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COMAROCYSTITES AND CARYOCRINITES.

Cystids with pinnuliferous free arms.

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(Continued from page 79.)

13. *The structure of the thecal plates.*—The exterior surface of the thecal plates of *Comarocystites punctatus* is deeply concave. The interior surface, however, appears more or less stellately convex. The convex appearance is due, in part, to the slopes of the suture planes, converging toward the center of the theca, and, in part, to the thinning of the plates toward the angles of their polygonal outlines. The stellate character is due to grooves separating the different sets of mesostereom plates, described later in this paragraph. These grooves narrow toward the angles, thus increasing the stellate appearance.

In cross-sections which are vertical to the surface of the thecal plates and perpendicular to the middle parts of the sutures between the plates, the inner surface of the plates presents an almost straight outline between the center of one plate and the center of the next, or there is a moderate outward bending of this outline at the suture. However, toward the angles where three plates meet, the inner surface of the plates curves so strongly outward as to produce the appearance of deep triangular pits at these points of junction. Owing to the deep concavity of the exterior surface of the plates, the thickness of these plates varies from five-tenths to six-tenths of a millimeter at the center to nearly two millimeters along the middle of the suture lines. Toward the angles, however, where three plates meet, and where the inner surface of the plates curves strongly outward, so as to approach the outer surface, the thickness of the plates frequently is reduced to about a quarter of a millimeter. Viewed from the interior of the theca, with the plates still connected, the deep triangular pits or depressions between the ends of the stellate rays characterizing the individual plates, form the most striking features.

Beneath the thin non-porous epistereom lies the thick mesostereom. That part of the mesostereom which is in contact with the epistereom forms a practically continuous sheet, penetrated only by pores, and from this sheet the greater part of the mesostereom is suspended in the form of vertical lamellæ. (Plate IV, figs. 3 and 1D.) Viewed along the suture planes, where exposed by the dismembering of the theca, these lamellæ appear thin and narrow toward their junction with the continuous exterior part of the mesostereom, but they thicken toward their inner terminations for a distance of almost a millimeter. These lamellæ do not radiate from the center of the thecal plates, but form groups, all lamellæ belonging to the same group being perpendicular to the same suture line between two adjacent plates. If imaginery lines be drawn from the center to the angles of each plate, then the lamellæ will be found grouped in triangles limited laterally by these imaginary lines. In each triangle the lamellæ will be found perpendicular to the suture line forming the base of the triangle, the triangles of adjacent plates forming rhombs, which, however, give no indication of their presence on the unweathered surface of the plates. The adjacent triangular groups of lamellæ are separated usually by grooves, widening toward the center of the plates and narrowing toward the angles. Both the lamellæ and the inter-lamellar spaces are directly connected across the suture planes.

The epistereom is thin and non-porous. However, if only slightly weathered, it is found to be underlaid by pairs of short lunate pores extending parallel to the epistereom, just beneath the latter, appearing on the weathered upper surface of the mesostereom as short lunate grooves, the concave sides of each pair facing each other. The presence of these pairs of lunate pores often is indicated on the exterior surface of the epistereom by short lunate ridges (Plate II, figs. 1A, 1B, also 1D), which correspond in size, form and position with the pores beneath. Three or four series of these pairs of lunate pores may occur between the centers of the thecal plates and the suture lines, the pairs of different series more or less alternating with each other in position.

Each lunate pore is connected near its distal end with a small circular or oblong pore penetrating the outer more or less continuous sheet of the mesostereom, and leading into the spaces between the vertical lamellæ. Pores of the same pair always connect with different inter-lamellar spaces, being separated by one of the lamellæ. The right hand pore of one pair, however, usually is connected with the same inter-lamellar space as the left hand pore of the nearest adjacent pair, proximally or distally, i.e., either nearer the center of the thecal plate or nearer the suture line. In this manner, three or four pores belonging to different pairs may be connected to the same inter-lamellar space. There is no connection between pores belonging to the same pair.

The pores penetrating the outer continuous sheet of the mesostereom are directed perpendicularly toward the suture lines between the plates, but incline more or less obliquely downward. They apparently widen in a direction parallel to the inter-lamellar spaces in passing through the outer sheet of the mesostereom, since, in strongly weathered specimens showing the inter-lamellar spaces (Plate III), the latter frequently appear interrupted by transverse partitions a short distance below the outer continuous sheet of the mesostereom. At the center of each thecal plate there is a space, at least a millimeter wide, within which no trace of the vertical lamellæ appears.

14. *Sections across the anal pyramid and the transverse apical food-groove.*—A cross-section of the anal pyramid of *Comarocystites* shows that the lower margin of the pyramid plates fits into a groove extending along the lower part of the proximal margin of the bordering thecal plates. The upper part of this proximal margin rises sufficiently to admit of the presence of some substance for opening the anal passage on the relaxation of the muscles holding the anal plates shut from within the thecal cavity.

The mouth, or opening into the interior of the thecal cavity, is scarcely a millimeter in diameter, and is located at the posterior end of the suture between the two anterior peristomial plates (a, a, in the text diagrams). In form this opening varies from nearly circular to more or less elliptical, with the longer diameter parallel to the direction of the transverse apical food-groove. From this mouth the lateral primary rays of the food-groove system diverge in opposite directions in such a manner as to produce a slightly curved transverse continuous groove across the apical end of the theca, with the convex side of the groove directed toward the front. This transverse food-groove, between the bases of the arm pairs, is frequently exposed, but the central mouth opening is rarely seen. Cross-sections perpendicular to the length of the transverse apical food-groove in one specimen indicate that the lower part of the posterior peristomial plates, projects slightly beneath the adjoining part of the anterior peristomial plates, especially toward the lateral extremities of this food-groove. To what extent this feature is present in other specimens is unknown.

15. *The arms of Comarocystites punctatus.*—Each pair of arms is supported by a single nodular stereom protuberance, but each protuberance is supplied with two more or less divergent facets (see facet 1, in fig. 1B on plate II.) for the attachment of the arms. Each end of the transverse apical food-groove, on coming in contact with the adjoining protuberance, bifurcates, each branch of the food-groove, together with its covering-plates, extending to one of the arm bases, and then rising along the adoral side of the first brachial.

Arms are known only in the case of two specimens, one found and figured by E. Billings, the other found and figured by Sir James

Grant. The first presents a clearly defined view of the lower half of the right posterior arm, with its attached pinnules. The second presents a much less clearly defined view also of what appears to be the right anterior arm, with its attached pinnules. Evidently both the brachials and pinnulars of these two arms are arranged in uniserial order. It is assumed that the left pair of arms presented the same characteristics. Only the right posterior arm attached to the Billings type-specimen is here described in detail.

Twelve brachials (Brachials 1 to 11 are numbered in the figure on plate III) are exposed, and each bears a single pinnule on its right side. All of the brachials above the first are flattened slightly from front to rear (Plate II, figs 3A, B, C), the ratio of the lateral diameter to the adoral-aboral diameter being as 10 to 9 (Fig. 3A). The length of each brachial usually equals about three-halves of its lateral diameter. The facets supporting the pinnules are concave (Fig. 3C), their margins being distinctly elevated, especially on their lower sides. The location of these facets is slightly above the middle of each brachial. On that side of the brachial which is opposite the pinnule (Fig. 3B), the brachial tends to be slightly more angular in a direction parallel to the length of the arm. The original length of the complete arm is unknown, but probably it equalled about three-halves of the length of the theca. The rate of tapering of the successive brachials, as far as preserved, is but moderate. Analogy with *Amygdalocystites* and *Canadocystites* suggests that the pinnules of all four arms of *Comarocystites* were attached to the right side of the arms, the aboral side of each arm facing the observer, and the distal end being directed upward.

16. *The pinnules.*—The length of the pinnules probably equalled 30 millimeters, and may have reached 35 millimeters. There is but little variation in the length and width of the pinnulars, about four occupying a length of five millimeters. Except in the case of the first two or three pinnulars, most of the pinnulars are strongly flattened transversely (Plate III; also figs. 4A, B, C, on plate II), the pinnules being placed, for purposes of description, in an approximately vertical position, with the aboral side facing the observer. The ratio of the transverse diameter to the adoral-aboral diameter (Fig. 4A) is about 8 to 5. The lateral edge of the pinnulars (Fig. 4B) tends to be more or less angular in a direction parallel to the length of the pinnule, thus giving the pinnulars a lens-shaped cross-section.

In the Billings type-specimen, here figured, a series of small, flat, quadrangular plates lines one side of two joints of that fragment of the pinnule which is marked D on plate III, and traces of similar small plates are seen at the point C, on one side of the pinnule attached to the eighth brachial. (See also fig. 4C on plate II.) These small quadrangular plates are interpreted as covering-plates. Their number varies from three in a length of one pinnular, to five in a length of two of these pinnulars.

17. *The absence of food-grooves on the brachials.*—In case of the right posterior arm of *Comarocystites,* one of the branches of the transverse apical food-grooves rises for a short distance along the ventral side of the first brachial, but disappears before reaching the top of this brachial. There are reasons for believing that the absence of food-grooves on the arms of *Comarocystites* is secondary and not primitive. The small quadrangular covering-plates along one side of the pinnules, as described above, suggest the former presence of a food-groove. As a matter of fact, no trace of an actual food-groove has been noticed so far on any pinnular, but analogy with *Amygdalocystites* demands that they should be present.

In *Amygdalocystites* the food-groove follows one of the narrower sides of the pinnule, the pinnulars being compressed laterally, and the food-groove faces the mouth. In a similar manner the few covering plates found so far on the pinnulars of *Comarocystites* are on the side facing the mouth, and the sides of these pinnulars are even more compressed than in *Amygdalocystites.* Originally, a food-groove must have followed that side of the pinnule supporting the covering-plates, and a second series of covering-plates must have existed along the same side, but beyond the food-groove. Formerly the food-groove on the pinnulars must have connected with one of the brachials, thus reaching the transverse food-groove along the apical side of the theca, if the analogy between *Comarocystites* and *Amygdalocystites* and *Canadocystis* is as great as here suspected. It should be noted, however, that the facets supporting the pinnules of *Amygdalocystites* are distinctly indented on the side where the branch from the food-groove on the arm passed on the base of the attached pinnule. In *Comarocystites,* however, the facets supporting the pinnules are circular, and show no such indentation. Evidently the absence of a food-groove extends to the lower pinnulars at least.

18. *The column or stem.*—The column or stem is cylindrical, with no evidence of pentamerism either exteriorly or interiorly. The segments or columnals are very thin, alternating in thickness, about 20 occurring in a length of six millimeters in the column attached to that Billings type-specimen which retains the arm. This column has a diameter of four millimeters. The surface of the column is ornamented by minute granules, seven in a width of one millimeter, arranged quincuncially, in diagonally intersecting rows. The lumen equals about one-fourth of the diameter of the column. The flat surfaces of the columnals are striated radially. The only known complete column is attached to the specimen discovered and described by Sir James Grant, and figured by him in the Transactions of the OTTAWA FIELD-NATURALISTS' CLUB, in 1880. In this specimen the

theca is 65 millimeters in height, the length of the column is 108 millimeters, its width near its attachment to the theca is 7 millimeters, at mid-length this width is nearer 5 millimeters, toward the base of the column it increases to 6 millimeters, and then, within a distance of 3 millimeters, the column widens rapidly into a circular attachment disk, about 17 millimeters in diameter. The upper surface of this attachment disk is convex, and the lower surface is sufficiently concave to suggest attachment to a more or less convex object. The outlines of this attachment disk probably were irregularly circular, certain parts extending farther than others from the center. There is no differentiation in size or form between the columnals along the middle third of the stem compared with the columnals toward either end. All are very thin and of approximately the same lateral diameter. During the growth of the stem the columnals probably were added at the top. The stem evidently was sufficiently strong to support the theca in a more or less erect position.

19. *Geological horizon and geographical distribution.*—*Comarocystites punctatus* Billings is known chiefly from the Trenton, in the vicinity of Ottawa, in Canada. Professor Percy E. Raymond, who has made a special study of the Ottawa area (Guide Book No. 3, International Geological Congress, 1913, p. 151), cites *Comarocystites punctatus* only from the quarry located in the angle between the two railroads, several hundred yards north of Walter's Axe Factory quarry, in Hull, a town on the opposite side of the river from Ottawa, northwestward. Here it occurs in the *Crinoid* zone, associated with *Edrioaster bigsbyi, Cyclocystoides halli, Isotelus latus,* and *Amphilichas cucullus.* The strata in this quarry consist of rather thick-bedded, coarse-grained, gray limestone, separated by black shale partings in which most of the fossils are found. The writer found two specimens of *Comarocystites* on the surface of the highest layer of massive limestone exposed in the Robillard quarry, three miles east of Ottawa, on the south side of the Montreal road. This massive limestone is referred by Raymond to the *Tetradium* zone, and belongs above the *Crinoid* zone. The top of the *Tetradium* zone is exposed also in the quarry immediately behind the axe factory, in Hull. In the overlying *Prasopora* zone Mr. James E. Narraway found several specimens of *Comarocystites.* Several small specimens were found by Mr. Narraway in the lower part of the *Cystid* zone exposures at Nepean Point, within a short distance of the horizon at which *Agelacrinites inconditus* is fairly common. This part of *Cystid* zone is probably not far above the top of the *Prasopora* zone. The well preserved theca illustrated by figure 1 on plate II of the present communication was found by Mr. Narraway, in the quarry at the northeast corner of Bell Street and Carling Avenue, immediately east of the railway leading into the lumber yard east of Dow lake. Here

Agelacrinites chapmani occurs in one of the lower layers of limestone, and the *Comarocystites* was found about five feet above this level. The exposures in the quarry belong to the upper part of the *Cystid* zone. It is evident that the types of *Comarocystites punctatus* were found in the *Cystid* zone, since Billings stated in his original description that the specimens occurred "generally along the water's edge, from the Rideau Falls to the Chaudiere." The remarkable specimen obtained by Sir James Grant from an excavation on St. Patrick street, near Chapel street, in Ottawa, also may have come from the *Cystid* zone, but there are no exposures at present in this area, by means of which the horizon may be established definitely. Evidently *Comarocystites* has a considerable vertical range in the Trenton of the Ottawa area, being unknown so far only from the *Dalmanella* zone, at the base of the Trenton, and from the *Hormotoma* or *Sponge* zone, at the top of the Trenton. In the intermediate zones it evidently occurs at more or less remote intervals, and is a comparatively rare fossil.

Possibly there are two species of *Comarocystites* in the Ottawa area; one of larger size, with more compressed theca, and with nearly smooth thecal plates; the other smaller, less compressed, with minutely granular thecal plates, marked by pairs of distinctly lunate short ridges. The second form is known to occur at the top of the *Tetradium* zone, immediately beneath the *Prasopora* zone, and in the *Cystid* zone. Possibly the smooth form occurs at a different horizon, but the number of well preserved specimens at hand is not sufficient to determine whether the smooth and ornamented forms in reality are distinct or not.

Comarocystites punctatus is cited by Rominger also from the Trenton, in section 17 of township 41, above the big bend in the Escanaba River, north of Little Bay de Noquette, in Michigan.

20. *Literature on Comarocystites punctatus*:—
Comarocystites punctatus Billings:

Billings, Canadian Journal, 2, 1854, p. 270, figs. 1-3.

Figure 1 in this paper corresponds to figure 2 on plate V of Decade III. Figure 2 is an apical view of the same specimen and corresponds to figure 2b in the Decade, but is not identical with the latter; there is no indication of a pair of arms at the upper end of the figure, but only of a single protuberance, and the location of the anal pyramid beneath the pair of arms in the lower part of the figure is shown. Figure 3 corresponds to figure 1 of the Decade.

Geol. Surv. Canada Rep. Progr. for 1853-56, 1857, p. 288.

Geo. Surv. Canada, Dec. 3, 1858, p. 61, pl. 5, figs. 1-1b, 2-2b.

Figure 1 (No. 1391g, in Victoria Memorial Museum) represents the right side of the theca; *o* is the anal pyramid. In figure 1b, the smooth proximal parts of the polygonal plates surrounding the anal pyramid are represented incorrectly as though forming a circle of separate plates surrounding the anal pyramid. In figures 1a and 2a, the non-porous epistereom has been removed by weathering from the marginal parts of the thecal plates. Figure 2 (No. 1391, in Victoria Memorial Museum) presents a view of the anterior side of the theca, with the anal opening on the left upper margin of the figure; the nodular stereom mass supporting the right pair of arms is seen immediately below the number 2, and the angle at the upper right hand margin of the figure indicates the location of the other stereom mass. Figure 2b is a very unsatisfactory representation of the transverse food-groove extending from the central mouth in opposite directions to the base of the stereom mass, where it forks dichotomously at each end.

Grant, Trans. Ottawa Field-Nat. Club, 1, 1880, pl. 1, figs. 1-5.

Figure 1 (No. 333 in Victoria Memorial Museum) probably presents a view of the anterior side of the theca, in addition to a view of the entire length of the column, including its base. Only the lower parts of the arms and pinnules of this specimen are represented in this figure. The remaining figures are re-publications of figures in Decade III, of Billings, figs. 2, 3, 4 and 5 corresponding to figs. 1, 2, 1b and 2b respectively of the Decade

Chapman, Exposition of the Minerals and Geology of Canada, 1864, p. 109.

Haeckel, Amphorideen u. Cystoideen, 1896, p. 70, pl. 1, figs. 4-4c.

Figure 4 is a reproduction of Billing's figure 1 on plate 5 of Decade III, amplified by Haeckel so as to suggest the appearance of a complete arm system and a complete column. The biserial arrangement of the pinnules is incorrect. In figure 4a, the series of small plates surrounding the transverse food-groove is imaginary; the figure evidently is based on figure 2b of the Decade.

Jaeckel, Zeits, d.d. geol. Gesell. 52, 1900, p. 676.

EXPLANATION OF PLATE III.

Comarocystites punctatus Billings. Upper part of type figured by Billings in his monograph on the Cystideae of the Lower Silurian rocks of Canada, in Decade III, of Canadian Organic Remains, in 1858, where it forms figure 1 on plate V. The specimen has been crushed in a direction perpendicular to the anal pyramid. Only the upper part of the right side of the theca is shown in the figure here presented, magnified 3 diameters. A considerable part of the right posterior arm is exposed. The brachials are numbered. The exposed surfaces are interpreted as the dorsal side, most of the brachials showing the facets for the attachment of the pinnules on the right. The pinnules are twisted so as to show both the narrow edges and the flat faces of the pinnulars at different points along the pinnules. The first brachial and several closely appressed pinnules belonging to the right anterior arm occupy the position indicated by B, but can not be distinguished in the figure here presented. Cover-plates may be seen along the right margin of the pinnulars marked D, and along the corresponding margin of several pinnulars marked C in the figure. The position of the anal pyramid and the smooth border of the surrounding thecal plates is indicated at A. The surface of the thecal plates is strongly weathered, except at the center, and indicates clearly the parallel arrangement of all folds and pores of the mesostereom; these are perpendicular to the same edge of the plates; consequently those groups which are perpendicular to different edges form angles with each other along the imaginary lines drawn from the center of the plates to the angles of the latter. The passages of the folds and pores perpendicularly across the sutures from plate to plate, in an apparently continuous manner, also is indicated. For the remainder of the specimen, see the figure presented by Billings. Figure based on photograph supplied by courtesy of the chief photographer of the Geological Survey of Canada. The original specimen is numbered 1391 in the collection of the Survey deposited in the Victoria Memorial Museum, at Ottawa.

NEW SPHÆRIIDÆ.

Dr. Victor Sterki has recently published in the Annals of the Carnegie Museum (Vol. X, Nos. 3 and 4, pp. 429-474), a preliminary catalogue of the Sphæriidæ of North America. The small bivalves of this family are remarkably abundant in the vicinity of Ottawa, and constitute no small part of the food of many fishes and birds. The whole of the material submitted to Dr. Sterki has not yet been thoroughly studied, and what was collected in 1915 and 1916 has not yet been submitted to him. Most of the shells are minute in size, and alike in colour, and for these and other reasons their determination is attended with great difficulty, and, not infrequently, with doubt. The trained eye of Dr. Sterki, and his keen mental apprehension of slight differences, have in my opinion, rendered him capable of accomplishing a task before which other have "backward shrank appalled." While the result of his labors, as published, are modestly stated to be tentative and preliminary, they undoubtedly constitute one of the most valuable contributions made in recent years to the study of our inland


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