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XLII.—Coccoliths

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XLII.—*Coccoliths*. By ERNEST H. L. SCHWARZ, A.R.C.S.
(From the Geological Research Laboratory, Royal College
of Science.)

COCCOLITHS were first discovered by Ehrenberg * in chalk, and described as inorganic bodies like those constituting “agaric-mineral” (calcium carbonate precipitated from solution in natural mineral water) or kaolin; according to him they were flat bodies having concentric rings on their surface, and later he gave them the name of “chalk morpholiths” †. Huxley ‡ and Wallich § declared these bodies occurring in the chalk to be the same as those existing in the sea at the present day; the former called them, “for convenience,” coccoliths—a term which has supplanted Ehrenberg’s morpholith. Huxley || distinguished two forms, one simple, the other double, and called them respectively discoliths and cyatholiths, which Hæckel ¶ later rechristened monodiscs and amphidiscs. In both the latter papers they were described as being formed as crystalloids in a giant *Amœba*—*Bathybius*—which had all the appearance of protoplasm, fibrillar network, &c., but which Murray and Buchanan ** proved to be gelatinous calcium sulphate precipitated by the alcohol in which the soundings were preserved. Up to this point they were not considered to be organisms themselves; but Sorby †† put forward this idea, which was stoutly contested by Barrois ‡‡, who, with many others, *e. g.* Harting §§, considered them to be mineral concretions. Gümbel ||| and Carter ¶¶ considered them to be connected with the reproduction of calcareous algæ—*Melobesia* &c.—and the former described

* Monatsber. Berlin Acad. 1836; Poggendorff’s ‘Annalen,’ 1836, vol. xxxix. pl. i. fig. 2 B.

† ‘Microgeologie,’ Leipzig, 1854, pl. xxv. fig. B, 16.

‡ Appendix to Capt. Dayman’s Report of Soundings taken in H.M.S. ‘Cyclops,’ 1858.

§ Ann. & Mag. Nat. Hist. 1868, ii. p. 317.

|| Quart. Journ. Micr. Sci. viii. 1868.

¶ Biol. Studien, Beiträge zur Plastidentheorie, p. 85 (1870).

** Proc. Roy. Soc. Lond. vol. xxxiv. p. 605.

†† Ann. & Mag. Nat. Hist. 1861, viii. p. 193.

‡‡ Ann. des Sci. Nat., Zoologie, 6 sér. t. iii. p. 70 (1876); ‘Recherches sur les terrains anciens des Asturies,’ Lille, 1882.

§§ ‘Recherches de Morphologie synthétique,’ Haarlem, 1872.

||| “Ueber Cocc. et Nullipores,” Wien. Verhandl. Geol. 1870, p. 201; also Neues Jahrbuch, 1870, p. 752, 1873, p. 299.

¶¶ I quote this on the authority of Barrois, having looked through most of Carter’s papers in vain. [Mr. Carter’s paper here referred to appeared in Ann. & Mag. Nat. Hist. ser. 4, vol. vii. 1871, pp. 184–189, “On *Melobesia unicellularis*, &c.”—Eds.]

their occurrence in all the known strata, even the earliest. Wallich first noticed that they were joined into spherical masses, which he called *coccospheres* *; in his later papers he considered these spheres as nothing else than embryonic foraminifera covered with coccoliths as spicules, and figures a *Nodosaria* and *Textularia* made up of such coccospheres. Sir Wyville Thomson, according to Wallich, noticed that, if threads be hung in sea-water overnight, they will be found to be full of coccoliths in the morning; so that these bodies are really found on the surface of the ocean, and not only at great depths, as those who do not believe in their organic nature have maintained.

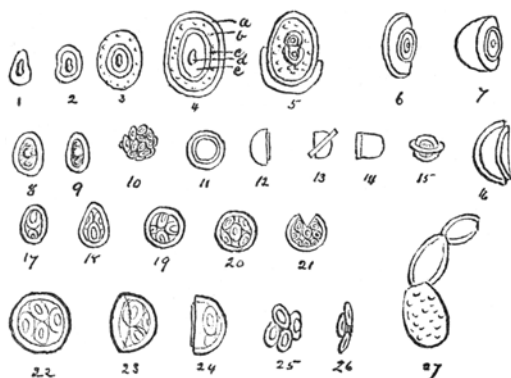
I first came to notice coccoliths when systematically washing the clays from the lias of the Dorset coast, where I found them in about 60 per cent. of the zones treated. They were most abundant, however, in a grey micaceous clay containing *Ammonites* (*Schlotheimia*) *angulatus*, Schloth., and a foraminifer, *Nodosaria*, which, according to Mr. F. Chapman, resembles *N. calomorpha*, Reuss. The coccoliths in this clay are peculiar in their transparency and for the great numbers of the double cyatholith forms, which nowhere else have I found in such abundance; and the following details have been obtained mostly from this material, though I have also used the chalk of Taplow and the gault of Folkestone.

The adult discoliths are minute oval bodies $\frac{1}{100}$ inch (Wallich) in their long diameter (figs. 2, 8, 9). In their centre is a bright highly refractive body, the "Centralkorn" of Hæckel, which is usually slightly, but frequently also markedly, raised above the surface as a knob when seen from the side; but I have never seen it forming a projecting rod, as Sollas † has figured from the Cambridge greensand. In the flat area surrounding the central point, the "Markfeld" of Hæckel, there are two or four slightly raised points, similar to the central one, but not nearly so much differentiated. Round the "Markfeld" is the "mark-ring," which is a refractive ring of calcite forming a thick rounded rim to the little plate, and in the older examples is slightly beaded. Hæckel then notices that this, which I consider to be the adult coccolith, surrounds itself with a granular ring (fig. 3), and finally with another brightly illuminated outer ring (fig. 4). This I take to be the first stage of the discolith (adult cocco-

* Ann. & Mag. Nat. Hist. 1860, vi. p. 457; *ibid.* 1861, viii. p. 52; *ibid.* 1862, ix. p. 30; Royal Institute Proc. 1858, p. 299; Franklin Institute Journal, xlii. 1861, p. 237; Quart. Journ. Micr. Sci. 1869, 1870, 1871, 1877, 1878.

† Geol. Mag. 1876, pl. xxi. fig. 17.

lith) transforming itself into a cyatholith (reproductive stage); the granular ring, which I have not observed in my fossil forms, being protoplasmic, and the outer ring the commencement of one of the cups. Still following Hæckel, we see that the internal discolith then divides (fig. 5), and traces of the



Figs. 1-7.—After Hæckel. 1. Incomplete form. 2. Fully formed discolith. 3. One with the granular ring. 4. Commencing cyatholith: *a*, outer ring; *b*, granular ring; *c*, mark-ring; *e*, Markfeld; *d*, central point. 5. One with dividing discolith and portion of the larger cup forming. 6, 7. Cyatholiths.

Figs. 8, 9.—*Coccolithus oceanicus*, the mature form (discolith).
Fig. 10.—Young discoliths just released from the cyatholith (coccosphere).

Figs. 11, 12.—Two positions of the fully formed cyatholith.

Figs. 13-15.—Cyatholith with the rim broken off.

Fig. 16.—Diagrammatic section through a cyatholith.

Figs. 17-21.—Successive stages in the division of the discolith.

Figs. 22-26.—A cyatholith containing four discoliths, which was turned over and then dissolved with acetic acid, setting the contents free, which were then moved about.

Fig. 27.—*Nodosaria calomorpha*, Reuss, associated with coccoliths in the clay containing *Schlotheimia angulata* (Schl.).

second, larger cup appear; the two cups are then completed, and the dividing discolith is shut in between them, the smaller cup forming a lid to the cavity of the larger (figs. 11, 12, 16). In the early stages of division the form is still oval (figs. 17, 18), but soon the cups become rounded, and the divisions go on irregularly till there are sixteen or more embryonic discoliths; intermediate forms with four, five, six, seven, &c. are frequent. In the later stages the cups of the cyatholith become brown and opaque, and finally, failing to adhere, they set free the baby discoliths in a mass (fig. 10); the empty shells are seen in almost every slide.

The discoliths seem to be imbedded in a common membrane, for they cohere in a mass for some time—in fact till they are mature, or nearly so—and then they constitute what is known as coccospheres, which have all the appearance of spheres; but when they are lifted on to their side they are seen to be really flat, or, rather, halves of hollow spheres. At first I took both the cyatholiths and coccospheres to be actually spheres; but on agitating the water on the slide containing them I noticed that, while some readily followed the flow of the water, others remained stolidly fixed and refused to move even when great masses of *débris* knocked against them; but suddenly, when the motion became too violent, they gently turned on their sides and revealed the hollowness of their nature. In the first instance they were, of course, resting on their convex surfaces, but when they refused to move they were with their concave surfaces downward. Sollas (*loc. cit.*) has figured these cyatholiths in the Cambridge greensand as “coccospheres, covered loosely with the oval form of the coccolith.” Some of the cyatholiths seem to have grown their larger cup too far forward, and the projecting part has then broken off, and appears surrounding the cyatholith like a Saturn’s ring (figs. 13, 14, 15); by carefully agitating the water the ring may be made to slip on to its proper place and off again.

The dividing discoliths here described were seen through the transparent calcite of the cup. To make sure that these really were discoliths within the cyatholith I ran in a little weak acetic acid on the slide (working with a $\frac{1}{8}$ -inch objective without a cover-glass); the cups became dissolved and the conjoined discoliths set free, when there was absolutely no mistaking the form. On running in a little magenta the outline of the cup reappeared, so that they are in all probability formed of a framework of horny material filled in with calcium carbonate. A very curious fact is that, while the two cups of the cyatholith dissolve freely in weak acid, the discoliths require fairly strong acid before they will disappear; and, comparing the rate of dissolution of both with that of a *Rotalia* in a washing containing all three from the gault, the cups went at about the same rate as the foraminifer, but the discoliths remained long after the latter had disappeared. Hence I am inclined to think that the discoliths are largely composed of calcium phosphate, a view which I was led to entertain from the fact that the phosphatic chalk of Taplow contains the discoliths (with few cyatholiths) in vast quantities.

Wallich considered the coccospheres to be embryonic fora-

minifera, such as *Globigerina**, and later† he figured them joining into linear aggregates to form *Nodosaria* or in alternate lines to form *Textularia*; but I have not been able to see from his figures whether he is dealing with the conventional coccospheres or really Foraminifera, in the external sarcode of which the discoliths have become imbedded; for he says the latter are arranged at *regular intervals* over the surface of the former.

When I first worked out the above details, some eighteen months ago, Prof. Judd, to whom I am indebted for much help, threw doubt on my results, because they were derived from fossil forms, while nothing of the kind had been seen in the recent ones, even when treated with greater skill and with better instruments than I could command; but I have gone over all the work again lately, and I can only conclude that the protoplasm of the recent ones obscured the details of their internal structure.

To recapitulate my results, then :—

The discolith represents the adult stage of the coccolith, and is a separate organic individual consisting of a phosphatic disk surrounded apparently with protoplasm. When they wish to reproduce themselves the protoplasm surrounds itself with a calcareous envelope consisting of two cups, one deep and enclosing the discolith, the other functioning as a lid. Division of the discolith then proceeds irregularly till some sixteen or more minute bodies, representing embryonic discoliths, are formed; the cups then separate and set their contents free in a mass. The latter then continue to grow, retaining the cup-like form of the cyatholith, and constitute the coccospheres of Wallich, Huxley, and Hæckel; finally the colony is disbanded, and the discoliths float about freely on the surface of the ocean.

As to their nature, I think there can be no doubt as to their being organic, and that they belong to that class of organisms which the zoologist and botanist have equal right in claiming to belong to his favourite kingdom; but they seem to have a preponderance of botanical resemblances, and may be put provisionally among the Phycochromaceæ, near to *Glæocapsa*, *Chroococcus*, &c., to which they seem to be allied by their reproduction.

As to their name, though Ehrenberg's morpholith undoubtedly preceded Huxley's coccolith, he used the word as descriptive and one which could, with equal propriety, be applied to

* Ann. & Mag. Nat. Hist. 1860, vi. p. 457.

† Ibid. 1862, ix. p. 30.

kaolin crystals &c., while Huxley definitely called these bodies, and these only, coccoliths. Since the above description of their reproduction settles them finally to be self-contained organisms, there arises the necessity for a true generic and specific name. Here, however, the differentiation of species, if they exist, is not possible, since they are so minute that different illuminations make them appear entirely different in contour and markings. Hence I propose for all the forms hitherto described, recent and fossil, the one name *Coccolithus oceanicus*, mihi.

P.S.—By a strange oversight I missed Carter's paper above referred to till my paper was printed. He considers coccoliths to be the cells of *Melobesia* living separately, and calls the oval and round *cyatholiths* respectively *M. unicellularis* and *M. discus*; but as the *discolith* is undoubtedly the adult form, it does not seem advisable to apply either of these specific names, clearly defined for a definite thing in one stage, to the same thing in another stage.

XLIII.—*Descriptions of some new Neotropical Muridæ.*

By OLDFIELD THOMAS.

THE British Museum has recently received two small collections of rodents from Peru and Venezuela, among which are several new species; and in working these out the opportunity has been taken of re-examining and, where necessary, describing the species contained in the general collection of South-American Muridæ. Among others, the two series from Peru obtained by Messrs. Stolzmann and Jelski, and worked out by me in 1882 and 1884*, have proved to need a considerable amount of revision in their determinations.

The first to be described represents a new genus, and is again the discovery of Mr. J. Kalinowski, the finder of the interesting fish-eating rat described last year †.

NEOTOMYS, gen. nov.

General form much as in *Sigmodon*; ears broad and rounded; fur very thick; tail short; thumb with a nail.

Skull with the nasals much expanded anteriorly; inter-

* P. Z. S. 1882, p. 98, 1884, p. 447.

† P. Z. S. 1893, p. 337.