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NANNOFOSSIL SPECIES RELATED TO CYCLOCOCCOLITHUS LEPTOPORUS (MURRAY & BLACKMAN)

STEFAN GARTNER, JR.
[Esso Production Research Company, Houston, Texas]

ABSTRACT

Individual placoliths of the coccolithophore *Cyclococcolithus leptoporus* often break apart into two shields. The genera *Tiarolithus* (type species, *Calcidiscus medusoides*) and *Calcidiscus* (type species, *C. quadriforatus*) are based on species here recognized as representing isolated distal and proximal shields, respectively, of *Cyclococcolithus leptoporus*. *Tiarolithus*, and *Calcidiscus*, therefore, are junior (subjective) synonyms of *Cyclococcolithus*.

DISCUSSION

In 1897 GEORGE MURRAY & V. H. BLACKMAN collected several samples of sea water from the North Atlantic and Caribbean while making a round trip from England to Panama on the mail-ship R. M. S. *Para*. Their purpose was to study the nature of coccospheres and rhabdospheres from these waters and to test techniques for extracting the minute organisms from the sea water. In the course of their investigation they noted a species of coccolithophore that had not been described or named previously. They named this species *Coccolithophora leptopora* and described the coccoliths of the species as follows:

> The coccolith is seen to possess two distinct limbs joined together by a central thick-walled collar. The outer limb is a round plate, convexo-concave in section, very like an inverted shallow watch-glass; the inner limb is a small circular flat plate; the two plates are joined together by a central collar. On the convex free surface of the outer plate there is a minute circular depression appearing in surface view as a clean area. The bottom of this depression is perforated by a canal which leads through the collar and opens out on the free surface of the lower limb.

Their description is of a circular placolith which has a larger distal shield and a smaller proximal shield, the two shields being connected at their centers by a hollow tube. The same authors noted also that some of the "plates" (placoliths) of this species have radial "striations" (sutures) whereas others seem to have curved "striations." In their illustrations they show both types of specimens, some with straight radial sutures, others with curved sutures (MURRAY & BLACKMAN, 1898, pl. 15, fig. 12). Another important feature that they discuss is the continuation of some of the radial striations in the conical depression at the center of the distal shield of the placolith. In their illustrations (MURRAY & BLACKMAN, 1898, pl. 15, fig. 4-5) these radial striations appear to be coarser or more pronounced in the depression than on the surface of the shield so that this central depression also gives the appearance of being partially obstructed by coarse, radially disposed ribs or bars.

In 1954 KAMPTNER redescribed the species in considerable detail and assigned it to the genus *Cycloccolithus* and in 1962 HAY & TOWE designated *Coccosphaera leptopora* as the type species of that genus. KAMPTNER noted several important features of the species which are significant for a correct interpretation. When viewed distally, sutures on the distal shield are curved and the convex side of the curvature is toward the clockwise direction. He also confirmed that specimens may have curved or straight radial sutures. In addition he noted that in cross-polarized light the species has a slightly rotated crosslike interference figure but that this figure extends only as far as the smaller proximal shield overlaps the larger distal shield. He attributed the interference figure to the cumulative effect of both shields on the polarized light beam, stating that the distal shield did not produce a sufficient path difference in the light by itself to form an interference figure. It should be noted also that the distal shield of the placolith of this species shows considerable relief in plain transmitted light and in phase contrast. The proximal shield, however, is barely visible unless the placolith is viewed in cross-polarized light. In that case the proximal shield is sharply defined, whereas the distal shield is only faintly visible (Pl. 1, fig. 4a-c).

The exact nature of the straight radial and curved sutures of *Cyclococcolithus leptoporus* first noted by Murray & Blackman (1898), and later by Kamptner (1954) was determined by examining electron micrographs of carbon replicas of this species (Pl. 1, fig. 1-2). In Pl. 1, fig. 1 part of the proximal surface of the distal shield is exposed where the proximal shield is broken, and sutures visible on the distal shield are nearly straight and radial. In Pl. 1, fig. 2 the preserved half of the distal shield clearly shows that sutures on the distal surface of the distal shield are curved, with the convex side of the curvature toward the clockwise direction. This is explained readily because the proximal surface of the distal shield of *Cyclococcolithus leptoporus* is nearly flat to very slightly concave. Thus, inclined planes separating adjacent elements of the shield intersect the nearly flat proximal surface of the distal shield in a straight line, thereby forming the straight, radial sutures on this surface. The distal surface of the distal shield, on the other hand, is strongly convex, and the intersection of the inclined planes that separate adjacent elements and of the curved distal surface of the shield, result in curved suture lines on the distal surface. Thus, with a light microscope it is possible, for example, to see radial and curved sutures on the same specimen of this species merely by varying the focus on a given specimen, as was observed by Kamptner (1954).

Some small specimens of *Cyclococcolithus leptoporus,* furthermore, definitely have curved sutures on the proximal surface of the distal shield (Pl. 1, fig. 3). This probably results from the greater amount of curvature of the shield in these small specimens. Sutures on the proximal shield of this species are straight and radial on both surfaces (Pl. 1, fig. 1-2; Pl. 2, fig. 2) indicating that the shield is very nearly flat and of relatively uniform thickness.

Kamptner also described in considerable detail the species *Calcidiscus medusoides* (Kamptner, 1954, p. 26-33, fig. 24-34) and later designated this species as the type of the genus *Tiarolithus* (Kamptner, 1958). *Calcidiscus medusoides* consists of a concavo-convex shield that is perforated at its center and has a hemispherical knob in the center of the concave or proximal surface. Kamptner (1954) indicated that the sutures are curved on both surfaces of the shield, being the same on the distal surface as they are on *Cyclococcolithus leptoporus* (Kamptner, 1954, fig. 34). In Kamptner's drawing the sutures on the proximal surface of *Calcidiscus medusoides* curve in the same way as on the distal surface, although they appear the reverse because the specimen is viewed from the opposite side (Kamptner, 1954, fig. 24). Close examination of *Calcidiscus medusoides* reveals that the sutures always are curved on the distal or convex surface but are commonly very nearly straight and radial on the proximal or concave surface of the shield, precisely as is the case with the distal shield of *Cyclococcolithus leptoporus*. Only by imprecise focusing or on small specimens can curved sutures be seen on the proximal surface of the shield. *Calcidiscus medusoides* does not yield a crosslike interference figure in cross-polarized light when a specimen is viewed either proximally or distally but instead an ill-defined bright area appears near the center and becomes weak and disappears toward the edge of the shield (Pl. 2, fig. 4c; see also Martini & Bramlette, 1963, pl. 102, fig. 1-2).

In addition to its unusual interference figure this species is conspicuous in the light microscope because of its strong optical relief; that is, it is easily visible against the background even in plain transmitted light without the use of phase optics (Pl. 2, fig. 4a,b,d), just as is the case with the distal shield of *Cyclococcolithus leptoporus.* This is due doubtless to the peculiar orientation of the calcite crystals that make up the elements of the shield of *Tiarolithus medusoides,* the same phenomenon that is responsible for the unusual interference figure of this species in cross-polarized light. Thus, construction as well as crystallographic properties indicate that *T. medusoides (=Calcidiscus medusoides)* is nothing more than the isolated distal shield of *C. leptoporus.* The frequency with which broken and otherwise damaged specimens of *C. leptoporus* are encountered tends to lend support to the conclusion that the two shields of this placolith often do separate, and even can lead to deceptive conclusions about the stratigraphic occurrence of the parent structure and its various parts (see MARTINI & BRAMLETTE, 1963).

It remains to be shown what happens to the proximal shield of *Cyclococcolithus leptoporus* when the two shields separate, for, theoretically at least, an isolated proximal shield must exist for every isolated distal shield. Actually, it appears that the proximal shield is more readily broken into smaller fragments than the distal shield, so that commonly fewer proximal shields are found in one piece. Also the proximal shield of *C. leptoporus* has very low optical relief, as can be seen in light micrographs (Pl. 1, fig. 4a-c) where the proximal shield of whole specimens rarely is visible except in cross-polarized light. As mentioned previously, sutures on both sides of the proximal shield are straight and nearly radial and on carbon replicas can be seen more distinctly on the distal side of the shield (Pl. 1, fig. 2; Pl. 2, fig. 2) than on the proximal side (Pl. 1, fig. 1,3). With the light microscope the sutures are only barely visible (Pl. 2, fig. 3a-c). Some specimens of *C. leptoporus* (Pl. 1, fig. 3) show an irregular set of bars, commonly 4 to 7, extending partly across the central perforation, and remnants of such bars can be seen also in the center of an isolated proximal shield (Pl. 2, fig. 2). Thus, in specimans of *C. leptoporus* having bars developed across the central perforation, these bars commonly remain with the proximal shield upon separation of the shields. Occasionally distal shields with remnants of bars in the center also are encountered (MARTINI & BRAMLETTE, 1963, pl. 102, fig. 1, 2). If small allowances are made for the strongly interpretive drawings of KAMPTNER, then the type species of *Calcidiscus quadriforatus* KAMPTNER can be identified as the proximal shield of *C. leptoporus* (see KAMPTNER, 1954, fig. 35-37). The two are nearly identical in all particulars. *C. quadriforatus* is only slightly curved and of uniform thickness as is the proximal shield of *C. leptoporus.* Both have low optical relief and a very sharp interference figure in cross-polarized light; the interference figure is rotated about 15° to counterclockwise. [In the illustration Pl. 2, fig. 3c, this rotation is reversed because of the peculiarity of the optical system with which the photograph was made.] In both the sutures are barely or not at all visible, and both have a slightly smaller average diameter than *Tiarolithus medusoides,* the larger distal shield of *C. leptoporus.*

The similarity of *Tiarolithus medusoides* and *Calcidiscus quadriforatus* to the distal and proximal shields, respectively, of *Cyclococcolithus medusoides* was recognized by KAMPTNER (1958, p. 81). He believed that the two shields resulted from "backwards development" (Rueckbildung) of *C. medusoides;* that is, two "phylogenetic developmental series" originating from the parent form, *Cyclococcolithus leptoporus.* In one *(T. medusoides),* the proximal shield does not develop, whereas in the other *(C. quadriforatus)* the distal shield and collar do not develop. Nothing can be seen on electron micrographs to indicate that such is the case. Rather, all isolated shields show evidence of breakage, and in no case is there any evidence of rudimentary development of the missing part, which would be expected if a part were reduced progressively as is suggested by KAMPTNER.

In summary, then, the genera *Tiarolithus* (type species *Calcidiscus medusoides*) and *Calcidiscus* (type species *Calcidiscus quadriforatus*) are based on species representing incomplete placoliths of *Cyclococcolithus leptoporus.* They are subjective junior synonyms (metanyms) of *Cyclococcolithus* and, therefore, should not be used.

SAMPLES

The Sigsbee knoll core samples used in this study were obtained through the courtesy of Dr. W. BRYANT and Mr. T. E. PYLE of Texas A & M University and are from core 64-A-9-5 taken by the research vessel Alaminos near the crest of one of the Sigsbee knolls. The core has been described in detail by BRYANT & PYLE (1965) and PYLE (1966). Dr. A. H. COOGAN, of Esso Production Research Company, collected the sample from the top of the San San Clay at San San Bay in Jamaica.

ILLUSTRATIONS

PLATE 1, FIGURES 1-4.——*Cyclococcolithus leptoporus.*—1. Proximal view of specimen, part of proximal shield broken away exposing proximal surface of distal shield; electron micrograph, ×10,000; from the 200-cm. level of Sigsbee knoll core, Gulf Mexico.——2. Distal view of specimen with part of distal shield broken away, exposing distal surface of proximal shield; electron micrograph, ×10,000; from 200-cm level of Sigsbee knoll core, Gulf Mexico.——3. Proximal view of small specimen on which sutures on proximal surface of distal shield are curved and several bars extend partly across perforation at center of coccolith; electron micrograph, ×10,000; from near the top of the San San Clay of Jamaica.——4. Distal view of complete specimen from the 250-cm. level of Sigsbee knoll core; light micrographs, ×2,500; 4a, phase contrast, 4b, bright field, 4c, cross-polarized light; note that proximal shield of this specimen is only very faintly visible in phase contrast and bright field, but has a distinct pseudointerference figure in cross-polarized light.

PLATE 2, FIGURES 1-4.——*Cyclococcolithus leptoporus.*—1. Proximal view of discrete distal shield; electron micrograph, ×10,000; from 200-cm. level of Sigsbee knoll core, Gulf Mexico.——2. Distal view of isolated proximal shield; electron micrograph, ×10,000; from 400-cm. level of Sigsbee knoll core, Gulf Mexico (note short bars extending partly across central perforation.)——3. Distal view of isolated proximal shield; light micrographs, ×2,500; from 250-cm. level of Sigsbee knoll core, Gulf Mexico; 3a, phase contrast, 3b, bright field, 3c, cross-polarized light.——4. Proximal and side views of isolated distal shield; light micrographs, ×2,500; from the 200-cm. level of Sigsbee knoll core, Gulf Mexico; 4a, phase contrast, proximal view; 4b, bright field, proximal view; 4c, cross-polarized light, proximal view; 4d, bright field, side view.

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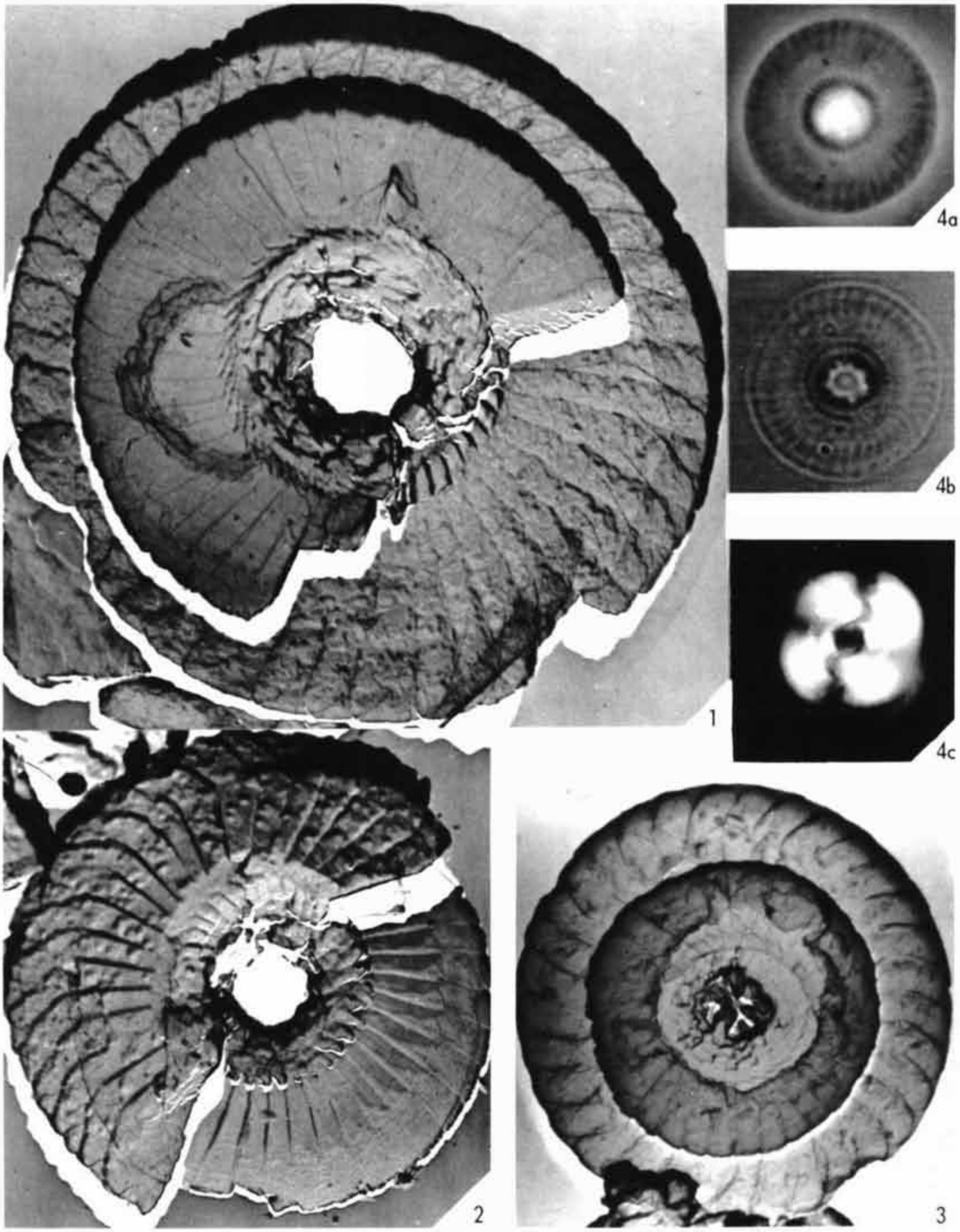
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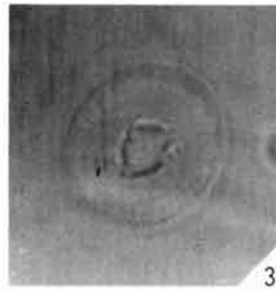
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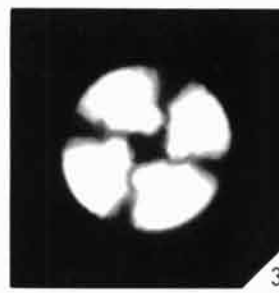
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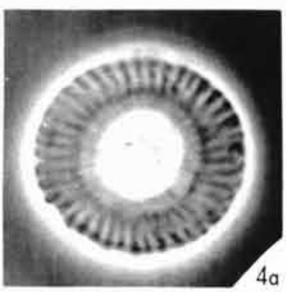
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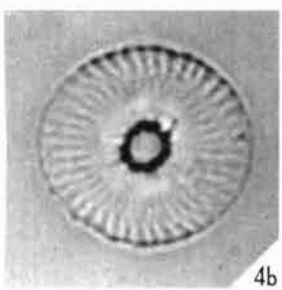
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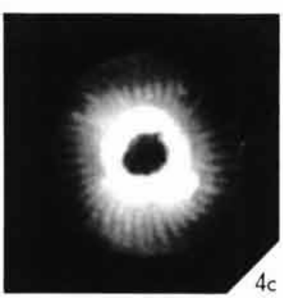
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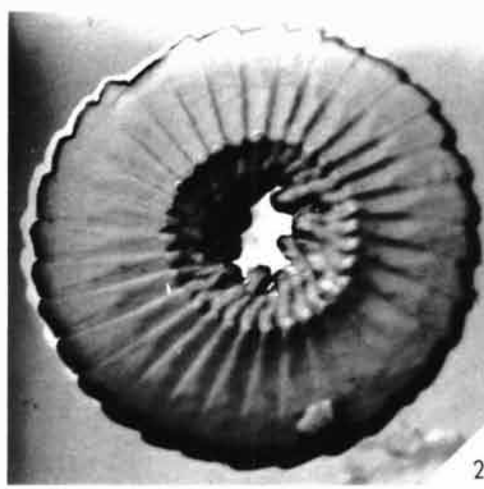
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