were cumbered with a very buoyant shell. Solger¹ concluded from the fact that an injury to the chambers and destruction of several septa made no apparent difference to the animal, which continued its growth without noticeable irregularity, that the Ammonite was benthonic before the accident and could not have been a swimmer. But this may only show that the buoyancy did not depend on the air-chambers only; and "bulk" in the case of a sharp-ventered, thin shell, was not necessary to enable its occupant to swim well and quickly. The damage to the earlier whorls of large and evolute shells at a late stage (large Arietids often have no centre like certain perforated *Nautili* of the Palæozoic or Triassic) probably would not have affected the buoyancy of the shell and mode of life of the animal more than the loss of its apex would have affected an *Orthoceras*.

The problem of disposing of superfluous calcium salts was probably never a pressing one in Ammonoids, for as in other tubular organisms growth could generally continue indefinitely whether the cone was coiled or straight, and when a large amount of mineral matter went to elaboration of one feature, the equilibrium was generally maintained. The periodical thickenings of ridges and flares, e.g., which are also found in the long-lived genera *Phylloceras* and *Lytoceras*, cannot in the writer's opinion be looked upon as such deposits of superfluous calcium-carbonate, after the manner of tabulæ, diaphragms, etc., in other tubular organisms,² and it must be remembered that very elaborate apertural structures seem to have been resorbed occasionally. A more fundamental problem than the necessity of getting rid of an excess of calcium-salts is presented by *Pinacoceras*, which represents the extreme in sutural elaboration among Ammonoids, and where the septal edge seems to be complicated beyond utility and mechanical requirements, and by the crowding of septa, which also occurs during the Triassic acme of the group. This is probably comparable with the specialization and running to extremes in other directions, e.g., size, ornamentation, or uncoiling, a phenomenon not confined to Ammonoid phylogeny, and generally followed by the extinction of the specialized lineage at or near the height of its career.

V.—NOTES ON YUNNAN CYSTIDEA. III. *SINOCYSTIS* COMPARED WITH SIMILAR GENERA.

By F. A. BATHER, D.Sc., F.R.S.

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A.—COMPARISON WITH *ARISTOCYSTIS*, *HIPPOCYSTIS* N.G., *CALIX*, AND *ARCHEGOCYSTIS*.

THE Diploporita, to which Order *Sinocystis* clearly belongs, have been divided into Families according to the greater or less extension of the subvective system over the theca and the modifications thus induced in the arrangement of the thecal plates.

¹ "Fossilien d. Mungo-Kreide": Geol. v. Kamerun, ii, p. 216, 1904.

² W. D. Lang, "Calcium Carbonate and Evolution in Polyzoa": GEOL. MAG., Dec. VI, Vol. III, No. 620, pp. 74-5, February, 1916.

All those in which the epithecal food-grooves do not extend beyond the adoral circle of plates are referred to the Sphæronidæ. The line between the Sphæronidæ and the more advanced Glyptosphæridæ cannot be drawn rigidly, and such a genus as *Proteocystis* constitutes a natural transition. *Sinocystis*, however, comes well within this boundary.

On the other side it is not easy to define the limit between the Sphæronidæ and the Aristocystidæ, from which, apparently, they were evolved. In 1899 and 1900, accepting the statement (which I was unable to disprove) that the genera referred to the latter Family had no exothecal skeletal processes (e.g. brachioles), and observing the irregular and apparently unspecialized arrangement of their pore-canals when present, I placed the Aristocystidæ in the Amphoridea. Jaekel (1899) removed from the Aristocystidæ all the genera that I was including in that Family, with the exception of *Aristocystis*, but added to it his new genus, *Trematocystis*, which will be discussed in Section B. In 1906 (Palæont. Indica, n.s., II, No. 3) I showed that the pores in *Aristocystis dagon* from Burma were haplopores, that is to say not yoked in couples but isolated and irregularly distributed, and that they might be connected by surface channels which had a radial arrangement and crossed the sutures. Consequently I was not induced to place *Aristocystis* with the Diploporita as Jaekel had done.

Taking *Aristocystis* as represented by its genotype, *A. bohémica*, with which *A. dagon* is in general agreement, one notices a considerable resemblance to *Sinocystis*: the extended peristome and the three other thecal openings occupy the same relative positions and have much the same shape in the two genera. The genera are distinguished by their pores, and by the less development of the brachiole-facets in *Aristocystis*. One would take *Sinocystis* to be derived from *Aristocystis*, but there is the possibility that Jaekel may be right in reversing the relation. Unfortunately there is at present no means of settling this question by reference to stratigraphical position.

It should be remembered that the pore-structures figured by Barrande for various specimens of *Aristocystis* fall into two categories. The pores found in the typical *A. bohémica* seem to be haplopores, united by surface-channels into series ranging from 2 to 6; in this species the channels do not cross the sutures. The channels are of approximately equal width throughout their length, but are sinuous and irregular. In the other category the pores are far more obviously in pairs, and those of each pair are connected by a rather narrow channel of horse-shoe shape, at the ends of which they lie (Barrande, 1887, pl. 13, figs. 4, 12, 13, 15, 18; pl. 17, fig. iii, 5; pl. 14, figs. 10, 11). On quite unimportant grounds of external shape, Barrande included these and other specimens in *A. bohémica* as varieties, but he did also suggest that none of those with horse-shoe channels really belonged to *Aristocystis*. The adoral region of the theca in the latter specimens is unknown, but the pore-character warrants their separation as a genus for which I propose the name *Hippocystis* in allusion to the horse-shoe. It may be left, pending further information, in the Aristocystidæ.

The genotype is *H. subcylindrica* (Barrande sub *Aristocystites*?), and for this the original of Barrande's pl. 13, figs. 1–4, is selected as Holotype. The holotype of *A. ? grandiscutum* (Barrande, pl. 17, fig. iii) should be referred to *H. subcylindrica*, and the two other specimens of *A. ? grandiscutum* (pl. 14, fig. 20, pl. 38, fig. 30) revert to *A. bohémica*. These specimens were associated by Barrande on account of a similarity in the basal attachment—a character of individual adaptation, insufficient to distinguish them from the species to which they are now referred.

Calix sedgwicki Rouault, which was placed by me in the Aristocystidae (1900), was, after examination of specimens, referred by Jaekel (1899) to the Sphæronidae. The adoral region remains unknown, but the structure of the thecal plates shows some resemblance to *Sinocystis yunnanensis*, viz., in the umbonal pustule, and in the frequent radial arrangement of the diplopores on the surrounding area of each plate. Jaekel, as previously mentioned (vol. V, p. 513), believes that the diplopores of *Calix* had a covering of epistereom. Some specimens referred by various authors to *Calix* may belong to *Aristocystis*; *Calix sedgwicki* itself may not be generically separable from *Codiacystis* Jaekel (= *Craterina* Barr. non Bory).

Archeogocystis Jaekel, with genotype *A. desiderata* (Barr.), may be mentioned here because Jaekel is uncertain whether the pores are diplopores or haplopores. Though found in the Lower Ordovician (D, 1, γ), it has five facet-bosses, each bearing five or six grooves, each of which presumably was provided with a brachiole as in *Codiacystis*. A hydropore-slit and gonopore are placed as in *Aristocystis*.

B.—COMPARISON WITH *MEGACYSTIS* (SYNN. *HOLOCYSTITES*,
TREMATOCYSTIS).

The fossils to which, at first sight, *Sinocystis* bears the strongest resemblance, are undoubtedly those from the Silurian of N. America which for many years passed under the name *Holocystis* (-ites). Justifiably, therefore, Dr. Reed alludes to these in his account of *Ovocystis mansuyi*, but to make the resemblances and the differences clear it will be well to go into greater detail.

1. *History of the Genus.*

The fossils referred to were first made known by James Hall, in the form of internal casts from the Niagara Limestone of Racine in Wisconsin (1861, Ann. Rep. Geol. Surv. Wisconsin, p. 23; 1862, Rep. Geol. Wisconsin, I, pp. 69 and 431, text-fig. 16/1 & 2). He published figures but no description, and distinguished two species under the names *Caryocystites cylindricum* (fig. 16/1) and *C. alternatum* (fig. 16/2). In the 20th Report of the New York State Museum, of which the earlier pages seem first to have been issued in 1864, Hall established the new genus *Holocystites* (p. 311) for the reception of these two species as well as the new species *H. abnormis*, from Racine, and *H. winchelli*, *H. scutellatus*, and *H. ovatus* from Waukesha, Wis. The complete Report was issued (presumably in a limited edition) in January, 1865, and (more freely) in 1867; a revised edition was published in 1870. By 1865

Hall had recognized that the name *Holocystis* had been used by Lonsdale in 1849 for a Cretaceous coral; he therefore proposed (1865, p. 380; 1870, p. 429) to replace his own *Holocystites* by *Megacystites*. To clear this matter of nomenclature out of the way at once, it may be mentioned that, though Hall's proposal was entirely overlooked by S. A. Miller, it was adopted by Sven Lovén in editing Angelin's "*Iconographia Crinoideorum*" (1878), by P. H. Carpenter (1891, J. Linn. Soc., Zool. XXIV, p. 47) and by myself (1900, Treatise on Zoology, p. 47). We have all used the form *Megacystis*, recognizing no difference but that of length and cumbrousness between the ending in *-ites* and those in *-us*, *-a*, or *-is*.

Beyond the general shape and the number of plates, very little could be ascertained by Hall from the material at his disposal. In December, 1865, A. Winchell and O. Marcy (Mem. Boston Soc. Nat. Hist. I, p. 9) described a new species, *C. sphericus*, from the Niagara [Racine] Limestone of Chicago, and mentioned a fine specimen of *Caryocystites cylindricus*, showing the anus.

The *Megacystis ovalis* of Angelin (1878, p. 30) belongs to the Rhombifera, and his "*M. alternata*, Hall, var." (loc. cit.) is a fragment, supposed from Kinnekulle, which may have belonged to any large elongate Sphæronid of Ordovician age.

It was not till October, 1879, when S. A. Miller (Journ. Cincinnati Soc. Nat. Hist., I, p. 129) began the description of species from the lower part of the Niagara Group in Indiana, that it was possible to form an adequate idea of the genus. Miller continued his descriptions through many years,¹ and raised the number of names for North American species from seven to forty-eight. In 1889 (op. cit.) Miller fixed the genotype as *H. cylindricus* Hall. The original of Hall's figure 16/1 of "*Caryocystites cylindricum*" is the holotype of the species (= pl. xii, fig. 4, and pl. xiii, fig. 7, of Hall, 1865-67).

Unfortunately Miller's conceptions of Echinoderm morphology were old-fashioned when he began and underwent no change. In reading his descriptions his use of the following terms must be kept in mind:—

"Ambulacral orifice"	Miller	= mouth or peristome.
"mouth"	"	= anus or periproct.
"anal aperture"	"	= hydropore, but may sometimes = gonopore.
"ventral" or "anterior"	"	= posterior.
"dorsal" or "posterior"	"	= anterior.
"right" and "left"	"	= left and right.

A list of the American species, with references, will be found in R. S. Bassler's "Bibliographic Index of American Ordovician and

¹ Dec. 1879. Journ. Cincinnati Soc. Nat. Hist., ii, pp. 104-8.

Jan. 1880. Tom. cit., p. 259.

Dec. 1882. Op. cit., v, p. 223.

1889. *N. Amer. Geol. and Pal.*, pp. 253-5.

1891. Adv. Sheets 17 Rep. Geol. Surv. Indiana, Palæontology, pp. 13-18.

Sept. 1892. Ditto, 18 Rep., pp. 8, 9.

July, 1892. With Faber. Journ. Cincinnati Soc. Nat. Hist., xv, p. 87.

Dec. 1894. With W. F. E. Gurley. Bull. Illinois State Mus., v, pp. 5-8.

Dec. 1895. With W. F. E. Gurley. Op. cit., vii, pp. 84-6.

Silurian Fossils" (1915, Bull. 92 U.S. National Mus.), under *Holocystites*. From the Racine Limestone of Wisconsin and Illinois there are the seven species already mentioned as described in 1864-5, as well as *H. jolietensis* Miller (1882), from Joliet, Ill. From the underlying Laurel Limestone near Waldron, Ind., is *H. pustulosus* Miller (1878). The Osgood Limestone of Indiana, which is slightly older, has yielded specimens in Jefferson county, mostly from Big Creek, near Dupont, but some from the neighbourhood of Madison, and in Ripley county, mostly from near Osgood. On these Miller based forty species.

In time, then, these species are confined to a period extending from the top of the Clinton to the middle of the Lockport, approximately equivalent to the age of the Woolhope Limestone and the lower half of the Wenlock beds. In space they are confined to the south-eastern quarter of Indiana and a strip bordering Lake Michigan on the south-west. That is to say, they inhabited the Indiana Basin of the Mississippian Sea, which derived its fauna, according to Schuchert (1910), from the Atlantic by way of the Gulf of Mexico. The bare record of *H. globosus*, from the Rochester Shale of Hamilton, Ont.,¹ is for the present unsupported by published evidence, but it was just on the border of the same Basin.

2. Specific Characters in *Megacystis*.

Everyone who has alluded to the forty-one species proposed by S. A. Miller (especially P. H. Carpenter, 1891; Jaekel, 1899; R. R. Rowley, 1903) has considered that they might be reduced to a far smaller number. Even Miller himself wrote in 1892: "The *Holocystites* are so variable in all respects that it is hard to tell exactly what should be considered specific characters and what should be regarded as variations among fossils belonging to the same species."

Here we obtain some guidance from the specimens of *Sinocystis*, which no one could regard as representing more than three species. The size and form of the theca are seen to vary within wide limits, in part no doubt with age, and the absolute number of plates is correlated with the growth of the theca. The positions of the thecal openings are also subject to slight individual variation, possibly connected with the position assumed by the theca. The size and shape of the base depend, as usual, on the surface to which the theca chanced to become attached, and on similar external conditions. There is no doubt a difference of general form between the pear-shaped *S. loczyi*, the more globose *S. yunnanensis*, and the egg-shaped *S. mansuyi*, but this of itself would not enable one to determine the species of such a specimen as I, 10. Slight differences seem to persist in the form of the facets and cover-plates, and some definite character might be deduced from a large series. But the most easily recognized and quite constant differentia lies in the individual thecal plates; these differ in tumidity, but above all in the size, form, and distribution of the diplopores.

Returning to the *Holocystites*, we find that the pores are just the

¹ W. A. Parks, 1913, Canada Geol. Surv. Guide-book No. 4, p. 132.

characters about which Miller and the other American authors give least information. There is one exception. Under *H. subglobosus*, 1889, Miller says that the pores are in pairs forming figures somewhat like an omega, ω . This striking character was seized on by Jaekel (1899, p. 413) to warrant the separation of this (as genotype) and any similarly constituted species from *Holocystis* (= *Megacystis*) Hall, as a new genus *Trematocystis* with the following diagnosis: [An Aristocystid with] "Theca irregular, oval or pyriform, attached by a rather small surface. Plates fairly large and not very numerous. Apparently as a rule four brachioles at the corners of the peristome. Diplopores with long multifariously irregular pore-passages joined to one another in groups." To this genus Jaekel by implication referred all Miller's species from the Osgood and Laurel Limestones, but possibly he did not mean to include *H. jolietensis* from the Racine Limestone.

The first question to decide is whether this character really distinguished *H. subglobosus* Miller from *M. cylindrica* Hall. Jaekel does not discuss this particular question, but takes the more drastic action of removing all the species referred to the genus by Hall, together with *Saccocystis* [whatever that unknown name may denote], to his Cladocrinoidea [essentially Crinoidea Camerata], of which he regards them as an aberrant type. He gives no reasons for this step, and I have been unable to discover any. The specimens from the Racine Limestone are not preserved so as to show either the smaller thecal openings or the structure of the pores, since they are for the most part internal casts or incomplete external moulds. The surface, however, is said to be strongly granulose, and this agrees with many of the species described by Miller. The specimen from the Racine Limestone of Joliet, described by Miller, is also known from internal casts, but on these Miller detected the marks of pores penetrating the pustules, as in *H. papulosus*. In Hall's figures the pustules are clearly indicated, especially in *H. abnormis*. The later figures of *H. cylindricus* and *H. alternatus* represent the pores as having a radiating arrangement (cf. *S. yunnanensis*). This is also noticeable in Miller's figure of *H. tumidus* from the Osgood Limestone. Therefore there seems no reason to doubt that the American authors are right in associating all these species.¹

This, however, does not fully answer the question whether all the species have the ω -channels. Owing to the peculiar preservation of the Racine fossils, it is not likely that direct evidence as to the structure of their pores will ever be available. It is legitimate to interpret them in the light of such forms as *H. papulosus*, *H. pustulosus*, and *H. ornatus*, which have plates ornamented with well-marked pustules, usually quite separate from one another. Setting minor differences aside for the present, I may express my conviction that these species, as well as all others from the Osgood Limestone, did possess ω -channels. This conviction is based on the following facts. Miller's silence on the subject, except in the case of *H. subglobosus* (1889), proves only that he attached far less importance to these structures than to the number of plates and the

¹ I do not include Hall's pl. xii, fig. 6, which if correct is almost certainly of a different genus.

shape of the theca; for ω -channels are clearly represented in the drawing of *H. sphaeroidalis* Miller & Gurley (1895); the drawings of *H. canneus* Miller (1889), and *H. hammelli* Miller (1889), seem intended to show them; irregular peripores are represented in *H. adipatus* Miller (1891), *H. amplus* Miller (1892), and *H. gyrinus* Miller & Gurley (1894), and seem to have been observed in *H. dyeri* Miller (1879), and possibly *H. ventricosus* Miller (1879). Examination of twenty-seven specimens from the Osgood Limestone of Big Creek, now in the British Museum, show that, whatever the differences of form or surface ornament, all possess or possessed ω -channels. Among these specimens are some determined (rightly or wrongly) by Miller himself as *H. scitulus* (E 16167-8-9) and *H. globosus* (E 16170-1). If Miller did not observe the ω -channels in these and other species, that may be due to the facts that on well-preserved surfaces they are not clearly exposed (E 7673, E 16167), and that on much-weathered surfaces they have often been worn away (E 16171). The reason for this will appear later; for the present I confine myself to the preceding justification of the belief that all Miller's species did have ω -channels, whether he said so or not. This, then, leads to the further conclusion that the species from the Racine Limestone also had ω -channels; at any rate their general resemblance is such that the burden of proof lies on those who would deny this conclusion. Finally it follows that all the American species belong to a single genus, for which Hall's name *Megacystis* (-ites) should be adopted.

It may here be suggested that *Allocystites* Miller, 1889, with genotype *A. hammelli*, from the Niagara group of Jefferson co., Ind., is a *Megacystis*. Jaekel (1899, p. 398) placed it in the Sphaeronidæ, believing that the pores were diplopores. I would go further, and point out that the drawing of these pores (Miller's fig. 242) indicates the presence of ω -channels. The unique holotype is drawn and described as having a raised margin to the periproct, and the peristome "covered by minute plates forming a pentagonal star". Possibly! but one cannot help doubting whether Miller correctly interpreted these peculiar appearances. There is already a *M. hammelli* (Miller, 1889), probably a synonym of *M. rotunda* (Miller, 1879).

VI.—THE CARBONIFEROUS LIMESTONE OF THE WREKIN DISTRICT.

By L. M. PARSONS, M.Sc., D.I.C., F.G.S.

THE Carboniferous Limestone cropping out near Wellington and near Newport in the Wrekin district has hitherto received little attention. One or two references to the Lower Carboniferous rocks of the area are made in *Geology in the Field*, in which the limestone is referred to the *Dibunophyllum* zone,¹ and the intrusive material underlying the limestone is described as an olivine-dolerite, probably of Tertiary age.² Apart from these references there does

¹ *Geology in the Field*, p. 762.

² *Idem*, p. 766.