the continental and littoral waters. This view is especially prevalent among European students of sedimentation problems as Johannes Walther (1893) and Hermann Schmidt (1935).

In the case of the Burden iron ore, the emergence of the eastern borderland of the geosyncline or of a geanticline directly east of the St Lawrence trough, which like the present Highlands was rich in magnetite, would have provided ample stores of iron. The washing out of the regolith of the entire borderland Appalachia supplied the iron for the long series of iron deposits in the Appalachian geosyncline save the secondary. This serves to prove that the long Appalachian geosyncline persisted from late Precambrian time as a continuous basin at least through early Ordovician time.

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Explanation of Figures

Figure 10

Figures 10 to 14 show the Deepkill, Normanskill chert Radiolaria. They are reproduced in the original arrangement. Enlargement of figures $\times 100$; drawn by R. Ruedemann. All originals in the New York State Museum.

- 1 *Sphaerocozium minutum* Rued. Holotype. Ordovician red Normanskill chert. Fly Summit, Washington county, N. Y.
- 2, 3, 4 *Cenosphaera antiqua* Rued. No. 2, holotype; nos. 3 and 4, paratypes. Lower Ordovician Deepkill chert. South end of Mt. Merino, Columbia county, N. Y.
- 5 to 7 *Cenosphaera pachyderma* Rüst. No. 5, holotype; nos. 6 and 7, paratypes. Ordovician red Normanskill chert. Fly Summit, Washington county, N. Y.
- 8 *Choenicosphaera multispinosa* Rued. Holotype. Lower Ordovician Deepkill chert. South end of Mt. Merino, Columbia county, N. Y.
- 9, 10 *Choenicosphaera brevispina* Rued. No. 10, holotype; no. 9, paratype. Ordovician Normanskill chert. Glenmont, Albany county, N. Y. New York State Museum, slide no. 1
- 11, 12 *Siphonosiphonia (Merosiphonia) streptosiphonia* Rued. No. 11, holotype; no. 12, paratype. Ordovician red Normanskill chert. Fly Summit, Washington county, N. Y.
- 13 *Xiphosphaera parva* Rued. Holotype. Lower Ordovician Deepkill chert. South end of Mt. Merino, Columbia county, N. Y.
- 14 *Xiphosphaera brachyacantha* Rued. Ordovician red Normanskill chert. Fly Summit, Washington county, N. Y.
- 15, 16, 17 *Xilosphaera macracantha* Rued. No. 15, holotype; nos. 16 and 17, paratypes. No. 15 Ordovician red Normanskill chert, Fly Summit, Washington county, N. Y.; nos. 16 and 17, Normanskill radiolarite, near Ghent, Columbia county, N. Y.
- 18 *Staurosphaera sancta* Rued. Holotype. Ordovician red Normanskill chert. Fly Summit, Washington county, N. Y.
- 19 *Staurosphaera crassispina* Rued. Holotype. Ordovician red Normanskill chert. Fly Summit, Washington county, N. Y.
- 20 *Stylostaurus hindei* Rued. Holotype. Ordovician Normanskill chert. Glasco, Ulster county, N. Y.
- 21, 22 *Acanthosphaera minuta* Rued. No. 22, holotype; no. 21, paratype. Lower Ordovician Deepkill chert. South end of Mt. Merino, Columbia county, N. Y.
- 23 *Acanthosphaera robusta* Rued. Holotype. Ordovician Normanskill radiolarite. Near Ghent, Columbia county, N. Y.
- 24 *Acanthosphaera perspinosa* Rued. Ordovician Normanskill chert. Glenmont, Albany county, N. Y.

Figure 11

- 1 *Heliosphaera venusta* Rued. Holotype. Lower Ordovician Deepkill chert. South end of Mt. Merino, Columbia county, N. Y.
- 2, 3, 4 *Heliosphaera haeckeli* Rued. No. 2, holotype; nos. 3 and 4, paratypes. Ordovician Normanskill radiolarite. Near Ghent, Columbia county, N. Y.
- 5, 6, 7, 8 *Heliosphaera riisti* Rued. No. 5, holotype; nos. 6 to 8, paratypes. Nos. 5, 7, 8 from Ordovician red Normanskill chert, Fly Summit, Washington county, N. Y.; no. 6 from Ordovician Normanskill chert, Victory Mills, Saratoga county, N. Y.

- 9, 10, 11, 12, 13 *Heliosphaera micropora* Rued. No. 9, holotype; nos. 10, 11, 12, 13, paratypes. Ordovician Normanskill chert breccia, Ghent, Columbia county, N. Y.
- 14, 15 *Haliomma antiquum* Rued. No. 14, holotype; no. 15, paratype. Lower Ordovician Deepkill chert, south end of Mt. Merino, Columbia county, N. Y.
- 16, 17 *Haliomma penrosei* Rued. No. 16, holotype; no. 17, paratype. Ordovician red Normanskill chert, Fly Summit, Washington county, N. Y.

Figure 12

- 1 *Dorydictyum minutum* Rued. Group of tests; (b) holotype; (a, c) paratypes. Lower Ordovician Deepkill chert. South end of Mt. Merino, Columbia county, N. Y.
- 2, 3, 4, 5 *Dorydictyum magnum* Rued. No. 2, holotype; nos. 3, 4, 5, paratypes. Nos. 2 and 5 from Ordovician Normanskill chert at Glenmont, Albany county, N. Y. No. 3 from Ordovician Normanskill radiolarite near Ghent, Columbia county, N. Y. No. 4 from Ordovician red Normanskill chert at Fly Summit, Washington county, N. Y.
- 6 *Doryplegma priscum* Rued. Holotype. Lower Ordovician Deepkill chert. South end of Mt. Merino, Columbia county, N. Y.
- 7, 8, 9, 10 *Doryplegma armatum* Rued. No. 8, holotype; nos. 7, 9, 10, paratypes. Nos. 7 and 8 from Ordovician red Normanskill chert at Fly Summit, Washington county, N. Y. Nos. 9 and 10 from Ordovician Normanskill chert at Victory Mills, Saratoga county, N. Y.
- 11 *Doryplegma nux* Rued. Holotype. Ordovician Normanskill red breccia. Near Ghent, Columbia county, N. Y.
- 12 *Triplosphaera (?) maxima* Rued. Holotype. Ordovician red Normanskill chert. Fly Summit, Washington county, N. Y.
- 13, 14 *Druppula simplex* Rued. No. 13, holotype; no. 14, paratype. Ordovician Normanskill chert. East of Flint Mine hill, Columbia county, N. Y.
- 15 *Spongoprimum oligoporum* Rued. Ordovician red Normanskill chert. Fly Summit, Washington county, N. Y.

Figure 13

- 1 *Spongotrochus primaevus* Rued. Holotype. Lower Ordovician Deepkill chert. South end of Mt. Merino, Columbia county, N. Y.
- 2, 3 *Sethocapsa pytine* Rued. No. 2, holotype; no. 3, paratype. Ordovician Normanskill chert. Fly Summit, Washington county, N. Y.
- 4 *Lithocampe (?) spinosa* Rued. Holotype. Ordovician red Normanskill chert. Fly Summit, Washington county, N. Y.
- 5 *Halicalyptra similis* Rued. Holotype. Ordovician red Normanskill chert. Fly Summit, Washington county, N. Y.
- 6 *Halicalyptra ambulans* Rued. Holotype. Ordovician red Normanskill chert. Fly Summit, Washington county, N. Y.
- 7 *Haliomma penrosei* Rued. Specimen showing distinctly the cortical and medullary shells and the connecting bars. Ordovician red Normanskill chert. Fly Summit, Washington county, N. Y.
- 8 ? *Heliosphaera haeckeli* Rued. Specimen with abnormal development and outline. Ordovician red Normanskill chert. Fly Summit, Washington county, N. Y.
- 9 Shadow of radiolarian test with sections of corona of long spines, diverging in all directions and showing the great development of spines, not observable in the thin sections. Ordovician red Normanskill chert. Fly Summit, Washington county, N. Y.

- 10, 11 Groups of spicules and fragments of radiolarian tests composing the chert. No. 10 from Ordovician Normanskill chert breccia at Ghent, Columbia county, N. Y. No. 11 from Ordovician Normanskill radiolarite near Ghent, Columbia county, N. Y.
- 12, 13, 14, 15 Sponge spicules from chert. No. 12 from Lower Ordovician Deepkill chert, south end of Mt. Merino, Columbia county, N. Y. No. 13 from Ordovician Normanskill chert at Victory Mills, Saratoga county, N. Y. Nos. 14 and 15 from Ordovician red Normanskill chert at Fly Summit, Washington county, N. Y.
- 16, 17 Problematica, possibly coprolites. Ordovician red Normanskill chert. Fly Summit, Washington county, N. Y.

Figure 14

Radiolaria Restorations

Restorations all 75 times enlarged. The frontal spines are left out in numbers 3, 4, 5, 7, 10 and 11, mainly to bring out the internal structure.

- 1 *Ccnosphaera pachyderma* Rued.
- 2 *Coenicosphaera brevispina* Rued.
- 3 *Siphonosphaera streptosiphonia* Rued.
- 4 *Xiphosphaera macracantha* Rued.
- 5 *Xiphosphaera brachyacantha* Rued.
- 6 *Staurosphaera sancta* Rued.
- 7 *Staurosphaera crassispina* Rued.
- 8 *Heliosphaera riisti* Rued.
- 9 *Halimma penrosei* Rued.
- 10 *Doryplegma armatum* Rued.
- 11 *Druppula simplex* Rued.
- 12 *Spongoprimum oligoporum* Rued.
- 13 *Halicalyptra similis* Rued.
- 14 *Sethocapsa pytine* Rued.
- 15 *Lithocampe (?) spinosa* Rued.

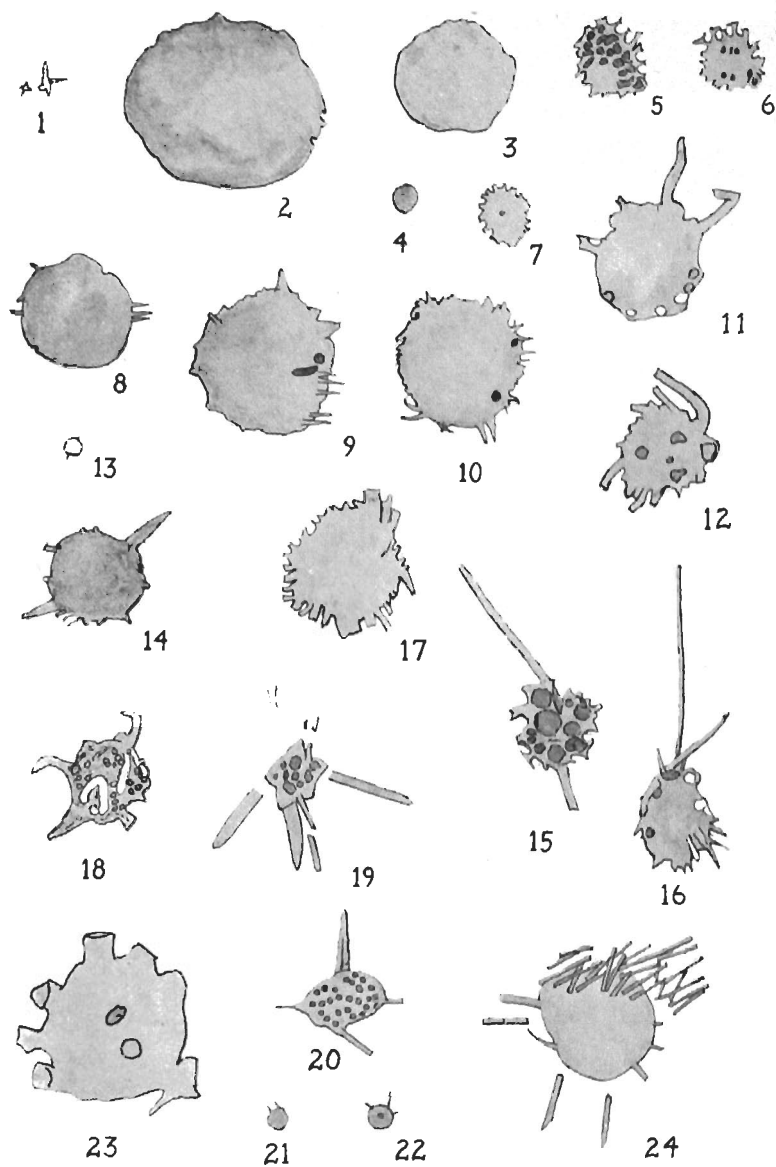


Figure 10

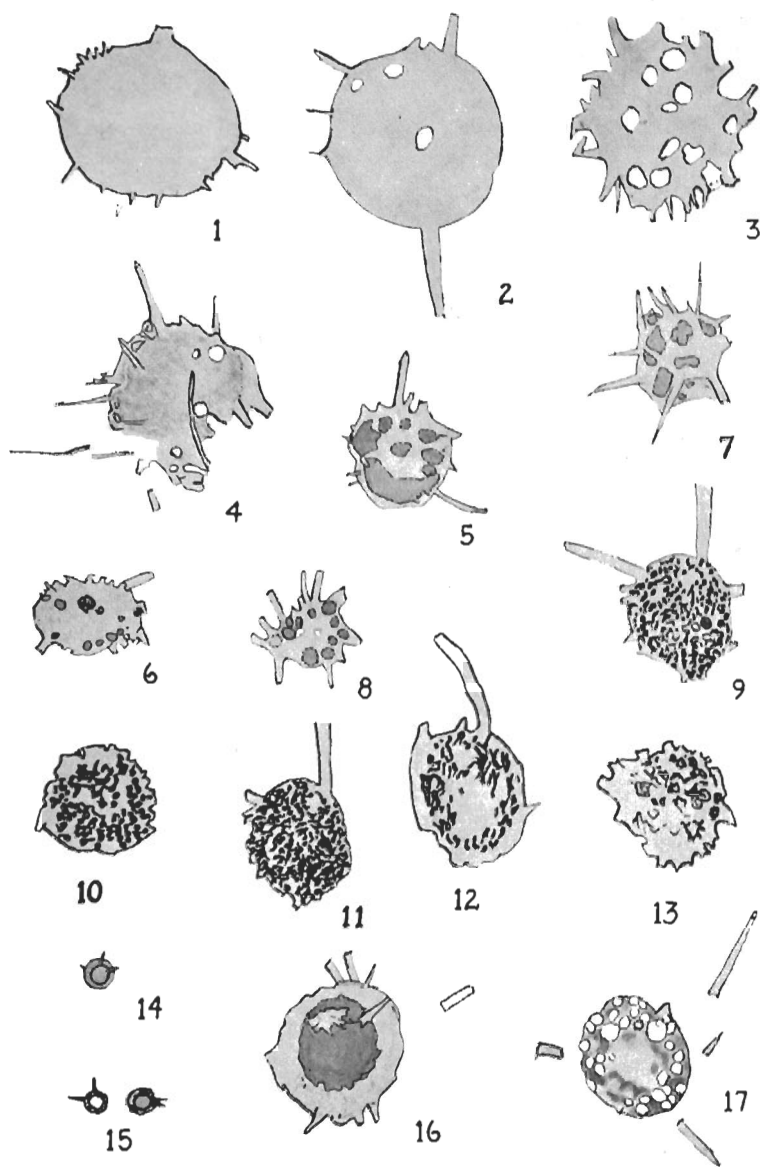


Figure 11

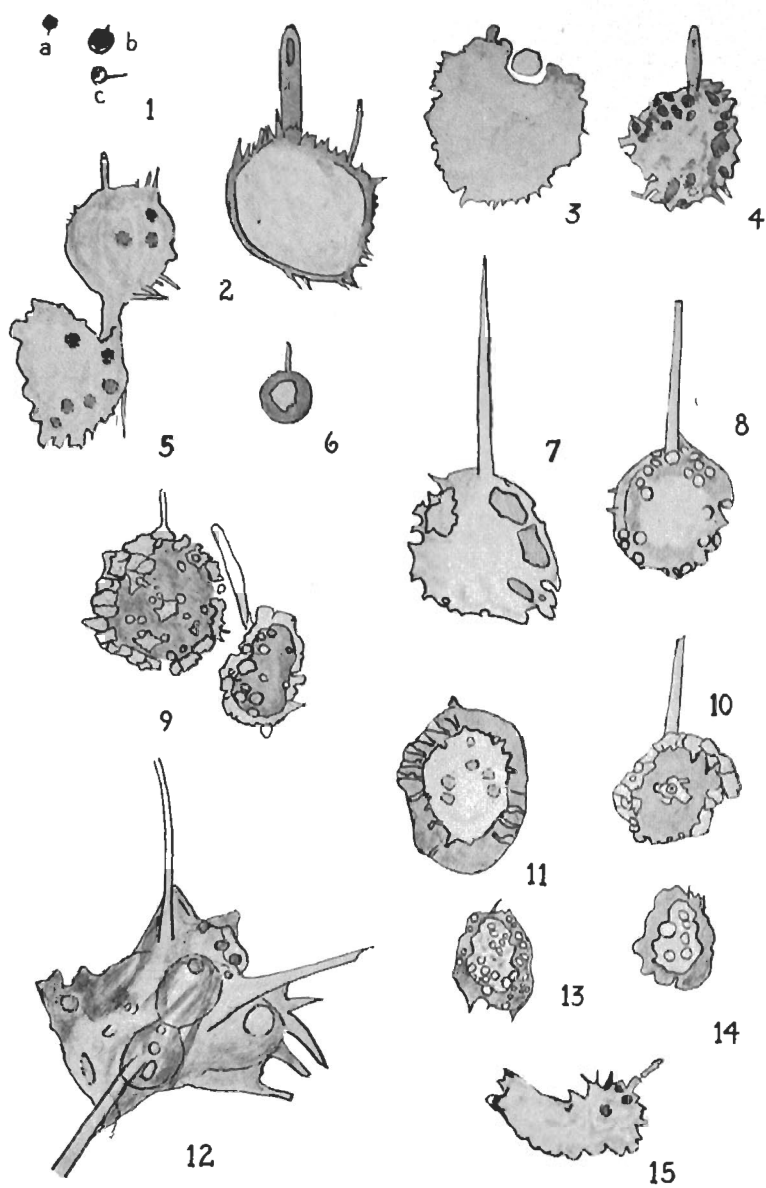


Figure 12

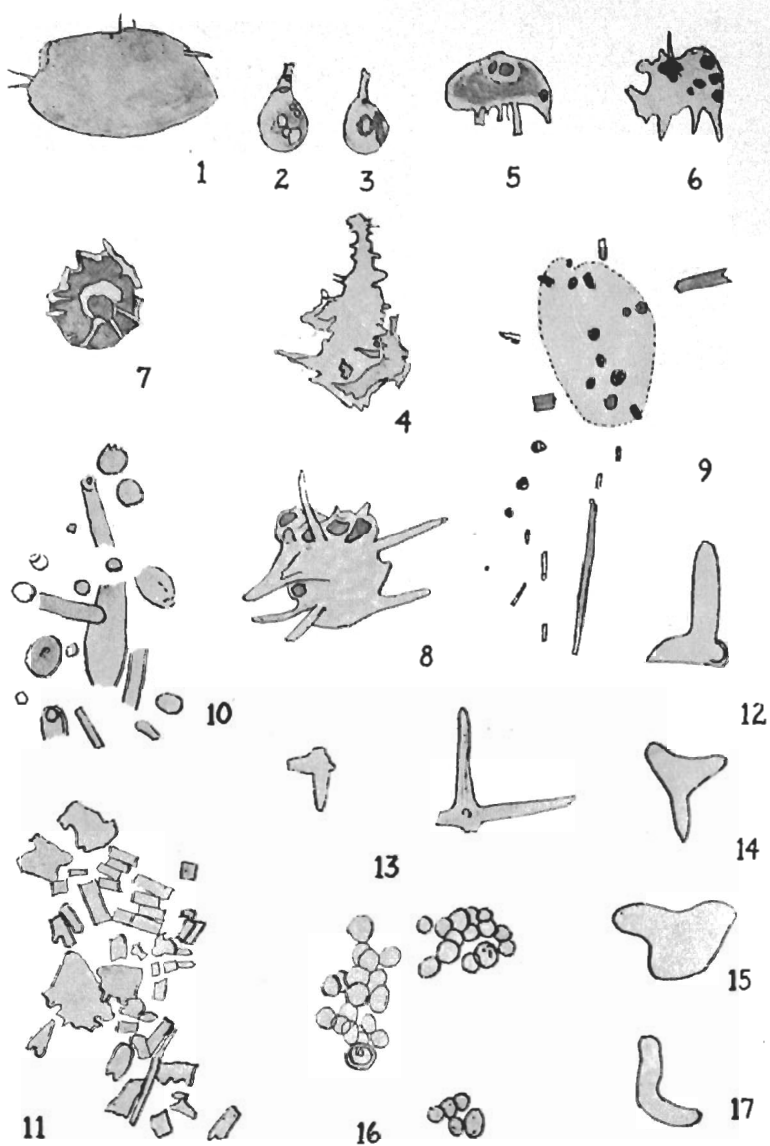


Figure 13

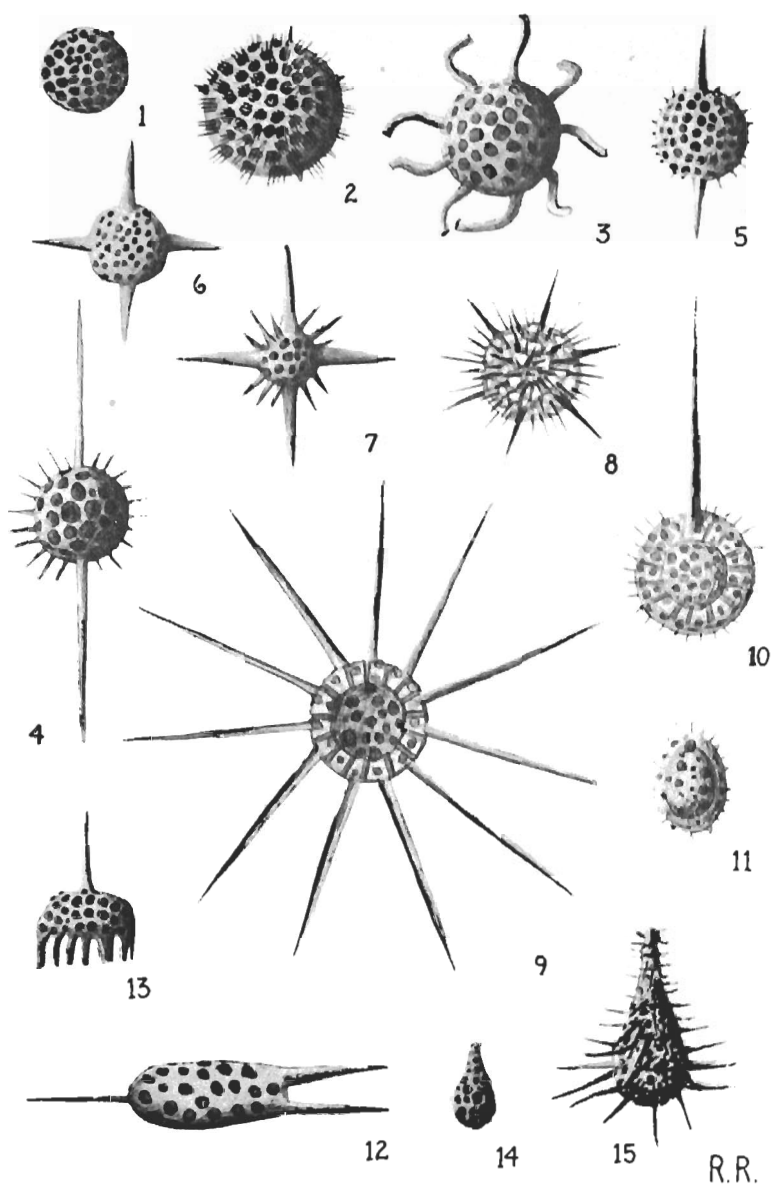


Figure 14

GEOLOGICAL STUDIES IN ULSTER COUNTY, NEW YORK

BY B. F. HOWELL PH.D.

Ulster county was settled by thrifty Dutch and English farmers and merchants, who developed its natural resources, as they were known to them, in the usual colonial fashion. They cleared the forests from the better farming lands, erected substantial homes, set up mills on the streams for grinding their grain and sawing their lumber and built roads to connect their farms with Kingston, the town built on the banks of the Hudson where the mouth of Rondout creek made a convenient anchorage for the ships which served their commerce. Agriculture was their basic industry and there were many prosperous farms throughout the county. The prosperity of the farmers swelled the trade of the town and the population of Kingston and many of her citizens became wealthy.

The well-to-do farmers and the successful merchants and professional men of the town built themselves solid and comfortable houses of the local limestones, which were well adapted to that purpose, and the farmers also burned the stone for lime. They made millstones from the conglomerates of Shawangunk mountain and paved their walks with slabs of an easily worked sandstone which they found in the Catskills. They built up their roads with the gravel and shale which was conveniently at hand in the hillsides and made bricks from the glacial clays which flanked the Hudson at some localities.

Limestones of different sorts outcropped at so many places in the county that quarries were opened in them at numerous localities and the farmers and quarrymen became acquainted with the various kinds of stones available. In 1818 a French engineer, named Vicat, discovered that some of the more magnesian limestones found in a belt extending from Kingston southwestward to the northeastern end of Shawangunk mountain were natural cement rocks, which needed only to be burned and ground to be ready for use. This very important discovery led to the development of an industry which flourished in the county for more than a hundred years and made the mining and milling of these rocks the most important local industry except agriculture.

The abundant natural outcrops of the region, and the many exposures of the cement rocks and the accompanying strata which were made during the mining operations made it possible for geologists

and engineers to learn much about the geology of the belt of rocks in which the cement companies were operating. These rocks were found to be Paleozoic deposits, mostly of marine origin and many of them filled with fossils. Their order of succession was not difficult to determine, but their tectonic structure was found to be very complex in some places.

Located, as they were, near several important centers of geological and paleontological research and in a state which had an active geological survey and museum, the rocks of Ulster county have been studied by many geologists and paleontologists and the county has become classic ground for students of the Earth sciences.

Near-by universities annually sent their classes to Kingston and Rosendale, at the two extremities of the cement rock belt, and professors and graduate students made intensive studies of some of the more interesting problems which they met in the course of these excursions. Princeton University made Rosendale the center for its field courses in geology and classes from that institution, led by the late Professor Gilbert Van Ingen, who had at one time been a member of the staff of the State Geological Survey, mapped much of the cement belt and collected a great deal of information on the stratigraphy and structure and many thousands of fossils.

Because of the economic importance of some of its geological natural resources, the State Geological Survey assigned men at various times to prepare reports on the rocks and the quarrying and mining industries of Ulster county. Two such reports were published by the Survey in 1894—one, by N. H. Darton, on the general geology of the county, the other, by F. L. Nason, on the economic geology. But only one detailed study has been made by a member of the Survey staff of any geological problem in the area. This was an investigation of the cement rocks and the associated beds at Kingston, which was carried out by Professor Van Ingen and P. E. Clark, the report on which was published in 1903. Professor Van Ingen joined the faculty of Princeton University not long after the completion of this investigation, and it was planned that he and his students should continue his studies of the geology of the county, with the hope that the results would be published by the New York State Museum in a series of papers which would make available to geologists and paleontologists generally a comprehensive description of the geology of the county and detailed descriptions of some of its more important, interesting and difficult features.

Professor Van Ingen and his students, of whom the writer was one, visited Ulster county many times and spent an aggregate of several years in the study of its geology. Unfortunately Professor Van Ingen did not live to complete any manuscript dealing with the region. He did, however, leave many carefully prepared field notes. It has fallen to the lot of the author, who has succeeded him at Princeton, to complete the task which he began. It is the author's wish that the series of papers on the geology and paleontology of this important area, of which this is the first and introductory one, may serve as a memorial to his teacher and may make available to others the fund of information about the fascinating geology of this classic district which Professor Van Ingen spent so many years in gathering.

The publication of this series of papers has been made possible by the active and helpful interest of Dr Rudolf Ruedemann, who was a lifelong friend of Professor Van Ingen. Dr Winifred Goldring has also given generously of her time and knowledge in helping to solve some of the paleontological problems which have had to be dealt with in the investigations on which these papers are based. The author is grateful also to her, and takes this opportunity to express his appreciation of her assistance.

There is no more interesting and instructive area of sedimentary rocks of equal extent in all eastern North America than the one encompassed by the boundaries of Ulster county. A natural scenic beauty, a pleasant summer climate, an amazing wealth and variety of geological exposures, and an abundance of well-preserved fossils all combine to make it an area which will always be a happy hunting ground for students of the Earth sciences and lovers of nature. It is hoped that the papers here presented, and the others which are to follow in this series, may aid future visitors to the county to enjoy and profit by their rambles over its hills, and may help its citizens to appreciate the natural wonders by which they are surrounded and to develop intelligently the geological natural resources of their farms.

A bibliography of publications dealing with the geology of Ulster county—especially the Rosendale-Kingston portion of it—is presented herewith:

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GRAPTOLITES FROM ORDOVICIAN NORMANSKILL SHALE AT KINGSTON POINT, ULSTER COUNTY, NEW YORK

BY B. F. HOWELL PH.D.

The Lower Ordovician Normanskill shale of New York has long been famous for its numerous species of graptolites, but the many fossils which have been found in it have been collected from only a few localities. Fifty years ago Whitfield described three sponges (*Rhombodictyon discum*, *R. reniforme*, and *R. reniforme rhombiforme*) from the type locality of the formation at Kenwood on the Normanskill just south of Albany ('86, p. 346-48). Later three brachiopods (*Leptobolus walcotti* Ruedemann, *Paterula amii* Schuchert and *Schizotreta papilliformis* Ruedemann) were recorded by Ruedemann from the formation at Mount Merino, near Hudson ('01, p. 569, 570). More recently unnamed algae and six species of eurypterids (*Dolichopterus breviceps*, *Eusarcus lingulatus*, *Pterygotus* (*Eusarcus*?) *nasutus*, *P. normanskillensis*, *Eurypterus chadwicki* and *Stylonurus modestus*) have been collected at Catskill. These were described by Clarke and Ruedemann ('12) in their monograph on the Eurypterida of New York.

It has seemed probable that fossils would be discovered in the Normanskill shale somewhere in the Hudson valley south of Catskill and paleontologists have frequently searched for them there; but no record of their discovery has been published, as far as the writer has been able to determine, except for the one with which this paper deals, and that record as published did not include the names of the species found or the exact age of the beds from which they were secured. It has therefore seemed worth while to call attention to this discovery, made by the late Professor Gilbert Van Ingen, in 1900, of what are known to be Normanskill graptolites on Kingston Point in Ulster county, 20 miles south of Catskill, and to record the identifications of these fossils that have since been made by Dr Rudolf Ruedemann and the present location of the specimens.

The writer is indebted to Doctor Ruedemann for the opportunity to publish his identifications.

The discovery of Ordovician fossils in the Kingston region was announced by Professor Van Ingen and P. E. Clark in 1903 (p. 1181). These authors recorded the finding of the brachiopods,

Sowerbyella sericca (Sowerby) and *Dalmanella testudinaria* (Dalman), and "a few graptolites" in "Champlainic" beds in the vicinity of Kingston. They did not state just where the brachiopods were discovered, but they gave Kingston Point as the locality from which the graptolites had been obtained.

Some of the brachiopods collected by Professor Van Ingen from the Ordovician beds in the vicinity of Kingston are now in the paleontological collection of Princeton University, and are labeled as having come from the Vlightberg at Rondout. It is believed that these fossils are of Snake Hill, not Normanskill, age, as stated on another page (83) of this Bulletin, and that the beds from which they were collected lie stratigraphically above those on Kingston Point which yielded the graptolites. These Kingston Point beds are proved by their graptolites to belong in the Normanskill formation.

Some at least of the graptolites collected by Professor Van Ingen are preserved at Princeton. They have been identified by Doctor Ruedemann as *Corynoides gracilis perungulatus* Ruedemann, *Climacograptus bicornis* (Hall), *Climacograptus modestus* Ruedemann, and *Diplograptus* (*Orthograptus*) *acutus* Lapworth. They are nos. 7439, 41,766, 41,767, 41,769-41,772, and 41,882-41,892 in the paleontological collection of Princeton University.

Most of these Kingston Point graptolites are fragmentary, and are not particularly valuable fossils as such. They are all, however, important as index fossils proving the presence of Normanskill beds in the Kingston region.

A single specimen of what may be an *Orthoceras* that was collected by Professor Van Ingen on Kingston Point is also preserved at Princeton. It is too poorly preserved for exact identification. It is no. 5950 in the Princeton collection.

Fossils are so rare in the Ordovician shales in the Hudson Valley region south of Albany that it is proving very difficult to unravel the stratigraphy and structure of those beds. It is therefore desirable that all new discoveries of such fossils be recorded. It is probable that continued search will be rewarded by the finding of additional specimens. When enough of them have come to light, we shall be able better to work out the geologic history of this important area.

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TWO NEW LOCALITIES FOR FOSSILS IN THE ORDOVICIAN SNAKE HILL SHALE OF ULSTER COUNTY, NEW YORK

By B. F. HOWELL PH.D.

The Middle Ordovician Snake Hill shale has been known as a distinct formation since 1912, when Ruedemann gave it its name ('12, p. 58-65; Cushing and Ruedemann, '14, p. 93-99). It was then recognized only in the region around the mouth of the Mohawk river, from near Saratoga southward to the vicinity of Albany. In that area it had yielded 78 species of invertebrates.

In 1926 Holzwasser (p. 61-64) found slates and graywackes containing a Snake Hill fauna in the Newburgh quadrangle, 75 miles south of Albany. This discovery made it seem probable that the formation would be found to outcrop somewhere between Newburgh and Albany. Van Ingen and Clark had in 1903 (p. 1181; see Sharp, '32, p. 355-61) recorded *Dalmanella testudinaria* (Dalman) and "*Plectambonites sericeus*" (= *Sowerbyella sericea jugata* Ruedemann)—two brachiopods common in the Snake Hill of the Albany and Newburgh regions—from the Vlightherg, at Kingston, 25 miles north of Newburgh. Examples of these brachiopods, collected from this locality by Professor Van Ingen in 1911, are preserved in the paleontological collection of Princeton University (no. 7343). They occur in a fine-grained sandstone. These species were known to occur in other shales than those of the Snake Hill, and could therefore not be used to prove that the beds holding them were referable to that formation. The presence of these brachiopods at Kingston made it seem probable, however, that further search in the Kingston region would be rewarded by the discovery of other fossils whose age could be more exactly determined.

This paper announces the finding of such fossils in black shale at two localities in the vicinity of Rosendale, 10 miles southwest of Kingston.

In 1922 a group of students from Princeton University, which was studying the geology in the vicinity of Rosendale, under the writer's direction, found crinoids, brachiopods and trilobites in an outcrop of what was proved by its fossils to be Snake Hill shale on the north side of the Wallkill Valley Railroad track at Hickorybush, about three miles north-northwest of Rosendale. There are also in the paleontological collections of Princeton University a few examples

of a pelecypod which was collected by Professor Van Ingen from this same shale at Lefever falls, about two miles east-northeast of Rosendale. The finding of these two new localities for Snake Hill fossils has seemed to call for a printed record of the discoveries and a description of the fossils.

The fossils found at Hickorybush were in a steep bank beside the railroad track, where the shale containing them had been well exposed in the grading of the roadbed. The Snake Hill at this locality is a thin-bedded, fissile, fine-grained black shale, which has been tightly folded as a result of the Taconic and Appalachian revolutions. The fossils are not common in it and must be carefully searched for in the small pieces into which the shale breaks up on weathering. They are made somewhat easier to find by the fact that they are stained brown, and thus differ in color from the shale in which they occur. They all occur as molds, none of the original hard parts of the animals being preserved. Most of the specimens are somewhat distorted.

All of the fossils found in this exposure came from approximately the same horizon, and are presumably the remains of a single fauna. They all appear to be referable to eight species—three crinoids, two brachiopods, two pelecypods and a trilobite, as described below.

The writer wishes to take this opportunity to thank Doctor Ruedemann and Dr Winifred Goldring for assistance in the identification of his fossils.

DESCRIPTION OF SPECIES

Crinoids

Heterocrinus sp. indet.

Two short sections of stem, with only the side exposed, and one stem segment, with only the end exposed, are included in the crinoid material. They can be identified as parts of a *Heterocrinus*, but their species can not be determined. They are nos. 41,773 and 41,774a in the paleontological collection of Princeton University.

Schizocrinus sp. a

Several short sections of stem and one stem segment of a *Schizocrinus* having a large canal and distinctly notched articulations between the stem segments appear to belong to a single species, which can not, however, be identified specifically. These specimens are nos. 41,774b, 41,775-41,780 and 41,796-41,799 in the paleontological collection of Princeton University.

Schizocrinus sp. b

A number of short sections of stem and three stem segments of a somewhat larger *Schizocrinus*, with a smaller canal than that of the preceding species and no visible notches between the stem segments, seem to be referable to a second species of that genus, although to exactly what species can not be determined. These specimens are nos. 41,781-41,795 and 41,830a in the paleontological collection of Princeton University. Similar stem segments accompany the brachiopods from the Snake Hill beds of the Vlightberg, collected by Professor Van Ingen and referred to on an earlier page, that are preserved at Princeton.

It is difficult to identify such fragments of crinoids as have been found in the Snake Hill beds at Hickorybush, and the above identification of the specimens now available may not be the proper one. It seems, however, the best one that can be made with the very imperfect material now in hand.

Brachiopods

Dalmanella rogata (Sardeson)

Brachiopods are the commonest fossils in the beds at Hickorybush. They are all referable to two species, *Dalmanella rogata* (Sardeson) and *Sowerbyella sericea jugata* Ruedemann. Of the two, *D. rogata* is much the less common.

When first identified in the Snake Hill fauna, *D. rogata* was identified as *D. testudinaria* (Dalman). It seems, however, to be more properly referred to Sardeson's species, *rogata*.

The specimens that have been found at Hickorybush are preserved in the paleontological collection of Princeton University, nos. 41,800-41,823 and 41,824a and 41,825a.

Some of the valves here referred to *D. rogata* have finer ribs than do the others. It is possible that they belong to a variety of the species. The specimens are, however, so poorly preserved and so much distorted that it seems best not to attempt to decide this question on the basis of the evidence that they afford.

Sowerbyella sericea jugata Ruedemann

In his 1912 description of the Snake Hill fauna Doctor Ruedemann stated that the fauna included a small brachiopod of the "*Plectambonites sericeus*" group, which was perhaps typical "*sericeus*," but which might possibly be a variety of that species. He suggested

that, if the form proved to be a variety, it should receive the varietal name "*jugata*." This form is the commoner of the two brachiopods in the Hickorybush beds.

The publication of Professor O. T. Jones' memoir (1928) has made it possible for American students to make more accurate comparisons of their forms of this genus with British forms. A comparison of the Hickorybush specimens with Professor Jones' figures of the holotype and other examples of *Sowerbyella sericea* (Sowerby) has led the writer to the conclusion that the two are different—the New York form being smaller and having finer ribs. He has therefore adopted Doctor Ruedemann's varietal name.

The Hickorybush specimens of this variety are nos. 41,824*b*, 41,825*b*, and 41,826-41,829, 41,830*b,c*, and 41,831-41,859 in the paleontological collection of Princeton University. They vary much in size, but all appear to be referable to the one variety.

Pelecypods

Ctenodonta subcuneata Ruedemann

A single young pelecypod valve found at Hickorybush is probably assignable to this species. It is Princeton no. 41,862.

Pelecypods and Trilobites

Cryptolithus tessellatus Green

Two fragments of the head shield of a *Cryptolithus* agree, as nearly as can be determined, with the cephalon of this species. Both are too poorly preserved for certain identification. They are nos. 41,863 and 41,864 in the Princeton collection.

The second new locality for Snake Hill fossils discovered in the vicinity of Rosendale is near Lefever falls, two miles northeast of Rosendale. In a very fine-grained black shale at that place there have been found a few pelecypods, as follows:

Ctenodonta prosseri Ruedemann

A single tiny pelecypod right valve appears to be that of a young individual of this species.

It is no. 41,860*a1* in the paleontological collection of Princeton University. Its counterpart is 41,860*b1* in the same collection.

Ctenodonta subcuneata Ruedemann

One adult and two young valves of a *Ctenodonta* seem referable to this species. They are nos. 41,860a,2,3,b1,2,c and 41,861a,b in the Princeton collection.

Further search in the Ordovician shales of Ulster county will doubtless be rewarded by the discovery of additional Snake Hill fossils which will help to make possible the working out of the difficult stratigraphy and structure of those beds.

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NEW LOCALITIES FOR FOSSILS IN THE DEVONIAN ESOPUS GRIT OF ULSTER COUNTY, NEW YORK

BY B. F. HOWELL PH.D.

The Esopus grit was deposited in marine waters in eastern New York and adjacent parts of New Jersey and Pennsylvania in the latter part of Oriskanian—late early Devonian—time. It thus forms the uppermost portion of the Lower Devonian stratigraphic column in that part of the Appalachian Belt. Although it is rather widely distributed areally and has long been known to paleontologists, it has yielded only a very few different kinds of fossils. Of the few, all are rare except the problematical one, *Taonurus caudagalli* (Vanuxem)—possibly a worm—which is abundant at some localities. Van Ingen and Clark ('03, p. 1204) recorded three brachiopods, *Leptocoelia acutiplicata* (Conrad), *Atrypa spinosa* (Hall), and an unidentified discinoid from the Esopus; and other species have been collected by G. H. Chadwick in the Catskill region (personal communication; and Goldring 1935); but except for these discoveries the Esopus has appeared to be barren of organic remains. Therefore the finding by Princeton University field parties under the direction of the writer, and by R. M. Fullé and J. T. Sanford, of several new localities where fossils are present in this formation seems deserving of record, and the fossils collected at those localities call for description in print.

The new localities are in Ulster county, New York, between Rosendale and Kingston.

The Esopus in the Rosendale-Kingston area is a dark gray to black, coarse-grained, shale, which shows few clear bedding planes and tends to break up into irregular hand specimens or small cubes. The fossils found in it are molds, the original hard parts of the organisms forming them having been removed. They are not common; but the fact that they are brown in color makes it easier to find them in the blackish shale.

The specimens that have been collected from these localities to date are referable to one species of corals, *Zaphrentis* cf. *tabulata* (Hall), one species of worms (represented by burrows only), four species of brachiopods, *Orbiculoidea ruedemanni*, n. sp., *Nucleospira parva* n. sp., *Meristella goldringae* n. sp., and *Anoplotheca flabellites* (Conrad), one species of gastropods, *Loxonema chadwicki*

n. sp. and one of conularids, *Conularia ulsterensis* n. sp. These are briefly discussed below.

The writer is indebted to Dr Rudolf Ruedemann and Dr Winifred Goldring for assistance in the identification of his specimens.

DESCRIPTION OF SPECIES

Corals

Zaphrentis cf. *tabulata* Hall

Figure 15 (1, 2)

Cf. *Zaphrentis tabulata*, (Hall), 35th Ann. Rep't N. Y. State Mus. Nat. Hist., p. 431, pl. 29, fig. 3, 4, 1884

The few fragments of corals that were found were all replaced by pyrite, and the finer details of their structure can not be seen. It is consequently impossible to be certain of their identity. They were examined by E. C. Stumm, and were said by him to be close to *Zaphrentis tabulata* (Hall); but they may be a new—perhaps an undescribed—species. They are nos. 41,893-41,896 in the paleontological collection of Princeton University, and were collected from a quarry west of the railway station at Cottekill.

Worms

A few small burrows, from one-twentieth to one-thirtieth of an inch in diameter, indicate that worms lived in the mud at the bottom of the Esopus sea. Nothing can be determined about the nature of these worms, but they were presumably Gephyrea. Three examples of the burrows are Princeton nos. 41,897-41,899.

Brachiopods

Orbiculoidea ruedemanni, sp. nov.

Figure 15 (3, 4)

A single dorsal valve of what appears to be a new species of *Orbiculoidea* was found in an outcrop one mile south-southeast of the town of Hurley. All that can be seen of its characters is shown in the figures of it here presented. It is a rather small species, of low convexity, its dimensions being 12 x 9 x 3 mm. The outer layers of the shell are not well enough preserved to permit a determination of the nature of the surface ornamentation.

The species is named in honor of Dr Rudolf Ruedemann.

Orbiculoides ruedemanni is not enough like any other species of its genus known to the author to require detailed comparisons to bring out its differences. *O. neglecta* (Hall) and *O. lodiensis* (Vanuxem) are of about the same size, but both have the beak of the dorsal valve farther from the edge of the shell than does *O. ruedemanni*, and both are much younger, *O. neglecta* being a Chemung species, and *O. lodiensis* being found in the Marcellus and Genesee shales.

The holotype is no. 42,067 in the paleontological collection of Princeton University.

Anoplothea flabellites (Conrad)

Figure 15 (5, 6)

Atrypa flabellites Conrad, Ann. Rep't on the Paleont. of N. Y. for 1841, p. 55

Leptocoelia propria Hall, N. Y. State Cabinet, Ann. Rep't 10, 1857, p. 108

Leptocoelia flabellites (Conrad), Hall. Paleontology of New York v. 3, 1859, p. 449-50, pl. CIII B, f. 1a-f, CVI, f. 1a-f

The commonest fossil found in the Esopus was this brachiopod, of which individuals of various sizes were collected from a number of localities. Examples are nos. 41,900-41,923 in the Princeton collection.

Nucleospira parva, sp. nov.

Figure 15 (7)

A single, poorly preserved valve which seems to be a new species was collected from the quarry west of the Cottekill railway station. All that can be seen of its characters is shown in the figure. The species is remarkable for its small size; it is only 4 mm long, 7 mm wide, and 1 mm high. Its surface is too poorly preserved to permit of a determination of its character. It is as small as *Nucleospira pisiformis* and *N. ventricosa*, and resembles those species in outline, but is less globose in form. *N. pisiformis* is a Silurian species; but *N. ventricosa* is a Lower Helderberg form, and may have been an ancestor of our species.

The holotype is no. 42,069 in the paleontological collection of Princeton University.

Meristella goldringae, sp. nov.

Figure 15 (8)

A single ventral valve of what is apparently a new species of *Meristella* was collected by Dr R. M. Fullé some years ago. The

record of the locality from which the specimen came was lost before the fossil came into the writer's hands, the label accompanying it reading "Esopus; Glenerie Falls?, Ulster County." As the rock in which the fossil is preserved has the lithologic characters of the Esopus and the specimen undoubtedly came from Ulster county, this valve is probably that of a member of the Esopus fauna and is therefore described here.

All that can be seen of the characters of the fossil is shown in the figure here presented. The shell is 8 mm long, 8 mm wide, and 3 mm high. Its surface is smooth, except for the lines of growth, which are prominent. The mesian sinus is shallow.

The species is named in honor of Dr Winifred Goldring.

The only species of *Meristella* known to the writer that resembles this one is *Meristella lenta* Hall, from the Oriskany of Cayuga, Ontario. Our species resembles the Ontario one in the external form of the ventral valve but is only half as large.

The holotype is no. 42,068 in the paleontological collection of Princeton University.

Gastropods

Loxonema chadwicki, sp. nov.

Figure 15 (9)

A single example of a snail, apparently a new species of *Loxonema* was found in the quarry west of the Cottekill railway station. All that can be seen of its characters is shown in the figures here presented. As the shell, itself, is not preserved and both extremities are broken away, the exact nature of the shell surface aperture and of the apex can not be determined. The shell is 16 mm long and its lost whorl is 8 mm in diameter.

This holotype is no. 42,070 in the paleontological collection of Princeton University.

The species is named in honor of George H. Chadwick.

Loxonema chadwicki resembles in form and size the *Loxonema*? sp. undet. described by Weller ('03, p. 294, pl. 32, figs. 9, 10) from the Coeymans of New Jersey. Weller's specimens were incomplete, and it is impossible to make detailed comparisons between them and our single internal mold. The difference in age of the New Jersey and New York forms argues against their being referable to the same species, however. *Loxonema attenuata* Hall is similar in form to ours, but is much larger and occurs in Lower Helderberg rocks.

Conularids

Conularia ulsterensis, sp. nov.

Figure 15 (10, 11)

Three imperfect specimens of a species of *Conularia* that is probably new were collected from the outcrop beside the road about a mile south-southeast of Hurley from which the holotype of *Orbiculoidea ruedemanni* was secured. All that can be seen of their form and ornamentation is shown in the figures. The most complete example is 2 cm long and 6 mm wide at its widest point.

The holotype is no. 42,071, and the two paratypes are nos. 42,072 and 42,073 in the paleontological collection of Princeton University.

The only species known to the writer with which this *Conularia* should be compared is *Conularia lata* Hall, from the Oriskany of New York. That species differs in form and size from the Esopus one, being broader and larger, but its ornamentation is similar.

This Esopus fauna is small both in the number of species and in the size of the individuals. Most of its species are small representatives of their genera.

This poverty of species and lack of size of individuals would seem to indicate that conditions of existence were not favorable for most kinds of marine invertebrates where the Esopus deposits were laid down. What made the environment unfavorable we have not yet been able to determine.

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Explanation of Figures

Figure 15

- 1, 2 *Zaphrentis* cf. *tabulata* Hall, x 3
- 3, 4 *Orbiculoidea ruedemannii*, sp. nov. Dorsal valve, holotype, top and side views, x 3
- 5, 6 *Anoplothecca flabellites* (Conrad). Dorsal and ventral valves, x 3
- 7 *Nucleospira parva*, sp. nov. Holotype, x 3
- 8 *Meristella goldringae*, sp. nov. Ventral valve, holotype, x 3
- 9 *Loxonema chadwicki*, sp. nov. Holotype, x 3
- 10, 11 *Conularia ulsterensis*, sp. nov.; 10 is holotype, x 3

All specimens are from the Esopus formation of Ulster county: nos. 1, 2, 7, 9 from the vicinity of Cottekill; nos. 3, 4, 10, 11 from a locality one mile south-southeast of Hurley; no. 8 from Glenerie Falls.

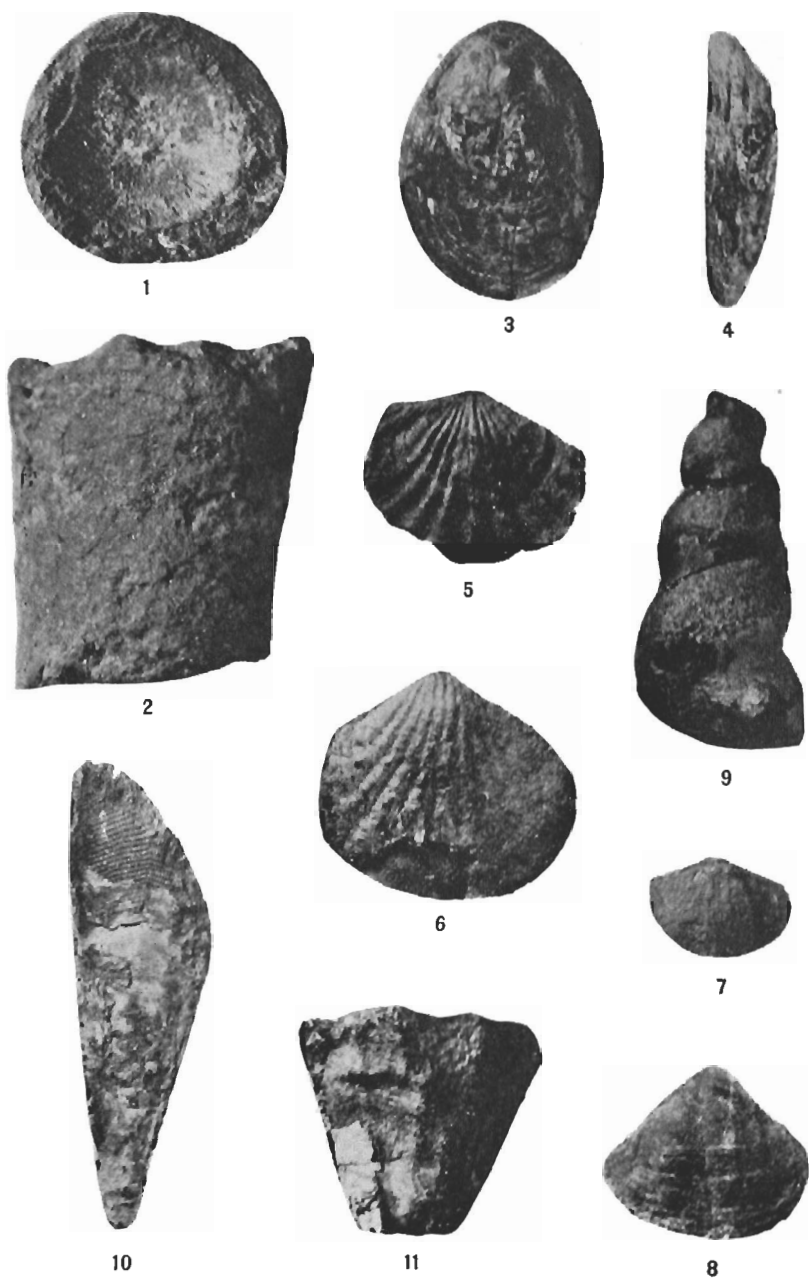


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