est height of the shell a short distance behind the beak, near the end of the dorsal angulation. Surface marked by faint radiating striæ on the body of the shell.

Measurements.—Length, 43+ mm.; greatest transverse diameter, 44 mm.; greatest convexity 16+ mm.; height from beak to base, 12 mm. (?).

This species is a very near relative of *H. fastigiata* Barrande, of the Bohemian Lower Devonic (Etage G.). That species has a more strongly arching slope above the beak which is nearer the base of the shell. In other respects, so far as our specimen permits of comparison, the two are identical. (See Barrande; Gastropodes, by Perner, pl. 123.)

Horizon and locality.—In the Amherstburg dolomite of the Detroit river region. One specimen.

CEPHALOPODA.

Genus ORTHOCERAS.

110. ORTHOCERAS cf. TRUSITUM Clarke and Ruedemann.

Shell small, nearly cylindrical; diameter 7.5 mm. Surface smooth. Sutures separated from 1.8 to 2.2 mm.; septa strongly concave, concavity about 1.5 mm. Siphuncle central, diameter about 1.8 mm. These specimens are provisionally referred to the above species with the young of which they seem to agree pretty closely. The species is common in the Guelph of western New York.

Horizon and localities.—In the Lucas dolomite of the Patrick quarry on Grosse Isle. Two fragments, (20024, 20028). The species occurs in the Guelph and in the Cobleskill.

Genus DAWSONOCERAS Hyatt.

111. DAWSONOCERAS ANNULATUM (Sowerby) var. AMERICANUM Foord.

(Plate XXVIII, Fig. 8; Plate XXIX, Fig. 1.)

This characteristic Siluric species is represented by several fragments in the brown Amherstburg dolomite of the Upper Monroe. It corresponds well in general characters to a specimen figured by Clarke and Ruedemann from the Lower Shelby dolomite (Guelph). (Guelph Fauna, pl. II, fig. 1). The greatest diameter of the specimen, which is somewhat compressed, is 22 mm. The distance between the tops of the annuli varies from 16 to 17 mm. On one of the molds of the exterior there are indications of septal sutures which are 1.4 to 2.6 mm. apart. The length of the largest fragment is 90 mm. The surface markings are not preserved.

Horizon and locality.—In the Amherstburg dolomite of the Detroit river, opposite Amerstburg, Ont. Rev. Thomas Nattress coll. The form also occurs in the Guelph.

Genus CYRTOCERAS.

CYCLOSTOMICERAS.

112. CYRTOCERAS (CYCLOSTOMICERAS) ORODES Billings.

(Plate XXVIII, Figs. 6-7; Plate XXIX, Figs. 2-3.)

1865. *Cyrtoceras orodes* Billings. Pal. Fossils, Vol. I, p. 162.
1895. *Cyrtoceras orodes* Whiteaves. Pal. Fossils, Vol. III, Pt. 2, p. 103, pl. 14, figs. 7-9.
1903. *Cyrtoceras orodes* Clarke and Ruedemann. Guelph Fauna in the State of N. Y. Mem. N. Y. State Mus. 5, p. 88, pl. 15, fig. 3-11.

Original description.—"Section nearly circular, the dorso-ventral diameter slightly greater than the lateral. Aperture 15 lines in diameter; shell at 9 lines from the aperture, 11 lines in diameter; depth of chamber of habitation 9 lines. The septate portion of the specimen is 21 lines in length measured on the ventral side, and in that distance there are 12 septa. The specimen is so gently curved that in a length of 30 lines the arch formed by the ventral outline is only 5 lines in height in the middle.

"This shell differs from *C. orestes* in being more gently curved, and in having the aperture expanded."

The original specimen came from the Guelph of New Hope, Ont. Whiteaves describes other specimens from the Guelph of Durham. He adds to the description the fact that the siphuncle "is evidently exogastric and situated close to the margin of the venter." Clarke and Ruedemann found a number of specimens of this species in the Lower Shelby dolomite (Guelph) of Rochester, N. Y. Our specimens agree closely with those from the New York Guelph and with the type specimen. The section of the young shell is nearly circular, that of the adult becoming slightly compressed. The curvature is a very gentle one, while the divergence of the sides is such that the transverse diameter is doubled in a length of about 35 mm. Septa 1.5 mm. apart in the younger, and 2.5 to 3 mm. apart in the older portion of the shell; moderately concave, the concavity being about 3 mm.; diameter of siphuncle 3.3 mm. where the diameter of the shell is 15 mm.

In the adult (or old age?) the septa become more closely crowded. Thus in a characteristic specimen the interval between the seventh and sixth septum from the living chamber is 2.8 mm.; between the sixth and fifth it is 2.4 mm., while the interval from the fifth to the first inclusive is only 3 mm., or on the average .75 mm. between the last five septa. In the best preserved specimen about 20 mm. of the living chamber are shown, the diameter increasing somewhat less than in the earlier portions.

Horizon and locality.—In the Amherstburg or transition layer from the Detroit river. It also occurs not uncommonly in the Raisin river beds of the salt shaft between 87 and 98 feet below the Sylvania. It occurs in the Guelph of New York and Ontario. Rev. Thomas Nattress coll.

Genus POTERIOCERAS McCoy.

113. POTERIOCERAS cf. SAURIDENS Clarke & Ruedemann.

(Plate XXIX, Fig. 4.)

1903. Cf. *Poterioceras sauridense* Clarke and Ruedeman, Guelph Fauna, Mem. 5, N. Y. State Mus., p. 93, pl. 14.

Among the material from the Upper Anderdon of the Detroit river (Nattress collection) is a single specimen of a fragment of the internal mold of the living chamber and one of the cameræ or air chambers of a breviconic cyrtoceracone, which seems to agree in all respects with those figured by Clarke and Ruedemann from the Lower Shelby bed (Guelph) of western New York. The mold is subcircular in section, the ventral border being flattened to a somewhat larger radius. The living chamber widens slightly to about one-third the length and then becomes contracted on the ventral and lateral sides until the aperture is less than at the base of the living chamber, after which slight expansion again occurs. The dorsal surface is regularly curved. As a consequence the aperture is dorsoventrally compressed. Last camera exceedingly shallow, almost wedge-shaped at the ventral border, the lateral margins faintly crenulate, the crenulations continuing on the mold of the living chamber as short longitudinal grooves. Siphuncle not preserved.

Although only a fragment has been found, the characteristics of this species are so marked that there is little question of the identity of our fragment with this Guelph species. Here, as in New York, it is associated with the preceding.

Horizon and localities.—Amherstburg dolomite, Detroit river, opposite Amherstburg, Ont. Rev. T. Nattress coll. Also Guelph of New York.

Genus TROCHOCERAS Hall.

114. TROCHOCERAS GEBHARDI Hall.

(Plate XXXI, Fig. 3 a-b.)

1852. *Trochoceras gebhardi*, Hall, Pal. of N. Y., Vol. II, p. 335, pl. 77, fig. 2; pl. 77a, figs. 1 a-d.

1900. *Trochoceras gebhardi*, Hall, Grabau. Bull. Geol. Soc. Am., Vol. XI, p. 371, pl. 21, fig. 3 a-b.

Grabau's description.—"This species originally described from the Coralline limestone of Schoharie county is represented by several specimens from the Manlius limestone (Akron dolomite) of Erie county. A very perfect specimen (pl. 21, [25], fig. 3 a-b) obtained by Messrs. Vogt and Piper from the cement quarries (Buffalo), preserves about four and one-half volutions, several being broken away at the apex. The shell has the aspect of a large gastropod with rounded, strongly embracing whorls. The umbilicus is wide and deep, the margin angular, cross section of body whorl irregularly subhemispherical. The apical angle of the spire is 60°, the sutures being moderately depressed below the outline. No septa are shown. In a specimen from Williamsville, referred to this species, the surface of the shell is marked with fine crowded lines of growth. No other surface ornamentation is shown.

"Greatest diameter of the spire of the illustrated specimen, 75 mm. This is about a volution younger than the type specimens, with which it agrees in all the points which admit of comparison. Where the body whorl has a height of 45 mm., the umbilicus has a diameter of 30 mm.

"In addition to the fine specimen obtained from Buffalo, a number of compressed portions of whorls have been obtained from this rock at Williamsville. These are in the state collection at Albany and appear to represent older and larger individuals. The fact that septa are not visible does not render the identification doubtful, as the form of the shell is very characteristic. The greater portions of the type specimens from Schoharie show no septa."

Horizon and localities.—In the Akron (Bullhead) dolomite of Buffalo and Williamsville and the Cobleskill (Coralline) limestone of Schoharie.

115. TROCHOCERAS ANDERDONENSE sp. nov.

(Plate XXVIII, Fig. 9; Plate XXIX, Figs. 5-6.)

Shell a low spire of about 5 whorls loosely embracing and leaving a very wide umbilicus open to the apex; whorls rounded, smooth, with nearly circular cross section and apparently not indented by the preceding whorl; slowly increasing in diameter. Septa strongly concave 1.8 mm. apart where the transverse diameter of the whorl is 10.5 mm. and the vertical diameter 9.5; apical angle 134°; height about 35 or 40 mm.; basal diameter about 70 mm.; diameter of umbilicus about 35 mm.; diameter of final whorl 21 mm. Siphuncle excentric—nearer the ventro-lateral (outer) margin, with a diameter on the septum of 1.7 mm., where the whorl has a maximum diameter of 10.5. Structure of siphuncle in cameræ not observed.

This species is of the form of *T. priscum* Barrande of Etage E, the Upper Siluric of Bohemia, though the spire is somewhat higher. Whether or not our species possess the moniliform siphuncle of the Bohemian form is not ascertainable on the only specimen known. If this should prove to be the case the two species must be regarded as representative in the faunas. It differs from *T. Gebhardi* of the Cobleskill in its much broader apical angle, and in the circular cross-section of the whorls; the umbilical angulation of *T. gebhardi* being absent. Hall (Pal. N. Y., III, p. 337) mentions the occurrence of a more depressed species in the Coralline (Cobleskill) of Schoharie, but this has never been described.

On the external mold of the shell lines of growth are observable which gently arch forward on the outer lateral margins of the whorls.

Horizon and locality.—Associated with *Conocardium monroicum* and *Spirifer modestoides* in the brown dolomite or Amherstburg bed of the Monroe in the Detroit river opposite Amherstburg. Rev. Thos. Nattress, B. A., collector.

ANNELIDA.

Genus SPIRORBIS Daudin.

116. SPIRORBIS LAXUS Hall.

(Plate XV, Fig. 12.)

1859. *Spirorbis laxus* Hall, Pal. N. Y., Vol. III, p. 349, pl. 54, fig. 18 a-e.

1900. *Spirorbis laxus* Sherzer, Geol. Sur. Mich., Vol. VII, Pt. 1, p. 225.

Shell small, normally forming a regular coil which is broadly umbilicated, but often also coiling loosely or irregularly to almost complete non-volution. Tubes circular in cross section, .6 mm. in diameter or less. Generally from two to three coils occur, the tube enlarging but slightly. Transverse ridges are generally developed though these are weaker than in the specimens from the Manlius limestone of New York.

Horizon and localities.—In the Raisin river dolomite of the Newport, and Monroe quarries, also at Little Lake and Little Sink. At the last locality the tubes are said to be coarser. It is often extremely abundant but occurs mainly as external molds. It occurs in the salt shaft between 118 and 120 feet below the Sylvania. It was originally described from the Manlius of New York.

Genus CORNULITES Schlotheim.

117. CORNULITES ARCUATUS Conrad.

(Plate XXII, Figs. 4-6.)

1842. *Cornulites arcuatus* Conrad, Acad. Nat. Sci. Journ., Vol. VIII, p. 276, pl. 17, fig. 8.

1903. *Cornulites arcuatus* Conrad, Clarke & Reudemann, Mem. N. Y. State Mus. 5, Guelph Fauna, p. 105, pl. IV, figs. 1-5.

Tube small, rapidly tapering basal portion in the only specimen seen, curved almost at right angles. Annulations about 10. In the internal mold the surface slopes gently outward and then suddenly contracts, so that the two surfaces are nearly at right angles. Sections becoming smaller toward the curved end; slightly irregular at the point of curvature. The only specimen in the collection, an internal mold, shows somewhat more of a tapering on the tube as a whole than is shown in most of the specimens figured by Clarke and Ruedemann from the Guelph of western New York. In this respect our specimen agrees more closely with fig. 1 of Clarke and Ruedemann, but that specimen is not curved at the base. Length about 7 mm.; diameter of tube at aperture 2.8 mm.

Horizon and localities.—In the brown Amherstburg dolomite of the Detroit river bed, opposite Amherstburg, Ont. One internal mold. The species is described by Clarke and Ruedemann from the Guelph of western New York.

OSTRACODA.

Genus LEPERDITIA Rouault.

118. LEPERDITIA SCALARIS (Jones) Grabau.

(Plate XXXII, Fig. 6 a-d.)

1858. *Leperditia gibbera* var. *scalaris* Jones. Annals and Magazine of Nat. Hist., 3rd series, Vol. IV, p. 250, pl. 10, fig. 7 a-b, 10 a-b, 11.

1900. *Leperidita scalaris* (Jones), Grabau, Bull. Geol. Soc. Am., Vol. II, p. 371-372, pl. 22, fig. 6 a-d.

1910. *Leperditia scalaris* Grabau & Shimer, North American Index Fossils, Vol. II. p. 340, fig. 1655.

Grabau's description.—"The general outline of the carapace is bean-shaped, as in Leperiditia generally. The greatest height is posterior to the middle. Hinge line straight, about two-thirds the length of the carapace, terminating anteriorly in an obtuse, slightly salient angle. Posterior extremity of hinge line likewise salient, with the posterior border below it uniformly rounded on a short radius. Anterior dorsal margin sloping off abruptly, making an angle of about 130° with the hinge line. Anterior end nasute, obtusely rounded. Basal margin a uniformly asymmetric curve, more convex in the posterior portion of the shell.

"A distinct marginal border or fold occurs on both anterior and posterior ends, the former being the stronger and the best defined. It is well flattened, with the margin sometimes slightly elevated. Occular tubercle about a third the length of the carapace from the anterior end and about a fourth of the height below the dorsal margin. The longitudinal contour is a flattened curve, rather more convex in the anterior third and becoming abrupt near the ends. Dorso-ventral contour an asymmetric curve, flatter near the

hinge line and abruptly incurved at the ventral border. The ventral border of the right valve overlaps that of the left valve, which is abruptly flattened.

"In the left valve occurs a strong, elongated fold or nodule situated just below the hinge line in the posterior half of the carapace. It begins about midway of the length of the hinge line and extends backward to half way between the center and the posterior end thus equaling in length about a fourth of the hinge line. This fold is accentuated by an abrupt depression of the valve below it, the fold thus becoming strongly pronounced below, but grading into the upper slope of the valves. This fold or "dorsal hump" is wanting in the right valve. Surface smooth. A perfect right valve measures; Length 11.5 mm.; height 7.5 mm.; hinge 9 mm.; greatest convexity 2.5 mm. Another measures 12x7 mm., with hinge line 8 mm. long. Another measures 11.5x6.5 mm. Three left valves from Williamsville measure respectively 10.5x5.5 mm., 9.2x5 mm., and 8.5x4.5 mm."

Horizon and localities.—Jones' original specimens were obtained by Charles Lyell from the "Waterline rock" of Williamsville. This is unquestionably the Bullhead or Akron dolomite, in which this species occurs abundantly, not only in Williamsville but elsewhere in Erie county, New York. The species is reported by Jones from black limestone of the "Scalent group" of Pennsylvania and it has been found in the dark calcilutites or waterlimes of other parts of New York. It also occurs in the Cobleskill limestone of High Falls, Ulster county, New York. The species has not been recorded so far in any of the other outcrops of the Upper Monroe, in Michigan, Ohio or Canada but will probably be found in the Amherstburg or Anderdon.

119. LEPERDITIA ANGULIFERA Whitfield.

(Plate XX, Figs. 28-30.)

1882, March. *Leperditia angulifera* Whitfield, Ann. N. Y. Acad. Sci., p. 196; ibid, Vol. V, 1891, p. 518, pl. 5, figs. 28-30, and Geol. of Ohio, Vol. VII, 1893, p. 418-419, pl. 1, fig. 28-30.

1910. *Leperditia angulifera* Grabau & Shimer, North Am. Index Fossils, Vol. II, p. 340, fig. 1654.

Whitfield's original description.—"Carpace of medium size, having a length, in adult individuals, of about three-eighths of an inch, by a height of one-fourth of an inch in the broadest part. General form of the outline broadly subovate and widest posteriorly; hinge-line straight, equal in length to two-thirds that of the entire valve; anterior end a little the shortest, narrowly rounding into the broadly-curved basal line; posterior end broadly rounded. Surface of the carpace highly elevated and prominent, forming a strong, somewhat angular, longitudinal node just within the basal margin, and near the middle of the length. From this point the surface slopes somewhat gradually upward to the hinge-line, with a barely perceptible convexity, except on the anterior end, where it is more strongly convex, and characterized by a rather prominent and well marked occular tubercle. From the angular node near the lower margin, there is, on well-preserved individuals, a perceptible angulation, extending along the surface to the point of greatest length on the anterior end, and a similar one, but less strongly marked, on the posterior side. There is no perceptible difference in form between the right and the left valves, each showing the features about equally developed. No appearance of striations radiating from the ocular tubercles can be detected, neither on the internal casts nor in the matrices; still the nature of the rock in which they are imbedded is such that very obscure markings would scarcely be preserved.

This species differs from *Leperditia alta* Conrad, of the same formation, in its larger size, and in the larger and more distinct eye tubercle, as well as in its slightly different position; but most distinctly in its subangular ridge-like node, and greater convexity of the lower border of the valves. This projecting node being situated near the lower margin, and also being the most prominent point of the valve, causes the rock to adhere to the more abrupt sides when fractured, and gives to the valves as they appear upon the fractured surfaces a very decidedly triangular aspect, entirely unknown in *L. alta*."

Horizon and locality.—Greenfield dolomite, Greenfield, Ohio, (Whitfield).

120. LEPERDITIA ALTOIDES nom. nov.

(Plate XXX, Fig. 27.)

1891. *Leperditia alta* (Conrad) Whitfield. Ann. N. Y. Acad. Sci., Vol. V, p. 517, pl. 5, fig. 27, and Geol. Ohio, Vol. VII, 1893, p. 417-418, pl. 1, fig. 27.

Whitfield's original description.—"Valves of the carpace transversely subovate, widest posterior to the middle and narrowed in front, the proportional height and length being somewhat variable, but are usually about as two to three. Hinge-line straight, nearly two-thirds as long as the entire valve, extremities salient. Anterior end of the valves narrowly rounded and the posterior extremity broadly curved; basal line curved but with a scarcely perceptible angularity just posterior to the middle of the length. Surface prominently convex and a little the fullest anterior to the middle; ocular tubercle small, situated a little below and just behind the anterior extremity of the hinge-line. Lower margin of the valve slightly inflected, and in some cases the posterior margin appears to have been bordered by a slightly thickened rim.

"The individuals examined are either internal casts or impressions of the exterior, owing to which fact the finer surface features of the crust cannot be definitely ascertained; enough is seen, however, to show its identity with those from the Tentaculite limestone of New York. The species as described by Mr. F. B. Meek, includes this and the following one, which are very distinct species, the differences being very strongly marked in the great prominence of the lower part of the valves of that one, and its strongly subangular form as well as in its greater size. The principle variation noticed among the individuals of this species, is in the greater proportional length of some of them, producing a cylindrical form. This feature is, however, seen occasionally among those from Schoharie, N. Y., but does not appear to be worthy of specific consideration."

This species is larger than typical *L. alta* (Conrad) of the Manlius limestone, its hinge line is proportionately shorter than in that species and the difference in height between the anterior and posterior ends is more marked.

Horizon and localities.—Lower Monroe formation of Bellevue, Sandusky county, Ohio. Also in Greenfield dolomite of Greenfield and Ballville, Ohio.

121. LEPERDITIA ALTA (Conrad).

1859. *Leperditia alta* (Conrad) Hall. Pal. N. Y., Vol. III, p. 373.

1910. *Leperditia alta* (Conrad) Grabau & Shimer, North American Index Fossils, Vol. II, p. 341.

This common Upper Siluric species seems to be well represented in the lower Monroe beds. It is characterized by its small size, strong convexity and similarity of valves, with the eye tubercle one-fourth the shell-length from the anterior and the dorsal margin.

Horizon and localities.—In the Put-in-Bay dolomite of Lake Erie, and the Manlius limestone of New York, etc.

Genus KLOEDENIA Jones and Holl.

122. KLOEDENIA MONROENSIS sp. nov.

(Plate XV, Fig. 11.)

1903. Compare *Beyrichia sussexensis* Weller, Pal. N. J., Vol. III, p. 253, pl. 23, figs. 3-4.

A single carapace from the Raisin River beds agrees in its general features with Weller's *Beyrichia sussexensis,* but shows some important differences which require its removal to a new species. The hinge-line is proportionately somewhat shorter, being about eight-tenths the entire length of the shell. The anterior end is somewhat lower than the posterior and the anterior border forms a rectangle with the hinge line, whereas the posterior border is curved to the hinge line. The dorsal grooves or sulci are about equally spaced, dividing that portion of the shell into three nearly equal lobes, whereas in Weller's species the posterior lobe is at the center of the shell. No connecting sulcus has been observed.

Measurements of a characteristic specimen give:—length 3 mm. greatest height 1.9 mm.

Horizon and locality. In the Raisin river calcilutites of the Newport quarry. Rare. The original of Weller's species was described from the Rondout of New Jersey.

TRIOBITÆ.

Genus PROETUS.

123. PROETUS CRASSIMARGINATUS Hall.

(Plate XX, Figs. 16-18.)

1888. *Proetus crassimarginatus* Hall and Clarke, Pal. N. Y., Vol. VII, p. 99, pls. 20, 22 and 25.

This characteristic Dundee (Schoharie and Onondaga) species is represented by a number of individuals from the Amherstburg dolomite. The cephalon is represented by a fragment which shows the characteristic marginal rim, and large convex glabella, delimited by pronounced furrows.

A number of pygidia show the characteristic features. A very large one (over 33.5 mm. long), though crushed, shows 14 rings to the axis, and the grooves on the limb are well developed in the anterior part but become obsolete posterior-wards. The pleural grooves become obsolete on the border which is 6.4 mm. wide, and of which the outer part (3.7 mm.) forms a prominent marginal rim which descends abruptly on the inside.

Another large pygidium 20.5 mm. long, 24 mm. wide at anterior end, shows a very narrow marginal rim, which is about 2 mm. wide in the anterior portion, but becomes narrower posteriorly until it is little more than 1 mm. wide. The pleural grooves come within about 1 mm. of the marginal rim, but there is no broad pronounced depression as in the previously described specimen. The number of recognizable rings on the axis is 14, but the final portion (about 4 mm.) is without recognizable rings. The characteristic angulation of the rings is shown. From the groove on either side of the axis the ring passes forward for about one-fourth the diameter of the axis. Then it suddenly bends back, and describes a low, backward curve across the center of the axis.

Horizon and locality.—In the brown Amherstburg dolomite of the Upper Monroe, from the bed of the Detroit river, opposite Amherstburg, Ont. Rev. Thomas Nattress coll. It occurs in the Schoharie and Onondaga elsewhere.

MEROSTOMATA.

Genus EURYPTERUS DeKay.

124. EURYPTERUS ERIENSIS Whitfield.

(Plate XXX, Figs. 31-32.)

1882, March. *Eurypterus eriensis* Whitfield. Ann. N. Y. Acad. Sci., p. 196; ibid, Vol. V, p. 515, pl. 5, figs. 31-32, and Geol. of Ohio, Vol. VII, 1893, p. 416-417, pl. 1, figs. 31-32.

1910. *Eurypterus eriensis* (Whitfield) Grabau and Shimer, North American Index Fossils, Vol. II, p. 407, fig. 1707.

Whitfield's original description.—"Among the fossils from the hydraulic limestones of Peach Point, Put-in-Bay Island, Lake Erie, there are several detached cephalic shields and one body, of a species of Eurypterus, which is so distinctly different from any of those described, that it seems necessary to class it as a separate species. The differences, so far as seen on the parts preserved, consist in the form of the cephalic plate, in the size and position of the eye tubercles, and in the proportions of the body as compared with the known forms. There are undoubtedly other and more important differences in the appendages, but as these are not preserved on any of the individuals examined, comparison is impossible.

"The cephalic shield is proportianally broader than that of *E. remipes* or *E. lacustris,* and is more regularly rounded or arched on the anterior border, lacking that subquadrate form characteristic of those species. The eyes are proportionally smaller, and situated near each other, and also farther forward, as well as being somewhat more oblique to the longitudinal axis of the body. The minute ocular points are somewhat larger than in *E. remipes,* are situated close together and are nearly opposite the posterior end of the real eye tubercles; they consist of a pair of distinctly elevated rings surrounding rather deep, although minute, central depressions; the inner margins of the rings being almost in contact. The head does not show evidence of having been margined by an elevated or thickened rim, as in those species, but as the specimens are rather impressions of the inner surface of the external crust than actual external surfaces (being more properly internal casts, the substance of the carapace having been entirely removed), this

feature may not be properly shown. The head-plate more closely resembles that of *E. microphthalmus* Hall (Pal. N. Y., vol. III, p. 407, pl. 80a, fig. 7), from the Tentaculite limestone near Cazenovia, N. Y., than of any other described species; it differs, however, in being proportionately much shorter, which gives it a more semicircular form. The eye tubercles are also more nearly of the size of those of that species and similarly situated.

"The thorax closely resembles that of *E. remipes* in its general form, but the lower three or four segments are proportionately shorter, giving the posterior extremity a much more compact character. The principal distinction between the two species, as shown by the thorax, exist in a difference of the ornamentation of the surface, as seen on the specimens used. This consists in the minute spine-like pustules or pointed granules, marking the surface of the crust, being arranged in irregular transverse lines across the body, and parallel to the anterior and posterior margins of the segments, instead of being irregularly disposed, as in all other species described. No indication of the longitudinal rows of larger pustules, marking the median line of the thoracic segments, can be traced. Caudal spine not observed."

Horizon and locality.—In the dolomite calcilutites of the Put-in-Bay horizon, at Put-in-Bay Island. Several specimens. Types in the collection of Columbia University.

PLANTÆ.

Plant remains of various kinds and of unidentifiable character have been found in various formations within the Monroe. In the Greenfield dolomites they occur arranged in radial bunches of subcylindrical stems. In the Raisin river beds of Roche de Boeuf, Lucas county, Ohio, they occur as similar stems not branching and not radially arranged. From the Akron dolomite of Buffalo, N. Y., *Nematophyton crassum* and *Bythotrephis lesquereuxi* have been described. Slender fucoids are also found at Put-in-Bay. In the Raisin river dolomites long, reed-like plant remains occur. The following new species are sufficiently well preserved for description:

Genus BYTHOTREPHIS Hall.

125. BYTHOTREPHIS CLAVELLOIDES sp. nov.

(Plate XII, Fig. 1.)

Plant consisting of repeatedly dichotomizing cylindrical stems, which frequently become slightly thickened towards the obtusely rounded apex. Branching often incomplete, the branches adhering for the greater part of their length. Diameter of main stem 4.6 mm. of smallest branch 2 mm.

This species is of the type of *B. ramosus* Hall of the Clinton group, but branches more rapidly and is less rigid.

Horizon and locality.—In the Akron (Bull Head) dolomite of North Buffalo, N. Y. It may be looked for in the Upper Monroe beds of Michigan.

Genus SPHAEROCOCCITES Sternberg.

126. SPHAEROCOCCITES (?) GLOMERATUS sp. nov.

(Plate XI, Fig. 1.)

Plant consisting of numerous fine nearly cylindrical branches which seem to be caught together in a common center, each plant forming a bunch an inch or less in diameter, thickest in the centre and with the somewhat flexuous branches irregularly radiating. The appearance of jointing in the branches is very common, many of them appearing as strings of short cylindrical segments. Rarely is the appearance of bifurcating produced; in no case is it absolutely determinable.

Average thickness of the branches 1 mm.; length of segment in jointed stem 1.3 mm.; diameter of branch from 18 to 30 mm.

Sometimes the branches are somewhat larger and more scattered, and occasionally the surface of the slab is covered by dissociated segments.

The generic reference is provisional. The species should probably be placed in a new genus.

Horizon and localities.—In the Greenfield dolomite, Greenfield, Ohio. Also the Raisin river dolomite of Roche de Boeuf, Lucas county, Ohio, and in the same formation in Monroe county, Michigan.

TABLE III.

Showing the Distribution of the Fossils of the Monroe Formation.	Lucas Dolomite.	Amherstburg Dolomite.	Anderdon Limestone.	Flatrock.	Raisin River Dolomite.	Put in Bay Dolomite.	Greenfield Dolomite.	Akron Dolomite.	Niagara.	Guelph.	Cobleskill.	Manlius.	Helderberg.	Schoharie Onondaga.	Hamilton.	Other localities.
STROMATOPOROIDEA.																
1. *Clathrodictyon ostiolatum* Nicholson		×	×							×	×					
2. *C. variolare* v. Rosen			×						×							
3. *Stromatopora galtense* Dawson			×							×	×					
4. *Coenostroma pustulosum* Grabau			×													
5. *Stylodictyon sherzeri* Grabau			×													
6. *Idiostroma nattressi.* Grabau		?	×													
ANTHOZOA.																
7. *Helenterophyllum caliculoides* Grabau			×									×				
8. *Cyathophyllum thoroldense* Lambe			×						×							
9. *Cyathophyllum hydraulicum* Simpson								×								
10. *Heliophrentis alternatum* Grabau	?	×												×		
11. *H. alternatum* mut. *compressum* Grabau		×														
12. *H. alternatum* mut. *magna* Grabau		×														
13. *H. carinata.* Grabau	?	×														
14. *Cylindrohelium profundum* Grabau	×															a
15. *C. heliophylloides* Grabau	×									×						
16. *Cystiphyllum americanum* mut. *anderdonense* Grabau		×	×													
17. *Acervularia* sp.		×														
18. *Synaptophyllum multicaule* Hall		×	×						×							
19. *Diplophyllum integumentum* Barrett		×	×								×					
20. *Romingeria umbellifera* Billings		×												×		
21. *Ceratopora regularis* Grabau		×														
22. *C. tenella* (Rominger)			×						×							
23. *Favosites basaltica* mut. *nana.* Grabau			×											O		
24. *F. rectangularis* Grabau			×											O		
25. *F. tuberoides* Grabau		×														
26. *F. concava* Grabau			×													
27. *F.* cf. *maximus* Troost				×											×	
28. *Cladopora bifurcata* Grabau	×	×	×						O							a
29. *C.* cf. *cervicornis* Hall		×														
30. *Cladopora* sp	×															
31. *Syringopora microfundulus* Grabau			×	×												
32. *S. cooperi* Grabau				×												b
33. *S. hisingeri* Billings		×		×												
BRYOZOA.																
34. *Fenestella* sp. 1		×														
35. *Fenestella* sp. 2		×														
BRACHIOPODA.																
36. *Pholidops* cf. *ovata.* Hall					×						×					
37. *Schuchertella hydraulica* Whitfield					×		×									
38. *S. interstriata* (Hall)	×	×			×			×			×					
39. *S. amherstburgense* Grabau		×														
40. *Stropheodonta vasculosa* Grabau		×														
41. *Stropheodonta demissa* mut. *homolostriata.* Grabau		×														
42. *S. præplicata* Grabau		×														
43. *Stropheodonta* sp		×														
44. *Pentamerus pes-ovis.* Whitfield							?									
45. *Camarotoechia hydraulica* Whitfield							×									
46. *C. semiplicata* Conrad	×												×			
47. *Camarotoechia* sp					×											
48. *Rhynchospira preaformosa* Grabau							×									
49. *Spirifer eriense* Grabau								×			×					
50. *Sp. ohioense* Grabau						×										
51. *Spirifer sulcata* mut. *submersa* Grabau		×														
52. *Sp. modestus* Hall	×															
53. *Prosserella modestoides* Grabau		×	×													
54. *P. modestoides* mut. *depressus* Grabau		×														
55. *P. lucasi* Grabau	×		×													

TABLE III.—CONTINUED.

Showing the Distribution of the Fossils of the Monroe Formation.	Lucas Dolomite.	Amherstburg Dolomite.	Anderdone Limestone.	Flatrock.	Raisin River Dolomite.	Put in Bay Dolomite.	Greenfield Dolomite.	Akron Dolomite	Niagara.	Guelph.	Cobleskill.	Manlius.	Helderberg.	Schoharie Onondaga.	Hamilton.	Other localities.
56. *P. subtransversa* Grabau	X	X														
57. *P. subtransversa* mut. *alta* Grabau	X	X														
58. *P. unilamellosus* Grabau	X															
59. *P. planisinosus* Grabau	X															
60. *Hindella (Greenfieldia) whitfieldi* Grabau							X									
61. *H. (Greenfieldia) rostralis* Grabau							X									
62. *H. (Greenfieldia) ? rotundata* (Whitfield)							X									
63. *Whitfieldella nucleolata* (Whitfield)								X								
64. *W. prosseri* Grabau					X	?										
65. *W. subsulcata* Grabau							X	X								
66. *W. sulcata* Vanuxem								X				X				
67. *Whitfieldella* sp		X														
68. *Meristospira michiganense* Grabau	?	X														c
69. *Meristina profunda* Grabau		?			X											
70. *M. profunda* mut. *sinosus* Grabau					X											
71. *Atrypa reticularis* Linn		X														
PELECYPODA.																
72. *Panenka canadensis* Whiteaves	X	X												O		
73. *Pterinea lanii.* Grabau					X											d
74. *P. bradti* Grabau	X									?						
75. *Goniophora dubia* Hall					X	X										
76. *Goniophora* sp	X															
77. *Cypricardinia canadensis* Grabau		X														
78. *Tellinomya* sp					X											
79. *Modiomorpha* sp					X											
80. *Conocardium monroicum* Grabau	X	X	X											O		
GASTROPODA.																
81. *Hormotoma subcarinata* Grabau	X	X														
82. *H. tricarinata* Grabau	X															
83. *Solenospira minuta* (Hall)	X				X							X				
84. *S. extenuatum* (Hall)	X											X				
85. *Loxonema parva* Grabau	X															
86. *Loxonema* sp. 1					X											
87. *Loxonema* sp. 2								X								
88. *Holopea subconica* Hall	X											X				
89. *H. antiqua var pervetusta* (Conrad)		X										X				
90. *Holopea* sp. 1					X											
91. *Holopea* sp. 2					X											
92. *Holopea* sp. 3					X											
93. *Pleurotrochus tricarinatus* Grabau	X															
94. *Acanthonema holopiformis* Grabau	X	X														
95. *A. holopiformis* mut. *obsoleta.* Grabau	X															
96. *A. laxa* Grabau	X	X														
97. *A. Newberryi* (Meek)	X															
98. *Strophostylus cyclostomus* (Hall.)		X							X	X						
99. *Pleuronotus subangulatus* Grabau	X													O		
100. *Euomphalus* cf. *fairchildi* (Clarke and Ruedemann)	X									X						
101. *Eotomari areyi* (Clarke and Ruedemann)	X	X								X						
102. *Eotomaria galtensis* (Billings)	X	X	?							X						
103. *Eotomaria* sp	X	X														
104. *Lophospira bispiralis* (Hall)	X	X								X						
105. *Euomphalopteris* cf. *valeria* (Billings)	X								X	X						
106. *Pleurotomaria* cf. *velaris* Whiteaves			X							X						
107. *Trochonema ovoides* Grabau	X	X											O			
108. *Poleumita* cf. *crenulata* (Clarke and Ruedemann)	X									X						
109. *Hercynella canadense* Grabau		X														
CEPHALOPODA.																
110. *Orthoceras* cf. *trusitum* (Clarke and Ruedemann)	X									X	X					
111. *Dawsonoceras annulatum* var. *americanum* Foord		X								X						

TABLE III.—CONCLUDED.

Showing the Distribution of the Fossils of the Monroe Formation.	Lucas Dolomite.	Amherstburg Dolomite.	Anderdone Limestone.	Flatrock.	Raisin River Dolomite.	Put in Bay Dolomite.	Greenfield Dolomite.	Akron Dolomite.	Niagara.	Guelph.	Cobleskill.	Manlius.	Helderberg.	Schoharie Onondaga.	Hamilton.	Other localities.
112. *Cyrtoceras (Cyclostomiceras) orodes* Billings		X			X					X						
113. *Poterioceras* cf. *sauridens* Clarke and Ruedemann		X								X						
114. *Trochoceras (Mitroceras) gebhardi* Hall								X			X					
115. *Trochoceras anderdonense* Grabau		X														
ANNELIDA.																
116. *Spirorbis laxus* Hall					X							X				
117. *Cornulites arcuatus* Conrad		X								X						
OSTRACODA.																
118. *Leperditia scalaris* Jones								X			X					
119. *L. angulifera* Whitfield							X									
120. *L. altoides* Grabau							X									
121. *L. alta* Conrad						X						X				
122. *Kloedenia monroensis* Grabau					X											
TRILOBITA.																
123. *Proetus crassimarginatus* Hall		X												X		
MEROSTOMATA.																
124. *Eurypterus eriensis* Whitfield						X										
PLANTAE.																
125. *Bythotrephis clavelloides* Grabau								X								
126. *Sphaerococcites? glomeratus.* Grabau					X		X									

a In the Siluric beds of the headquarters of the Saskatchawan River, Canada.
b Monroe beds of Mackanic Island.
c Upper Siluric (Corrigan) formation of Maryland.
d Monroe beds of eastern Wisconsin.

CHAPTER V.

STRATIGRAPHIC AND PALÆONTOLOGIC.

SUMMARY OF THE MONROE FORMATION.

BY A. W. GRABAU.

The distribution of the faunas of the various formations is shown in the preceding tables. It will be seen at once that there are almost no species in common between the Lower and Upper Monroe; of the few recorded the majority are imperfectly preserved and doubtfully identified. This goes far to prove the importance of the hiatus represented by the Sylvania sandstone. The Lower Monroe fauna lacks altogether the coral element which is so large a feature of the Upper Monroe, where 27 species of corals and 6 species of stromatoporoids are known. The gastropod element is likewise almost wanting in the Lower Monroe, only three or four species occurring, while 24 species occur in the Upper Monroe. Six species of cephalopods representing that number of genera occur in the Upper Monroe, but only one of these has been found in the Lower Monroe. Of the 33 species of brachiopods, 18, or a little over one-half the number, occur in the Upper Monroe. This includes all the species of the subgenus Prosserella, the Stropheodontas, and a few others while the Whitfieldellas, Spirifers of the *S. crispus* type, and the Meristinas characterize the Lower Monroe.

Such a complete and striking difference in the two faunas is indicative of a pronounced geological break or hiatus, and this is represented by the desert sands of the Sylvania. It is not saying too much, that the interval corresponds to several hundred feet of sedimentation, the unrepresented middle Monroe series being no doubt of equal magnitude with that of either of the other two divisions.

THE FAUNAS IN DETAIL.

A. LOWER MONROE.

a. The Greenfield fauna. This fauna at Greenfield, Ohio, ranges probably through 100 feet of strata, and is found again at Ballville in northern Ohio. It was formerly identified by the author with the Bullhead or Akron fauna of western New York, but a critical comparison of the actual specimens, preserved in the collection of Columbia University, shows agreement in few points only. To begin with, both the cephalopods and the coral element, absent from the Lower Monroe, are found in the Akron. At the same time the Whitfieldella type of brachiopod, the *crispus* type of Spirifer, and the ostracods are characteristic of the Akron and seem to link it with the Ohio Greenfield. The most characteristic brachiopod of the Greenfield fauna *Schuchertella hydraulica* finds its nearest relative in *S. interstriata* of the Akron. The species referred to *Hindella* with a query have their nearest representation in the Clinton of Ohio, and in the Anticosti group.

From the most abundant and characteristic type, this fauna may be called the *Schuchertella hydraulica* fauna.

b. The Put-in-Bay fauna. This is a typical upper Siluric fauna. *Spirifer ohioensis* and *Goniophora dubia* are the predominant types, the latter being the most characteristic, so that the fauna may well be named the *Goniophora dubia* fauna. Both the characteristic species have their nearest analogues in the Manlius limestone. *Spirifer ohioensis* is a modification of *S. vanuxemi,* both being probably derived from *S. crispus* of the Niagaran. *S. ohioensis* appears to be intermediate between *S. vanuxemi* and *S. crispus*. *Goniophora dubia* of the Put-in-Bay beds has not been differentiated from the species of the Manlius limestone of Schoharie to which the name was originally applied. The species is represented by a single impression in the collections from the Raisin river beds of the Monroe quarries, but by a number of individuals in the salt shaft. This together with the fact that *Whitfieldella prosseri* occurs in some of the higher beds of Put-in-Bay island, indicates the close relationship between the Put-in-Bay and Raisin river beds. The common Leperditia of these beds seems to be identical with *L. alta* of the Manlius. The presence of Eurypterus in these strata side by side with the marine fossils, should be noted. The genus is most characteristic of the Bertie Waterlime, but the species most nearly related to if not identical with *E. eriensis* of the Monroe, is found in the Manlius of New York.

c. The Raisin river fauna. The fauna of the Raisin river beds is another typical upper Siluric fauna. The most characteristic species is *Whitfieldella prosseri,* which appears to be a derivative

of the Niagaran *W. nitida*. The characteristic Siluric genus Meristina is likewise represented in the higher beds of this series and the little Pholidops identified by Weller as *P. ovata,* and occurring in the Upper Siluric (Rondout?) of New Jersey, also has been found. The identification with Hall's Helderbergian species is probably incorrect. The pelecypods are well represented by *Pterinea lanii,* which is abundant and well preserved. It is a somewhat distant relative of *Megambonia aviculoidea* of the Manlius, with which it has often been identified. Apparently identical individuals occur in the corresponding strata in Wisconsin and in southern Pennsylvania. Other pelecypods are a species of Tellinomya, and a small species of Modiella ??

The gastropods are represented by several specimens, chiefly Loxonema and Solenospira, *S. minutum* and *S. extenuatum* being among those provisionally identified. Holopea also is represented by one or more species, but the material is too imperfect for absolute identification. These species are represented in the Manlius limestone of eastern New York but the identity of our specimens is not fully established.

The little *Kloedenia sussexensis* described by Weller from the Decker Ferry formation of New Jersey, is represented in this division by *K. monroensis*. The worm tube *Spirorbis laxus* is another Manlius type abounding in these strata.

On the whole the Lower Monroe faunas are intimately related to the Upper Siluric (Manlius and Rondout) of eastern New York. This is especially true of the Put-in-Bay and Raisin river beds, only here the fauna is distributed through at least 300 feet of strata, while in New York the beds aggregate less than 100 feet.

THE UPPER MONROE FAUNAS.

d. The faunas of the Flatrock, Anderdon and Amherstburg beds. The faunas of these three beds must be considered together since they constitute a unit. Its most characteristic feature is its Devonic element. If the fauna were considered by itself, it would probably be pronounced a Schoharie or an Onondaga fauna without a moment's hesitation, though there is a considerable Siluric element. The position of this fauna beneath 200 to 250 feet of the Lucas dolomite with a Siluric fauna, forces us to consider this as Siluric. A detailed consideration of the fauna will bring out its relationships. The Stromatoporoids which are wholly confined to this fauna are among its most characteristic elements. Of these three species *Clathrodictyon oslcolatum*, *C. variolare* and *Stromatopora galtense* are characteristic Siluric fossils, the first and third occurring in the Guelph of Canada and New York, and in the Cobleskill of eastern New York, while the second is a characteristic Siluric species in Europe. Two of the remaining species, however, though new, are of genera heretofore known only from mid-Devonic formations. Thus *Stylodictyon sherzeri* is of the type of *S. columnare,* characteristic of the Dundee (Columbus) limestone of Ohio and elsewhere. *Idiostroma nattressi* is closely related to another small Idiostroma abundant in the Upper Traverse of Michigan and is also similar to a form of the European middle Devonic. The only described American species of that genus *I. cæspitosa* is a characteristic Upper Traverse species. The third new species *Cœnostroma pustulosa,* is most nearly related to Siluric types.

Among the corals *Helenterophyllum calyculoides* appears to be an immediate derivative of *Enterolasma caliculus,* a characteristic Niagaran type. It has also been found in the Manlius limestone of New York. *Cyathophyllum* cf. *thoroldense* is compared with a Niagaran type, and *Heliophrentis* represented by four mutations is only a slight modification of a Niagaran type. Thus *Heliophrentis alternatum* is a modified *Zaphrentis racinensis* of the Niagaran of Wisconsin, while the other species are modifications of this type, chiefly through carination of the septa. This species is represented by a closely related if not identical form in the Schoharie of the Helderbergs. *Cystiphyllum americanum* mutation *anderdonense* is a type whose nearest relative is a characteristic Hamilton species. *Acervularia sp.* is likewise a Devonic type, though a somewhat similar species occurs in the Niagaran below the Dundee. *Synaptophyllum multicaule* on the other hand is a Siluric type, being well represented in the Niagaran. *Diplophyllum integumentum* is otherwise known only from the Cobleskill and Decker ferry, while a closely related species, *D. cæspitosum* is a characteristic Niagaran type. *Romingeria umbellifera* is again a Devonic type, being most characteristic of the Onondaga of Canada and elsewhere. *Cladopora regularis* is very closely related to *Cladopora subtenuis* of the Helderbergian of New York but it is much larger. *Ceratopora tenella* is a Niagaran species. The Favosites are without exception Devonic types, their nearest relatives being Dundee species. Thus *F. basaltica* var. *nana* is only a smaller form of *F. basaltica* of the Columbus limestone. *F. rectangulus* is a cylindrical type of the same character, while *F. tuberoides* is a reduced representative of *F. tuberosus* of the Dundee. It is not unlikely that these species represented in a distinct genetic series, the stages in development represented by the corresponding Mid-Devonic species in their genetic succession. *F. concava* and *F. maximus* also are Devonic types, the former representing the structure of *F. epidermatus.* The genus Cladopora is represented by several species, one of which, *C. dichotoma,* most characteristic of the Anderdon bed, also found in the limestones of the Upper Saskatchewan, has its nearest relative among the known Siluric species, while another is identified with a typical Devonic form. Syringopora is represented by one Siluric species, *S. retiformis,* but the other two, *S. cooperi* and *S. hisingeri,* are Devonic types.

The brachiopods are represented by a number of species in this fauna. *Schuchertella interstriata* is a Siluric type occurring in the Cobleskill of eastern New York. A modified type of the same structure though resembling somewhat an Oriskany type is *S. amherstburgense.* The genus Stropheodonta is represented by species of Devonic affinities. Thus *S. vasculosa* comes nearest to Schoharie types though a Helderbergian form (*S. patersoni-bonamica* Clarke) also closely resembles our species. A variety of *S. demissa,* resembling the forms from the Schoharie and Onondaga is not uncommon in the Amherstburg beds, while *S. præplicata,* a close relative of *S. plicata* of the Hamilton, further emphasizes the Devonic aspect of this fauna. The Spirifers are chiefly represented by the subgenus Prosserella with *P. modestoides* and its mutation *depressus* predominating. These species, characterized by closely parallel dental lamellæ, are of types not definitely known from the Siluric elsewhere, though a species found in the Cobleskill of eastern New York has the form and general characters of the Anderdon species, the internal structure being, however, unknown. Species with the type of internal structure and external form characteristic of Prosserella occur in the Mid-Devonic limestone of the Eifel district. There is, however, a species of Siluric affinities in the Amherstburg fauna. This is *Spirifer sulcatus* mut. *submersus*, which is most nearly identical with *Sp. sulcatus* as developed in the European Siluric, though not of the form of that species in the American Niagaran. On the whole brachiopods are not common in the formations in question. Besides those mentioned there are a number of others more or less perfectly preserved, among which *Atrypa reticularis* has been doubtfully identified.

Of pelecypods, the two most common and characteristic species are Devonic types. These are, *Panenka canadensis* and *Conocardium monroicum*. The former was described by Whiteaves as a "Corniferous" or Dundee type, and its nearest relative is found in *Panenka dichotoma* of the Schoharie grit. *Conocardium monroicum* finds its nearest relative in *C. trigonale* of the Schoharie and Onondaga fauna. The two, while distinct, may very readily be mistaken the one for the other. This species is widely distributed through the Anderdon and Amherstburg beds, being abundant in nearly every exposure. It also passes up into the base of the overlying Lucas dolomites. Cypricardinia, the only other characteristic pelecypod is rather indeterminate; its affinities seem to be with lower Devonic species.

The gastropods of this fauna are all Siluric species, or when new, have their nearest relatives among Siluric species. Many of them are types characteristic of the overlying Lucas, making their first appearance in the Amherstburg bed. Others are so far unknown from the overlying beds, but clearly belong to the gastropod fauna of those beds. It is clearly an immigrant fauna of a new type which has entered this region at the end of the period of dominance of the coral fauna of the Anderdon.

The fauna is best considered as a whole under the discussion of the Lucas fauna.

The cephalopods of this fauna are with one exception so far known only from the Amherstburg beds. They are Siluric types, several of the species being characteristic Siluric forms. These are *Cyrtoceras orodes* and *Poterioceras sauridens* characteristic of the Guelph of Canada and New York. Only the first of these has been found in the Lower Monroe. The annulated cephalopods are represented by a variety of *Dawsonoceras annulatum* characterized by close-set septa, while the turreted cephalopods are represented by a smooth species of Trochoceras (*T. anderdonense*) which has its nearest relative in *T. priscum* Barrande of Etage E, the upper Siluric of Bohemia. In fact it is questionable if our species is not merely a local representative of the Bohemian species.

The tubicular annelids are represented in this fauna only by *Cornulites armatus* Conrad, a species occurring in the Guelph of New York as well as in the Cobleskill.

Finally the Trilobites are represented by a species indistinguishable from *Proëtus crassimarginatus* of the Schoharie and Onondaga faunas.

To sum up, the stromatoporoids of this fauna are partly Siluric and partly of Devonic types. The corals are represented by 9 Siluric species and 13 species identical with or most nearly like Mid-Devonic species. The brachiopods are, with two exceptions, of types otherwise known only from the Mid-Devonic. The pelecypods are similarly Mid-Devonic types and so are the trilobites. The gastropods and cephalopods on the other hand are without exception upper Siluric types.

THE LUCAS FAUNA.

This is the highest fauna of the Monroe group, and it is throughout a Siluric fauna. The only corals found in it are *Cylindrohelium profundum*, a derivative of the Siluric *Diplophyllum integumentum* of the underlying beds and also characteristic of the limestone on the upper Saskatchewan; *Cladopora dichotoma*, also a Siluric type, persisting from the Anderdon, and a calyx of Heliophyllum? not unlike that of *H. pravum*, and also occurring in the Guelph of western New York. The brachiopods are mainly persistent types, passing upwards from the lower formations of the Upper Monroe. They include *Schuchertella interstriata*, and four species of the Spiriferoid genus Prosserella. *P. lucasi*, which is most characteristic, *P. subtransversa* and *P. unilamellosus* mainly in the lower beds, and *P. planisinosus*. Apparently species of this latter type are found in the Cobleskill limestone of eastern New York. The closely related upper Siluric *Spirifer modestus*, and the Upper Siluric and lower Devonic *Camarotocchia semiplicata* also occur in this horizon. The pelecypods are few, consisting for the most part of species continued into the lower Lucas from the Anderdon and Amherstburg horizons, as *Pananka canadensis* and *Concar-*

dium monroicum. In the higher beds of the salt shaft the only pelecypod is *Pterinea bradti,* apparently a derivative of the Lower Monroe *P. lanii.* Goniophora appears also to be represented by a species related to the characteristic form of the Lower Monroe.

The gastropod fauna, as already noted, is a Siluric fauna, and moreover one mostly exotic in character. It makes its first appearance in the Amherstburg bed side by side with the members of the indigenous Anderdon-Amherstburg fauna.

The genus Hormotoma with species in the Ordovicic and the Devonic, as well as the Siluric, is represented by two species, which are very abundant in individuals. Their nearest relatives occur in the Upper Siluric beds of Gotland (*H. cavum, H. moniliformis, H. obtusangulus* and *H. subplicata* Lindström) where the genus is well represented. Solenospira appears to be represented by two minute species also found in the Manlius limestone, and perhaps also in the upper beds of the Lower Monroe. The genus Holopea is represented in the fauna by the species characteristic of the Manlius limestone of the eastern region, i. e., *H. antiqua pervetusta* and *H. subconicus.* The genus Pleurotrochus with one species is well represented among the "Murchisonias" of Gotland, there being several species in the Upper Siluric of that region, at least one of which appears to be a very close relative of our species. Acanthonema appears to be a derivative of Pleurotrochus. It is so far unknown from other formations. One of our species *A. newberryi* was originally referred to the "Corniferous," in the Palæontology of Ohio. It is, however, a Lucus type and unknown outside of the Upper Monroe.

Strophostylus cyclostomus is a characteristic Niagaran species while the species of Eotomaria and Lophospira are such as have been previously obtained from the Guelph of America, and have their close relatives in the Siluric of Gotland. Euomphalopterus is a typical Siluric genus with several species in the foreign Siluric and one in the American Siluric. Our species though very fragmentary seems nearest to *E. valeria* (Billings) of the Guelph, while the closely related *Pleurotomaria velaris* Whiteaves is also represented. Only two species are similar to the Devonic forms. These are *Pleuronotus subangularis* which is apparently closely related to *P. decewi* of the Dundee; and *Trochonema ovoides* which has a

close relative in *T. lescarboti* Clarke of the Helderbergian of the Gaspé region. The remarkable genus Hercynella has heretofore been known only from the lower Devonic, being abundantly represented in Div. G. of the Bohemian series.

It thus appears that the Anderdon fauna was a local invasion probably from the north of a highly specialized indigenous fauna, which was later replaced by an immigrant fauna of European origin and probably entering the region through eastern United States. This immigrant Siluric fauna consisted mainly of gastropods and cephalopods, while the brachiopod-pelecypod-trilobite element together with the corals and stromatoporoids are of indigenous development. This indigenous fauna later on returned as the Schoharie fauna and by modification and immigration developed into the Onondaga and later into the Traverse faunas.

CHAPTER VI.

CORRELATION OF THE MONROE FORMATION OF MICHIGAN, OHIO AND CANADA, WITH THE UPPER SILURIC OF EASTERN NORTH AMERICA AND ELSEWHERE.

BY A. W. GRABAU.

The correlation of the Monroe formation with the known Siluric formations of New York—the type section for eastern North America—is a matter of considerable difficulty. So long as the true thickness and character of this division remained unknown the general correlation with the late Siluric beds of New York seemed possible. The relation of Waterlime (Bertie) and Salina in the western New York region seemed to be reproduced in the Ohio region, where the calcilutites of Greenfield, Ohio, Put-in-Bay and Lucas county, and their extension into southern Michigan were denominated the Waterlime group, while the dark or gray shales found beneath them in some localities were correlated with the Salina. From the fact that the Waterlime (and Tentaculite or Manlius) were in the older classifications classed with the Helderbergian formations as Lower Helderberg, this term was pretty generally applied to the formations between the Salina and Oriskany or Onondaga. Thus in Ohio these beds were generally known by the name Waterlime, while in Michigan the term Lower Helderberg has been widely applied to this formation. At first it was thought that this so-called "Lower Helderberg" series bridged the gap between the Salina and the Oriskany, the great hiatus between these two formations being unrecognized, and when further the hiatus between the Waterlimes and the Onondaga became apparent, it was at first thought that this series might be in part representative of the Salina of New York as well as the Waterlime and Manlius.

Lane in 1893, proposed the term Monroe for the entire series of the formations lying between the Niagara and the Dundee. This is synonymous with the term Cayugan of Clarke and Schuchert. Moreover it was assumed that the line of division between the Salina and the overlying waterlime series was an indefinite one and not always at the same level. It is becoming more and more apparent, however, that the line of contact between the Salina and the overlying calcilutites is a very distinct one, the former representing physical conditions widely distinct from the marine conditions indicated by the latter. Grabau has repeatedly pointed out the close agreement of the Salina formation with the requirements of the theory of desert origin of these deposits and their total disagreement with the requirements of the bar theory of Ochsenius, which was used by Hubbard to explain the salt deposits of Michigan, and has been more or less generally accepted.[1]

One of the chief points to be considered is the total absence of organic remains in the strata enclosing the salt,—whereas, according to the theory defended by Hubbard, remains of marine organisms should be abundant in these deposits, as shown by the most typical modern examples of salt deposits found under the conditions required by the bar theory—the Kara Bugas gulf on the eastern border of the Caspian and the Bitter seas of Suez. Another point[2] is the absence outside of the salt area of marine deposits corresponding to the salt beds, for if the present area of these salt beds marks the limit of their accumulations as is indicated by the fact that they are overlapped by higher strata of late Siluric age, there should be just outside of the salt area extensive deposits with marine fossils representing the time period during which the salt accumulated in the cut-off portion of the sea. This marine series should be wide spread, for only from an extensive body of sea water, capable of furnishing the salt supply of the water in the cut-off by washing across the shallow bar can extensive beds of salt accumulate. There is nowhere in North America a suitable marine formation which would fill these requirements, but without the evidence of the former existence of such a formation, the bar theory breaks down utterly. Nor can the advocates of the bar theory appeal to erosion as having removed this purely marine "Salina" formation, for the higher marine beds the typical Monroe which overlie the Salina beds also overlap and rest upon the eroded surface of Niagaran or earlier formations. If a marine series corresponding to the Salina did exist, it should be preserved beneath the cover of the later marine Silurics. But in all directions, these marine upper Silurics, where they do not rest

[1]See Geol. Michigan, Vol. V, Pt. II, 1895, introduction, p. xiii.
[2]Grabau, A. W., Jour. of Geology, XVII, p. 245. An extensive discussion of this problem is in preparation, of which the passages here given are a condensation.

upon the Salina itself, rest upon the eroded surfaces of pre-Salina formations. This indicates land all around the basin in which the Salina was deposited, and extensive erosion. This condition is compatible only with the theory of the desert origin of the salt deposits.

Whether or not we consider the non-marine origin of the salt deposits as proven, there can be no doubt of the marine origin of most of the overlying beds, for they contain typical marine fossils. Furthermore, since the fossiliferous beds overlie the salt beds, there can be no other interpretation than that pure marine conditions succeeded the peculiar conditions existing during Salina time in Michigan, Canada and western New York, and that these marine conditions were more widely spread than the preceding Salina conditions. For this reason, as repeatedly urged by the author, it is desirable to restrict the name Monroe to the marine deposits following the Salina, especially since the deposits at Monroe, Michigan, from which the name is derived, are all of this marine type, the Salina here being in great part if not wholly overlapped.

The author has elsewhere proposed[3] to rearrange the North American Siluric formations according to the following plan:

3. Upper Siluric or Monroan.
2. Middle Siluric Salinan.
1. Lower Siluric or Niagaran.

This represents a more satisfactory division than that heretofore in use, and expresses the present state of our knowledge. It is in accordance with this subdivision that the term Monroe is used in this paper.

The Lower Monroe beds have not been well exposed in Michigan but they are penetrated by the salt shaft, but even in this, owing to the difficulty of examination, we are unable to get a very satisfactory evidence of their relationship with the underlying Salina. All that can be said is that the salt appears to be succeeded conformably by some member of the Lower Monroan which higher up is fossiliferous. That the Greenfield dolomite of Ohio represents the lowest exposed Monroe beds is most probable, though this can not be absolutely proven until the series in Ohio has been thoroughly investigated over wider areas. Wherever exposed in

[3]Science N. S., Vol. XXVII, 1908, p. 622. See also Physical and Faunal Evolution of North America during Ordovicic, Siluric and early Devonic time. Journ. of Geology, Vol. XVII, pp. 209-252. (Correlation table.)

southern as well as northern Ohio the Greenfield rests upon the Niagaran surface. The Greenfield was formerly correlated by Grabau with the Akron or Bullhead dolomite of Buffalo, which in turn has been correlated with the Cobleskill of eastern New York. Both correlations can not be correct since this would give us a total of nearly 900 feet of Siluric strata in Michigan and Ohio, above the horizon of the Cobleskill.

From a comparison of the Cobleskill and Akron faunas it becomes evident that the two faunas are very closely related. In fact all the most important species of the Akron fauna are typical also of the Cobleskill. Moreover the relation of the Akron and the underlying Bertie Waterlime is a very intimate one, the latter grading up into the former, while some of the fossils of the Akron already made their appearance in the upper Bertie. Moreover this relationship of the two formations is traceable through most of western New York, while in central New York near Union Springs on Cayuga Lake, where the Cobleskill is typically developed, the Bertie with its characteristic Eurypterus is found to underlie it,[4] while the Rondout and Manlius overlie it, followed after a disconformity and hiatus by the Oriskany.

In looking over the divisions of the Monroe which might be taken as the western representative of the Cobleskill, or better, of which the Cobleskill is the eastern extension, the Anderdon and Amherstburg beds appear to be the most available ones. Certainly none of the Lower Monroe beds have the faunal character which we should expect to characterize such a formation, but such a character is found in the faunas of the two formations mentioned. Of the two the Amherstburg bed is probably to be considered the more direct equivalent of the Cobleskill. Faunally the Cobleskill shows its relationship to the Upper Monroe in the presence of *Clathrodictyon ostiolare* and *Stromatopora galtense*; *Diplophyllum integumentum* and probably some of the Favosites are likewise common to both, and so is *Schuchertella interstriata*. It is quite likely also that some of the pauciplicate and smooth species of brachiopods described as Spirifers or perhaps under other generic names, may belong to the genus Prosserella and possibly other brachipods may be found in common between the two. Other species in common between the two faunas are *Orthoceras trusitum* and *Cornulites arcuatus* and possibly some pelecypods.

[4]Hartnagel, Rep. N. Y. State Pal., 1902, p. 1134.

If we correlate the Cobleskill with the Amherstburg and accept the correlation of the Cobleskill and Bullhead of Buffalo, we are forced to the conclusion that a great hiatus exists between the Bertie and the Salina of the western New York section. This we have to assume, because the Salina of Michigan—a thousand feet thick is followed by nearly a thousand feet of marine strata of which the Amherstburg, the assumed correlative of the Cobleskill, forms one of the upper members, while in western New York, the Salina less than 400 feet thick, and probably representing only the Vernon and Pittsford shales or a part of them, of the more eastern localities, is succeeded by about 60 feet or less of Waterlimes, the upper beds of which carry the Eurypterus fauna, and pass upward into the overlying Akron with a Cobleskill fauna. Of course the whole of the Salina, as represented by the central New York and the Michigan deposits may never have been deposited in western New York, since continental deposits are notably of an irregular character. If the Bertie waterlime represents marine conditions, as is generally held, and as seems to be indicated by the molluscan and brachiopod elements of its fauna, though not necessarily by the Eurypterid elements—then it must be regarded as the first invasion of the sea over the Salina area of New York. But this invasion was preceded by a long period of marine conditions in Michigan and Ohio, during which the Lower Monroe beds were deposited. This series of formations represents an invasion possibly from the Atlantic through a passage connecting the lower Monroe sea either with the region of the present Gulf on the south or with the Atlantic in the Maryland region. The marine fauna of the lower Monroe is essentially an Atlantic upper Siluric fauna, if we may judge from its similarity to the Manlius fauna which is believed to be an Atlantic fauna though on the correlation here considered a younger fauna than the lower Monroe. It is certain that the invasion was not from the northeast, since here continental conditions continued longer, as shown by the overlaps of the marine beds in that direction.

Thus while the whole, or the greater part of the Monroe seems to be present in Maryland, only the Upper Monroe appears to be represented by the Lewistown of central Pennsylvania. In New York the Decker Ferry formation together with the underlying Bossardville and Poxino island beds includes nearly 60 feet of

Upper Monroe, the summit being formed by the Cobleskill. Above this are the Rondout 39 feet, and the Manlius 39 feet, making a total of nearly 139 feet of Upper Siluric strata. In the Rosendale region of Ulster county, New York, the High Falls (Upper Salina) shales are succeeded by a limestone generally less than a foot in thickness (Wilbur limestone), and this by the Rosendale cement bed 22 feet thick, the Cobleskill limestone 14 feet, and the Rondout 20 feet, and Manlius[5] 42 feet. In the Kingston region the Cobleskill rests directly upon the Hudson River shales,[6] while in the northern Helderberg,[7] and at Becraft mountain,[8] the Manlius with perhaps a suggestion of the Rondout rest upon the Ordovicic Hudson River beds. A progressive northward and northeastward overlap is thus shown throughout Monroe time.

In Maryland the beds immediately succeeding the Niagaran have been referred to the Salina. These beds are well exposed on the Baltimore and Ohio R. R. near Potomac, (Pinto) Maryland. This section was first described in 1900 by C. C. O'Harra in the report on Alleghany county, Md. (Md. Geol. Survey). It was more fully discussed by Schuchert,[9] in 1903, whose interpretation differs somewhat from that of O'Harra; among other changes he places the dividing line between the Niagara and "Salina" nearly 25 feet higher up in the series. A somewhat careful study of this section with O'Harra's paper as a basis and without reference to Schuchert's work led me to place the dividing line at the exact place determined on by Schuchert.[10] This interpretation was wholly on physical grounds, for the evidence of a profound hiatus and disconformity was obtained. At the top of the Niagaran series, which is here a ripple-marked sandstone, is a mass of disintegrated rock containing rounded boulders of limestone, the aspect of these boulders being such as to indicate water wear and not disintegration, since the boulders are wholly unaffected by the disintegration of the surrounding rock. These boulders probably mark the first readvance of the sea over an old land surface of

[5]Hartnagel, C., N. Y. State Palaeon. An. Rept. 1903. VanIngen, G. and Clark, P. E., N. Y. State Geol. 17th An. Rept., and N. Y. State Museum 51st An. Rept., Vol. II. 1899.

[6]Grabau, A. W., Bull. 92, N. Y. State Mus., p. 312.

[7]Prosser. C. S., N. Y. State Geol. 18th An. Rept. See also N. Y. State Mus., Bull. 92, p. 286.

[8]Grabau, A. W., Stratigraphy of Becraft Mountain, N. Y. State Palaeontol. Rept., 1903, pp. 1030-79.

[9]Schuchert, Chas., Proc. U. S. Nat. Mus., Vol. XXVI, pp. 413-424.

[10]Schuchert's paper was not consulted until after return from the field, and the difference in interpretation between the two authors was not noted until that time.

Niagaran rock. No fossils have been seen in the boulders and their age is indeterminate. They may be anywhere from Niagaran to early Monroan, though from the fact that they rest upon the Niagaran beds, they probably belong to the lower horizon. The confirmatory palaeontologic evidence furnished by the restudy of Schuchert's paper makes the interpretation practically unassailable. He finds that *Leperditia* makes its first appearance in this section at this point, and that "no part of its (the Niagara) fauna is found higher up, unless it be a few of the *Ostracoda* which remain undetermined."[11] Schuchert, however, considers that "the Niagaran deposits are seen to pass without apparent break into the Salina."[12] The break, however, may be determined by a study of the disintegrated zone.

The beds of the Lower Monroe of this section, the so-called Maryland Salina, are nearly all calcilutites, mostly thin-bedded, well stratified, and of the general type of the Monroe formation elsewhere. Fossils, while not very abundant as compared with the Michigan strata, nevertheless occur, being mostly ostracods of the genera Leperditia, Bollia, Octonaria, etc. These range through the lower 600 feet or more. The beds above this were referred by O'Harra to the "Helderberg," but Schuchert includes nearly the entire series in the Salina (525 feet) and regards the top of the section as the lowest Manlius. The succeeding "Manlius" exposed at Keyser, W. Va., (110 feet) has recently been made the subject of a careful and detailed faunal study by Dr. T. Poole Maynard of Johns Hopkins University. The series have been named the Corrigan formation, and in the outline presented before the Geological Society of America at the Cambridge meeting, 1909-10, it was shown that the fauna was a unit and of the Upper Siluric (Cobleskill-Manlius) type. A comparison of the fossils with those of the Upper Monroe formation of Michigan has convinced both Mr. Maynard and the author of the relationship of the faunas, some of the characteristic Michigan species, such as *Meristospira michiganense* Grabau, Panenka, etc., being present in the Corrigan. While thus the Corrigan of Maryland (Manlius of Schuchert, Helderbergian of O'Harra's Potomac section) must be regarded as representative of the Upper Monroe, together with a part of Schuchert's Salina, i. e., that part referred by O'Harra to the Helderbergian, the Lower

[11]Loc. cit. pp. 415-416.

[12]Loc. cit. p. 415.

Salina of Schuchert (Salina of O'Harra's Potomac section), is with equal confidence referred to the Lower Monroe of Michigan. There is absolutely no stratigraphic break between the two series, in fact as shown by Schuchert, deposition here was continuous from the time it commenced in post-Niagaran time through the Coeymans of the lower Devonic. But according to my interpretation of the facts and section this marine deposition commenced in post-Salina time, this latter—the mid-Siluric—being wholly unrepresented in the Maryland region.

In central Pennsylvania, the Lewistown succeeds generally the Longwood shale, which is a red continental deposit of Salina age, and which in turn rests upon the Shawangunk conglomerate. This latter rock has been recognized for some time by the author as a characteristic fan of continental origin[13] (continental river deposits) formed in early Saline time.[14]

Lately Mr. Paul Billingsley, a graduate student in the author's laboratory at Columbia University, has undertaken a detailed investigation of this problem, the results of which were announced before Section E., A. A. A. S., Cambridge meeting, 1909-10, and the New York Academy of Sciences. The full detail will be published shortly, but it may be stated that Mr. Billingsley's investigations fully demonstrate the torrential origin of the Shawangunk, and the continental conditions of the Appalachian region at the time of its formation. The contained Eurypterid fauna is also shown to be in harmony with this interpretation, these Merostomes being either fresh water forms or capable of entering the streams which discharged into the contracted sea of late Niagaran and early Salinan time.

The Lewistown limestone for the most part represents upper Monroe, as shown by the abundance of stromatoporoids and corals of the types found in the Anderdon limestone. A study of the Lewistown fauna now in progress at Columbia will, it is believed, help to fully establish this relationship on faunal grounds. The limestone in some places seems to grade downwards into the Salina shales, the Ostracods making their appearance in the upper part of these shales. This, however, is to be expected when on the transgression of the sea across a region of previous continental sedimentation, the upper beds of this continental series are reworked, and so incorporated with the basal marine series, while at the same time the existing hiatus is obscured or rendered invisible.

[13] Journ. of Geology, XVII, 1909, pp. 245-246.
[14] Geol. Soc. American Bull., Vol. XVI, p. 582, 1906.

ALTERNATIVE CORRELATION.

If correlation were to be based on faunal evidence alone, a different interpretation of the stratigraphy of Michigan would probably be adopted. In that case the lower Monroe would be correlated with the upper Cuyugan, i. e., the beds from the Cobleskill upwards. Faunally there is a striking correspondence between the Raisin River and Put-in-Bay beds and the Manlius of New York. This extends even to the Eurypterids as determined by Ruedemann. *Spirorbis laxus, Goniophora dubia,* and *Leperditia alta* are represented in both, and *Spirifer ohioensis* and *Pterinea lanii* have their representatives in *Spirifer vanuxemi* and *Pterinea aviculoidea* of the Manlius of New York.

Faunally the upper Monroe might be considered as the indigenous lower Devonic, with a sparse mingling of foreign types of this age, such as Hercynella. On this hypothesis, the Sylvania would represent the continental condition appearing at the end of the Siluric during the temporary retreat of the Siluric sea and before the expansion of the Helderbergian sea. Thus considered, the upper Monroe would represent a provincial phase of the lower Devonic distinct from the Helderbergian.

Since the Monroe beds and underlying formations are all involved in slight folding which took place in post-Monroe and pre-Dundee times, this folding and the subsequent erosion would have to be referred to the Oriskany. Though much longer than usually assumed, from the partial representation of this formation in eastern United States, it may be questioned of Oriskany time was long enough to permit all this deformation and erosion which in places removed the entire upper Monroe so that the Dundee rests upon the Sylvania or lower beds.

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THE CORRELATION AS ADOPTED.

All facts considered, we may conclude that the correlation first discussed is approximately correct, the correspondence being as follows:

Michigan and Ohio.	Western New York.	Eastern New York.	Appalachians.
Dundee.	Onondaga.	Onondaga to Coeymans.	Coeymans.
Hiatus and disconformity	Hiatus and disconformity.	Continuity of deposition.	Continuity of deposition.
Lucas dolomite.	wanting.	Manlius limestone. Rondout waterline.	Corrigan formation of Maryland with perhaps part of Upper "Salina" of Schuchert's section. Lewistown formation of Pennsylvania.
Amherstburg dolomite. Anderdon limestone. Flat Rock dolomite. Hiatus.	Akron dolomite. Bertie waterlime.	Cobleskill limestone. Rosendale waterlime.	
Sylvania sandstone. Hiatus.	Hiatus and Disconformity.	Hiatus and Disconformity.	
Raisin River beds. Put-in-bay limestone. Tymochtee shale. Greenfield dolomite.			Continuity of depositon. "Salina" of Maryland. Wanting (?) in Pennsylvania.
Hiatus and disconformity.			
Salina formation. Niagaran series. Continuous deposition from Ordovicic.	Salina series. Niagaran series. Continuous deposition from Ordovicic.	Longwood High Falls shales (N. Y. to Penn.) Shawangunk conglom. (N. Y. to Penn.)	Hiatus and disconformity in Maryland.
		Hiatus and unconformity.	Niagaran.
		Ordovicic beds.	

CHAPTER VII.

PALÆOGEOGRAPHY OF MONROE TIME.

BY A. W. GRABAU AND W. H. SHERZER.

The Palæogeography of Monroe time is that of the North American Upper Siluric. The Middle Siluric period, or that of the Salina deposits, was characterized at the beginning, by the withdrawal of the wide-spread Niagaran sea, and the gradual dessication of the continental block. The sea may have lingered in arctic North America, but at present we have no knowledge of the details of sedimentation there. So far as the United States were concerned, there appears to have been no marine area in Salina time. During the progress of contraction of the sea, while still a remnant remained in the New York-Michigan area, elevation took place in the Northern Appalachians, which caused the torrential deposits now constituting the Shawangunk conglomerate. The Eurypterids living in the streams which formed these deposits, and the remains of which are found in fragmentary condition in the intercalated black shales, were also carried out into the remnant of the Niagaran sea, where they were probably able to exist in waters not too salt, and where their remains became embedded in the early strata of the Salina series, which are the direct depositional successors of the Guelph formation. With the complete disappearance of the sea from the North American continent, the climate became more arid, and the deposition of the extensive red shale series (Longwood) of eastern New York and Pennsylvania commenced. Over the Michigan-Ontario-Western New York area, which constituted one or more basin-shaped depressions, the deposition of the Salina muds began. These were derived from the erosion of the earlier marine strata, especially the Niagaran series, which according to all indications had a wide distribution in pre-Salina time. Since the Niagaran is so largely calcareous, the resultant detrital material made more or less argillaceous calcilutites or lime-mud rocks. These were carried by the intermittent desert streams to the center of the Salina desert, which was in the Michigan region, and there deposited in shallow playa lakes. This accounts for the fine stratification and other depositional features of these formations. The deposits carried by rivers from the northern Appalachians, were mostly argillaceous and at first predominantly red. These are now found in the lower Salina shales of New York, etc. The salt and gypsum found in these deposits was the old sea-salt imprisoned in the Niagaran and earlier marine stata at the time of their formation under the sea. On exposure of these salt impregnated limestones (the salt in which constituted about one per cent of the mass), to the dry and hot desert climate of Salina time, the salt and gypsum formed as an efflorescence upon the surface of the exposed rocks, and this in rainy periods was washed towards the center of the basin; i. e., the Michigan and New York regions. Here it was deposited on the evaporation of the shallow playa lakes, after the manner of deposition of salt in desert basins of today. To produce a salt bed 100 ft. thick, and covering an area of 25,000 square miles, which is probably in excess of the area covered by the thick salt beds, it would require the erosion of 100 ft. of marine limestone covering an area of 2,500,000 square miles, or 400 ft. of limestone covering an area of 625,000 square miles, and the concentration of the derived salt in the basin 25,000 square miles in area. Thus for the production of a pure mass of rock salt covering 25,000 square miles, and 100 ft. thick, the erosion of 400 ft. of limestone from Wisconsin, Minnesota, the upper Great Lake region, and the Ontario region west of Toronto would suffice. But since we know, that the thickness of the Niagaran limestone over this region was at least twice 400 ft., not to mention the thickness of the lower marine strata which have also been removed by erosion, it will be seen that the removal of the Niagaran limestones from this area would give a salt mass 200 ft. thick and covering an area of 25,000 square miles, or approximately 1,000 cubic miles of rock salt. This is probably much more than the total quantity of rock salt in the Salina of Michigan, while that of Canada, with a total thickness of 126 ft. at Goderich, comprises probably not much over 100 cubic miles of salt, and that of New York perhaps less than half that amount. It is therefore probable, that the Niagara formation alone was able to furnish all the salt found in the succeeding Salina formation, of New York, Ontario, and Michigan.

Succeeding the desert conditions of the Salina, came the marine

invasion of the lower Monroe. This was from the Atlantic, as shown by the Atlantic type of the fauna. The path of invasion was across Maryland and Northern Virginia, and spread westward to Ohio and Indiana, where the Kokomo dolomite probably represents lower Monroe. The lowest beds were apparently deposited in Ohio, and the series spread northward and westward into Michigan and the Lake Erie region, where the earliest beds seem to be the Put-in-Bay dolomites. At Monroe, a greater thickness, (600 ft. +) was deposited, than in the Detroit region (360 ft.) owing probably to overlap of the higher beds at Detroit. In the Monroe region, the Monroe formation rests directly on the Niagaran series, but a short distance to the north, the Salina comes in between the two, and at the Royal Oak well north of Detroit, where the lower Monroe is 550 ft. thick, the Salina is over a thousand feet thick, with about 600 ft. of rock salt.

The Lower Monroe invasion extended across Michigan and into Wisconsin, where today near Milwaukee, some small areas are underlain by this formation. The maximum advance was followed by a partial retreat of the sea, and an exposure of quartz sandstone, such as the St. Peter of Wisconsin and the Superior sandstone of the Upper Peninsula, from which the sands of the Sylvania could be derived. The sea did not wholly retreat from North America, as shown by the continuity of the Monroe deposition in the Maryland region, but central North America was probably laid bare. While the drifting Sylvania sands probably represented an extensive sand-dune area covering most of Michigan, a part of Ohio, and Ontario, it probably did not represent a return of the extreme desert conditions which existed here during Salina time. The sands seem to have been the only type of subaërial deposit formed during this interval, and they probably do not represent typical desert conditions, but conditions comparable to some of the semi-deserts along our modern coasts.

Following these semi-desert conditions of Sylvania time, we have a renewed invasion of Michigan by the sea, this time most probably from the north, as indicated by the section of the overlap of the beds of this series. This invasion brought with it the marine fauna developed from the early Siluric fauna, with perhaps some elements added by imigration from the northwest. The Anderdon reefs flourished over Michigan and Canada, and the waters slowly extended eastward. At first only low mud flats, in which the mud derived largely from a calcareous shore, was a lime mud, existed over much of western New York. These mud flats constituted the waterlimes of which the Bertie is a most typical example. Eastward they are represented by the quartz sandstones and greenish pyritiferous shales (Brayman) of Schoharie valley, these overlapping the Salina and resting on eroded Ordovicic strata. The Atlantic sea also transgressed northward and westward from the Maryland region, the beds progressively overlapping towards the north as the sea encroached. The formation of marine limestones in New Jersey and southeastern New York, with an Atlantic Siluric fauna indicates this late Siluric transgression of the Atlantic sea. Meanwhile the purer water condition which permitted the formation of coral reefs extended eastward, and with it the fauna of the lower members of the Upper Monroe beds. The Atlantic fauna likewise encroached so that in the Cobleskill limestones we have the results of the meeting of the two faunas, the Atlantic and the interior, the eastern extension of this limestone containing the Atlantic Siluric fauna with *Halysites* in abundance, while the more western portion contained a larger element of the Upper Monroe fauna. The entrance of the Atlantic fauna from the east, effected in Cobleskill time, was succeeded by the entrance of the upper Siluric gastropod and cephalopod fauna also from the east. This fauna, exposed in Michigan, Canada and Ohio, constituted the Lucas fauna. This fauna became dominant and superseded the Anderdon-Amherstburg fauna, although certain elements of the earlier fauna seem to have held on throughout Lucas time.

The Anderdon fauna apparently had its center of evolution in northwestern North America. A small collection of fossils made by Miss Adams from the headwaters of the Saskatchewan and Athabasca rivers in Alberta, Canada, shows as one of the most abundant and characteristic species *Cylindrohelium profundum* Grabau, a species characteristic of the lower Lucas of Michigan and Ohio, but so far unknown elsewhere. This species is a derivative of *Diplophyllum integumentum* which is characteristic of the Anderdon formation. *Cladopora bifurcata* is another upper Monroe species associated with *Cylindrohelium* in the Palæozoic rocks of Alberta.

There seems thus little doubt, that we may expect to find in the

unexplored Palæozoics of the Canadian Rockies, the record of the evolution of the late Siluric faunas from the early Siluric or Niagaran faunas, as well as the origin of the indigenous element of the Schoharie and Onondaga faunas.

The origin of the typical Lucas fauna is probably to be sought in western Europe. Certainly the majority of the species have a great similarity to west European upper Siluric types, especially those of Gotland. Many of these species had found their way into the American interior sea in lower Siluric or Niagaran time, but were destroyed during the Salina interval of land conditions. They continued, however, with only slight modifications to the end of Siluric time in the more open sea of that period, and on the opening of the Atlantic channel again made their way into the newly reëstablished interior sea.

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PLATES AND EXPLANATIONS.

PLATE VIII.

(Salt Shaft Fossils.)

1. *Stromatopora galtense* Dawson. Portion of a mass showing astrorhizae, natural size. Anderdon coral bed, salt shaft.

2. *Idiostroma nattressi* Grabau. A polished surface of rock showing the size and form of this species, natural size. Anderdon coral bed, salt shaft.

3. *Idiostroma nattressi* Grabau. An individual enlarged two diameters. Anderdon coral bed, salt shaft.

4. *Stylodictyon sherzeri* Grabau. A portion of a mass, natural size. Anderdon coral bed, salt shaft.

5. *Stylodictyon sherzeri* Grabau. A portion of the preceding enlarged three times.

6. *Clathrodictyon ostiolatum* Nicholson. A portion of an average mass, showing sharp mamelons. Natural size. Anderdon coral bed, salt shaft.

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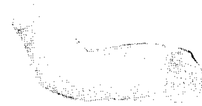

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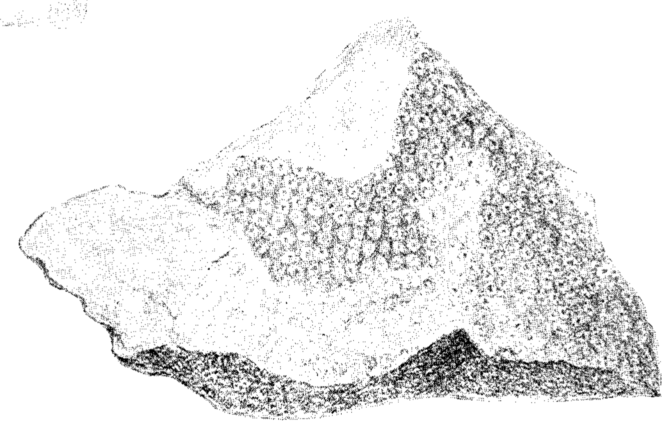

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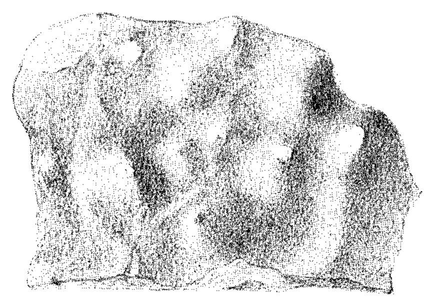

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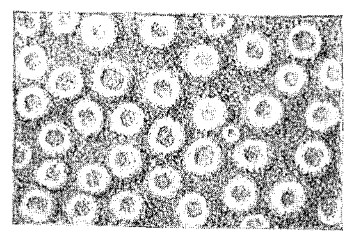

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PLATE IX.

1. *Clathrodictyon variolare* von Rosen. View of a polished surface x2. Anderdon coral reef, Anderdon quarry.

2. *Clathrodictyon variolare* von Rosen. Surface showing astrorhizae. Natural size; same as preceding.

3. *Coenostroma pustulosum* Grabau. Enlargement of surface x4, showing the sub-equally spaced pustules. Anderdon coral reef, Anderdon quarry.

4. *Coenostroma pustulosum* Grabau. A fragment of the coenosteum, natural size, showing the numerous branching astrorhizae. Anderdon coral reef, Anderdon quarry.

5. *Idiostroma nattressi* Grabau. A fragment of a branch, natural size. Anderdon coral reef, Anderdon quarry.

6. Enlargement of a portion of the preceding x6, showing surface features.

7. *Idiostroma nattressi* Grabau. Another fragment, natural size. With the preceding.

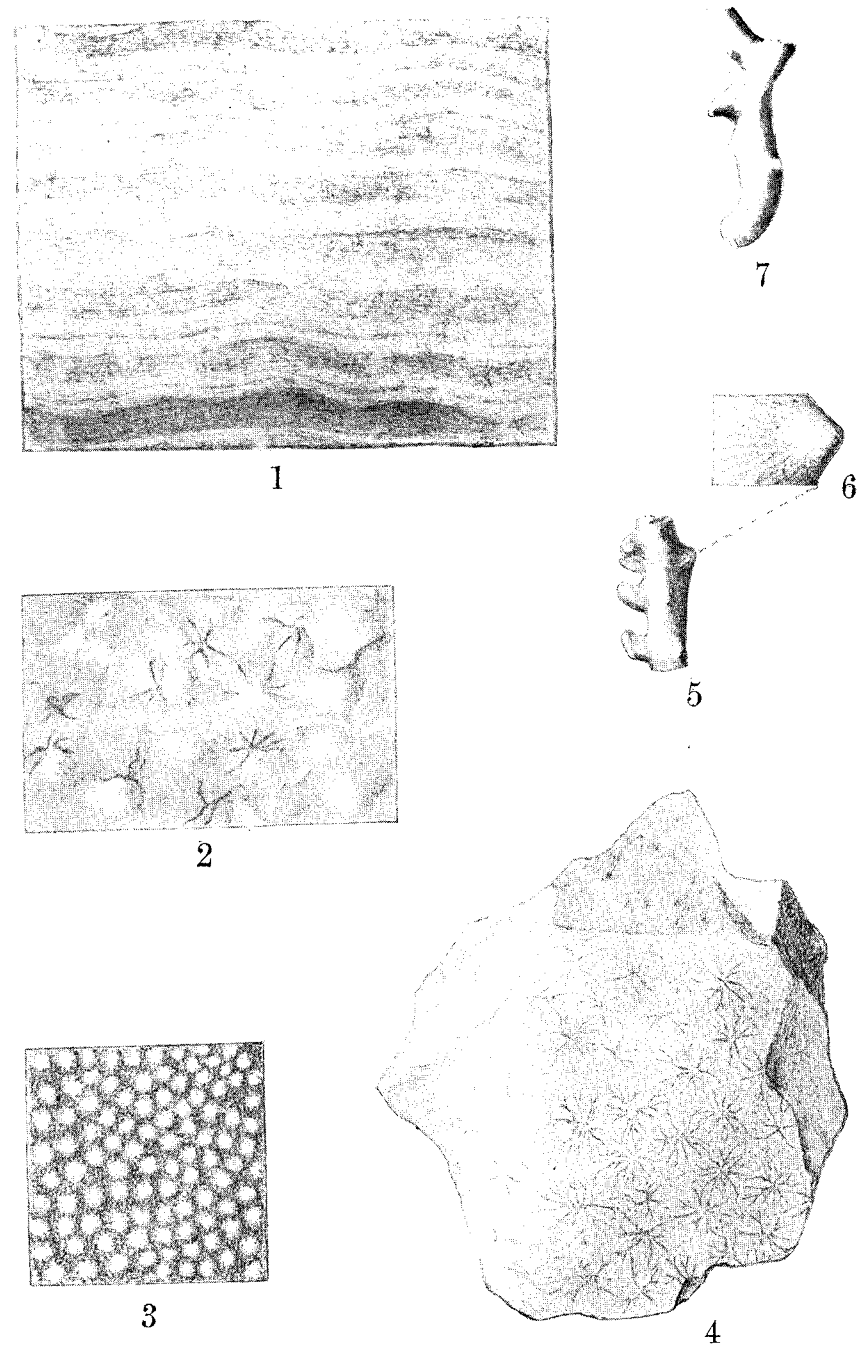


PLATE X.

(Salt Shaft Fossils.)

1. *Diplophyllum integumentum* Barrett. A corralum split, showing the thickened peripheral area, the septa and tabulæ x2. Anderdon coral bed, salt shaft.

2. *Cladopora bifurcata* Grabau. A characteristic view of a split corallum as usually found x2½. Anderdon coral bed, salt shaft.

3. *Cladopora bifurcata* Grabau. A specimen with the external characters preserved, and showing form and disposition of apostures x2. Anderdon coral bed, salt shaft.

4. *Cladopora bifurcata* Grabau. A characteristic cross section as seen on the rock fragments x4. Anderdon coral bed, salt shaft.

5. *Favosites basaltica* var *nana* Grabau. Two coralliites showing character and distribution of pores x6. Anderdon coral reef, salt shaft.

6. *Favosites basaltica* var *nana* Grabau. A fragment showing faces of corallites and pores x2. Anderdon coral bed, salt shaft.

7. *Cylindrohelium heliophylloides*. Mold of calyx showing impression of carinae and uniform septa x3. Lucas dolomite, salt shaft.

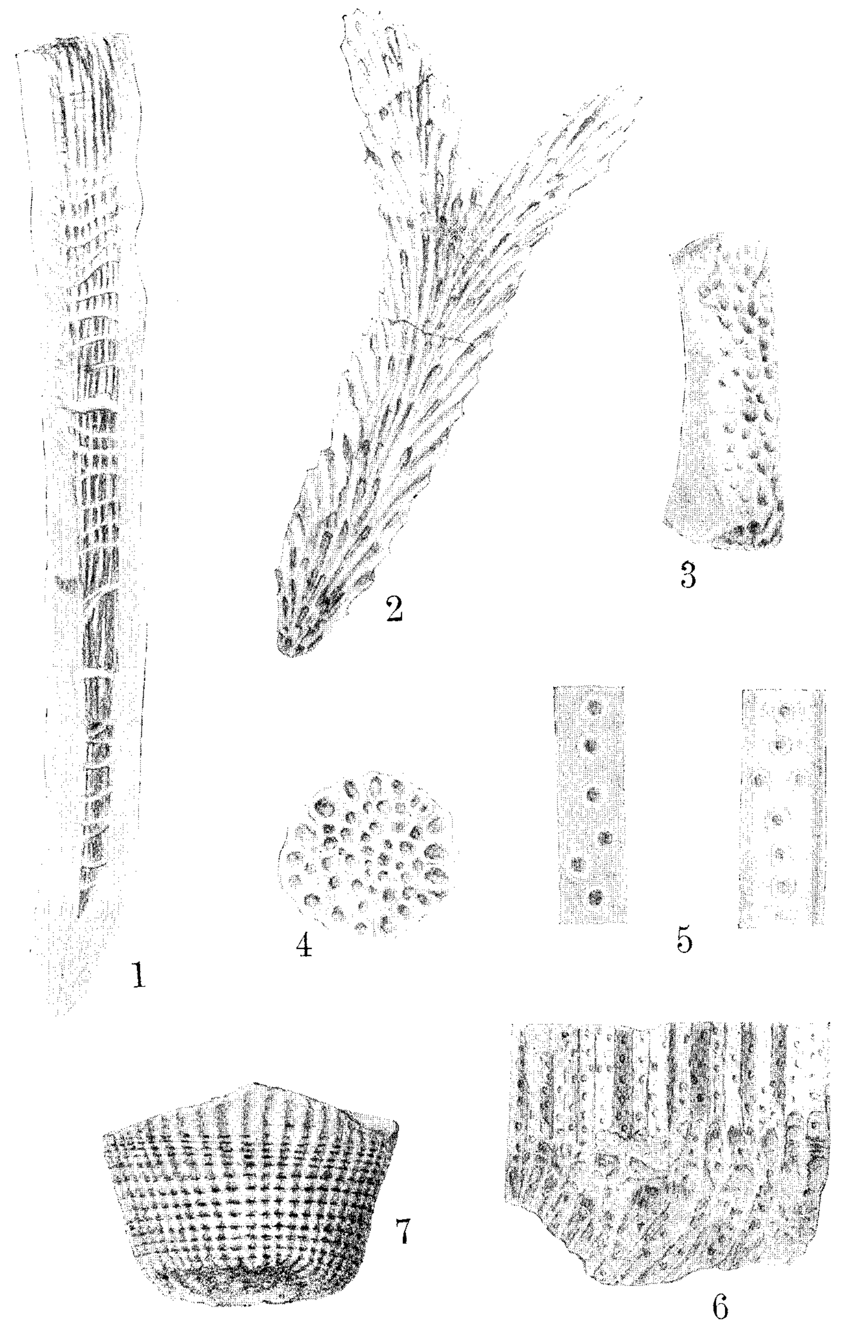


PLATE XI.

1. *Sphaerococcites ? glomeratus* Grabau. A single bunch of stems x2. Greenfield dolomite, Greenfield, Ohio.

2. *Helenterophyllum caliculoides.* A characteristic specimen x2. Anderdon coral reef, Anderdon quarry.

3. *Helenterophyllum caliculoides.* Enlargement of the calyx of the preceding showing carinated septa x4.

4. *Cylindrohelium profundum* Grabau. Gutta percha cast of exterior, natural size. Lucas dolomite, Webster quarry near Sylvania, Ohio.

5. *Cylindrohelium profundum* Grabau. The internal mold of the calyx showing the impressions of the carinated septa, alternating in size x2. Same as preceding.

6. *Cylindrohelium profundum* Grabau. Calicinal view (partly filled) of a specimen from the Paleozoic (Siluric?) limestones of the headwaters of the Saskatchewan, Alberta, Canada, collected by Miss Adams x4.

7. Enlargement of the septa of the same x16.

8. *Ceratopora regularis* Grabau. Internal mold x2 Amherstburg dolomite, Detroit river.

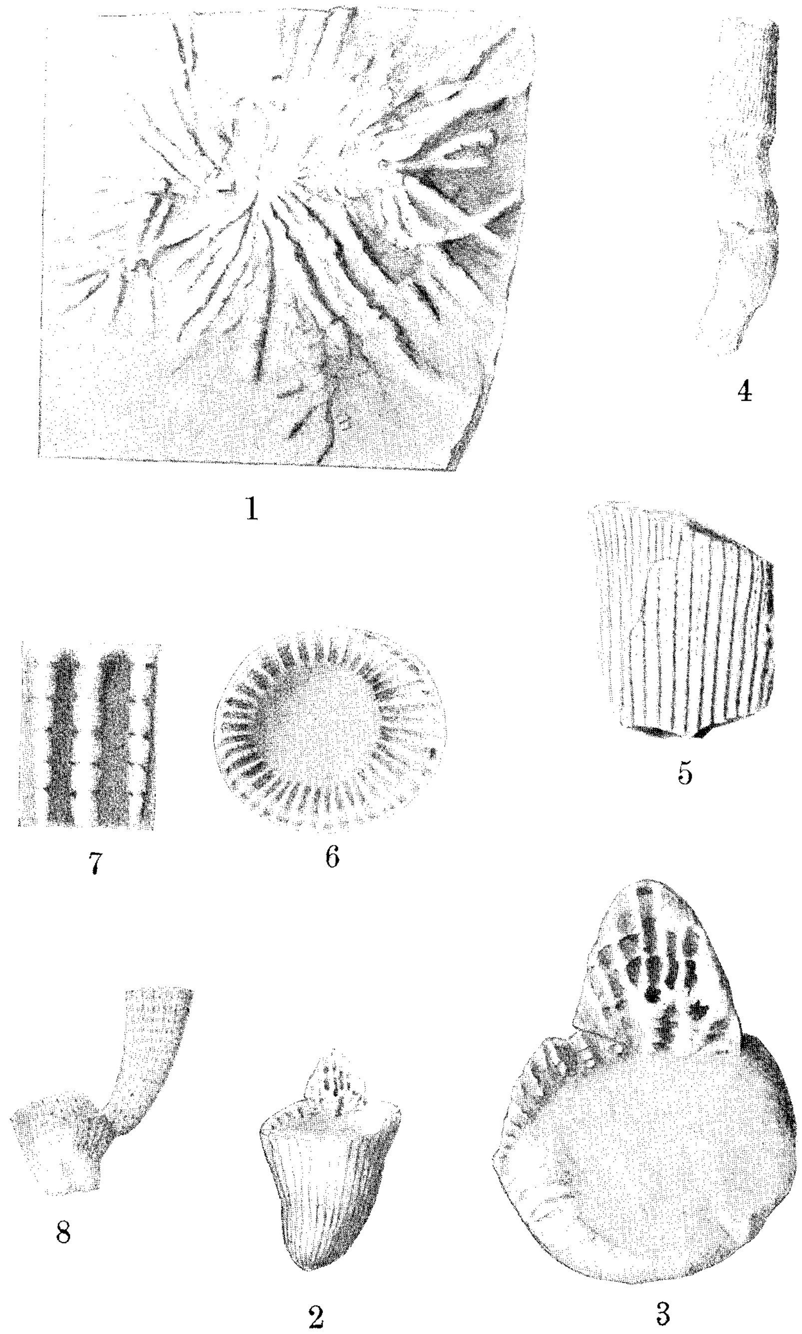


PLATE XII.

1. *Bythrotrephis ciarcilioides* Grabau. A specimen from the Akron dolomite of Buffalo. Natural size.

2. *Heliophrentis carinatum* Grabau. View of a gutta percha cast of a part of the calyx showing fossula and carinae x2. Amherstburg dolomite. Detroit river.

3. *Cystiphyllum americanum* mut. *anderdonense* Grabau. View of the cast of the calyx. Amherstburg dolomite. Detroit river. Natural size.

4-5. Cross sections of the calyx. Natural size.

6. *Synaptophyllum multicaule* (Hall). A cast from the natural rock mold, natural size. Amherstburg dolomite, Detroit river.

7. *Cladopora bifurcata* Grabau. Stem showing disposition of apertures, natural size. Anderdon coral reef, Anderdon quarry.

8. Enlargement of a part of the surface of the same x4.

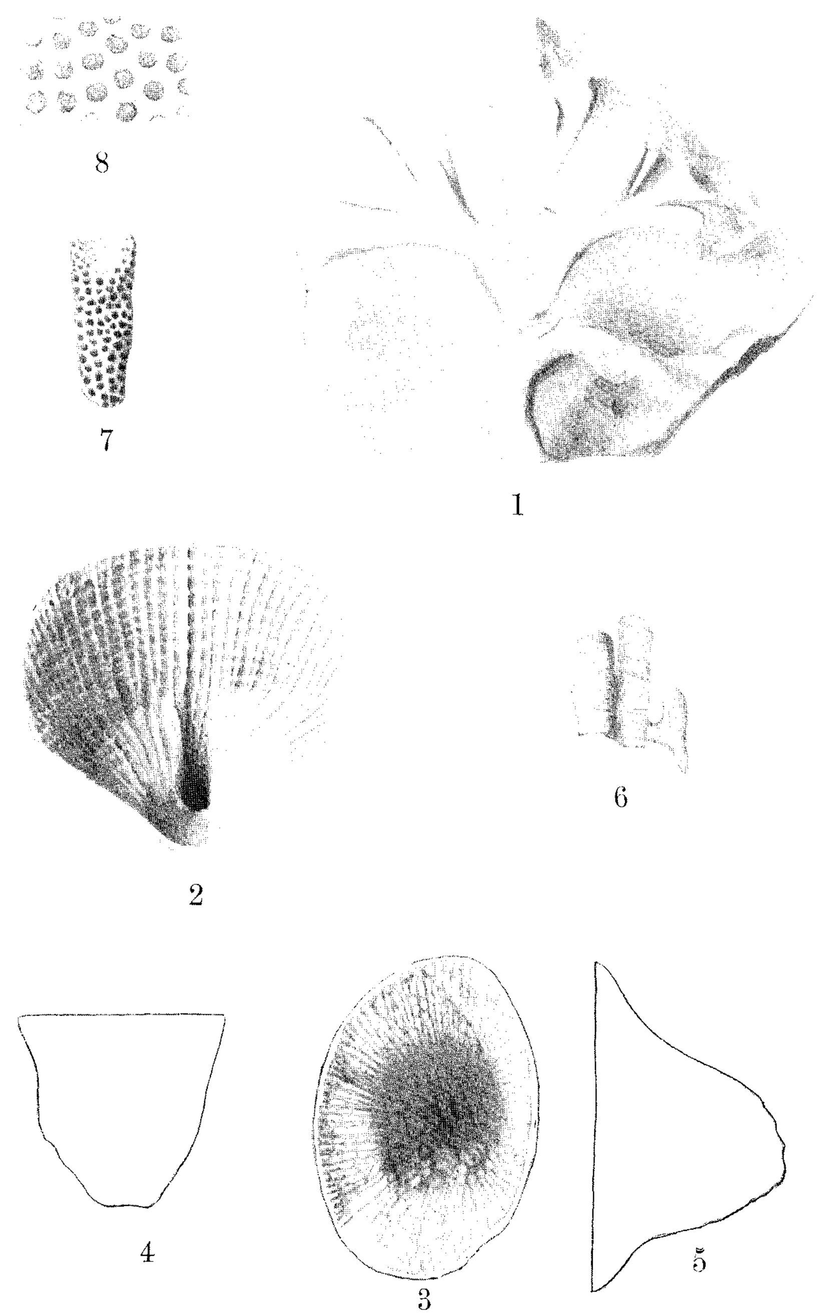


PLATE XIII.

1. *Clathrodictyon ostiolatum* Nicholson. A characteristic coenosteum, showing the finger-like prolongations. One-half natural size. Amherstburg dolomite, Gibraltar quarry.

2. *Heliophrentis alternatum* Grabau. Natural mold of interior of calyx showing alternation of septa. Natural size. Amherstburg dolomite, Detroit river.

3. *Heliophrentis alternatum* Grabau. Natural mold of a calyx of a young individual seen below. Lower Lucas dolomite, Silica quarry, near Sylvania, Ohio. Natural size.

4. *Heliophrentis alternatum* mut. *compressa* Grabau. View of fossular side of an internal calicinal mold. Natural size. With the preceding.
5. Side view of the preceding. Natural size.

6. *Heliophrentis alternatum* mut. *magna* Grabau. Mold of interior of calyx. Natural size. With the preceding.

7. *Heliophrentis carinatum* Grabau. Cast of the exterior of a corallum. Natural size. Amherstburg dolomite, Detroit river.

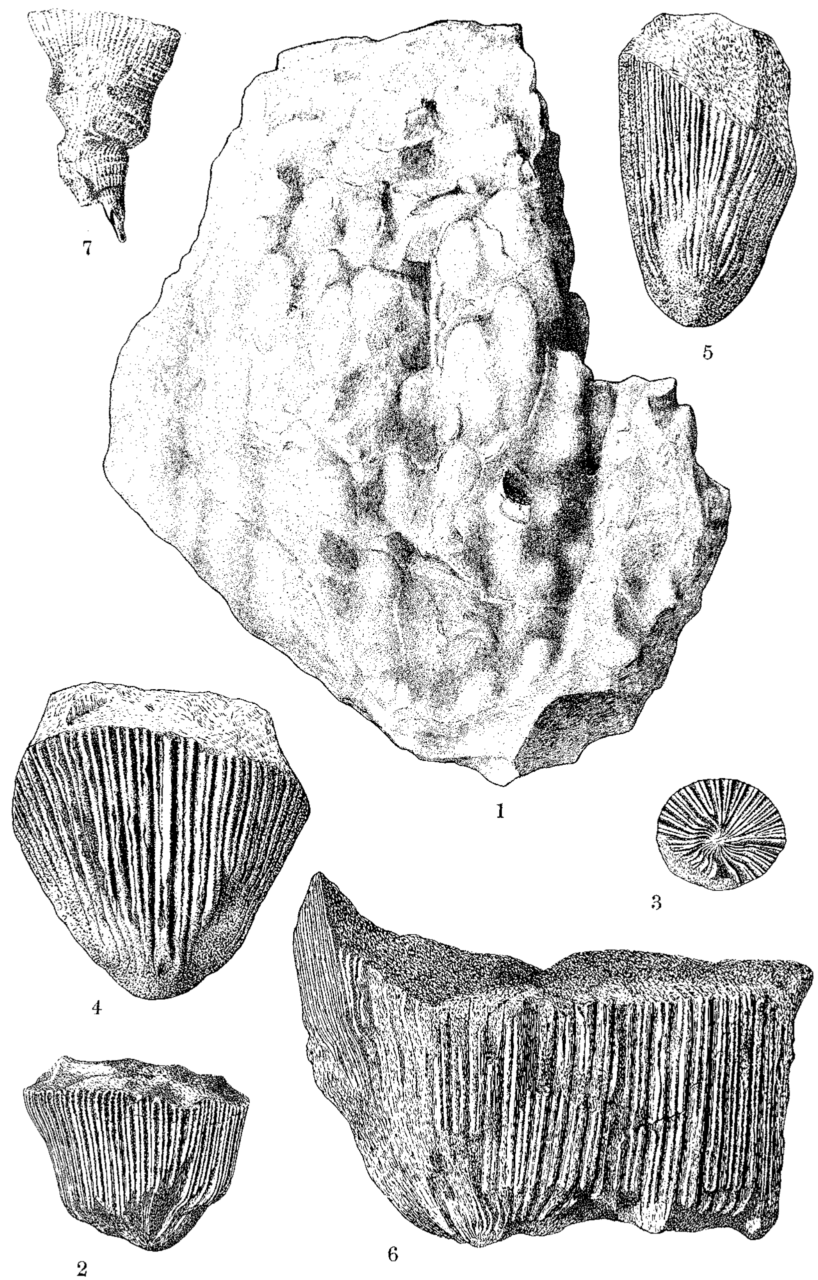


PLATE XIV.

1. *Syringopora cooperi* Grabau. Part of a characteristic colony enlarged x4, showing the close-set corallites and the frequent transverse bars. Flatrock dolomite, Detroit salt shaft.

2. *Favosites tuberoides* Grabau. View of a silicified specimen showing the squamulæ and incomplete tabulæ x4. Amherstburg dolomite, Detroit river.

3. *Favosites rectangularis* Grabau. Sectional view of a characteristic branch, showing the abrupt deflection of the corallites. Natural size. Anderdon coral reef, Detroit salt shaft.

4. Enlargement of a portion of the preceding x4.

5. *Cladopora* cf. *cervicornis* Hall. From a gutta percha cast, showing characteristic branching and form of deep apertures. Natural size. Amherstburg dolomite, Detroit river.

6. *Ceratopora tenella* (Rominger). A characteristic group of corallites x2. Anderdon coral reef, Anderdon quarry.

7. *Romingeria umbellifera* (Bill). A gutta percha cast of impression of part of a colony x2. Amherstburg dolomite, Detroit river.

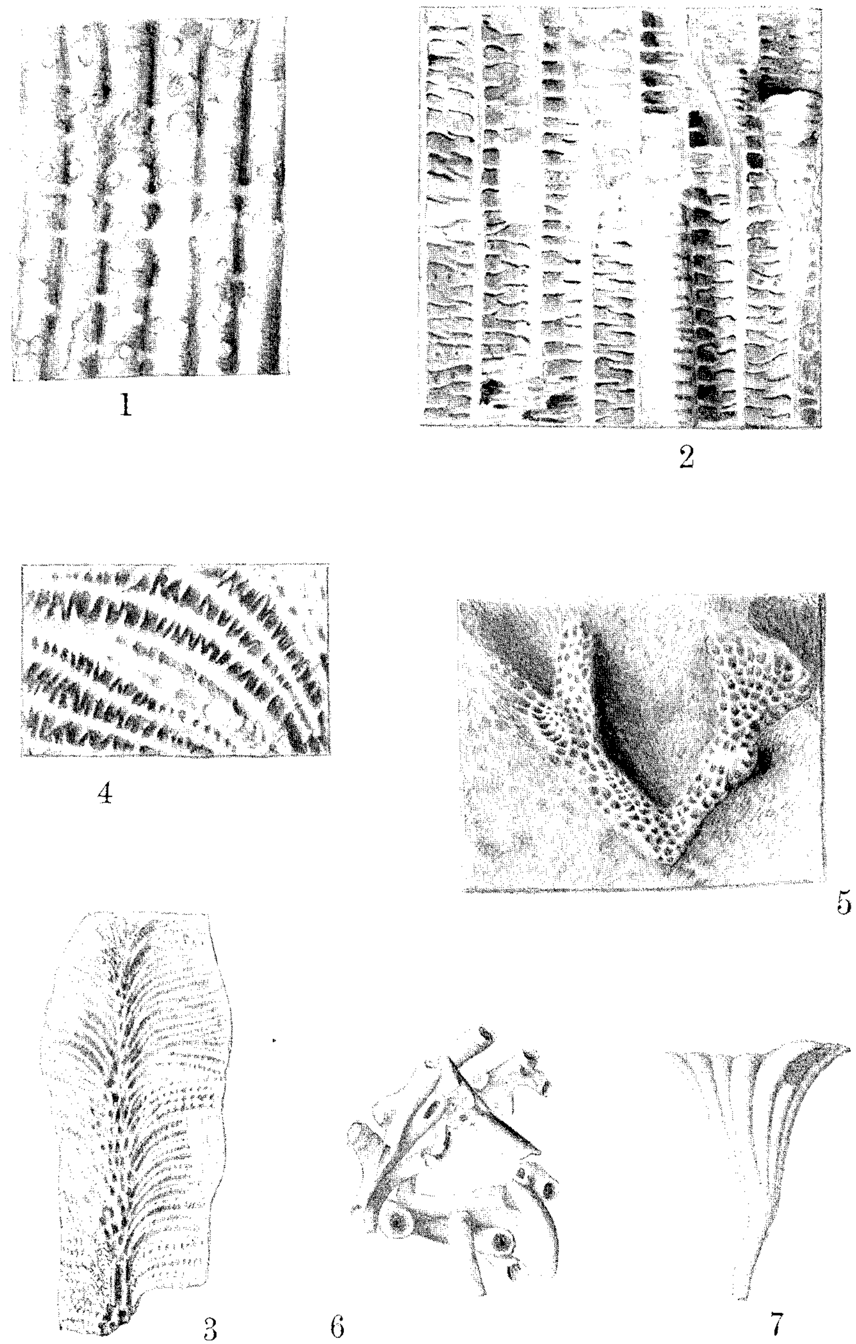


PLATE XV.

1. *Cladopora bifurcata* Grabau. Enlargement of the tip of a branch showing the form of the corallites and the scattered pores x3. Anderdon coral reef, Detroit salt shaft.

2. *Favosites concava* Grabau. Several corallites enlarged showing the zone of crowded tabulæ x2. Anderdon coral reef, Anderdon quarry.

3. *Favosites concava* Grabau. View of under side of several corallites of the same colony showing base of concave (convex downward) septa x2½.

4. *Favosites* cf. *maximus* Troost. A fragment showing several pores and tabulæ with their funnel like prolongation x2. Flatrock dolomite, salt shaft.

5. *Favosites* cf. *maximus* Troost. Interior of two corallites showing characteristic funnel-shaped prolongations of tabulæ. Dundee ? limestone, Sandusky, Ohio.

6. *Acervularia* sp. Several calices showing characteristic features. Natural size. From a cast. Amherstburg dolomite, Detroit river.

7-8. *Syringopora microfundulus* Grabau. Two corallites enlarged x8 to show the peculiar cone-in-cone arrangement of the tabulæ. Base of Anderdon coral bed, salt shaft.

9. *Diplophyllum integumentum* Barrett. A characteristic specimen. Natural size. Anderdon coral reef, salt shaft.

10. End view of the same. Natural size.

11. *Beyrichia monroensis* Grabau. A left valve enlarged x8. Raisin River dolomites. Newport, Michigan.

12. *Spirorbis laxus* Hall. A specimen enlarged. Raisin River dolomites, Newport, Michigan.

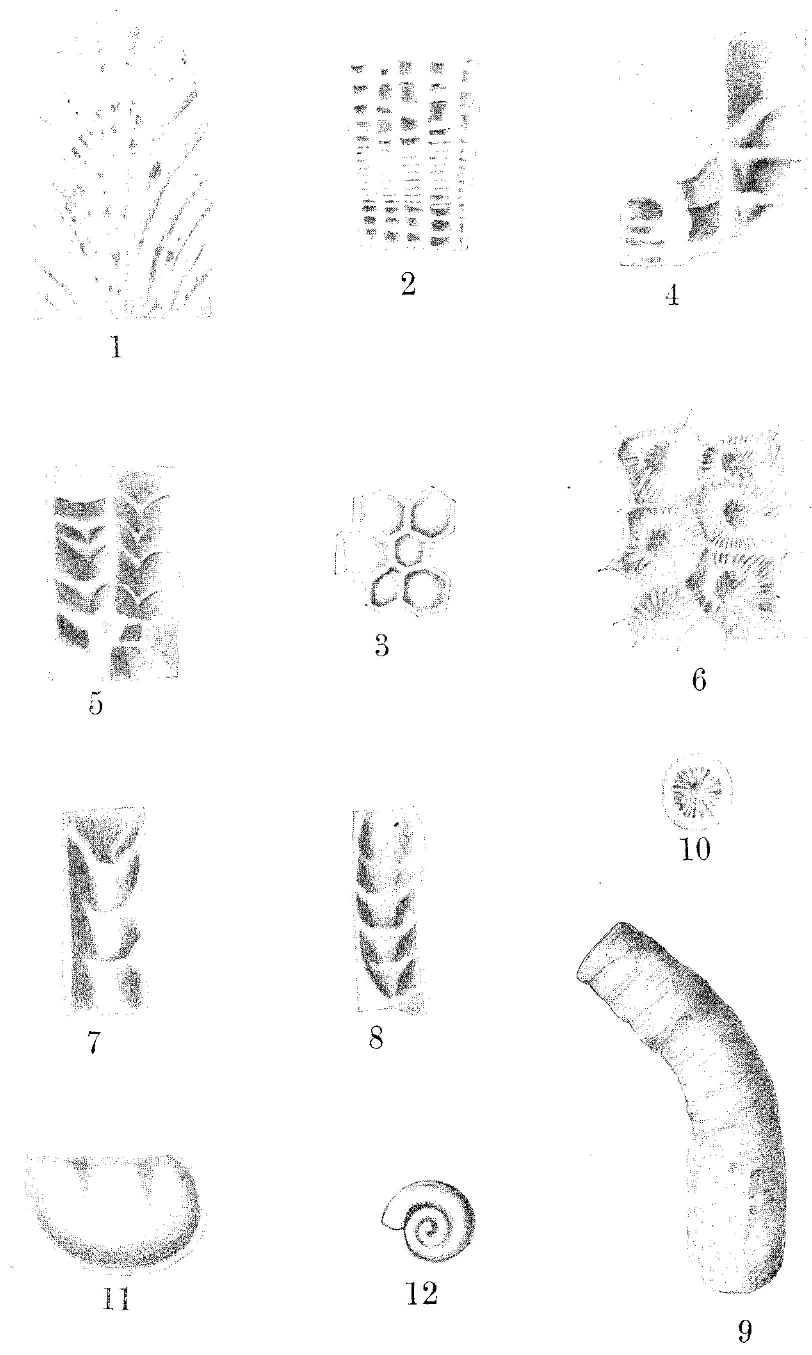


PLATE XVI.

(Salt Shaft Fossils.)

1. *Conocardium monroicum* Grabau. Fragment showing posterior end. Natural size. Anderdon coral bed, salt shaft.

2. *Conocardium monroicum* Grabau. Fragment showing ventral aspect of a much flattened specimen. Natural size. Anderdon coral bed, salt shaft.

3. *Conocardium monroicum* Grabau. Lateral view of a crushed specimen. Natural size. Anderdon coral reef, salt shaft.

4. *Acanthonema holopiformis* Grabau. A cast which does not show the surface ornamentation. Lucas dolomite, salt shaft x4.

5. *Pleurotrochus tricarinatus* Grabau. An imperfect cast x3. Lucas dolomite, salt shaft.

6. *Loxonema parva* Grabau. Cast of the type specimen enlarged x2. Lucas dolomite, salt shaft.

7. *Solenospira ? extenuatum* (Hall). From a gutta percha cast x2. Lucas dolomite, salt shaft.

8. *Solenospira minuta* (Hall). Enlargement from a gutta percha cast. x2. Lucas dolomite, salt shaft.

9. *Pterinea bradti* Grabau. Left valve, natural size. Lucas dolomite, salt shaft.

10. *Pterinea bradti* Grabau. Right valve, natural size. With the preceding.

11. *Spirifer modestus* Hall. Cardinal view of a gutta percha cast x1½. Lucas dolomite, salt shaft.

12. *Spirifer modestus* Hall. Internal rock mold x1½. Lucas dolomite, salt shaft.

13. *Camarotoechia semiplicata* (Conrad). Cardinal view of internal mold. Natural size. Lucas dolomite, salt shaft.

14. *Camarotoechia semiplicata* (Conrad). Ventral view of internal mold. Natural size. Lucas dolomite, salt shaft.

15. *Diplophyllum integumentum* Barrett. Transverse section showing dense peripheral portion and septa. Natural size. Anderdon coral bed, salt shaft.

16. *Cyathophyllum cf. thoroldense* Lambe. A corallum. Natural size. Anderdon coral reef, salt shaft.

17. *Diplophyllum integumentum* (Barrett). Fragment partly enclosed by *Clathrodictyon ostiolatum* Nichols. Anderdon coral reef, salt shaft. Natural size.

18. *Clathrodictyon ostiolatum* Nicholson. Surrounding *Diplophyllum,* stem, cross section enlarged x2. Anderdon coral bed, salt shaft.

19. *Prosserella planisinous* Grabau. Brachial valve. Natural size. Anderdon coral reef, salt shaft.

20. *Prosserilla modestoides* Grabau. Brachial valve. Natural size. Anderdon coral bed, salt shaft.

21. *Prosserella lucasi* Grabau. A characteristic internal mold of a pedicle valve. Natural size. Lucas dolomite, salt shaft.

22-23. *Prosserella modestoides* Grabau. Two views of the type a pedicle valve. Natural size. Anderdon coral reef, salt shaft.

24-25. *Spirifer modestus* Hall (?). Two views of a gutta percha cast, enlarged x1½. (Possibly young of *Proserella*). Lucas dolomite, salt shaft.

26. *Prosserella planisinosus* Grabau. Pedicle valve—the type specimen. Natural size. Lucas dolomite, salt shaft.

27. *Poleumita cf. crenulata* Whiteaves. Fragment of internal mold. Natural size. Lucas dolomite, salt shaft.

28. *Euomphalus fairchildi* Clarke and Ruedemann. An internal mold. Natural size. Lucas dolomite, salt shaft.

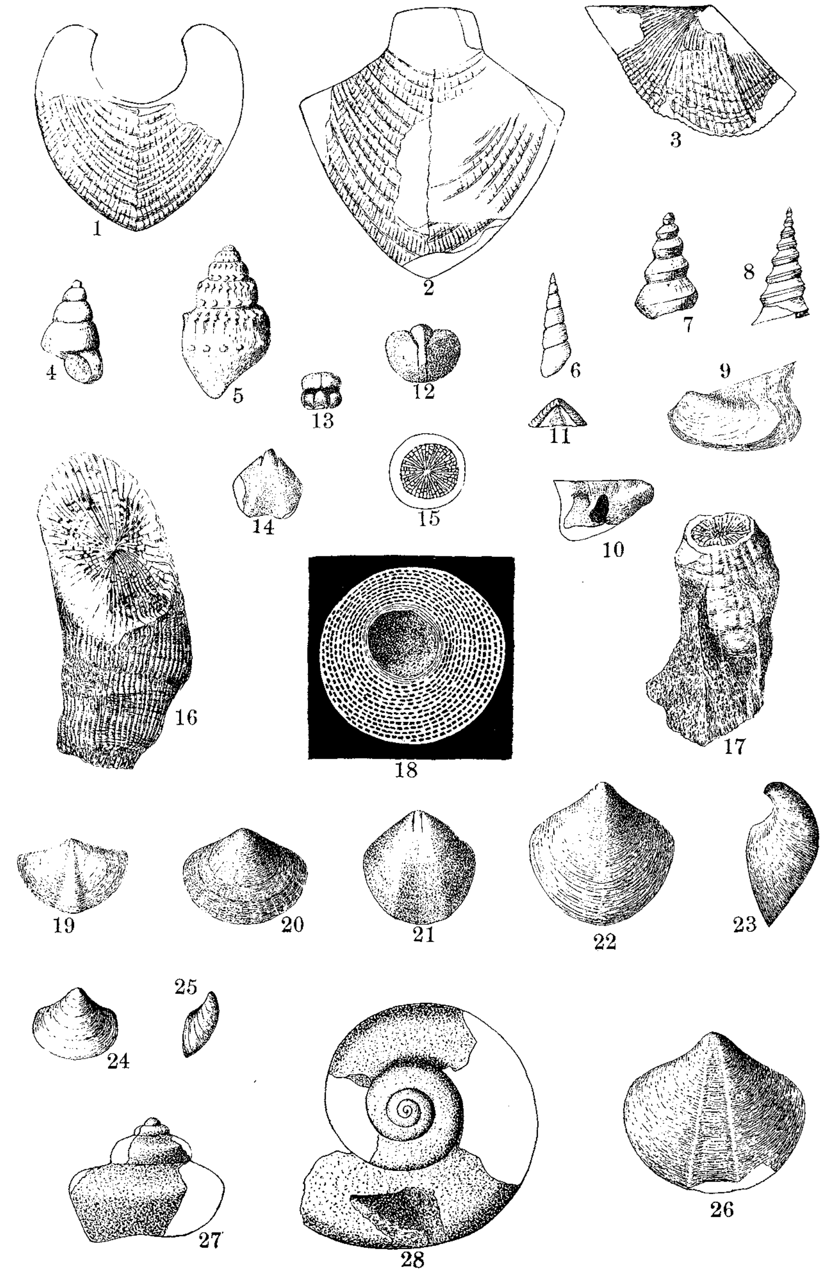


PLATE XVII.

1. *Schuchertella amherstburgense* Grabau. View of pedicle valve x4. Amherstburg dolomite, Detroit river.

2. Side view of same x4.

3. Cardinal view of same x4.

4. *Schuchertella interstriata* (Hall). Enlargement of a portion of the surface of a pedicle valve x4, showing the characteristic intercalation of the striæ. Bullhead dolomite, Buffalo, N. Y.

5. *Schuchertella interstriata* (Hall) variety. Showing gradation of striæ x4. Amherstburg dolomite, Detroit river.

6. *Stropheodonta demissa* var. *homalostriatus* Grabau. A cast of a characteristic specimen x2. Amherstburg dolomite, Detroit river.

7. *Schuchertella hydraulica* (Whitfield). Enlargement of a portion of surface of an average size shell showing the alternating coarse and fine striæ x4. Greenfield dolomite, Ballville, Ohio.

8. *Stropheodonta vasculosa* Grabau. Characteristic view of the internal mold of a pedicle valve. Natural size.

9. Cardinal view of the same x1.

10. Cross section of a specimen replaced by calcite x1.

11. A cast of a brachial valve showing external characters x2. All from Amherstburg dolomite, Detroit river.

12. *Stropheodonta praeplicata* Grabau. View of a cast of the type x2. Amherstburg dolomite, Detroit river.

13. *Pholidops* cf. *ovata* Hall. Mold of interior of valve. Amherstburg dolomite, Detroit river.

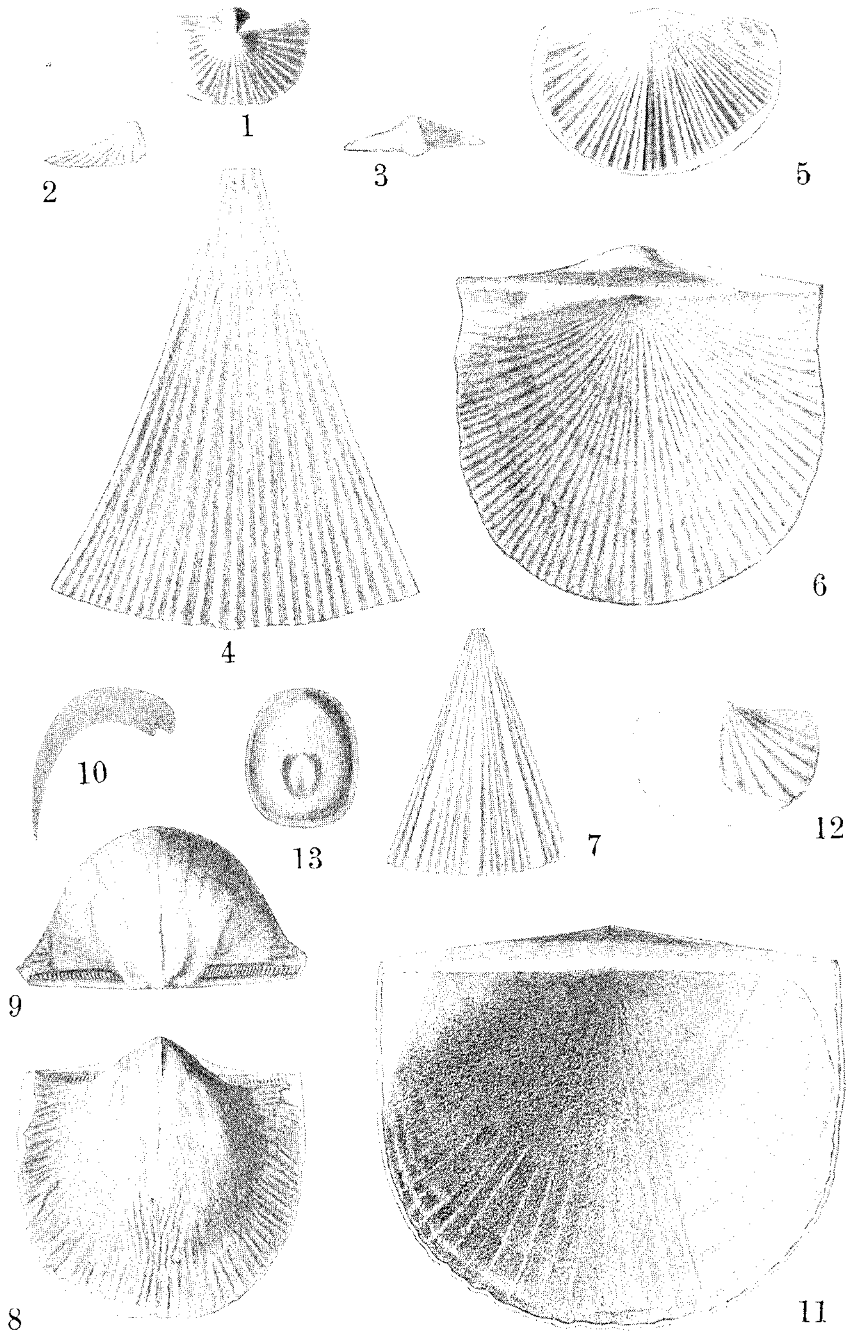


PLATE XVIII.

1. *Spirifer ohioensis* Grabau. A characteristic brachial valve x2. Put-in-Bay dolomite, Put-in-Bay Island, Lake Erie, Ohio.

2. *Spirifer ohioensis* Grabau. A characteristic pedicle valve x2. With the preceding.

3. *Spirifer ohioensis* Grabau var. A pedicle valve with very faint plications x2. With the preceding.

4. *Spirifer sulcata* mut. *submersa* Grabau. An immature pedicle valve x2. Amherstburg dolomite, Detroit river.

5-6. *Spirifer sulcata* mut. *submersa* Grabau. Two brachial valves showing characteristic features x2. With the preceding.

7. *Prosserella subtransversa* Grabau. Cast of a nearly perfect small shell, without plications x4. Lucas dolomite, Gibraltar quarry.

8. *Prosserella planisinosus* Grabau. A brachial valve x2. Cobleskill limestone, Schoharie, N. Y.

9. *Prosserella subtransversa* Grabau. Cast of interior of brachial valve x2. Amherstburg dolomite, Detroit river.

10. *Prosserella subtransversa* mut. *alta* Grabau. The type specimen x2. Amherstburg dolomite, Woolmith quarry.

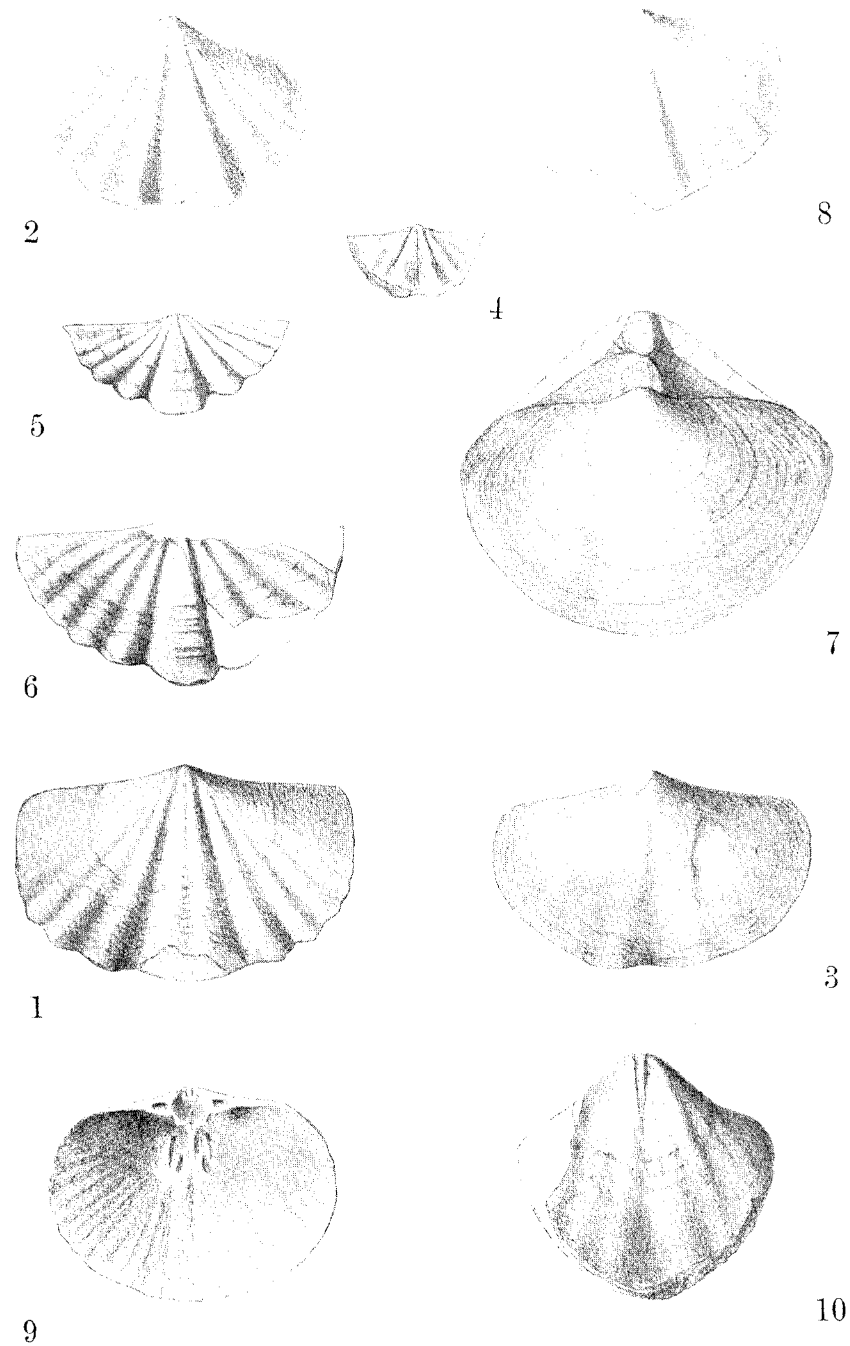


PLATE XIX.

1. *Prosserella subtransversa* Grabau. Natural size. A cast of a nearly complete specimen. Lucas dolomite, Patrick quarry.

2. *Prosserella lucasi* Grabau. An internal mold of a characteristic pedicle valve x2. Lucas dolomite, Western quarry, near Sylvania, Ohio.

3. *Prosserella lucasi* Grabau. A brachial valve showing pronounced frontal development of median fold and short plications. From a cast x2. With the preceding.

4. *Prosserella subtransversa* Grabau mut A. Internal mold of a pedicle valve characterized by narrow ribs x2. Amherstburg dolomite, Woolmith quarry.

5-6. *Prosserella subtransversa* Grabau mut. B. Two views of an internal mold of a specimen characterized by smooth surface and high hinge areas x2. Amherstburg dolomite, Woolmith quarry.

7-8. *Prosserella subtransversa* Grabau. A typical internal mold with shallow sinus and short round plications x2. Amherstburg dolomite, Woolmith quarry.

9-10. *Prosserella unilamellosus* Grabau. Ventral and cardinal view of an internal mold of a small (young) pedicle valve, showing the union of the dental lamellæ before they reach the bottom of the valve, thus forming a spondylium x2.

11. *Prosserella unilamellosus* Grabau. Internal mold of an adult shell showing faint plications and median sinus, together with the single growth caused by the united lamellæ x2. Lucas dolomite, Patrick quarry.

12. *Prosserella subtransversa* Grabau. Cast of interior of a brachial valve, showing the characteristic hinge plate, septum, etc., x4. Lucas dolomite, Gibraltar quarry. (See Plate XXI, Figure 27.)

13. *Prosserella subtransversa* Grabau. Cast of the cardinal portion showing beaks, hinge line, etc. Amherstburg dolomite, Detroit river.

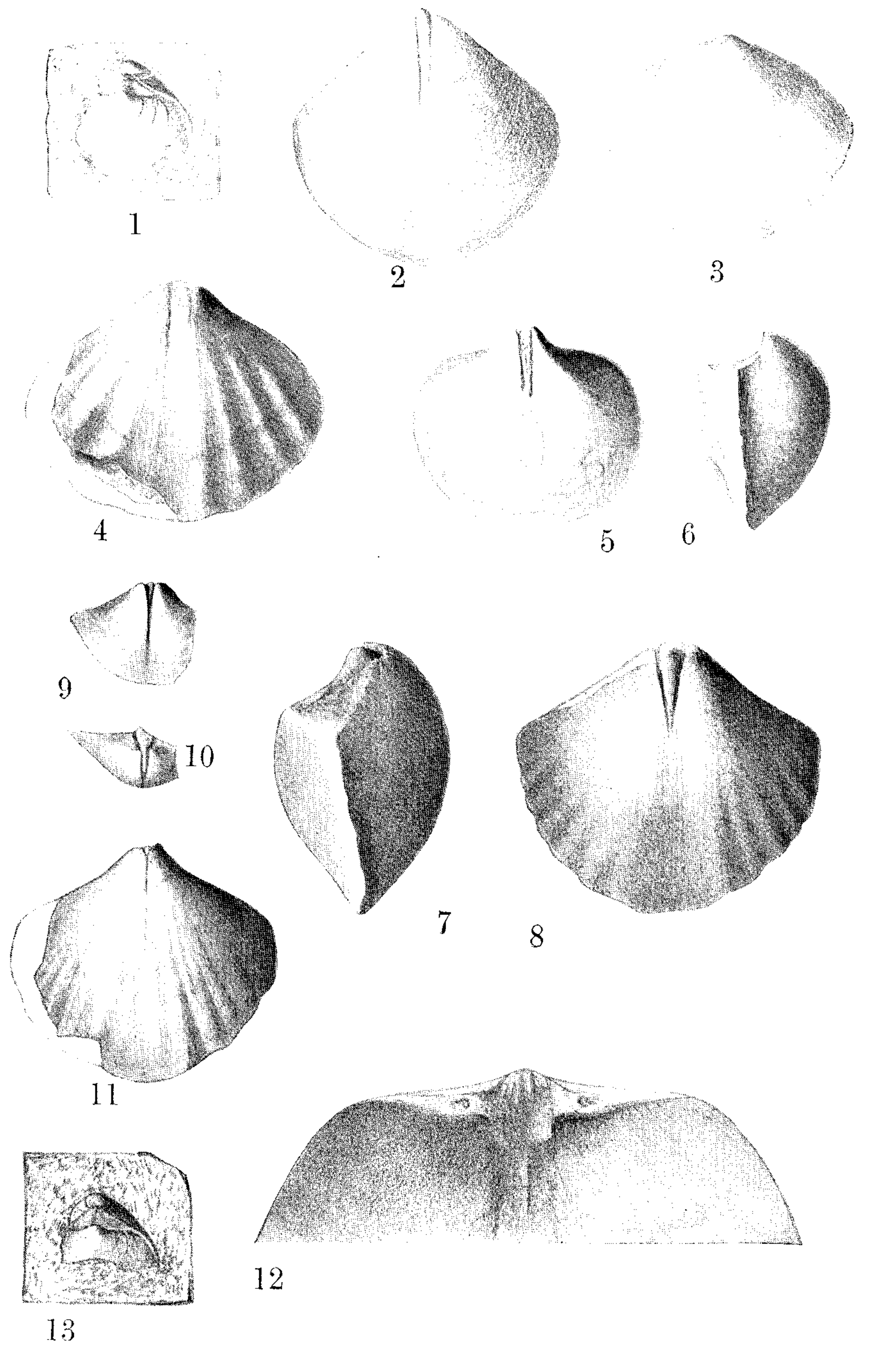


PLATE XX.

1. *Atrypa reticularis* Linn (?) Cast of a minute pedicle ? valve x3. Amherstburg dolomite, Detroit river.

2-3. *Rhynchospira præformosa* Grabau. Lateral and cardinal views of a fragmental cast x3. Greenfield dolomite of Greenfield, Ohio.

4. *Hindella ? (Greenfieldia) whitfieldi.* A brachial valve x2. Greenfield dolomite. Greenfield, Ohio.

5-6. *Meristospira michiganense* Grabau. Cast of interior of rostral cavity, and corresponding internal mold x3. Amherstburg dolomite. Woolmith quarry. (For other views of this specimen see Plate XXI, Fig. 4-6.)

7-11. *Meristospira michiganense* Grabau. Cast of interior of rostal cavity, and cardinal lateral, ventral and dorsal views of an internal mold of a more convex form with strong pallial sinuses x2. Amherstburg dolomite, Woolmith quarry.

12. *Camarotœchia semiplicata* Hall. Cast of rostral cavity of the internal mold figured on Plate XVI, Fig. 13-14 x3. Lucas dolomite, salt shaft.

13. *Pterinea lanii* Grabau. A typical left valve x2. Raisin River dolomites. Newport, Michigan.

14. *Conocardium monroicum* Grabau. Basal view of a characteristic internal mold. Natural size. Amherstburg dolomite, Woolmith quarry.

15. *Conocardium monroicum* Grabau. Lateral view of internal mold. Natural size. A little rock adheres to the beak.

16. *Proetus crassimarginatus* Hall. Portion of a pygidium showing the characteristic angulations on the axis and the marginal rim. Natural size. Amherstburg dolomite, Detroit river.

17. *Proetus crassimarginatus* Hall. A large crushed pygidium. Natural size. With the preceding.

18. *Proetus crassimarginatus* Hall. A fragmentary cephalon restored in outline. With the preceding.

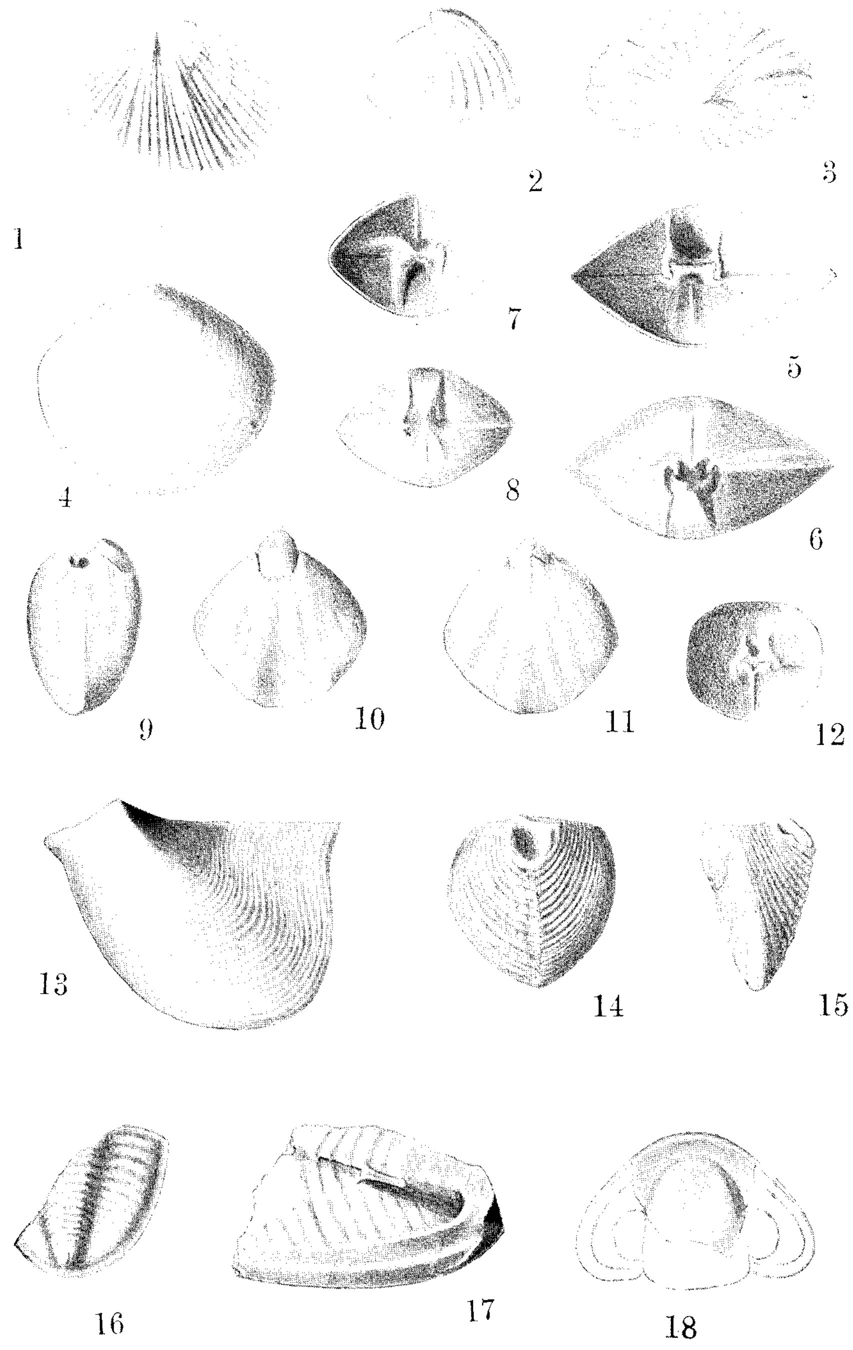


PLATE XXI.

1-2. *Hindella? (Greenfieldia) rostralis* Grabau. Cardinal and dorsal view of a characteristic internal mold. Natural size. Greenfield dolomite. Greenfield, Ohio.

3. *Whitfieldella prosseri* Grabau. An internal mold of a small pedicle valve. Natural size. Raisin River dolomites, Newport, Michigan.

4-6. *Meristospira michiganense* Grabau. Dorsal, ventral, and lateral view of an internal mold (see Plate XX, Fig. 5-6). Amherstburg dolomite, Woolmith quarry.

7. *Hindella? (Greenfieldia) rostralis.* A somewhat less perfect mold than of Fig. 1-2. Natural size. Greenfield dolomite, Greenfield, Ohio.

8. *Whitfieldella prosseri* Grabau. Internal mold of a brachial valve. Natural size. Raisin River beds, Newport, Michigan.

9. *Whitfieldella prosseri* Grabau. Cardinal view of a characteristic internal mold of a pedicle valve. Natural size. Raisin River dolomites, Newport, Michigan.

10. *Whitfieldella sp.* Fragment of an internal mold of a large pedicle valve. Natural size. Amherstburg dolomite, Detroit river.

11. *Hindella? (Greenfieldia) whitfieldi* Grabau. Cardinal view of a cast. Natural size. Greenfield dolomite, Greenfield, Ohio.

12-13. *Whitfieldella prosseri* Grabau. Ventral and lateral views of an internal mold of a typical pedicle valve. Natural size. Raisin River dolomites, Newport, Michigan.

14-15. *Meristina profunda* mut. *sinosus* Grabau. Cardinal and ventral views of an internal mold of the pedicle valve described. Raisin River dolomites just below Sylvania sand, claim 432, Monroe county, Michigan.

16. A cast of the preceding showing the internal characters of the pedicle valve. Natural size.

17. *Hindella? (Greenfieldia) whitfieldi* Grabau. A cast showing both valves, and the large foramen. Natural size. Greenfield dolomite, Greenfield, Ohio.

18-19. *Hindella? (Greenfieldia) whitfieldi* Grabau. A fragmentary cast of a pedicle valve, with side view. Natural size. Greenfield dolomite, Greenfield, Ohio.

20. *Meristina profunda* Grabau. An internal mold of a pedicle valve. Raisin River dolomites just below Sylvania. Raisin River.

21. Restoration of pedicle valve of preceding to show internal characters. Natural size.

22. Gutta percha cast of same, showing internal characters incompletely. Natural size.

23. *Prosserella lucasi* Grabau. Internal mold of pedicle valve. Natural size. Lucas dolomite, Patrick quarry.

24-25. *Prosserella modestoides* mut. *depressus* Grabau. Frontal and dorsal view of a fragmentary cast referred to this mutation. It is transitional to *P. subtransversa* though less transverse. Natural size. Amherstburg dolomite, Detroit river.

26. *Prosserella modestoides* mut. *depressus* Grabau. Cardinal view of an internal mold of a pedicle valve. Natural size. With the preceding.

27. *Prosserella subtransversa* Grabau. A natural mold of the interior of a pedicle valve. (For cast from same see Plate XIX, Fig. 12.) Natural size. Lucas dolomite, Gibraltar quarry.

28-30. *Prosserella modestoides* Grabau. Cardinal, ventral, and lateral views of a typical internal mold of a pedicle valve. Natural size. Amherstburg dolomite, Detroit river.

31-32. *Prosserella modestoides* mut. *depressus* Grabau. Ventral and lateral view of an internal mold of a characteristic pedicle valve. With the preceding.

33. *Prosserella modestoides* mut. *depressus* Grabau. Internal mold of a slightly plicated valve. Natural size. With the preceding.

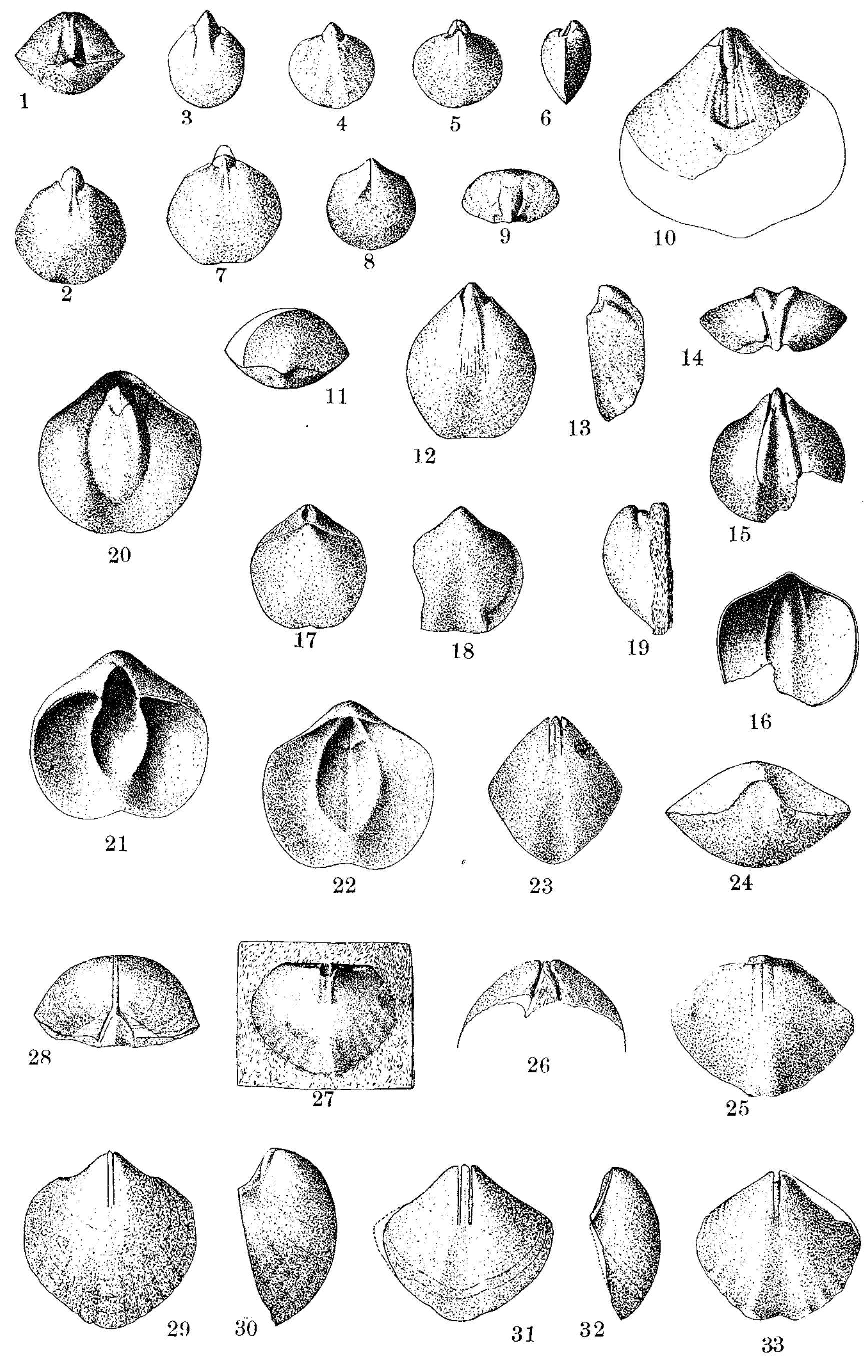


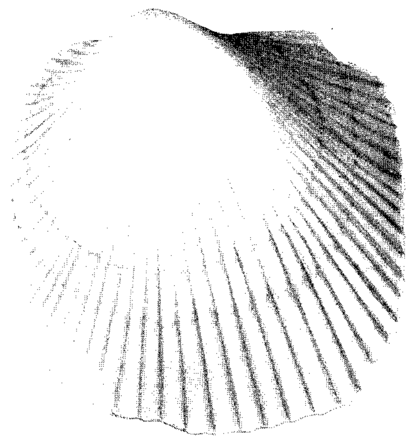
PLATE XXII.

1. *Panenka canadensis* Whiteaves. View of a characteristic left valve. Natural size.

2. Cardinal view of same. Natural size. Amherstburg dolomite, Detroit river.

3. *Conocardium monroicum* Grabau. Cast of an impression of a nearly complete shell showing the posterior shelly prolongation or hood. Natural size. Amherstburg dolomite, Detroit river.

4-6. *Cornulites arcuatus* Conrad. Three views of the only specimen found x4. Amherstburg dolomite, Detroit river.



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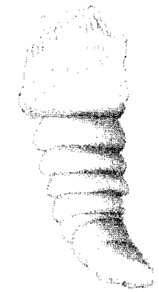

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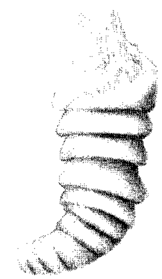

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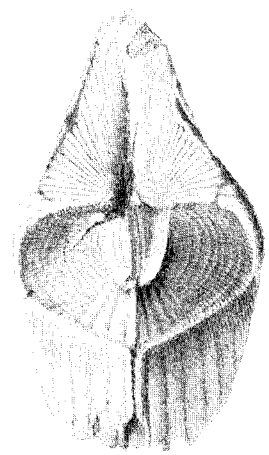

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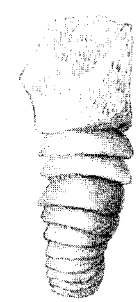

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PLATE XXIII.

1-2. *Pleurotomaria velaris* Whiteaves. Lateral and umbilical views of an internal mold from the Anderdon coral reef of the Anderdon quarry. Natural size.

3-4. *Trochonema ovoides* Grabau. Lateral and apical views of a large shell from the Amherstburg dolomite of the Detroit river. Natural size.

5. *Eotomaria arcyi* Clarke and Reudemann. An internal mold with the characters of this species. Natural size. Amherstburg dolomite, Detroit river.

6-7. *Acanthonema holopiformis* Grabau. Lateral and umbilical views of internal mold of this species, enlarged x3. Amherstburg dolomite, Detroit river.

8. *Acanthonema holopiformis* Grabau. Internal mold x3. With the preceding.

9-10. *Stophostylus cyclostomus* Hall. Umbonal and apical views of an internal mold from the Amherstburg dolomite of the Detroit river. Natural size.

11. *Strophostylus cyclostomus* Hall. A cast of a small fragment preserving the impression of the surface striæ. With the preceding, but from another individual.

12-13. *Trochonema ovoides* Grabau. A young individual, the whorls somewhat less rapidly enlarging than in the larger specimen (Fig. 3-4). Amherstburg dolomite, Detroit river.

14. *Cypricardinia canadensis* Grabau. A left valve of an individual somewhat larger than general. Natural size. Amherstburg dolomite, Detroit river.

15. *Cypricardinia canadensis* Grabau. A smaller left valve. Natural size. With the preceding.

16. *Lophospira bispiralis* (Hall). A cast from an external mold; in the Lucas dolomite of the Gibraltar quarry. Natural size.

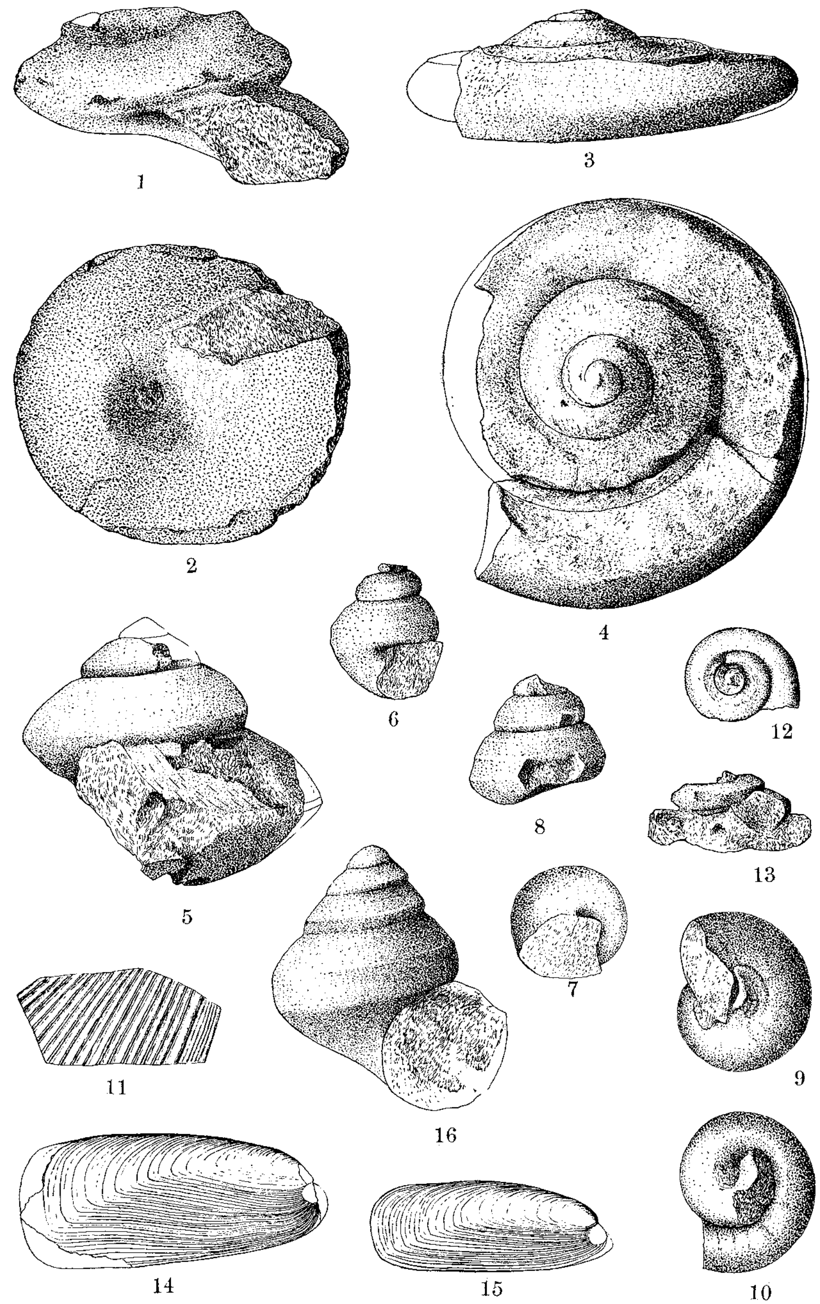


PLATE XXIV.

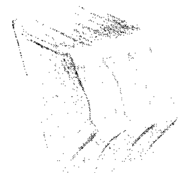
1. *Hormotoma subcarinata* Grabau. Cast from a mold in the Lucas dolomite of the Gibraltar quarry x4.

2. *Hormotoma subcarinata* Grabau. A fragmentary cast of eight whorls. With the preceding.

3. Enlargement of a part of the peripheral band of the preceding.

4. *Hormotoma subcarinata* Grabau. A smaller individual with eight whorls, from a gutta percha cast. With the preceding.

5. *Hormotoma subcarinata* Grabau. Basal portion of a shell, showing the slightly prolonged lower lip x6. Lucas of Gibraltar quarry.



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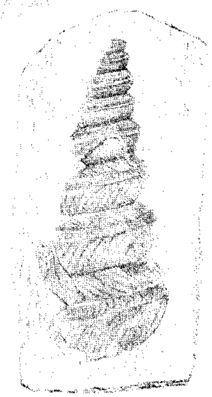

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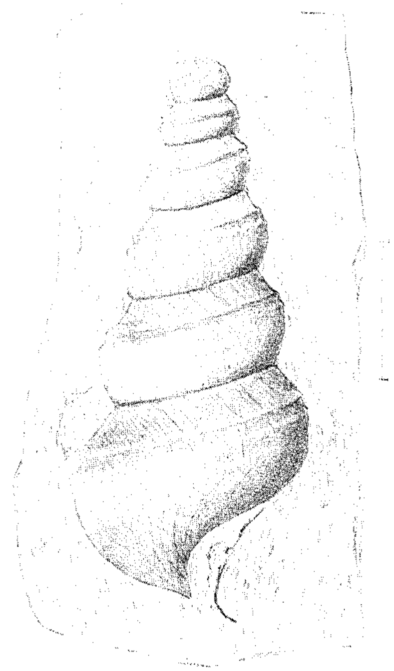

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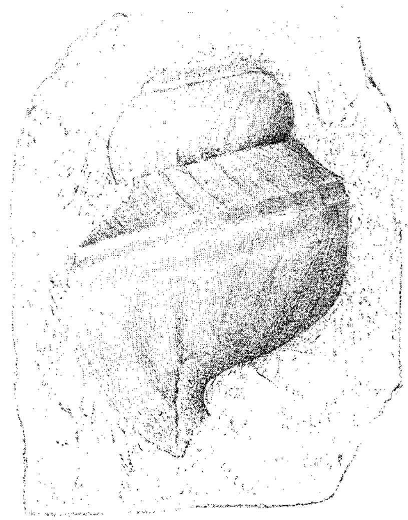

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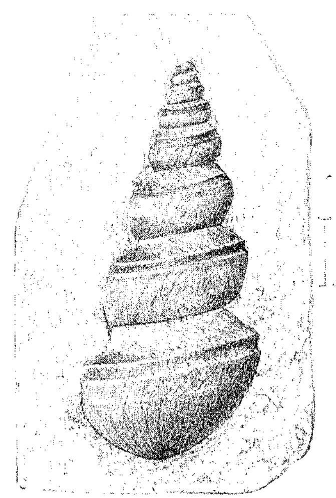

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PLATE XXV.

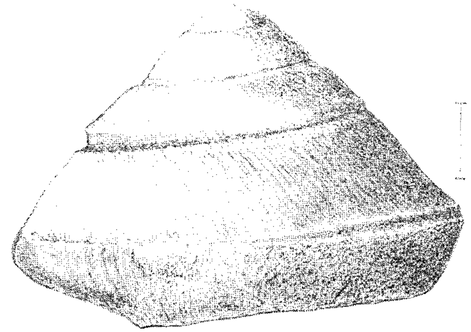
1. *Eotomaria galtensis* (Billings). Cast of a nearly perfect mold from the Amherstburg dolomite of the Detroit river x4.

2. *Eotomaria galtensis* (Billings). Cast of a fragmentary mold x4. With the preceding.

3. *Homotoma tricarinata* Grabau. Cast of an imperfect mold, showing the lower carination x6. Lucas dolomite, Gibraltar quarry.

4. *Homotoma tricarinata* Grabau. A cast of a somewhat more perfect individual x6. With the preceding.

5-6. *Hercynella canadensis* Grabau. The type and only specimen known—slightly restored. Natural size. Amherstburg dolomite, Detroit river.



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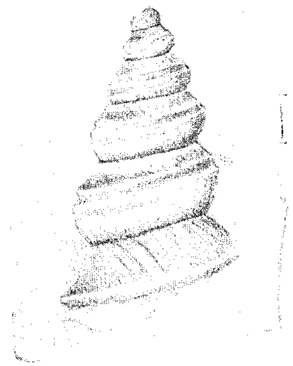

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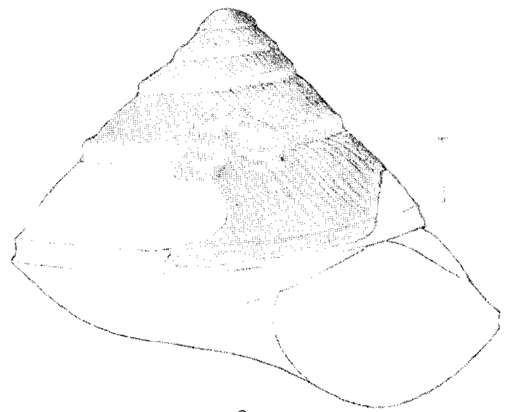

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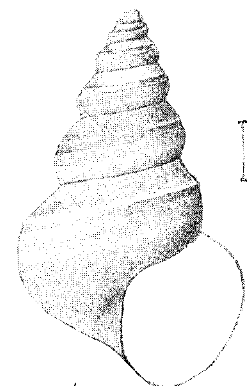

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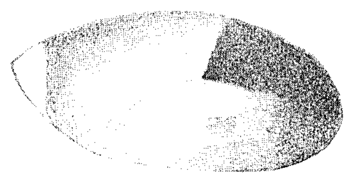

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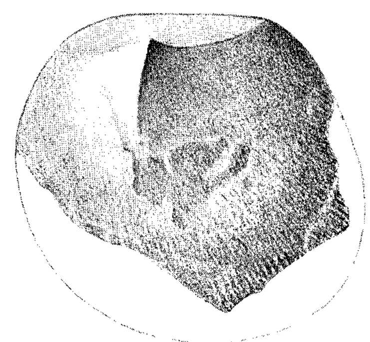

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PLATE XXVI.

1. *Acanthonema holopiformis* Grabau, and var. *obsoleta* Grabau. Gutta percha cast of typical individuals x6. Lucas dolomite, Gibraltar quarry.

2. *Acanthonema holopiformis* Grabau. Gutta percha cast of a small imperfect specimen x6. With the preceding.

3. *Acanthonema holopiformis* Grabau. Gutta percha cast of a more angularly whorled individual x6. With the preceding.

4. *Acanthonema laxa* Grabau. Cast of a specimen in which the ornamentation of the last whorl becomes obsolete x6. With the preceding.

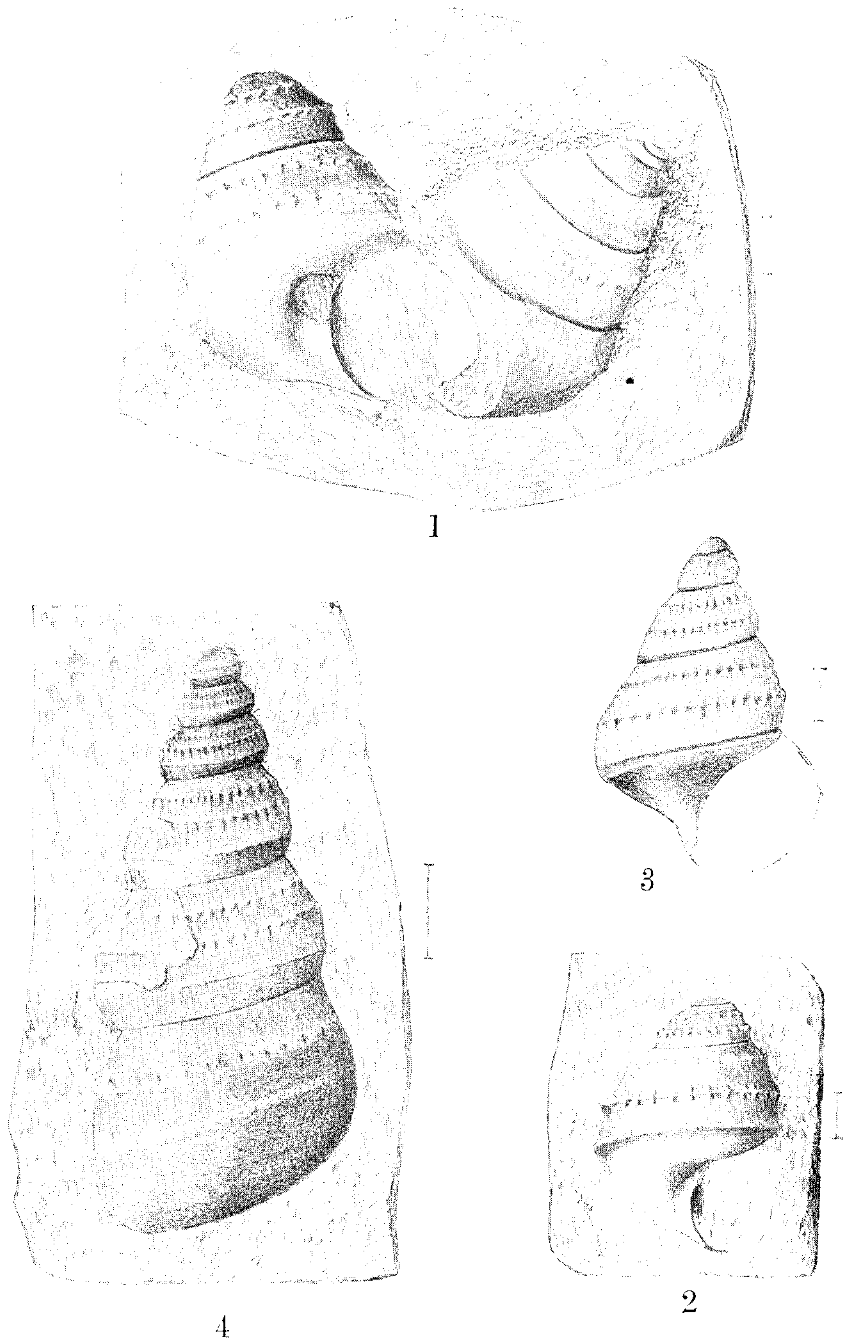


PLATE XXVII.

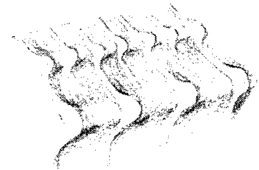
1\. *Pleurotrochus tricarinatus* Grabau. Gutta percha cast of a mold in the Lucas dolomite of the salt shaft x8.

2\. Enlargement of a portion of the surface of a whorl x12, showing the arrangement of the emargination.

3\. *Acanthonema laxa* Grabau var. Cast of a small specimen intermediate between this species and *A. holopiformis* x6. Lucas dolomite, Gibraltar quarry.

4\. *Acanthonema laxa* Grabau. A cast of a characteristic individual x6. Lucas dolomite, Gibraltar quarry.

5\. *Acanthonema newberryi* (Meek). View of a gutta percha cast of the type from the Lucas dolomite of Lucas county, Ohio. x4.



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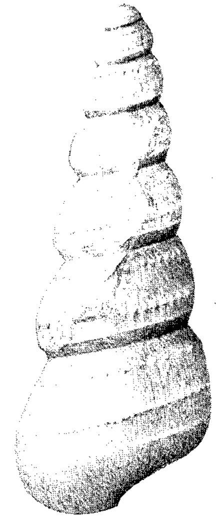

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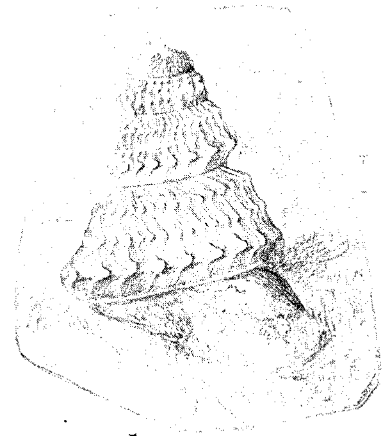

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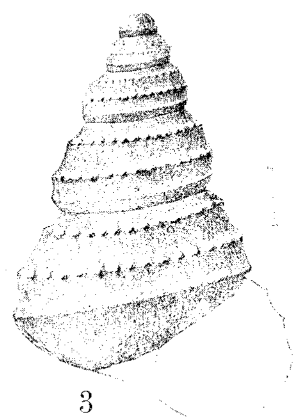

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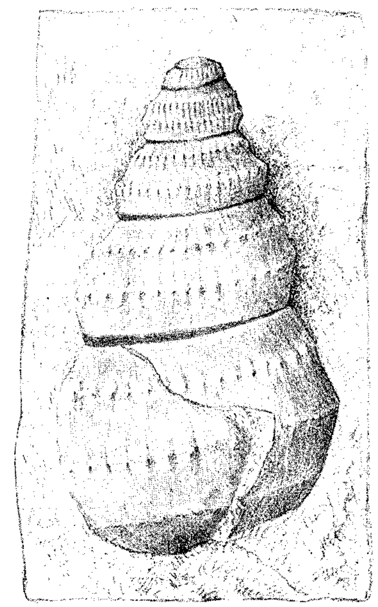

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PLATE XXVIII.

1. *Euomphalopterus valeria* (Billings). Internal rock mold of a part of a whorl showing the compressed flange. Natural size.

2. End view of the same fragment. Natural size. Lucas dolomite, salt shaft.

3. *Euomphalopterus valeria* (Billings). Umbilical view of a cast from the Guelph of Ohio for comparison. Natural size.

4-5. *Holopea antiqua* var. *perectusta* (Conrad). Apical and lateral views of a gutta percha cast from a mold in the Amherstburg dolomite, Detroit river.

6-7. *Cyrtoceras orodes* Billings. Two views of a characteristic internal rock mold showing form and septation. Natural size. Amherstburg dolomite, Detroit river.

8. *Dawsonoceras annulatum* var. *americanum* Foord. Internal rock mold, with part of an external mold in continuation. The irregular annuli and septa are shown. Natural size. Amherstburg dolomite, Detroit river.

9. *Trochoceras anderdonense* Grabau. The type specimen, partly external and partly internal rock mold—the inner whorls showing septation. Natural size. Amherstburg dolomite, Detroit river.

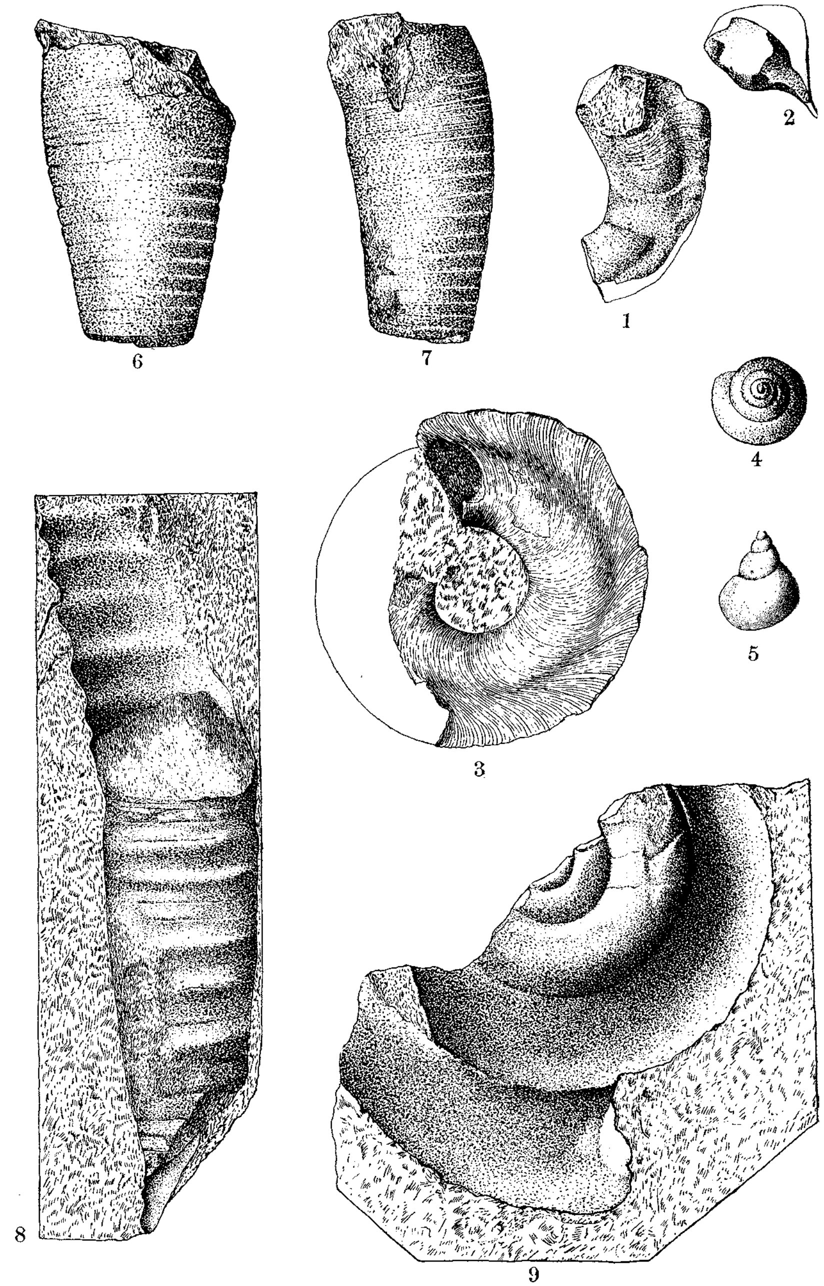


PLATE XXIX.

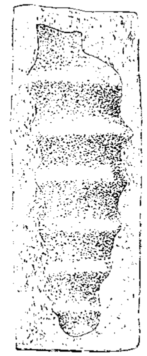
1. *Dawsonoceras annulatum* var. *americanum* Foord. Cast from a fragmentary mold showing the annuli. Natural size. Amherstburg dolomite, Detroit river.

2. *Cyrtoceras orodes* Billings. Another characteristic internal mold, showing septation and a part of the living chamber. Natural size. Amherstburg dolomite, Detroit river.

3. *Cyrtoceras orodes* Billings. Basal view of a fragment showing septum and position of siphuncle. Natural size. With the preceding.

4. *Poterioceras* cf. *sauridens* Clarke and Ruedemann. An internal rock mold of the living chamber and one camera. Natural size. With the preceding.

5-6. *Trochoceras anderdonense* Grabau. Two views of a model representing an accurate restoration of this shell, made from the molds represented in Plate XXVIII, Fig. 9. Natural size.



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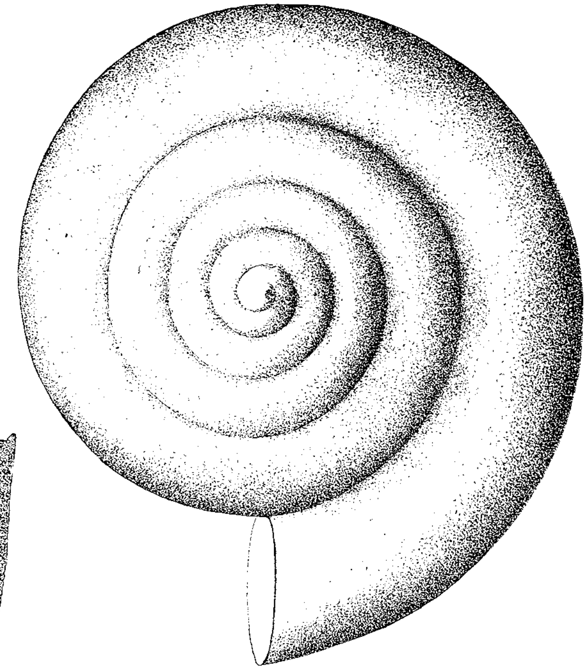

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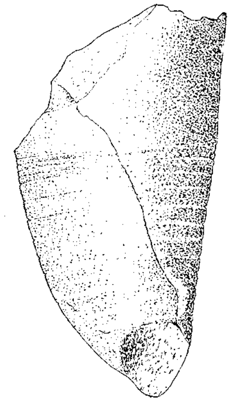

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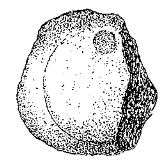

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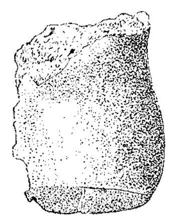

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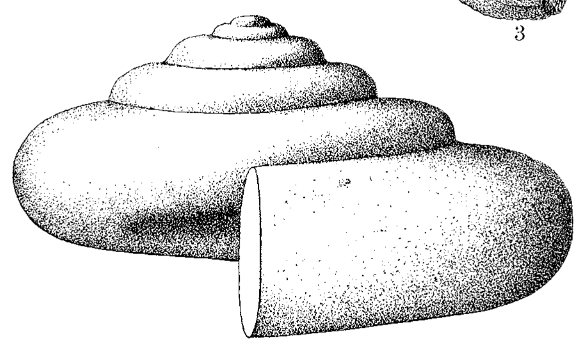

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PLATE XXX.

(Reproduction of Plate V, Vol. V, Annals N. Y. Acad. of Sciences—after Whitfield.)

1-3. *Schuchertella hydraulica* (Whitfield). (*Streptorhynchus hydraulicum* Whitf.). Cast of pedicle valve x2, and brachial valve natural size and enlarged. Greenfield dolomite, Greenfield and Ballville, Ohio.

4-5. *Spirifer ohioensis* Grabau (var.). (*Spirifer vanuxemi* Whitfield). Brachial and pedicle valves. Natural size (the ribs are too strongly emphasized for the specimen). Put-in-Bay dolomite, Put-in-Bay Island, Peach Point.

6-7. *Whitfieldella prosseri* Grabau (*Meristella lævis* Whitfield). Pedicle and brachial valves from the Raisin River beds of Lucas county (?), Ohio. Natural size.

8. *Hindella? (Greenfieldia) Whitfieldi* Grabau. (*Meristella bella* Whitfield). A pedicle valve. Natural size. Greenfield dolomite, Greenfield, Ohio.

9-10. *Hindella? (Greenfieldia) Whitfieldi* Grabau. (*Meristella bella* Whitfield). Ventral and dorsal views of an internal mold. Natural size. Greenfield dolomite, Greenfield, Ohio.

11-14. *Hindella? rotundata* (Whitfield) (*Nucleospira rotundata* Whitfield). Two specimens of different sizes. Greenfield dolomite, Greenfield, Ohio.

15-16. *Rhynchospira præformosa* Grabau. (*Retzia formosa* Whitfield). Views of brachial and pedicle valves. Greenfield dolomite, Greenfield, Ohio.

17. *Camarotœchia hydraulica* (Whitfield) (*Rhynchonella hydraulica* Whitfield). Cast of a brachial valve. Greenfield dolomite, Greenfield, Ohio. Natural size.

18-22. *Pentamerus pes-oris* Whitfield. Various illustrations of the type material. 18-21 pedicle valves; 22 brachial valve. Lower Monroe, Adams county, Ohio.

23. *Pterinea lanii* Grabau (*Pterinea aviculoidea* Whitfield). A cast of a somewhat imperfect mold. Raisin River dolomites, Lucas county (?) or Put-in-Bay Island, Ohio.

24-26. *Goniophora dubia* Hall. (Whitfield). Right valve, natural size and enlarged. Cardinal view of united valves. Put-in-Bay dolomite, Peach Point, Put-in-Bay Island, Lake Erie.

27. *Leperditia altoides* Grabau. (*Leperditia alta* Whitfield). A characteristic right valve. Greenfield dolomite, Ballville, Ohio.

28-30. *Leperditia angulifera* Whitfield. Right and left valves and outline of complete carapace, showing characteristic form. Greenfield dolomite, Greenfield (?), Ohio.

31-32. *Eurypterus eriensis* Whitfield. Views of parts of a nearly complete carapace. Natural size. Put-in-Bay dolomite, Put-in-Bay, Lake Erie.

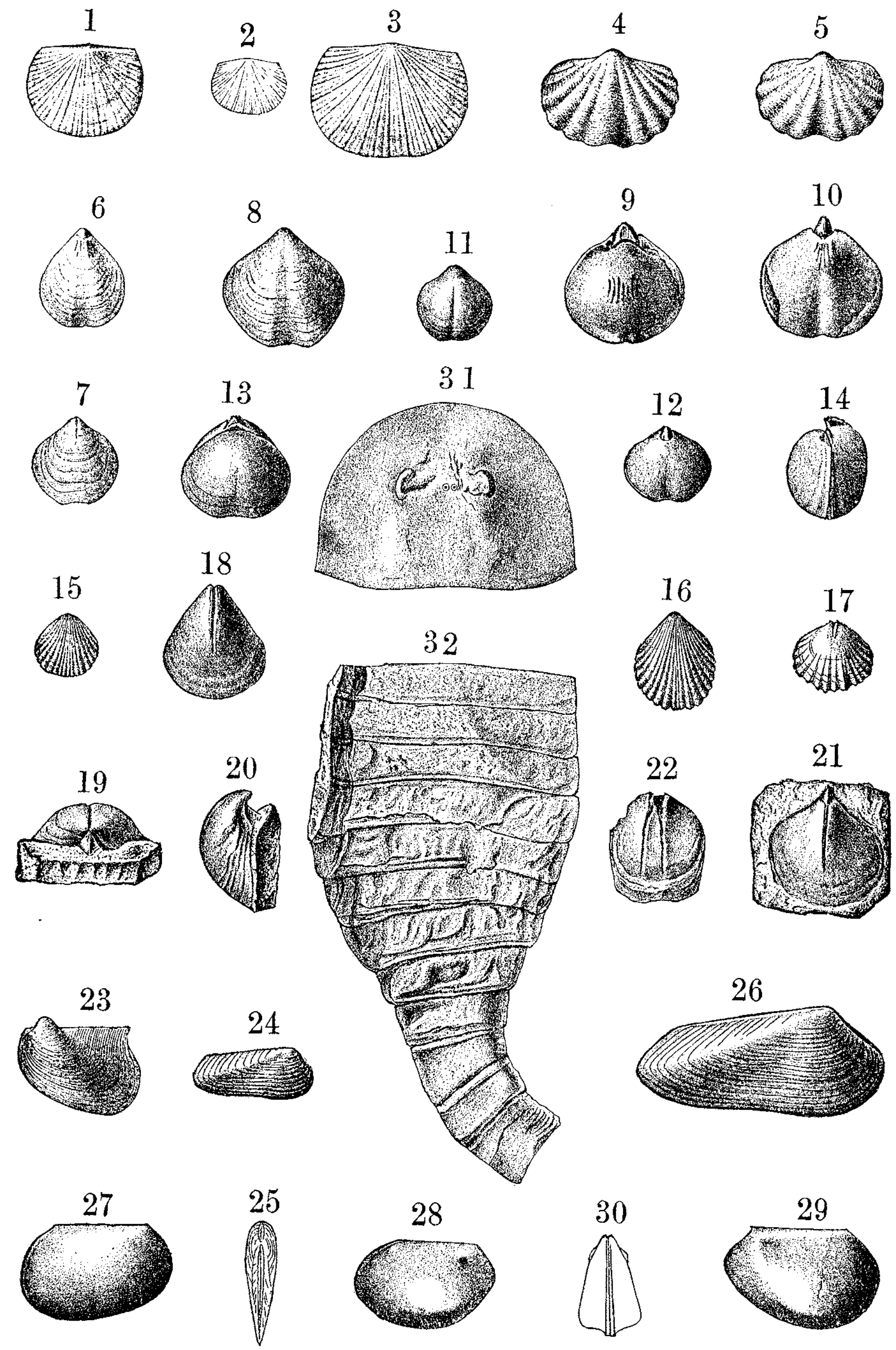

PLATE XXXI.

(Copied from Grabau, Bull. Geol. Soc. American, Vol. XI, Pl. XXI.)

1 a-d. *Cyathophyllum ? hydraulicum.* Lateral and calicinal views of casts of typical material. Akron dolomite, Buffalo, N. Y.

2 a-b. *Spirifer eriensis* Grabau. Pedicle and brachial valves of the types. Enlarged. Akron dolomite, Buffalo, N. Y.

3 a-b. *Trochoceras gebhardi* Hall. A nearly complete internal mold, but showing no septa. Akron dolomite, Buffalo, N. Y.

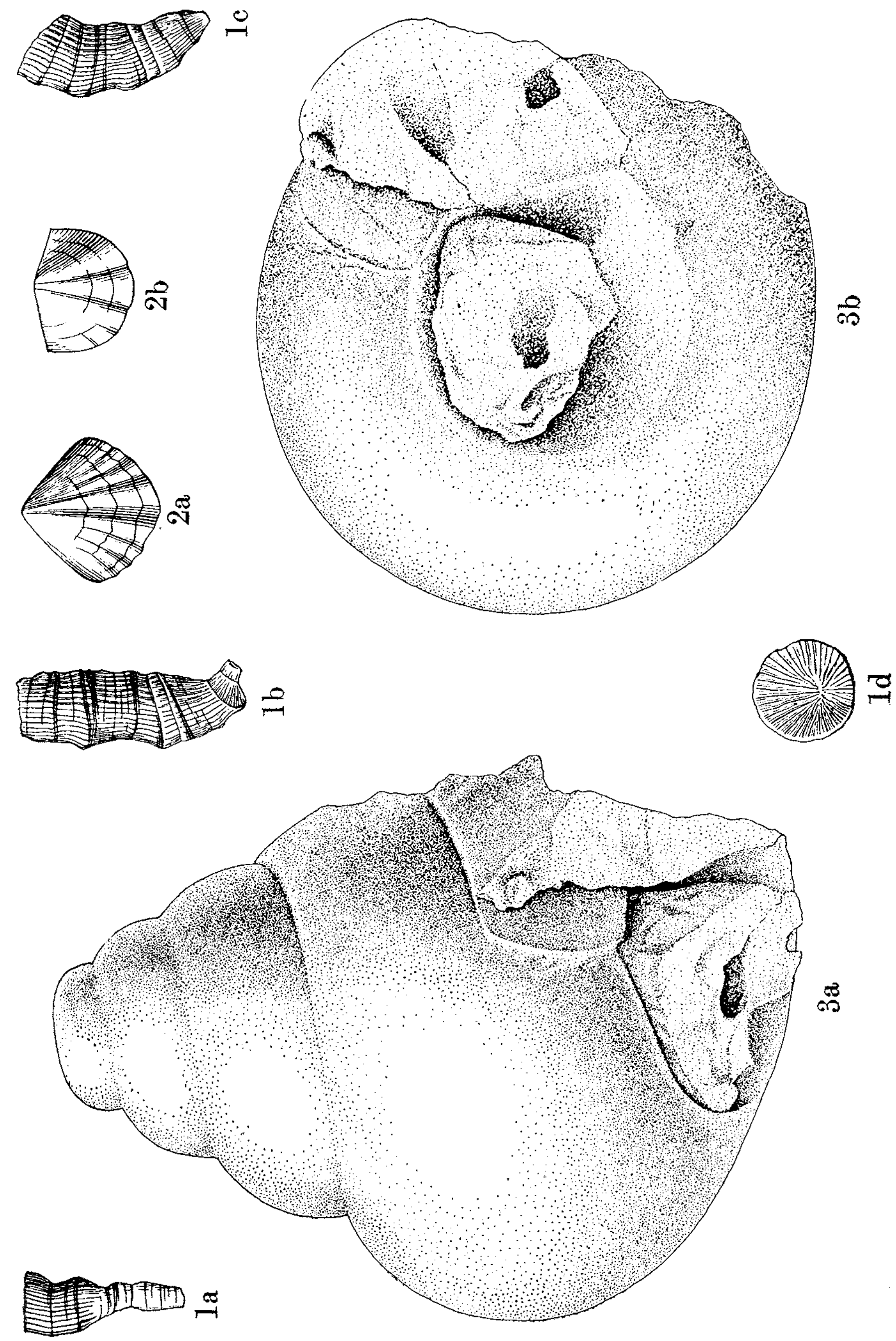

PLATE XXXII.

(Copied from Grabau, Bull. Geol. Soc. Am., Vol. XI, Pl. XXII.)

1 a-c. *Schuchertella interstriata* (Hall).
 1 a. Cast of brachial valve with hinge area of pedicle valve showing x2⅔.
 1 b. Same viewed from above x3⅓.
 1 c. Cast of interior of small pedicle valve x2⅔. Akron dolomite, Buffalo, N. Y.

2 a-d. *Whitfieldella sulcata* (Vanuxem).
 2 a. An individual of average type.
 2 b. Cast of another individual.
 2 c-d. Two views of a cast of a third characteristic specimen. All x2⅔. Akron dolomite, Akron, N. Y.

3 a-b. *Whitfieldella* cf. *nucleolata* (Hall). Two views of a brachial valve (erroneously called pedicle valve in the original description) x2⅔. Akron dolomite, Akron, N. Y.

4 a-d. *Whitfieldella subsulcata* Grabau.
 4 a-b. Two views of natural internal mold of a pedicle valve.
 4 c. Gutta percha cast of same.
 4 d. Another mold of pedicle valve.
 All x2⅔. Akron dolomite, Akron, N. Y.

5. *Lexonema ?* sp. An internal mold. Akron dolomite, Buffalo, N. Y.

6 a-d. *Leperditia scalaris* Jones. Two left and two right valves x2⅔. Akron dolomite, Buffalo, N. Y.