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REVISION OF THE MESOZOIC NANNOFOSSIL GENERA BIDISCUS, BISCUTUM, AND DISCORHABDUS[1]

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ABSTRACT

Morphologic and biostratigraphic differences among the three Mesozoic nannofossil genera *Bidiscus* Bukry (1969), *Biscutum* Black in Black and Barnes (1959), and *Discorhabdus* Noël (1965) are illustrated. *Bidiscus* is interpreted to include those Cretaceous nannofossils having two circular, closely appressed shields lacking any central rod. The Mesozoic genus *Biscutum* is similar morphologically to *Bidiscus* except that the shields are elliptical rather than circular. Complete specimens of the Jurassic genus *Dicorhabdus* have a central rod.

INTRODUCTION

In reexamining the taxonomy and biostratigraphy of the Mesozoic nannofossil genera *Bidiscus* Bukry (1969), *Biscutum* Black (Black & Barnes, 1959), and *Discorhabdus* Noël (1965b), I found morphologic, environmental, and evolutionary distinctions on which a more useful taxonomy could be based. These genera have been reported from North American, European, and several other widely scattered Mesozoic localities. Their sporadic, worldwide distribution has resulted in two different systematics, one for North America and one for Europe. This study, which formulates a single taxonomic interpretation for these three genera, was initiated because of difficulties with taxonomic placement of specimens from the Cretaceous of southeastern Oklahoma.

Morphologically, these Mesozoic genera are remarkably similar. In particular, many specimens of the Jurassic genus *Discorhabdus* lose their central rods so that the remaining basal shields, which are circular, bear a striking resemblance to those of the Cretaceous genus *Bidiscus*. *Discorhabdus* (without rod) and *Bidiscus* shields also resemble those of another Mesozoic genus, *Biscutum*, except that the shield in *Biscutum* is elliptical. The distinctions discussed in the taxonomy section and graphically displayed in the figures should eliminate much of the confusion these similarities have produced.

Discorhabdus and *Bidiscus* preferred the warm shallow waters of the Mesozoic seas and occupied similar ecologic niches, *Bidiscus* during the Cretaceous and *Discorhabdus* during the Jurassic. The Upper Jurassic and Cretaceous genus *Biscutum* is found worldwide, although known occurrences suggest that warm shallow seas were preferred. One can only speculate about

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the evolutionary link between these genera as no suitable transition genus is known to link *Discorhabdus* and *Bidiscus* except perhaps *Biscutum*.

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SYSTEMATICS

Genus BIDISCUS Bukry, 1969

Type species.—Tremalithus ignotus Górka, 1957 (p. 248, pl. 11, fig. 9). Material apparently conspecific with that bearing this name was redescribed in two subgenera by Bukry (1969): *Bidiscus cruciatus cruciatus* and *B. c. multicruciatus*. Because I am herein resurrecting the name *Bidiscus* for forms lacking the rod, but Shumenko (1971) determined that Bukry's material was conspecific with that of Górka, the correct names for the two members of the type species of *Bidiscus* are *Bidiscus ignotus ignotus* (Górka) and *B. i. multicruciatus* Bukry.

Description.—"This small circular coccolith is constructed of 2 monocycle shields, each composed of a small number of radial elements. The proximal shield is a little smaller than the other and both are slightly convex distally. The very small central area shows varied ornamentation. Coccospheres are spherical and constructed of about 16 coccoliths" (Bukry, 1969).

Discussion.—This genus is apparently restricted to Cretaceous and possibly Danian sediments (Fig. 1) and is common in the Upper Cretaceous of Europe and North America. It differs from the Jurassic genus *Discorhabdus* (Noël, 1965a) in lacking a rod; however, confusion results from the close resemblance of Cretaceous specimens of *Bidiscus* to those Jurassic specimens of *Discorhabdus* that have lost their central rod.

BIDISCUS IGNOTUS (Górka)

Tremalithus ignotus Górka, 1957, p. 248, pl. 11, fig. 9.

Biscutum tredenale Reinhardt, 1965, p. 32, pl. 1, fig. 3.

Biscutum ignotum (Górka) Reinhardt and Górka, 1967, p. 245, pl. 31, fig. 9-13.

Discorhabdus ignotus (Górka) Perch-Nielsen, 1968, p. 81, pl. 28, fig. 6-9.

Bidiscus cruciatus Bukry, 1969, p. 27, pl. 6, fig. 10-12; pl. 7, fig. 1, 2.

Bidiscus ignotus (Górka) Hoffman, 1970, p. 194, pl. 7, fig. 4, 6; pl. 9, fig. 1.

Discorhabdus cruciatus (Bukry) Shumenko, 1971, p. 104, pl. 19, fig. 5, 6.

Discussion.—Perch-Nielsen (1968) synonymized three of Górka's original four species *(Tremalithus postremus, T. similis, T. pulaviensis)* with *Tremalithus ignotus* and transferred that species to *Discorhabdus*. Less than one year later, Bukry described similar specimens from Texas material and named them *Bidiscus cruciatus*. Both names were accepted as synonymous, although European authors favored *Discorhabdus* and American authors favored *Bidiscus*. In 1971 Shumenko did name *Bidiscus cruciatus* as junior subjective synonym of *Discorhabdus ignotus;* however, that did not receive universal acceptance due to remaining inconsistency between the Cretaceous and Jurassic forms. This species is similar to specimens of *Discorhabdus* that have lost their central rod. No Cretaceous specimens of *D. ignotus* have been observed with a central rod; therefore, assignment to *Discorhabdus* seems undesirable.

Although Bukry's original type species of the genus *Bidiscus* appears invalid as it is a junior subjective synonym of *Tremalithus* Górka (1957), and the genus therefore has been ignored by others, its usefulness is readily apparent because it is both stratigraphically and morphologically distinct from the older genus *Discorhabdus*.

Norbert Hoffman (1970) first assigned *Tremalithus ignotus* to *Bidiscus* but interpreted *Biscutum testudinarium* Black in Black and Barnes (1959) as its junior synonym. Because

sufficient differences exist between *Biscutum testudinarium* and *Tremalithus ignotus*, the interpretation of Hoffman is not accepted here.

BIDISCUS IGNOTUS IGNOTUS (Górka)

Bidiscus cruciatus cruciatus Bukry, 1969, p. 27, pl. 6, fig. 10, 11.

Discussion.—The differing central structures of the two subspecies of *Bidiscus ignotus* are distinctive (*B. i. ignotus* having a single crosslike element arrangement, *B. i. multicruciatus* having several) and the subspecies should be retained.

Occurrence.—Lower Turonian of northeastern France (Reinhardt, 1966); Santonian to Campanian of Texas (Bukry, 1969); Maastrichtian of Germany and Denmark (Perch-Nielsen, 1968).

BIDISCUS IGNOTUS MULTICRUCIATUS Bukry

Bidiscus cruciatus multicruciatus Bukry, 1969, p. 27, pl. 6, fig. 12; pl. 7, fig. 1, 2.

Discussion.—The differing central area crystal

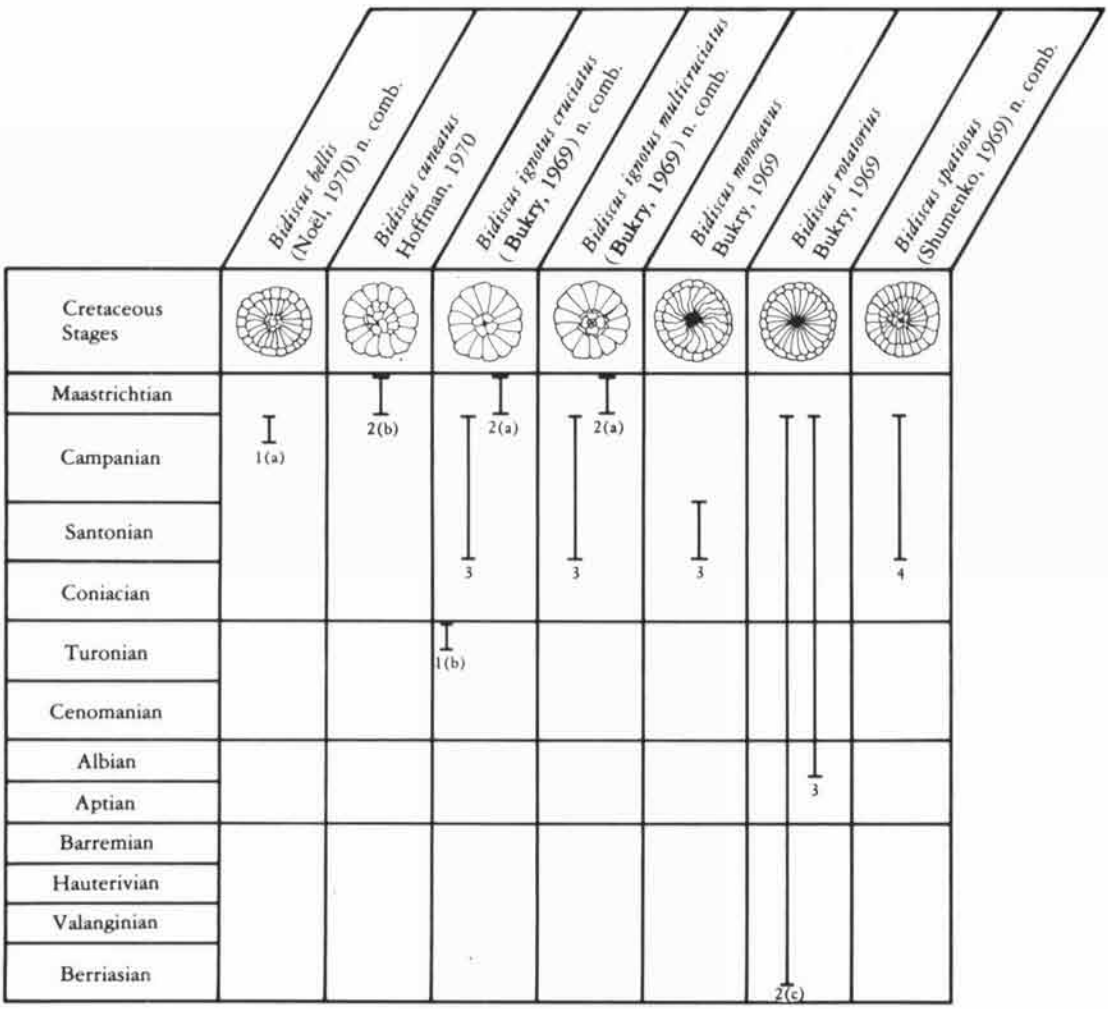

FIG. 1. Published ranges for species of *Bidiscus* Bukry.——1. France: (a) Noël, 1970; (b) Reinhardt, 1966.——2. Germany, Scandinavia, Switzerland: (a) Perch-Nielsen, 1969; (b) Hoffman, 1970; (c) Thierstein, 1973.——3. Texas, midcontinent USA: Bukry, 1969.——4. USSR: Shumenko, 1969.

arrangements found on *Bidiscus ignotus* should be subdivided as originally described by Bukry (1969). See discussion under *Bidiscus ignotus ignotus* (Górka).

Occurrence.—Santonian to Campanian of Texas (Bukry, 1969); Maastrichtian of Denmark (Perch-Nielsen, 1968).

BIDISCUS BELLIS (Noël)

Discorhabdus bellis Noël, 1970, p. 89, pl. 32, fig. 8, 11, 13.

Occurrence.—Upper Campanian of France.

BIDISCUS CUNEATUS Hoffman

Bidiscus cuneatus Hoffman, 1970, p. 195, pl. 9, fig. 3, 4.

Occurrence.—Maastrichtian of northern Germany.

BIDISCUS MONOCAVUS Bukry

Bidiscus monocavus Bukry, 1969, p. 27, pl. 7, fig. 3, 4.

Occurrence.—Santonian of Nebraska.

BIDISCUS ROTATORIUS Bukry

Bidiscus rotatorius Bukry, 1969, p. 27, pl. 7, fig. 5-9.

Discorhabdus rotatorius (Bukry) Thierstein, 1973, p. 42, pl. 5, fig. 13-16.

Occurrence.—Albian to Campanian of Nebraska (Bukry, 1969); lower Berriasian to Campanian of the northwest Atlantic, southeastern France, and Switzerland (Thierstein, 1973).

BIDISCUS SPATIOSUS (Shumenko)

Discorhabdus spatiosus Shumenko, 1969, p. 155, pl. 2, fig. 5.

Discussion.—Originally assigned to *Discorhabdus,* this form belongs to *Bidiscus.* Although closely resembling *Biscutum blackii* Gartner (1968), it differs by having a circular rather than elliptical outline.

Occurrence.—Santonian to Campanian on the Russian platform.

Genus BISCUTUM Black in Black and Barnes, 1959

Type species.—Discolithus constans Górka, 1957.

Description.—Coccolith composed of two closely appressed elliptical discs formed by a small number of radially arranged elements. The proximal disc is smaller than the distal, the central area having small openings or a granular arrangement of rhombic crystals.

Discussion.—Black (in Black & Barnes, 1959) described this genus rather broadly as "imperforate coccoliths consisting of more than one layer of plates, the plates of one layer being closely moulded onto those of the adjacent layer or layers." His descriptions of *Biscutum testudinarium* and *B. castrorum* add the information that members of the genus show the elliptical shield outline of individual coccoliths. This outline clearly separates the genus from both *Bidiscus* and *Discorhabdus.* The genus occurs widely in Cretaceous rocks with one species ranging into the Upper Jurassic (Fig. 2).

BISCUTUM CONSTANS (Górka)

Discolithus constans Górka, 1957, p. 279, pl. 4, fig. 7.

Tremalithus melaniae Górka, 1957, p. 245, 270, pl. 4, fig. 12.

Discoaster floridus Górka, 1957, p. 283, pl. 5, fig. 11.

Biscutum testudinarium Black in Black & Barnes, 1959, p. 325, pl. 10, fig. 1; Reinhardt, 1966, p. 30, pl. 19, fig. 1.

Cribrosphaera tectiforma Reinhardt, 1964, p. 758, pl. 2, fig. 4.

Biscutum constans (Górka) Black, 1967, p. 139.

Coccolithus oregus Stover, 1966, p. 139, pl. 1, fig. 8, 9; pl. 8, fig. 4.

Biscutum melaniae (Górka) Reinhardt, 1970a, p. 936, pl. 1, fig. 5.

Discussion.—Noël (1970) discussed the history of this form in detail and included *Biscutum castrorum* as a junior synonym of this species, as noted in discussion of *B. castrorum.*

Occurrence.—Valanginian to Barremian of the northwestern Atlantic (Wilcoxon, 1972); Albian to Campanian of Europe and Texas (Bukry, 1969); also known from the Indian Ocean.

BISCUTUM ASYMMETRICUM Perch-Nielsen

Biscutum asymmetricum Perch-Nielsen, 1968, p. 80, pl. 23, fig. 2, 3, 13-15.

Occurrence.—Maastrichtian of Denmark (Perch-Nielsen, 1968); Santonian and Maastrichtian (Forchheimer, 1974), location not given.

BISCUTUM BLACKII Gartner

Biscutum blackii Gartner, 1968, p. 18, pl. 1, fig. 7; pl. 6, fig. 2; pl. 8, fig. 8-10; pl. 11, fig. 8; pl. 15, fig. 2; pl. 16, fig. 8.

Discussion.—This species differs from *Biscutum constans* (Górka) Black (1967) in that central calcite elements are arranged in a rosette pattern; commonly, however, this central rosette is obscured by secondary overgrowth. Thus, larger size and the more imbricate and less symmetric nature of the proximal shield elements of *B. blackii* can be used to distinguish the species.

Occurrence.—Maastrichtian of Texas (Gartner, 1968); Albian to Maastrichtian Forchheimer, 1974), location not given.

BISCUTUM? BOLETUM Wind and Wise

Biscutum? boletum Wind and Wise, 1976, p. 297, fig. 1; pl. 23, fig. 6, 7.

Discussion.—Assignment of this species to *Biscutum* is questionable because it differs significantly from the norm of that genus. The two shields are not closely appressed; instead, the proximal shield is incorporated in a rodlike projection from the central area of the distal shield. Furthermore, the proximal shield is not composed of imbricate elements but has elements vertically aligned in relation to the distal shield.

Occurrence.—Maastrichtian on the Falkland Plateau, southwestern Atlantic Ocean.

BISCUTUM CASTRORUM Black

Biscutum castrorum Black in Black and Barnes, 1959, p. 326, pl. 10, fig. 2.

Biscutum constans (Górka) Noël, 1970, p. 91.

Discussion.—This form differs from *Biscutum asymmetricum* Perch-Nielsen (1968) by being less elongate and composed of fewer elements. Noël (1970, p. 91) regarded *B. castrorum* as a synonym of *B. constans* (Górka) Black (1967); however, *B. castrorum* has six to eight more shield elements, which are both smaller and more imbricate than those of *B. constans*. These differences warrant their separation.

Occurrence.—Coniacian to Maastrichtian of England (Black & Barnes, 1959).

BISCUTUM CORONUM Wind and Wise

Biscutum coronum Wind and Wise, 1976, p. 297, pl. 24, fig. 10-12.

Discussion.—On the basis of the original description, questions remain as to the details of the fine structure of the central area and general configuration of the proximal shield.

Occurrence.—Maastrichtian on the Falkland Plateau, southwestern Atlantic.

BISCUTUM? DIMORPHOSUM Perch-Nielsen

Biscutum? dimorphosum Perch-Nielsen, 1969, p. 318, pl. 32, fig. 1-3a, 4, text-fig. 32.

Discussion.—This species is distinguished by the distal shield elements, which are rhombic. The form is questionably assigned to the genus because construction of the proximal shield is unknown.

Occurrence.—*Cruciplacolithus tenuis* Zone, upper Campanian to lower Maastrichtian of Germany (Perch-Nielsen, 1969); also known from Scandinavia and North Africa.

BISCUTUM DISSIMILIS Wind and Wise

Biscutum dissimilis Wind and Wise, 1976, p. 298, pl. 23, fig. 1-5; pl. 24, fig. 3-6.

Discussion.—This species is variable both in element design and shield curvatures but generally satisfies criteria for the genus. It is distinguished by the massive distal shield elements at either end of the longitudinal axis and the relatively thin proximal shield elements.

Occurrence.—Upper Albian to Maastrichtian on the Falkland Plateau, southwestern Atlantic.

BISCUTUM KENNEDYI Bukry

Biscutum asymmetricum Bukry, 1969, p. 27, pl. 7, fig. 10, 11.

Biscutum kennedyi Bukry, 1970, p. 167, *nomen substitutum*.

Occurrence.—Santonian of Texas (Bukry, 1969).

BISCUTUM MAGNUM Wind and Wise

Biscutum magnum Wind and Wise, 1976, p. 298, pl. 20, fig. 4-6; pl. 21, fig. 2; pl. 24, fig. 1, 2;

pl. 30, fig. 1; pl. 50, fig. 1.

Discussion.—The dovetail extension of the distal elements and triangular to subrounded extensions of the proximal elements lining the central cavity are distinguishable in both light and electron microscopy.

Occurrence.—Maastrichtian on the Falkland Plateau, southwestern Atlantic.

BISCUTUM MINIMUM (Reinhardt & Górka)

Watznaueria? minima REINHARDT and GÓRKA,

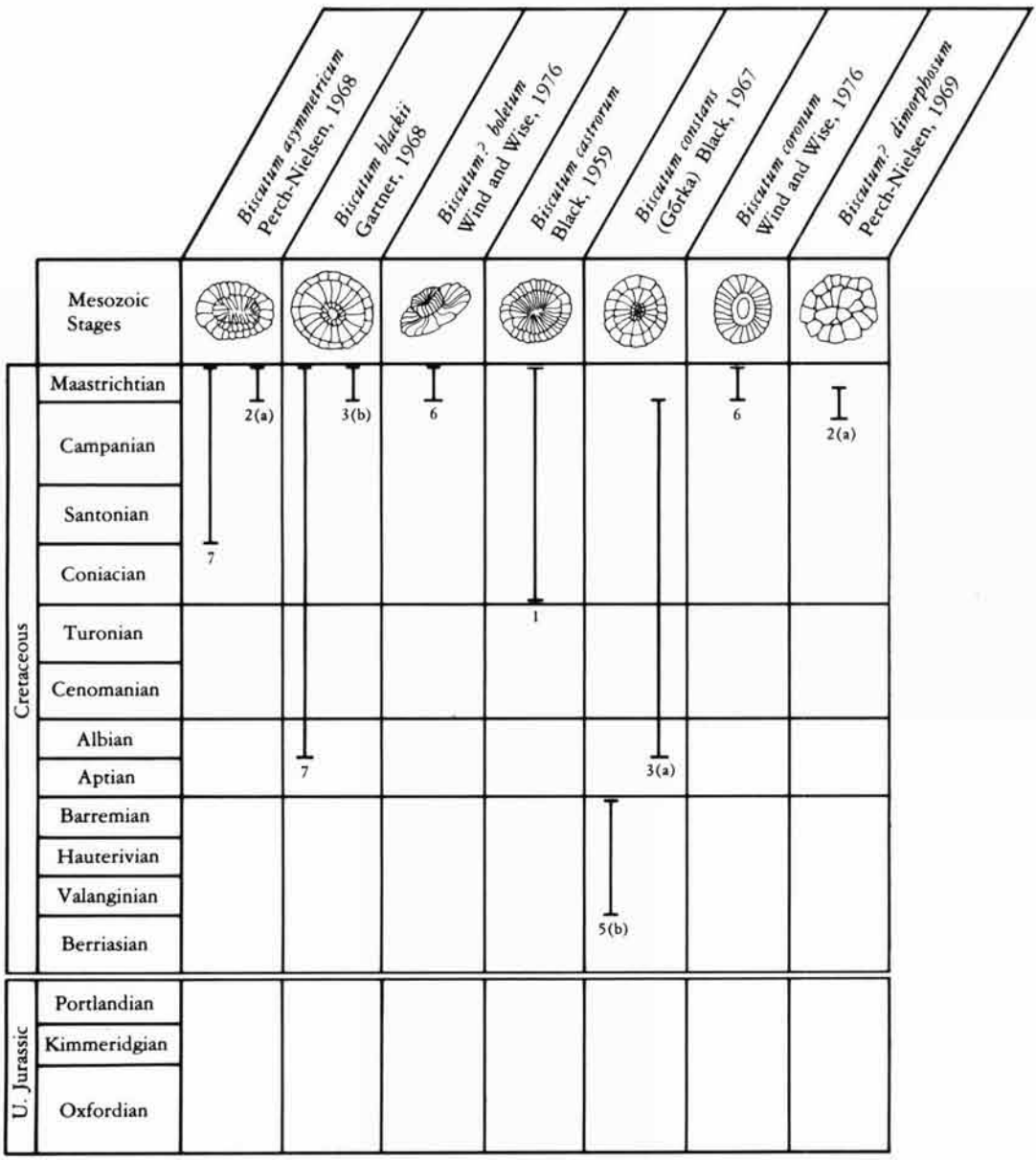

FIG. 2. Published ranges for species of *Biscutum* Black.——1. France, England: Black in Black and Barnes, 1959. ——2. Germany, Scandinavia, Switzerland: (a) Perch-Nielsen, 1969; (b) Reinhardt, 1970b.——3. Texas, midcontinent USA: (a) Bukry, 1969; (b) Gartner, 1968.——4. USSR: Shumenko, 1969.——5. Northwest Atlantic Ocean:

1967, p. 248, pl. 31, fig. 24; pl. 33, fig. 6.

Watznaueria virginica BUKRY, 1969, p. 34, pl. 13, fig. 4-6.

Biscutum minimum (REINHARDT & GÓRKA) REINHARDT, 1970b, p. 20, fig. 35.

Biscutum virginica (BUKRY) WIND and WISE, 1976, p. 298.

Occurrence.—Maastrichtian of Germany (Reinhardt, 1970b); Campanian of Texas (Bukry, 1969).

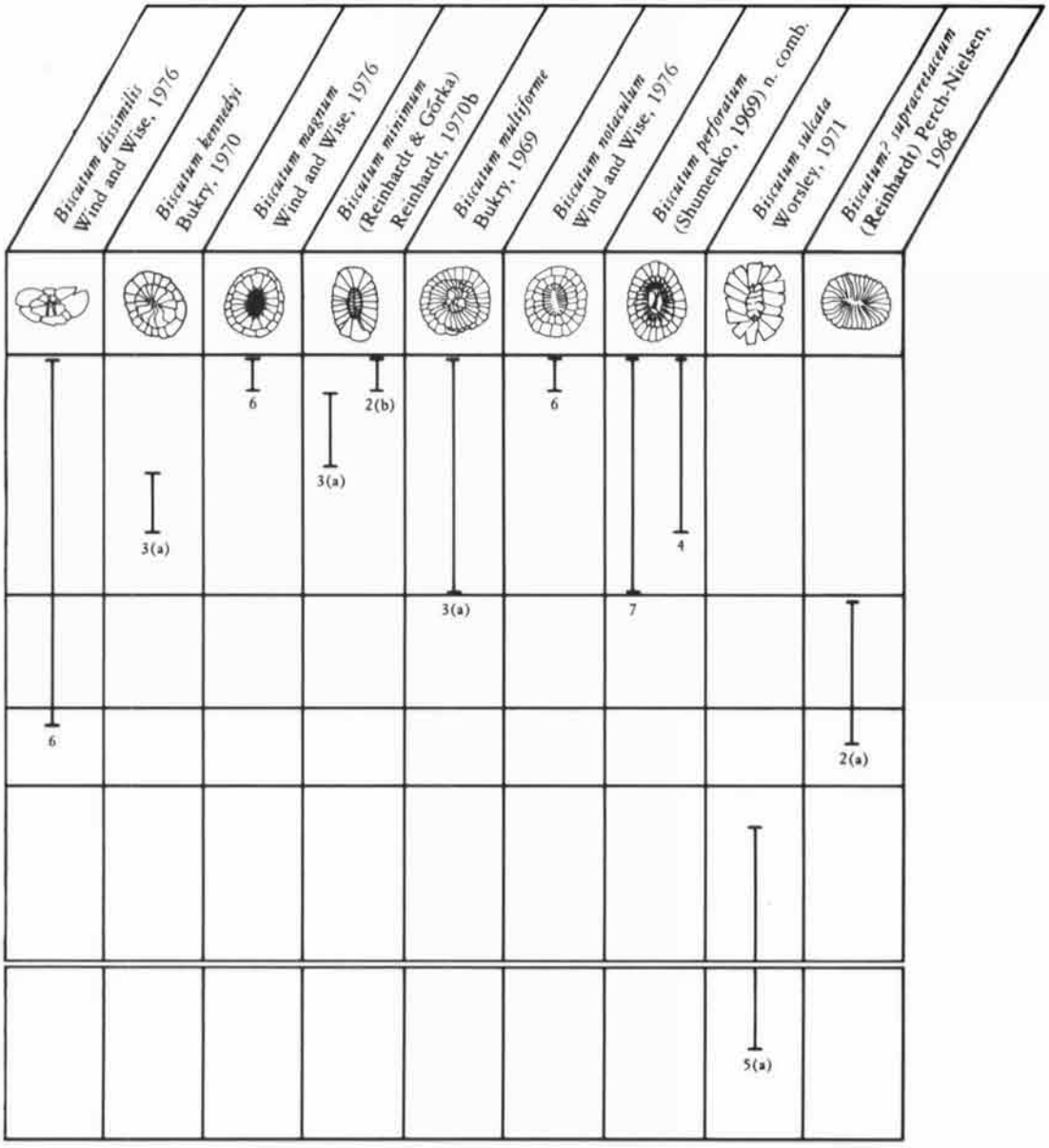

FIG. 2. (Continued from preceding page).
(a) Worsley, 1971; (b) Wilcoxon, 1972.——6. Southwest Atlantic Ocean: Wind and Wise, 1976.——7. Forchheimer, 1974.

BISCUTUM MULTIFORME Bukry

Biscutum multiforme Bukry, 1969, p. 28, pl. 8, fig. 4-6.

Occurrence.—Coniacian to Maastrichtian of France.

BISCUTUM NOTACULUM Wind and Wise

Biscutum notaculum Wind and Wise, 1976, p. 298, pl. 26, fig. 4; pl. 30, fig. 16.

Discussion.—The scanning electron microscope (SEM) illustration of the paratype of *B. notaculum* Wind and Wise (1976, pl. 26, fig. 4) shows a specimen that apparently underwent considerable dissolution, which may have affected preservation of the central area. Additional SEM analysis of this species is needed to determine fully the construction of this central area.

Occurrence.—Maastrichtian on the Falkland Plateau, southwest Atlantic.

BISCUTUM PERFORATUM (Shumenko)

Discorhabdus perforatus Shumenko, 1969, p. 156, pl. 8, fig. 4-6.

Discussion.—This species, composed of two elongate shields lacking a central rod, is included in *Biscutum* rather than *Discorhabdus*. If the distinguishing indentations along the sutures of the proximal shield result from dissolution along proximal elements, this form may be simply a variant of *Biscutum castrorum*, which it closely resembles.

Occurrence.—Santonian to Maastrichtian on the Russian platform (Shumenko, 1969); Coniacian to Maastrichtian (Forchheimer, 1974), location not given.

BISCUTUM SULCATA Worsley

Biscutum sulcata Worsley, 1971, p. 1306, pl. 1, fig. 4-6.

Occurrence.—Kimmeridgian to Hauterivian in the northwestern Atlantic.

BISCUTUM? SUPRACRETACEUM (Reinhardt)

Coccolithites supracretaceous Reinhardt, 1965, p. 40, pl. 2, fig. 7, 8.

Biscutum? supracretaceum (Reinhardt) Perch-Nielsen, 1968, p. 80, pl. 23, fig. 9-12.

Discussion.—This form has two closely appressed elliptical shields, with a moderate number of imbricate elements that seem to justify assignment to *Biscutum*. The degree of imbrication and general shape of the elements, however, suggest uncertainty in this assignment. The polarized extinction figure resembles that of *Watznaueria*, to which this form may be assigned after more extensive analysis.

Occurrence.—Albian to Turonian of Germany (Perch-Nielsen, 1968); also noted in equatorial Pacific Deep Sea Drilling Project Leg 17 samples.

Species Erroneously Assigned to Biscutum

Manvitella pemmatoidea (Deflandre, *ex* Manivit) Thierstein, 1971.—*Biscutum patella* Risatti (1973, p. 26, pl. 3, fig. 11, 12) is a junior subjective synonym of *Manivitella pemmatoidea* (Deflandre, *ex* Manivit) Thierstein (1971, p. 480, pl. 5, fig. 1-3).

Genus DISCORHABDUS Noël 1965

Type species.—*Rhabdolithus patulus* Deflandre *in* Deflandre and Fert, 1954, p. 48, fig. 97.

Description (translated from Noël, 1965b).—Circular base, composed of two closely appressed simple discs, perforated in the center to allow the passage of a rod, which may vary in development and structure. The upper disc (distal) consists of a single series of calcite elements, radially arranged, joined throughout their length to form a disc with a nearly continuous outline, without festoons. The lower disc (proximal) is generally smaller than the upper disc, or more or less equal to the latter, is constructed of the same number of calcite elements, and the plates are often thinner, equally joined and disposed radially. This lower disc is slightly convex, forming a complete base, pierced only in its center at the foundation of the rod. The axial rod, having a variable diameter, length, and morphology, is constructed of nearly square or elongate rhombohedral calcite crystals, arranged around a central canal. The edge of the rod is closely appressed to the interior edge of the perforation in the upper and lower disc.

Discussion.—This genus having a central rod appears to be restricted to Jurassic sediments (Fig. 3. Noël (1965b) noted that many specimens of *Discorhabdus* had lost their central rods, apparently through mechanical alteration. Therefore,

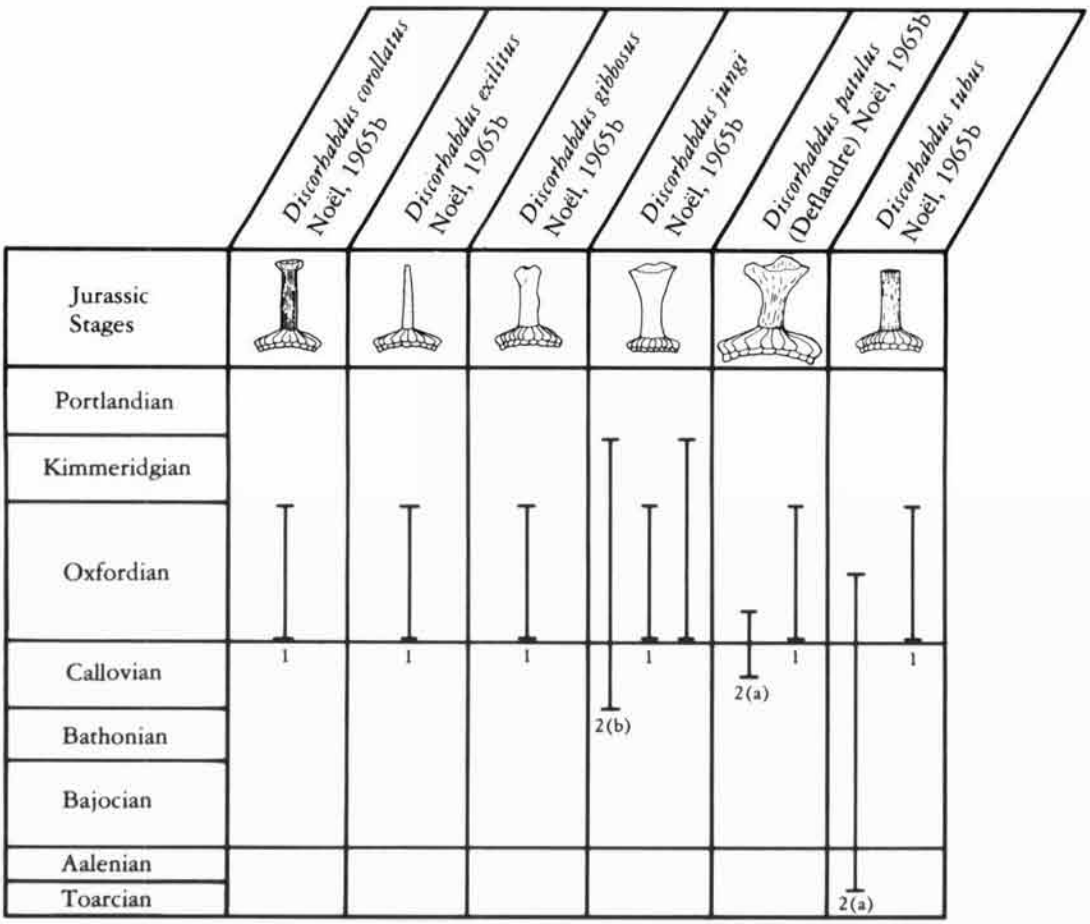

FIG. 3. Published ranges for species of *Discorhabdus* Noël.——1. North Africa: Noël, 1965b.——2. England, France: (a) Barnard and Hay, 1974; (b) Medd, 1970.——3. Northwest Atlantic Ocean: Wilcoxon, 1972.

these specimens closely resemble specimens of *Bidiscus* and *Biscutum*. Specimens retaining a central rod have not been noted in the Cretaceous; this age disparity between *Discorhabdus* and *Bidiscus* justifies the separation of the genera.

DISCORHABDUS PATULUS (Deflandre) Noël

Rhabdolithus patulus DEFLANDRE in DEFLANDRE and FERT, 1954, p. 97, pl. 15, fig. 40-45.

Discorhabdus patulus (DEFLANDRE) NOËL, 1965b, p. 141, pl. 21, fig. 6-8, 10, 11; pl. 22, fig. 1, 2, 7, 9, 10.

Occurrence.—Oxfordian of France and North Africa (Noël, 1965b); Oxfordian to Kimmeridgian of the northwestern Atlantic (Wilcoxon, 1972); Callovian to Kimmeridgian of England (Medd, 1970).

DISCORHABDUS COROLLATUS Noël

Discorhabdus corollatus NOËL, 1965b, p. 147, pl. 22, fig. 6.

Occurrence.—Oxfordian of North Africa.

DISCORHABDUS EXILITUS Noël

Discorhabdus exilitus NOËL, 1965b, p. 147, pl. 23, fig. 1.

Occurrence.—Oxfordian of North Africa.

DISCORHABDUS GIBBOSUS Noël

Discorhabdus gibbosus Noël, 1965b, p. 146, pl. 22, fig. 3.

Occurrence.—Oxfordian of North Africa.

DISCORHABDUS JUNGI Noël

Discorhabdus jungi Noël, 1965b, p. 144, pl. 22, fig. 5.

Occurrence.—Oxfordian of North Africa (Noël, 1965b); upper Callovian to lower Oxfordian of England (Barnard & Hay, 1974).

DISCORHABDUS TUBUS Noël

Discorhabdus tubus Noël, 1965b, p. 145, pl. 21, fig. 4, 15.

Occurrence.—Oxfordian of North Africa (Noël, 1965b); uppermost Toarician to middle Oxfordian of England (Barnard & Hay, 1974).

Species Erroneously Assigned to Discorhabdus

Hayesites radiatus (Worsley) Thierstein, 1976.—*Discorhabdus biradiatus* (Worsley) Thierstein in Roth, 1973, is a junior subjective synonym of *Hayesites radiatus* (Worsley); see Thierstein, 1976.

Podorhabdus biperforatus (Rood, Hay, & Barnard, 1973, p. 381, pl. 3, fig. 7).—*Discorhabdus biperforatus* Rood, Hay, and Barnard shows characters (elliptical shields and the two prominent perforations in the arch supports for the rod) that indicate the form belongs in the genus *Podorhabdus*. I hereby propose the following new combination: *Podorhabdus biperforatus* (Rood, Hay, & Barnard). The species occurs in the Bathonian of France (Rood, Hay, & Barnard, 1973).

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INDEX TO NAMES OF TAXA

(Names with questioned taxonomy enclosed in square brackets.)