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Electron Microscope Studies of Oxford Clay Coccoliths

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ABSTRACT

This paper is the first detailed work on Upper Jurassic (Callovian and Oxfordian) coccoliths since the work of NOEL (1965). The research forms the basis for a later paper on the stratigraphical ranges, and evolution of these flora. Thirty-six species are described, of which eleven are new species, and six new combinations. The status of many of the orders, families, sub-families and genera is discussed. Three orders, two families, seven sub-families and two genera are proposed as new.

Introduction

During recent years emphasis has been given to the study of calcareous nannoplankton, particularly their systematics and stratigraphic use. Most of this research was concentrated on coccoliths from the Tertiary (HAY et al., 1967; BRAMLETTE & WILCOXON, 1967) and the Cretaceous (ČEPEK & HAY, 1969; REINHARDT 1966; GARTNER, 1968; BUKRY, 1969).

Research on the Jurassic has been sparse and consists chiefly of early optical and electron microscope studies (DEFLANDRE & FERT, 1954) and brief mentions of Jurassic genera and species in more comprehensive works (STRADNER, 1963; REINHART, 1966). The most important recent research on Jurassic coccoliths (NOEL, 1965) consists of an electron microscope study of species from selected scattered localities and horizons from NW-Europe and N-Africa. This work concentrates on the systematics, not on an overall stratigraphical approach, although the monograph forms the basis of further studies on Jurassic coccoliths.

Using optical methods, PRINS (1969) produced a short but important account of the suggested evolution of Liassic coccoliths; unfortunately a number of both the genera and species remain to be validated.

In view of the paucity of research on the Jurassic coccoliths in general, and almost complete lack of published work on those in Britain, it was considered appropriate to commence a systematic investigation in order to build up a stratigraphic framework to provide a basis for the use of these fossils for correlation.

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Earlier work (STRADNER, 1963) suggests the Callovian to Oxfordian coccolith floras to be considerably more abundant and diverse than those of the Middle and Lower Jurassic. Consideration of this, together with the availability of a new, but temporary, section at Millbrook (Bedfordshire) spanning a considerable range of the Callovian and Oxfordian, encouraged the authors to publish first on the Upper Jurassic ("Oxford Clay").

Close biostratigraphic control was obtained using the existing ammonite zones, so that this research could be used as a guide to future work.

Stratigraphy

Details of the stages and zones of the relevant parts of the Upper Jurassic, and the ranges covered by the localities are given in Figure 1, based on Callomon (1962).

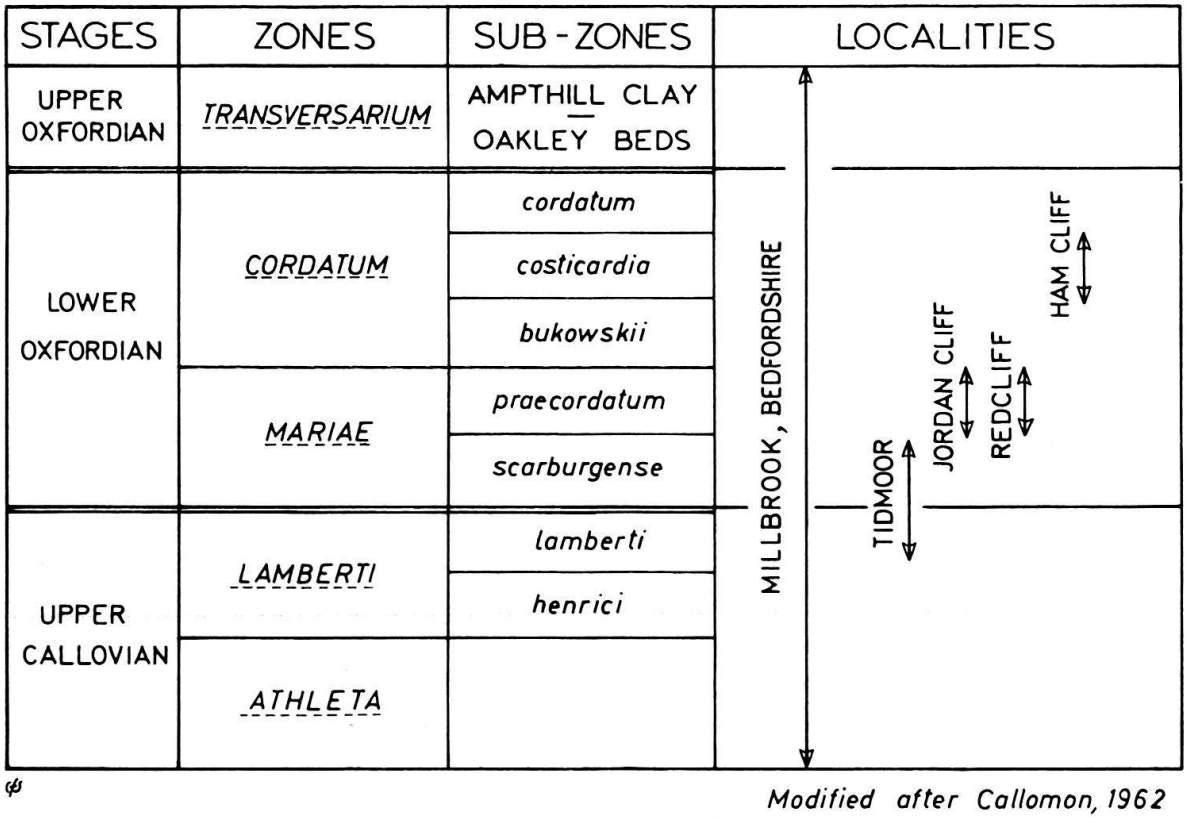

Figure 1. Comparative ranges of sections studied.

The localities which provided the samples studied can be divided into two groups:

1. Millbrook (Bedfordshire) where there is an almost continuous section, representing the ammonite zones *athleta-cordatum*, with remnants of the local facies, Oakley Beds and Ampthill Clay, with little ammonite control except indications of the *transversarium* zone.

2. Isolated exposures of Oxford Clay (clay facies) along the Dorset Coast (Fig. 3) of the Fleet and Weymouth Bay. Detailed descriptions of the sections at Tidmoor Point (*lamberti* zone), the promontory S.E. of Tidmoor Point (lower *mariae* zone), Jordan Cliff (*precordatum* subzone), Recliff (*precordatum* subzone) and Ham Cliff (*cordatum* zone) are all given in ARKELL (1947).

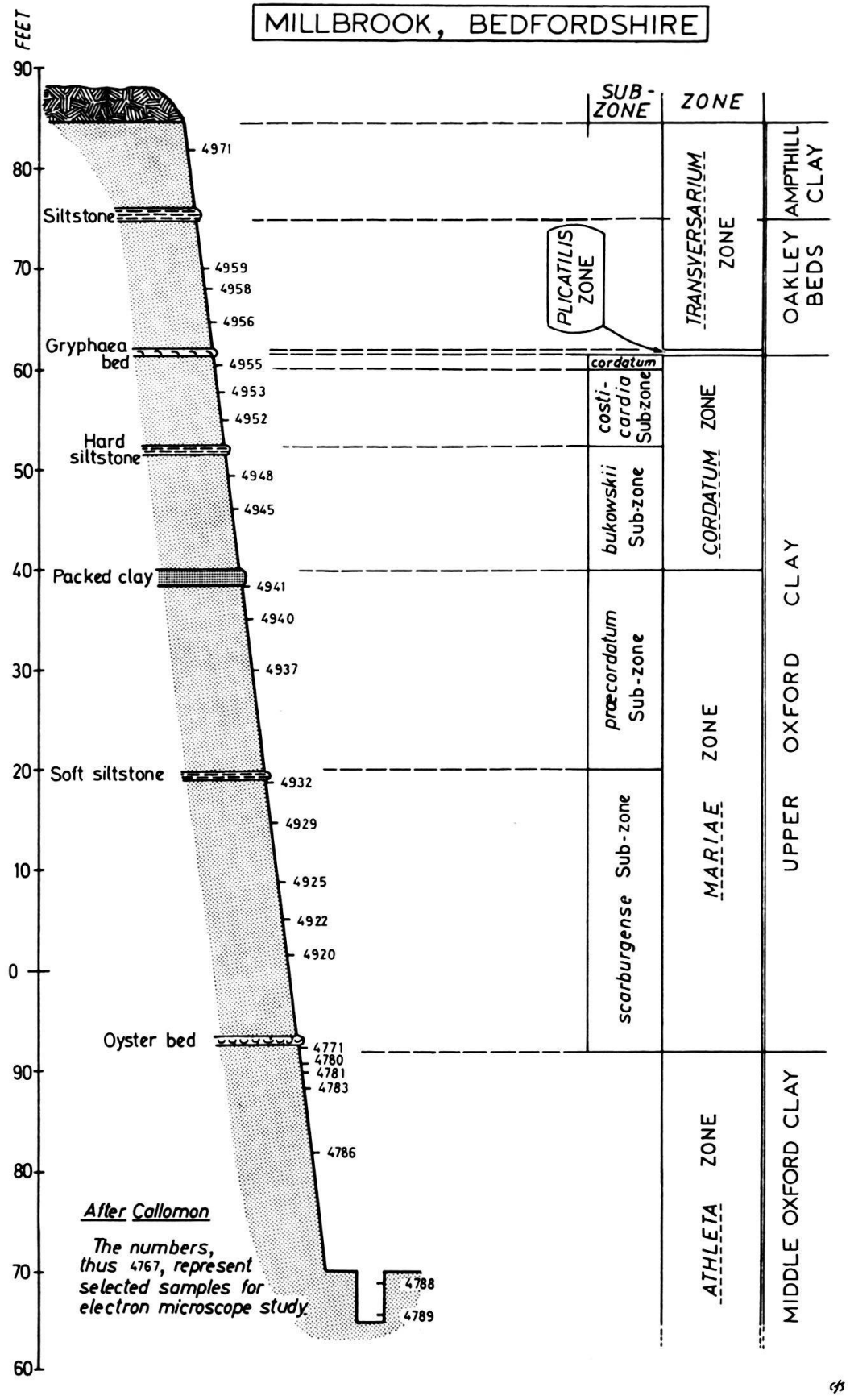

Figure 2. Temporary section at Millbrook (Bedfordshire) exposed during the Autumn of 1968.

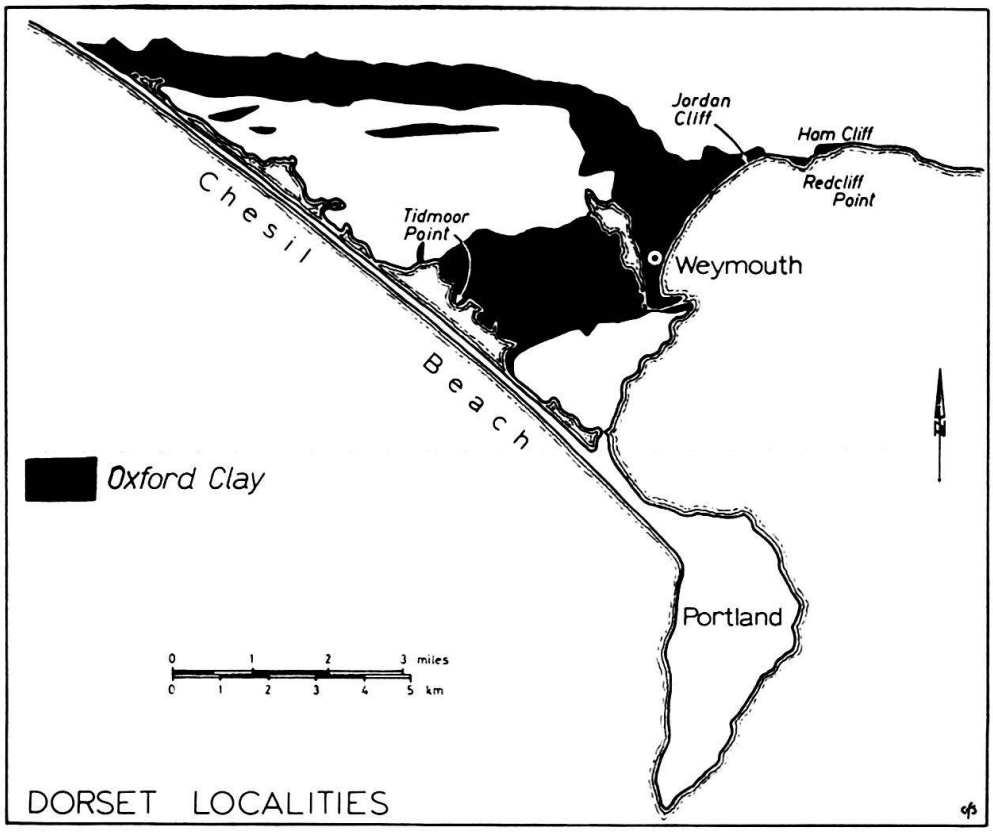

Figure 3. Localities in Dorset, Oxford Clay.

Details of the sections, together with the sample numbers (preserved in the Micropalaeontology Dept., University College, London) are given in Figures 2 and 3.

SYSTEMATIC PALEONTOLOGY

Kingdom PLANTAE

Division CHRYSOPHYTA

Class COCCOLITHOPHYCEAE Rothmaler, 1951

Order EIFFELLITHALES, new order

Diagnosis

Coccoliths with a simple marginal area (eiffellithalid rim) consisting solely of a double cycle of elements; the two cycles are superposed in such a way that they appear as a single cycle in most proximal and distal views, a suture being visible only on the inner surface of the circlet, facing the central area. Central structures are variable, consisting of a cross, bar or more complex feature which may be surmounted by a spine.

Family Ahmuellerellaceae REINHARDT, 1965

Definition

Coccoliths with an eiffellithalid rim having a central structure consisting of a cross aligned in the major and minor axes of the ellipse.

Genus *Vekshinella* LOEBLICH & TAPPAN, 1963

Type: *Ephippium acutiferra* VEKSHINA, 1959.

Synonyms

Ephippium VEKSHINA, 1950 (homonym of *Ephippium* BOLTON, 1798) objective senior synonym with the same type species; *Valgalapilla* BUKRY, 1969, subjective junior synonym (type: *Vekshinella imbricata* GARTNER, 1968) established because *Vekshina*'s illustration of the side view of *Ephippium acutiferra* indicated a slight proximal extension of the stem, a feature unknown in any of the species assigned by GARTNER to *Vekshinella*, nor reported in any subsequent work. It now seems evident that the proximal projection indicated by VEKSHINA was not an integral part of the coccolith, and replacement of *Vekshinella* by *Vagalapilla* is here regarded as unwarranted.

Vekshinella stradneri, new species

Plate I, Figure 2

1968 *Zygolithus crux* (DEFLANDRE & FERT) of STRADNER, ADAMIKER & MARESCH, Pl. 28, p. 36–37.

Diagnosis

Coccoliths with an eiffellithalid rim and a central cross aligned in the major and minor axes of the ellipse; the short bar of the cross is slightly offset at the center.

Description

The rim of this species is narrow, with a slightly inclined peripheral wall, and consists of about 40 strongly imbricate wedges on the distal side. The bars of the cross are constructed of large overlapping tabulae. The shorter arms of the cross are offset at the center. At the point of juncture between the arms, the cross and the rim, the arms expand slightly in the direction of inclination of the overlapping rim segments. A circular stem arises from the center of the cross.

Differentiation

This species is distinguished from other members of the genus by its relatively simple construction and by the offset of the shorter arms at the center.

Remarks

Named after Dr. H. Stradner in recognition of his pioneer work in the study of coccoliths.

Holotype: 34.5.1
Paratypes: 34.1.2, 34.8.1
Dimensions: length 3.2 μm, width 2.4 μm
Type locality: Millbrook (Bedfordshire)
Type level: *transversarium* zone (4971)

Vekshinella quadriarculla NOEL, new combination
Plate I, Figure 1

1965a *Discolithus quadriarcullus* NOEL, Fig. 7, p. 4.
1965b *Discolithus quadriarcullus* NOEL, NOEL, Fig. 7, Pl. 1, Fig. 14–15, Pl. 2, Fig. 1–2, p. 74–75.

Remarks

NOEL (1965) refused to accept the opinion of LOEBLICH & TAPPAN (1963) that the generic name *Discolithus* is properly attributed to HUXLEY, 1868 and preferred to consider it to have been first validated by KAMPTNER, 1949. LOEBLICH & TAPPAN, 1963 substituted the taxon *Discolithina* for *Discolithus* as the latter is, in the Animal Kingdom, a homonym of *Discolithus* FORTIS, 1802. If the name *Discolithus* is correctly attributed to HUXLEY, it was almost certainly intended to be a taxon in the Animal Kingdom, and must be replaced by *Discolithina* LOEBLICH & TAPPAN; if it is attributed to KAMPTNER, then it was probably intended to be a plant, and might be allowed to stand as NOEL suggested. NOEL noted that LOEBLICH & TAPPAN designated *Discolithus vigintiforatus* as type of *Discolithina* ipso facto *Discolithus*. As in the case of the type designation of *Zygolithus*, discussed below, she refused to accept the prior designation, and proposed one of her new species, *Discolithus quadriarcullus* as type. This is unacceptable because of 1. the prior valid type designation by LOEBLICH & TAPPAN, and 2. the species selected was not among those originally included in the genus. Of current valid genera, *Vekshinella* is nearest to including this species. *Vekshinella quadriarculla* is, however, a unique member of the genus in that the arms of the central cross have curved margins, becoming narrower between the rim and the center. The four openings are oval, but pointed at the ends, rather than having the shape of a quarter of a circle as in other members of the genus.
Hypotype: 34.6.1
Paratypes: 33.8.2, 27.8.1, 27.2.2
Dimensions: length 3.1 μm, width 2.3 μm

Family Zygodiscaceae HAY & MOHLER, 1967

Definition

Coccoliths with an eiffellithalid rim and a central structure developed either (1 as a stem having quadripartite construction with sutures oriented in the equal of the ellipse and touching the margin of the ellipse in the minor axis (Subfamily *Parhabdolithoideae* GARTNER, 1968), or (2) with or without a stem arising from a bar in the minor axis of the ellipse (Subfamily *Zygodiscoideae* BUKRY, 1969).

Subfamily Zygodiscoideae BUKRY, 1969

Definition

Coccoliths with an eiffellithalid rim and a bar oriented in the minor axis of the ellipse. The bar may be complex, and most commonly consists of four optically continuous regions separated along the major and minor axes of the ellipse. In many species, the bar is surmounted by a short spine having a circular cross section. Cocco-

liths of this sort superficially resemble the original concept of "zygolith" of KAMPTNER (1937, 1941).

Genus *Zeugrhabdotus* REINHARDT, 1965

Type: *Zygolithus erectus* DEFLANDRE, 1954
Synonym: "*Zygolithus*" of many authors.

Definition

Elliptical coccoliths with an eiffellithalid rim, a bar in the minor axis of the ellipse, and a short stem or circular cross section arising from the bar.

Remarks

Considerable confusion has arisen over the designation or the type species of the genus *Zygolithus* KAMPTNER *ex* MATTHES, 1956. KAMPTNER (1963) designated *Coccolithus sculptus* KAMPTNER, 1952, as type species, but this cannot be accepted as this species was not among those originally included in the genus. MASLOV (1963) designated *Zygolithus dubius* DEFLANDRE, 1954, as type species; this designation is valid and must be accepted according to the rules of botanical nomenclature. LOEBLICH & TAPPAN (1963) designated *Zygolithus erectus* DEFLANDRE, 1954, as type species, but as noted by LOEBLICH & TAPPAN (1966), this was subsequent to the designation of *Z. dubius* as type species by MASLOV, and must be disregarded. NOEL (1965, pp. 57–58) presented a detailed account of the nomenclatural problems, noting that "en ce qui concerne la désignation de l'espèce type, celle de V.P. MASLOV (*Z. dubius*) étant antérieure à celle de A.R. LOEBLICH et H. TAPPAN, est seule valable". In spite of her awareness of the valid type designation of MASLOV, NOEL proceeded to designate a new type species for *Zygolithus*, *Zygolithus bussoni* NOEL, 1956, a species not among those originally included in the genus. MASLOV's selection of *Zygolithus dubius* as type is in many ways a fortunate choice, because *Z. dubius* is conspecific with or very closely related to *Neococcolithes lososnensis* SUJKOWSKI (HAY & MOHLER, 1967; BLACK, 1967), so that *Zygolithus* becomes a junior synonym of *Neococcolithes* SUJKOWSKI, 1931. This effectively solves the problem of the difference of the concept of the term "zygolith" as originally used by KAMPTNER (1937, 1941) and the concept of the genus *Zygolithus*. The term "zygolith" was originally used to refer to coccoliths of the Recent genus *Zygosphaera*. These coccoliths are elliptical in plan view, and also have a bridge which is oriented in the minor axis of the ellipse and is surmounted by a short spine. However in side view, the difference between coccoliths of this sort and Mesozoic coccoliths referred to *Zygolithus* is evident. The Recent coccoliths have a strongly curved bridge which rises high above the rim, giving the coccolith the aspect of a stirrup in side view. The short spine or knob arises from the peak of the arched ridge. In Mesozoic forms, such as "*Zygolithus*" *erectus* the bar lies in the plane of the elliptical rim. A further significant difference has been revealed by electron microscopic investigation of Recent relatives of *Zygosphaera* – all of the closely related forms studied thus far have been found to be holococcoliths, constructed of minute rhombs or prisms of calcite.

REINHARDT (1965) assumed that the designation of *Coccolithus sculptus* KAMPTNER, 1952, as type of *Zygolithus* was correct, and considered the genus to be restricted

to forms with a single cycle of rim elements and a crossbar in the minor axis. For forms with a double cycle of rim elements and a crossbar in the minor axis surmounted by a stem, REINHARDT proposed the genus *Zeugrhabdotus*, designating *Zygolithus erectus* DEFLANDRE, 1954, as type. In his monographic study, REINHARDT (1966) noted that KAMPTNER's designation of *Coccolithus sculptus* must be invalid because it was not among the species originally included in *Zygolithus*, and unaware of MASLOV's designation of *Zygolithus dubius* DEFLANDRE, 1954, he accepted LOEBLICH & TAPPAN's (1963) designation of *Zygolithus erectus* as type of *Zygolithus*, and thus concluded incorrectly that his own genus *Zeugrhabdotus* would be a junior objective synonym of *Zygolithus*.

Because MASLOV's designation of *Zygolithus dubius* as type of *Zygolithus* is valid and has priority, REINHARDT's genus *Zeugrhabdotus*, with *Zygolithus erectus* as its type species, is valid and the correct name for a number of Mesozoic species.

Zeugrhabdotus erectus (DEFLANDRE)

Plate I, Figure 3

1954 *Zygolithus erectus* DEFLANDRE in DEFLANDRE & FERT, Fig. 60–61, Pl. 15, Fig. 14–17 [not Fig. 62]. p. 150.
not 1965 *Zygolithus erectus* DEFLANDRE of NOEL, Fig. 2, Pl. 1, Fig. 3–4, p. 62–64.
1965 *Zeugrhabdotus erectus* (DEFLANDRE) REINHARDT, p. 37.
1966 *Zygolithus erectus* DEFLANDRE, REINHARDT, Pl. 15, Fig. 3, p. 40.

Remarks

DEFLANDRE designated as holotype the specimen illustrated in his Figures 14–15, Pl. 15, and text Figure 60 (p. 150) (Note: in the explanation of plate 15, all four Figures, 14–17 are referred to as holotype, but the last two Figures are certainly micrographs of a different specimen from that illustrated in the first two Figures). From the illustrations of the holotype it is evident that the rim is very narrow, and the openings large. Electron microscope investigation shows that the two openings are spanned by a delicate perforate sheet which is indetectable with either phase contrast illumination or polarised light.

Hypotype: 26.3.2.

Dimensions: length 4.5 μm, width 3.0 μm

Zeugrhabdotus noeli, new species

Plate I, Figure 4

1954 *Zygolithus erectus* DEFLANDRE in DEFLANDRE & FERT, Fig. 62.
1955 *Zygolithus erectus* Deflandre of NOEL, Fig. 2, Pl. 1, Fig. 3–4, p. 62–64.
1968 *Zygolithus erectus* Deflandre of STRADNER, ADAMIKER & MARESCH, Pl. 25, Pl. 26, Fig. 1–2, p. 34–35.

Diagnosis

A species of *Zeugrhabdotus* with a wide margin and small central openings.

Description

The margin appears in distal view to be constructed of 16–22 overlapping wedges. The bridge is constructed of a few large elements. The stem is hollow, pierced by a circular opening. The diameter of the central openings is about $^1/_3$ the diameter of the coccolith.

Differentiation

This species is readily separated from *Zeugrhabdotus erectus* by the relative proportions of the central openings in this species the central openings are $^1/_3$ or less the width of the coccolith, while in *Z. erectus*, the openings are more than $^2/_3$ the width of the coccolith.

Remarks

Extensive descriptions of this species have been presented by NOEL (1955) and STRADNER, ADAMIKER & MARESCH (1968). The species is named after Dr. D. NOEL in recognition of her pioneer work into Jurassic coccoliths.

Holotype: 34.9.1.

Paratype: 34.1.1.

Dimensions: length 2.9 μm, width 1.8 μm.

Type locality: Millbrook (Bedfordshire)

Type level: *transversarium* zone (4971)

Zeugrhabdotus salillum (NOEL), new combination

Plate I, Figure 5

1965a *Discolithus salillum* NOEL, Fig. 5–6, p. 4.
1965b *Discolithus salillum* NOEL, NOEL, Fig. 5–6, Pl. 1, Fig. 8–12, p. 72–74.

Remarks

The reason why NOEL placed this species in the genus *Discolithus* rather than in *Zygolithus* (= *Zeugrhabdotus*) is not clear. The structure of the rim of *Z. salillum* appears to be more complex, but this is due in part to the fact that the width of the marginal rim at its proximal and distal surfaces is markedly different, the distal surface being almost three times the width of the proximal surface. The view through the replica of the long sutures between the imbricate wedges of the peripheral surface of the rim creates a complex image, best understood by viewing stereoscopic pairs of electron micrographs. In *Zeugrhabdotus erectus*, the width of the rim varies only slightly between the proximal and distal surfaces, so that the micrographs indicate a simply constructed coccolith. The major difference between this species and the type of the genus is the slope of the perphery of the rim therefore this species is transferred to *Zeugrhabdotus*.

Hypotype: 24.4.2.

Dimension: length 3.3 μm, width 2.5 μm.

Family Actinozygaceae, new family

Diagnosis

Elliptical coccoliths with an eiffellithalid rim and a complex central structure consisting of either (1) six or more bars disposed symmetrically with respect to the major and minor axes (Subfamily *Actinozygoideae*, new subfamily), or, (2) four or more bars disposed asymmetrically in such a way that one end of the coccolith may be duplicated by rotation of the other end through 180 degrees (subfamily *Diadozygoideae*, new subfamily).

Subfamily Actinozygoideae, new subfamily

Diagnosis

Elliptical coccoliths with an eiffellithalid rim and six or more bars disposed symmetrically with respect to the axes of symmetry of the ellipse. A spine may arise from the point of juncture of the bars in the center of the coccolith. In addition to the type of genus, *Pontilithus* GARTNER, 1968, belongs here.

Genus *Actinozygus* GARTNER, 1968

Type: *Tremalithus regularis* GORKA, 1957

Definition

Elliptical eiffellithalid coccoliths with 6–10 symmetrically arranged bars.

Remarks

LOEBLICH & TAPPAN (1969) considered this genus to be invalid because the type species (*Rhabdolithus splendens* DEFLANDRE, 1954) of a previously described genus (*Rhabdolithina* REINHARDT, 1967) was included in it by GARTNER. GARTNER was unaware of REINHARDT's (1967) paper, and inasmuch as the type species of *Rhabdolithina* and *Actinozygus* are markedly different, recognition of both genera is warranted.

Actinozygus geometricus (GORKA), new combination

Plate I, Figure 6

1957 *Discolithus geometricus* GORKA, Pl. 4, Fig. 8, p. 259, 279.
1968 *Zygolithus geometricus* (GORKA) STRADNER, ADAMIKER & MARESCH, Pl. 36, Pl. 37, Fig. 1–4, p. 40.

Remarks

This species is readily recognized by its strict symmetry, with six bars: two in the minor axis of the ellipse, and four arranged at 60 degrees on either side of the minor axis.

Hypotype: 28.6.2.

Dimension: length 3.1 μm, width 2.1 μm.

Subfamily Diadozygoideae, new subfamily

Diagnosis

Elliptical or rhomboidal coccoliths with an eiffellithalid rim and a central structure constructed of four or more bars distribued so that rotation of one half of the coccolith by 180 degrees repeats the other half.

Remarks

Members of this subfamily probably gave rise to the calciosoleniids before the Albian.

Genus *Diadozygus*, new genus

Type: *Diadozygus rotatus*, n. sp.

Diagnosis

Elliptical to rhomboidal coccoliths, with six or more bars disposed asymmetrically so that one end of the coccolith may be repeated by diad (180 degrees) rotation of the other. A pair of bars extending part of the length of the coccolith but offset at the center, are diagnostic of most species of the genus.

Diadozygus asymmetricus, new species

Plate I, Figure 7

Diagnosis

A species of *Diadozygus* with elliptical outline and eight asymmetrically disposed bars.

Description

The eight bars extend from the center of the ellipse to the margin in an asymmetrical manner, not occupying any of the axes of symmetry of the ellipse. The openings between the bars in the ends of the coccolith are larger than those closer to the minor axis. The bars fuse in a large elliptical central platform from which a spine having circular cross section arises.

Differentiation

This species differs from the only other eight rayed member of the genus, *Diadozygus emendatus* (LYUL'EVA) [= *Dictyolithus emendatus* LYUL'EVA, 1967, Geol. Zhurnal, v. 27, p. 92, 96, Pl. 4, Fig. 41; *Corolithion emendatus* (LYUL'EVA) ČEPEK & HAY, 1969, Gulf Coast Assoc. Geol. Socs., Trans., v. 19, p. 327] in being elliptical rather than rhomboidal in outline.

Remarks

The name *asymetricus* was given to the species, because of its diagnostic asymmetry.

Holotype: 24.5.1
Paratype: 24.10.1
Dimensions: length 3.3 μm, width 2.5. μm
Type locality: Millbrook (Bedfordshire)
Type level : *athleta* zone (4789)

Diadozygus callomoni, new species
Plate I, Figure 8

Diagnosis

An elliptical species of *Diadozygus* with ten asymmetrically arranged radial bars.

Description

The six central radial bars extend from a central platform to the periphery; the four radial bars in the ends of the ellipse are joined to the central platform by two short sublongitudinal bars tangential to the platform. The central platform supports a spine.

Differentiation

This species differs from the only other ten-rayed outline of *Diadozygus*, *D. rotatus*, n. sp., in having an elliptical, not rhombic, outline.

Remarks

The species was named after Dr. J. H. Callomon in recognition of his assistance in placing the samples in a definite ammonite control, and for his help in the field.
Holotype: 31.1.1.
Dimensions: length 3.1 μm, width 1.9 μm
Type locality: Tidmoor Point (Dorsetshire)
Type level: *lamberti* zone (4653)

Diadozygus rotatus, new species
Plate I, Figure 9; Plate II, Figure 1

Diagnosis

A rhombical species of *Diadozygus* with ten asymmetrically arranged radial bars; the four bars in the ends of the rhomb are connected to the center by short sublongitudinal bars.

Description

Six of the radial bars extend from the central platform to the margin; two of these meet the margin at corners of the rhomb. The four radial bars in the ends of the rhomb are connected to the central platform by short sublongitudinal bars tangential to the central platform. The central platform supports a spine.

Differentiation

This species differs from the other ten-rayed species of the genus *D. callomoni* n. sp., in having a rhomboidal rather than elliptical outline. It differs from the similar rhomboidal form *D. emendatus* LYUL'EVA (common in the Cretaceous) in having ten rather than eight radial bars.

Remarks

The species was named *rotatus* because by rotating half the coccolith through 180 degrees the two halves are the coincident.
Holotype: 30.9.2.
Paratypes: 29.2.2, 30.7.2
Dimensions: length 3.8 μm, width 2.5 μm, stem length 13 μm.
Type locality: Millbrook (Bedfordshire)
Type level: *lamberti* zone (4771)

Diadozygus dorsetense, new species

Plate II, Figures 2, 3

Diagnosis

An elliptical species of *Diadozygus* with fourteen asymmetrically arranged radial bars.

Description

Two pairs of radial bars extend from the central platform to the margin; four other pairs of radial bars extend from two longer sublongitudinal bars to the margin. The sublongitudinal bars are tangential to the central platform, but extend to join the rim near the ends, where they are offset in the direction of overlap of the rim elements.

Differentiation

This is the only recorded member of the genus with fourteen bars.

Remarks

The species was named after the type locality.

Holotype: 27.3.2.
Paratypes: 19.11.2, 29.11.1
Dimensions: length 2.8 μm, width 1.7 μm
Type locality: Redcliff Point (Dorsetshire)
Type level: *mariae* zone - *praecordatum* subzone (4659)

Genus Truncatoscaphus, new genus

Type: *Zygolithus delftensis* STRADNER & ADAMIKER, 1966

Diagnosis

Elongate coccoliths with an eiffellithalid rim and truncate ends; the longer sides are curved or broadly obtusely angled, the ends are flat so that the overall outline is that of an elongate subhexagonal ring.

Remarks

This genus is probably derived from *Diadozygus*, but intermediate forms are unknown.

Truncatoscaphus delftensis (STRADNER & ADAMIKER), new combination

Plate II, Figures 4, 5

1966 *Zygolithus delftensis* STRADNER & ADAMIKER, Fig. 8–11, Pl. 2, Fig. 3, p. 338.
1968 *Zygolithus delftensis* STRADNER & ADAMIKER, STRADNER, ADAMIKER & MARESCH, Pl. 39, p. 41.

Remarks

The overlapping elements of the rim of this species present a sawtooth pattern in oblique or side views. Specimens from the Oxfordian resemble those from the Albian except that the sides appear to be more curved than angled. This is a subtile difference, and erection of a new name for the Oxfordian forms seems unwarranted.

Hypotypes: 27.11.2, 25.8.2
Dimensions: length 2.6 μm, width 1.3 μm

Genus *Diadorhombus* WORSLEY, 1971

Type: *Diadorhombus rectus* WORSLEY, 1971

Diagnosis

Rhombic coccoliths with an eiffellithalid rim and four or more internal bars supporting a central stem.

Remarks

The asymmetry and rhomboidal outline of this genus suggests a close affinity to *Diadozygus*, n. gen., but intermediate forms are as yet unpublished.

Diadorhombus minutus, new species

Plate II, Figure 6

Diagnosis

Equilateral rhombic rims with and asymmetric central cross oriented at 30° to the axes joining the corners of the rhomb.

Description

The rhomboidal rim displays typical eiffellithalid construction, with nearly vertical sides; the central cross is asymmetrically disposed to the axes of the rhomb, its bars form an angle of about 30 degrees with the axes joining the corners of the rhombic rim. At the point of juncture between the arms of the cross and the rim, there is an extension of the arm into the acute angle between the arm and the rim so that the cross has a slight swastika-like shape. A stem arises from the center of the cross.

Differentiation

This species is distinguished from members of the genus *Corollithion* by its asymmetry. Rhombic rims have been described from the Upper Cretaceous under the generic term *Dictyolithus* by GORKA, but the details of their structure are unknown, and GORKA did not illustrate any species with a central cross.

Remarks

The species is named *minutus* on account of its diminutive size.

Holotype: 26.11.1
Paratype: 27.1.1, 28. 4.2
Dimensions: Side length 1.4 μm
Type locality: Millbrook (Bedfordshire)
Type level: *mariae* zone (4932)

Family Stephanolithionaceae Black, 1968, emended

Diagnosis

Elliptical, circular, or polygonal coccoliths with a rim constructed of large, thick slightly overlapping elements; at least two cycles of elements are present, although one cycle may be very large and the other very small.

Subfamily Crepidolithoideae, new subfamily

Definition

Elliptical coccoliths of the Family *Stephanolithionaceae* with no external projections.

Genus *Crepidolithus* NOEL, 1965

Type: *Discolithus crassus* DEFLANDRE, 1954

Definition

Coccoliths with a broad elliptical rim constructed of a proximal cycle of thin tabular elements extending into the center of the coccolith, and a much thicker distal cycle of slightly prismatic elements. As noted by PRINS (1969), a vestige of a central cross is usually visible between crossed polarizers.

Crepidolithus crassus (DEFLANDRE)

Plate II, Figure 7

1954 *Discolithus crassus* DEFLANDRE in DEFLANDRE & FERT, Fig. 49, Pl. 15, Fig. 12–13, p. 144.
1965a *Crepidolithus crassus* (DEFLANDRE), NOEL, p. 5, Fig. 17–21.
1965b *Crepidolithus crassus* (DEFLANDRE), NOEL, Fig. 17–21, Pl. 2, Fig. 3–7, Pl. 3, Fig. 1–5, p. 85–91.

Remarks

Specimens from Millbrook seem to be better preserved than those from Anncot and Vassy figured by NOEL. The center of the coccoliths is spanned by a grille with polygonal openings. Between crossed nicols, the center appears to be roughly cruciform, as noted by PRINS (1969), suggesting that the grille is constructed of four optically continuous areas.

Hypotype: 27.5.1
Dimensions: length 13.0 μm, width 9.1 μm
Locality: Millbrook (Bedfordshire)
Level: *mariae* zone - *praecordatum* subzone (4941)

Subfamily Stephanolithionoideae VEKSHINA, 1959

Definition

Circular, hexagonal, or polygonal coccoliths of the Family *Stephanolithionaceae* with external projections.

Genus *Stephanolithion* DEFLANDRE, 1939

Type: *Stephanolithion bigoti* DEFLANDRE, 1939

Definition

Coccoliths with a hexagonal or polygonal rim constructed of one cycle of thin tabular elements and a much thicker cycle of slightly imbricate prismatic elements; lateral projections extend outward from the rim.

Stephanolithion bigoti DEFLANDRE
Plate II, Figure 8

1939 *Stephanolithion bigoti* DEFLANDRE, Fig. 1–9, p. 1332.
1965a *Stephanolithion bigoti* DEFLANDRE, NOEL, Fig. 9–14, p. 5.
1965b *Stephanolithion bigoti* DEFLANDRE, NOEL, Fig. 9–14, Pl. 5, Fig. 1–10, Pl. 6, Fig. 1–2, p. 78–83.
1968 *Stephanolithion bigoti* DEFLANDRE, BLACK, Pl. 152, Fig. 1, p. 807–808.

Remarks

The structure of this species has been discussed at length by Noel. The number of lateral spines is variable, ranging from six to ten, although the vast majority of specimens have six. STRADNER (1963, p. 13) has noted that this species tends to break up, so that some samples have numerous fragments resembling minute letters, especially E's, T's, and U's.

Hypotype: 38.7.2

Dimensions: Diameter across spines, 10.0 μm.

Order PODORHABDINALES, new order

Diagnosis

Coccoliths with a marginal area constructed of two petaloid cycles of elements which are not at all, or only very slightly, imbricate. The marginal areas of members of this order have a characteristic appearance in bright phase field phase contrast illumination, being much darker than the background.

Family Podorhabdaceae NOEL, 1965

Definition

Elliptical coccoliths with a podorhabdid rim.

Subfamily Podorhabdoideae, new subfamily

Diagnosis

Elliptical coccoliths with a podorhabdid rim and four or more radial bars supporting a central stem.

Genus *Podorhabdus* NOEL, 1965

Type: *Podorhabdus grassei* NOEL, 1965

Definition

Coccoliths with a podorhabdid rim and a central stem supported by four bars.

Podorhabdus (?) *rahla* NOEL
Plate II, Figure 9

1965b *Podorhabdus rahla* NOEL, Pl. 9, Fig. 8, p. 105.

Remarks

This species is recognized by the appearance of the stem in side view. At a height above the base approximately equal to the diameter of the base, four broad and short

projections extend outward from the stem. NOEL did not figure the plan view of this species, but in the Oxfordian material, it has been noted that it may have four or six supporting arms. Transitional forms have two additional small openings added in the ends of the elliptical base. Observation of the base is frequently hampered by the large projections of the stem. According to the definitions of the genera proposed by NOEL, some of the four-armed specimens of this species should belong to *Podorhabdus*, and the six-armed specimens to *Hexapodorhabdus*.
Hypotype: 27.2.1
Dimensions: length approximately 18 μm.

Podorhabdus cylindratus Noel
Plate III, Figure 1, 2

1965a *Podorhabdus cylindratus* NOEL, Fig. 30, p. 6 [invalid].
1965b *Podorhabdus cylindratus* NOEL, Fig. 30, Pl. 9, Fig. 3, 7, p. 103–104.
1968 *Podorhabdus cylindratus* NOEL, BLACK, Pl. 150, Fig. 1, p. 806.

Remarks

This species is distinguished from *Podorhabdus grassei* NOEL, 1965, by having a relatively narrower stem.
Hypotypes: 31.10.2, 32.10.1
Dimensions: length 6.0 μm, width 5.1 μm

Genus *Hexapodorhabdus* NOEL, 1965

Type: *Hexapodorhabdus cuvillieri* NOEL, 1965.

Definition

Coccoliths with a podorhabdid rim and a stem supported by six bars.

Hexapodorhabdus cuvillieri NOEL
Plate III, Figure 3

1965b *Hexapodorhabdus cuvillieri* NOEL, Pl. 9, Fig. 4–6, p. 105–106.

Remarks

This is the only species of *Hexapodorhabdus* described by NOEL, and is recognized in top view only. There is no way of differentiating six-rayed specimens of *Podorhabdus rahla*, from which the upper part of the stem has been broken away, from specimens of *Hexapodorhabdus cuvillieri*.
Hypotype: 33.9.1
Dimensions: length 5.2 μm, width 4.0 μm

Genus *Octopodorhabdus* NOEL, 1965

Type: *Octopodorhabdus praevisus* NOEL, 1965.

Definition

Coccoliths with a podorhabdid rim and a stem supported by eight bars.

Octopodorhabdus decussatus (MANIVIT) new combination
Plate III, Figure 4

1959 [1961] *Discolithus decussatus* MANIVIT, Pl. 1, Fig. 7, p. 14.
1963 *Rhabdolithus decussatus* (MANIVIT), STRADNER, Pl. 5, Fig. 8–8a, p. 9.

Remarks

This species differs from the type of the genus in having arms which lie in the major and minor axis of the ellipse. The other four arms do not extend from the center margin, but join the longitudinal bar near the foci of the ellipse.
Hypotype: 28.3.1.
Paratypes: 30.8.1, 35. 3.1.
Dimensions: length approximately 7 μm, width 5.6 μm.

Genus *Polypodorhabdus* NOEL, 1965

Type: *Polypodorhabdus escaigi* NOEL, 1965

Definition

Coccoliths with a podorhabdid rim, a stem, and many bars in the central area.

Polypodorhabdus escaigi NOEL
Plate III, Figures 5, 6

1965a *Polypodorhabdus escaigi* NOEL, Fig. 32, p. 6.
1965b *Polypodorhabdus escaigi* NOEL, NOEL, Fig. 32, Pl. 10, Fig. 6–8, p. 109–110.

Remarks

Oxfordian specimen have bars in the major and minor axes of the ellipse, bars in the equal axis of the ellipse, and two additional pairs of bars extending from the mid-lengths of the major and minor axes to the margin. The stem is prominent in many specimens. NOEL's specimens from Niort show an extra pair of bars extending from that in the major axis to the margin in the ends of the ellipse.
Hypotypes: 27.3.1, 27.10.2
Dimensions: length 6.7 μm, width 5.0 μm.

Subfamily Ethmorhabdoideae, new subfamily

Diagnosis

Coccoliths with a podorhabdid rim and a solid or cribrate center.

Remarks

In addition to the type genus, *Cretarhabdus* BRAMLETTE & MARTINI, 1964, and *Rhagodiscus* REINHARDT, 1967, belong here.

Genus *Ethmorhabdus* NOEL, 1965

Type: *Ethmorhabdus gallicus* NOEL, 1965

Definition

Coccoliths with a podorhabdid rim and a cribrate center.

Ethmorhabdus gallicus NOEL
Plate III, Figure 7

1965 a *Ethmorhabdus gallicus* NOEL, Fig. 33–34, p. 6.
1965 b *Ethmorhabdus gallicus* NOEL, NOEL, Fig. 33–34, Pl. 10, Fig. 1–2, 5, p. 110–112.
1968 *Ethmorhabdus gallicus* NOEL, BLACK, Pl. 150, Fig. 3, p. 806.

Remarks

Specimens from the British Callovian and Oxfordian closely resemble the holotype.
Hypotype: 33.2.1
Dimensions: length 6.6 μm, width 4.9 μm

Ethmorhabdus anglicus, new species
Plate III, Figure 8

Diagnosis

A species of *Ethmorhabdus* with only two cycles of large perforations.

Description

Elliptical podorhabdid coccoliths with two cycles of perforations, the outer cycle with about 16 openings, the inner cycle with about 8. The openings are polygonal, about 0.5 μm in diameter. A central stem is present.

Differentiation

This species is distinguished from *E. gallicus* NOEL by having only about half as many perforations.

Remarks

The species was named *anglicus* because of its occurrence in England.
Holotype: 36.11.1
Paratype: 32.1.2
Dimensions: length 5.0 μm, width 4.1 μm
Type locality: Millbrook (Bedfordshire)
Type level: *mariae* zone - *scarburgense* subzone (4780)

Subfamily Sollasiteoideae, new subfamily

Diagnosis

Elliptical coccoliths with a podorhabdid rim, a transverse bar, and three or more longitudinal or sublongitudinal bars. No central stem is present.

Genus *Sollasites* BLACK, 1967

Type: *Sollasites barringtonensis* BLACK, 1967 (= *Coccolithus horticus* STRADNER, ADAMIKER, and MARESCH, 1966)

Synonyms

Costacentrum BUKRY, 1969, subjective junior synonym with *Coccolithus horticus* STRADNER, AKADEMIKER & MARESCH, 1966, as type.

Definition

Elliptical coccoliths with a podorhabdid rim, a transverse bar, and three or more longitudinal to sublongitudinal bars.

Sollasites horticus (STRADNER, ADAMIKER & MARESCH)
Plate III, Figure 9

1966 *Coccolithus horticus* STRADNER, ADAMIKER & MARESCH, Pl. 2, Fig. 4, p. 337.
1967 *Sollasites barringtonensis* BLACK, Fig. 4, p. 144.
1968 *Coccolithus horticus* STRADNER, ADAMIKER & MARESCH, GARTNER, Pl. 10, Fig. 2, Pl. 25, Fig. 6–8, Pl. 26, Fig. 1, p. 18.
1968 *Sollasites horticus* (STRADNER, ADAMIKER & MARESCH) BLACK, Pl. 144, Fig. 1–2, p. 798.
1969 *Costacentrum horticum* (STRADNER, ADAMIKER & MARESCH) BUKRY, Pl. 21, Fig. 12, Pl. 22, Fig. 1–4, p. 44.
1969 *Sollasites horticus* (STRADNER, ADAMIKER & MARESCH) ČEPEK & HAY, p. 325.

Remarks

This species is distinguished by having three parallel longitudinal bars.
Hypotype: 28.8.2
Dimensions: length 2.9 μm, width 2.4 μm

Sollasites lowei (BUKRY) new combination
Plate IV, Figure 1

1969 *Costacentrum lowei* BUKRY, Pl. 22, Fig. 5–6, p. 44.

Remarks

This species has a central straight longitudinal bar flanked by two curved sublongitudinal bars which join the central bar at its outer extremities.
Hypotype: 29.8.2
Dimensions: length 4.5 μm, width 3.3 μm

Sollasites concentricus, new species
Plate IV, Figure 2

Diagnosis

A species of *Sollasites* with a straight longitudinal bar flanked by four curved sublongitudinal bars.

Description

The central area is large, and the transverse bar is wide. The central longitudinal bar is straight. The four curved sublongitudinal bars remain equidistant from the marginal rim, and join the straight longitudinal bar at regular spaced intervals.

Differentiation

This species differs from *S. lowei* BUKRY in having four rather than two sublongitudinal bars.

Remarks

The diagnostic concentric arrangement of the bars suggests this species name.
Holotype: 27.8.2
Dimensions: length 2.3 μm, width 1.7 μm
Type locality: Millbrook (Bedfordshire)
Type level: *mariae* zone - *praecordatum* subzone (4941)

Sollasites bipolaris, new species

Plate IV, Figure 3

Diagnosis

A species of *Sollasites* with two pairs of concentric bars surrounding the foci of the elliptical central area.

Description

The central structure consists of a transverse bar which expands towards the margin, but may not be complete at the center. In each end of the coccolith, symmetrical about the foci of the elliptical central area, are two concentric curved bars. The inner pair of concentric bars forms a figure 8, the outer pair a more open figure.

Remarks

The arrangement of the central bars resembles a bipolar magnetic field, hence the name *bipolaris*.

Differentiation

The bipolar nature of the bars of this species serves to distinguish it readily from other members of the genus.

Holotype: 27.6.1

Paratypes: 28.13.1, 32.12.2

Dimensions: length 3.0 μm, width 2.0 μm

Type locality: Millbrook (Bedfordshire)

Type level: *mariae* zone - *praecordatum* subzone (4941)

Subfamily Paleopontosphaeroideae, new subfamily

Diagnosis

Elliptical coccoliths with a wide podorhabdid rim and a narrow central area lacking prominent bars, but with a central spine commonly present.

Genus *Paleopontosphaera* NOEL, 1965

Type: *Paleopontosphaera dubia* NOEL, 1965.

Definition

Elliptical coccoliths with a wide podorhabdid rim and no supplementary cycles of elements around the central depression of the distal shield.

Paleopontosphaera dubia NOEL

Plate IV, figure 9

1965a *Paleopontosphaera dubia* NOEL, Fig. 8, p. 4.

1965b *Paleopontosphaera dubia* NOEL, NOEL, Fig. 8, Pl. 7, Figs. 1–13, pp. 76–78.

Remarks

Specimens investigated in this study frequently have a short knob or spine in the center of the depression in the distal shield.

Hypotype: 28.9.2

Dimensions: length 3.1 μm, width 2.5 μm

Family Prediscosphaeraceae, new family

Diagnosis

Circular coccoliths with a podorhabdid rim.

Remarks

BLACK (1967) proposed a Family *Deflandriaceae* including the single genus *Deflandrius* BRAMLETTE & MARTINI 1964. *Deflandrius* is here regarded as a synonym of *Prediscosphaera* VEKSHINA, 1959. The family name proposed here is not a *nomen substitutum* for the Family *Deflandriaceae* of BLACK, but is more broadly defined and includes several genera.

Subfamily Prediscosphaeroideae GARTNER, 1968, emended.

Diagnosis

Circular coccoliths with four buttresses supporting a square stem constructed of a few long laths.

Remarks

The original definition of this subfamily corresponds closely to the current definition of the Order *Podorhabdinales*. The emended definition of the subfamily indicated above corresponds to the definition of the Family *Deflandriaceae* BLACK. The genus *Prediscosphaera* VEKSHINA is the sole member of this subfamily as emended; it is not known to range below the Albian.

Subfamily Discorhabdoideae NOEL, 1965

Diagnosis: Circular coccoliths with a circular stem constructed of many short laths.
Ramarks: A single genus, *Discorhabdus* NOEL, 1965, is referred to this family.

Genus *Discorhabdus* NOEL, 1965

Type: *Rhabdolithus patulus* (DEFLANDRE), 1954.

Definition

Coccoliths with a circular podorhabdid bar and a circular stem constructed of numerous small laths.

Remarks

The species of this genus are distinguished by the shape and size of the stem as seen in side view.

Discorhabdus patulus (DEFLANDRE)

Plate IV, Figure 4

1954 *Rhabdolithus patulus* DEFLANDRE in DEFLANDRE & FERT, Fig. 97–98, Pl. 15, Fig. 40–45, p. 163.
1965a *Discorhabdus patulus* (DEFLANDRE), NOEL, Fig. 55–57, p. 10.
1965b *Discorhabdus patulus* (DEFLANDRE), NOEL, Fig. 55–57, Pl. 21, Fig. 6–8, 10–11, Pl. 22, Fig. 1–2, 7, 9–10, p. 141–144.

Remarks

Diagnostic for this species is the moderately thick stem which flares slightly distally.
Hypotype: 32.7.2.
Dimensions: Stem length 4.6 μm

Discorhabdus jungi NOEL
Plate IV, Figures 5, 6

1965b *Discorhabdus jungi* NOEL, Pl. 22, Fig. 5, p. 144–145.

Remarks

The stem of this species is thicker than in *D. patulus*, and flares distally to become almost as wide as the base.
Hypotypes: 6.1.2., 25.7.1.
Dimensions: Diameter of base, 10 μm

Discorhabdus tubus NOEL
Plate IV, Figure 7

1965b *Discorhabdus tubus* NOEL, Pl. 21, Fig. 4, 15, p. 145–146.

Remarks

The diagnostic features of this species are the long slender cylindrical stem which does not flare distally.
Hypotype: 28.6.1.
Dimensions: Diameter of base, 9.5 μm

Discorhabdus sp.
Plate IV, Figure 8

Remarks

Isolated bases of *Discorhabdus* are not yet assignable to the species recognized above.
Hypotype: 33.12.1.
Dimensions: Diameter 3.5 μm.
Type Locality: Millbrook (Bedfordshire)
Type Level: *transversarium* zone (4959)

Order COCCOLITHALES, new order

Diagnosis

Coccoliths with a marginal area constructed of three cycles of elements; two cycles extend outward peripherally to form proximal and distal shields, connected by an intermediate cycle forming a tube or girdle (coccolithid rim).

Family Watznaueriaceae, nom. subst.

Definition

Elliptical or circular coccolithids having a coccolithid rim with crystallites oriented so that both shields produce an interference figure between crossed polarizers.

Remarks

NOEL (1965) proposed a Family *Ellipsagelosphaeraceae*, but because *Ellipsagelosphaera* NOEL,1965, is a junior subjective synonym of *Watznaueria* REINHARDT, 1964, the taxon *Watznaueriaceae* is proposed as a replacement. The genera *Actinosphaera* NOEL, 1965, and *Calolithus* NOEL, 1965, are here regarded as fragments of *Watznaueria* and hence junior subjective synonyms, so that neither the Subfamily *Actinosphaeroideae* NOEL, 1965, nor the Subfamily *Ellipsagelosphaeroideae* NOEL, 1965, is recognised.

Genus *Watznaueria* REINHARDT, 1964

Type: *Watznaueria angustoralis* REINHARDT, 1964

Synonyms

Colvillea BLACK, 1964 (homonym of *Colvillea* BOJER & HOOKER, 1834) subjective senior synonym because the type, *Tremalithus barnesae* BLACK, 1966 is probably conspecific with *W. angustoralis*; *Maslovella* LOEBLICH & TAPPAN, 1966, nomen. subst. pro *Colvillea* BLACK with the same type, subjective junior synonym; *Ellipsagelosphaera* NOEL, 1965, subjective junior synonym because the type, *Ellipsagelosphaera frequens*, NOEL, 1965, is closely related to *W. angustoralis; Actinosphaera* NOEL, 1965, subjective junior synonym because the type, *Actinosphaera deflandrei* NOEL, 1965, is a *Watznaueria* from which the central cycle of elements on the distal shield has been removed; *Calolithus* NOEL, 1965, subjective junior synonym because the type, *Calolithus martelae* NOEL, 1965, is based on a fragment of a species of *Watznaueria.*

Definition

Elliptical coccoliths with a coccolithid rim and one or more supplementary cycles of elements in the central area of the distal shield.

Watznaueria communis REINHARDT

Plate V, Figures 1, 2, 3, 4

1964 *Watznaueria communis* REINHARDT, Pl. 2, Fig. 5, p. 756.
1965a *Ellipsagelosphaera frequens* NOEL, Fig. 35–39, 42, p. 8.
1965b *Ellipsagelosphaera frequens* NOEL, NOEL, Fig. 35–40, Pl. 11, Fig. 7–10, Pl. 12, Fig. 1–10, Pl. 13, Fig. 1–10, p. 119–126.
1966 *Watznaueria communis* REINHARDT, Fig. 3, Pl. 4, Fig. 3, 5–6, Pl 23, Fig 5, p 17–18

Remarks

This is the most abundant species in all the samples studied. It is distinguished by the relatively small central area.
Hypotypes: 15.8.1, 11.8.1., 29.10.2.
Dimensions: length typically 5.0 μm, width typically 4.0 μm

Watznaueria britannica (STRADNER)

Plate V, Figure 5

1963 *Coccolithus britannicus* STRADNER, Pl 1, Fig 7–7a, p 10
1964 *Watznaueria britannica* (STRADNER) REINHARDT, Fig. 5, Pl 2, Fig 3, p 753
1965a *Ellipsagelosphaera lucasi* NOEL, Fig. 40–41, p 8.
1965b *Ellipsagelosphaera lucasi* NOEL, NOEL (pars), Fig. 41–42, Pl. 11, Fig. 1–3, 5, 6, p. 126–129.
1966 *Watznaueria britannica* (STRADNER) REINHARDT, REINHARDT, Fig. 4a–b, Pl. 4, Fig. 7a–b, p. 17.

Remarks

The type of *Ellipsagelosphaera lucasi* Noel closely resembles the type of *W. britannica* and two are here regarded as conspecific. This species is distinguished by a large central opening by a brige in the minor axis of the ellipse.
Hypotype: 20.9.1.
Dimensions: length 7.0 μm, width 6.0 μm.

Watznaueria reinhardti, new species

Plate V, Figure 6

1965b *Ellipsagelosphaera lucasi* NOEL (pars), Pl. 11, Fig. 4, p. 126–129.

Diagnosis

A species of *Watznaueria* with a very large central opening spanned by a bridge in the minor axis.

Description

The rim is unusually narrow, and the central opening very large. The bar in the minor axis bifurcates as it joins the rim.
Differentiation: The relative proportions of the width of the rim and large central opening distinguish this species from *W. britannica* (STRADNER).
Holotype: 33.4.1.
Paratype: 28.10.1
Dimensions: length 4.7 μm, width 4.1 μm.
Type Locality: Millbrook (Bedfordshire).
Type Level: *cordatum* zone - *bukowskii* subzone (4945).

Watznaueria sp.

Plate V, Fig. 7.

Remarks

A species of *Watznaueria* in which the major and minor axes are almost equal in size. The relatively small central opening, typical of *Watznaueria communis* (REINHARDT), is spanned by a delicate bridge.
Hypotype: 33.5.1
Dimensions: length 5.6 μm, width 5.0 μm.
Type Locality: Millbrook (Bedfordshire).
Type Level: *cordatum* zone – *bukowskii* subzone (4945).

Genus *Cyclagelosphaera* NOEL, 1965

Type: *Cyclagelosphaera margereli* NOEL, 1965

Definition

Circular coccoliths with a coccolithid rim and one or more supplementary cycles of elements in the central area of the distal shield.

Cyclagelosphaera margereli NOEL, 1965

Plate V, Figures 8, 9

1965a *Cyclagelosphaera margereli* NOEL, Fig. 45–48, p. 12.
1965b *Cyclagelosphaera margeli* NOEL, NOEL, Fig. 44–46, Pl. 17, Fig. 4–9, Pl. 18, Fig. 1, 2, Pl. 20, Fig. 2–4, p. 130–132.
1968 *Cyclagelosphaera margereli* NOEL, BLACK, Pl. 144, Fig. 5, p. 798.

Remarks

A circular coccolith falling within the Family *Watznaueriaceae*. The innermost cycle of elements often closes the central tube.

Hypotypes: 34.7.2, 11.10.2

Dimensions: Diameter typically 4 μm.

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Plate I*

Fig. 1 — *Vekshinella quadriarcullus* (NOEL), distal side
Hypotype 34.6.1
Millbrook (Bedfordshire); *transversarium* zone (4971)
15,900 ×

Fig. 2 — *Vekshinella stradneri*, n. sp., distal side
Holotype 34.5.1
Millbrook (Bedfordshire); *transversarium* zone (4971)
15,600 ×

Fig. 3 — *Zeugrhabdotus erectus* (DEFLANDRE), distal side
Hypotype 26.3.2
Millbrook (Bedfordshire); *mariae* zone – *scarburgense* subzone (4932)
11,900 ×

Fig. 4 — *Zeugrhabdotus noeli*, n. sp., distal side
Holotype 34.9.1
Millbrook (Bedfordshire); *transversarium* zone (4971)
18,300 ×

Fig. 5 — *Zeugrhabdotus salillum* (NOEL), distal side
Hypotype 24.4.2
Millbrook (Bedfordshire); *athleta* zone (4789)
12,400 ×

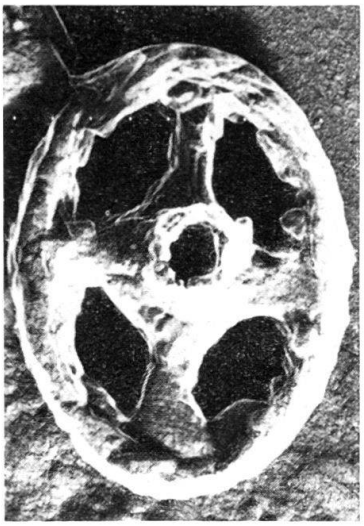
Fig. 6 — *Actinozygus geometricus* (GORKA), distal side
Hypotype 28.6.2
Millbrook (Bedfordshire); *cordatum* zone – *bukowskii* subzone (4948)
16,600 ×

Fig. 7 — *Diadozygus asymmetricus*, n. gen., n. sp., distal side
Holotype 24.5.1
Millbrook (Bedfordshire); *athleta* zone (4789)
13,400 ×

Fig. 8 — *Diadozygus callomoni*, n. gen., n. sp., proximal side
Holotype 31.1.1
Tidmoor Point (Dorsetshire); *lamberti* zone (4653)
14,900 ×

Fig. 9 — *Diadozygus rotatus*, n. gen., n. sp., distal side
Holotype 30.9.2
Millbrook (Bedfordshire); *lamberti* zone (4771)
11,400 ×

* Plates I–V, are electron micrographs of platinum-shadowed carbon replicas.



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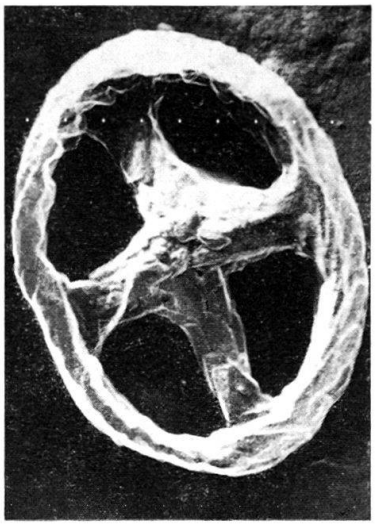

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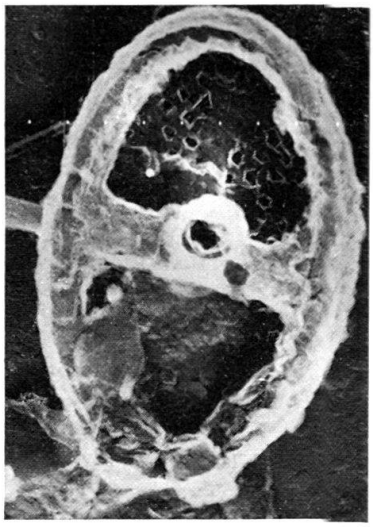

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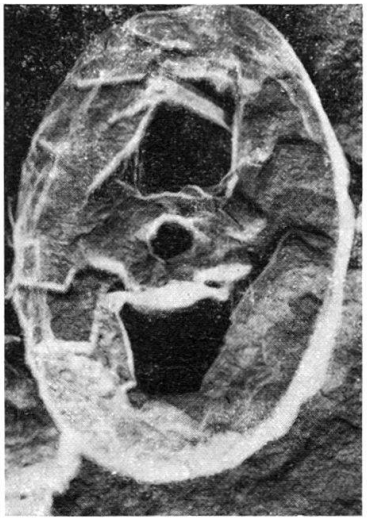

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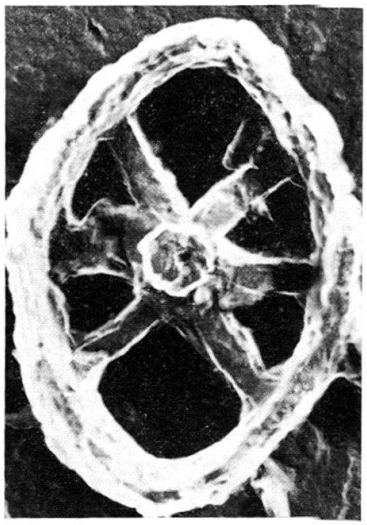

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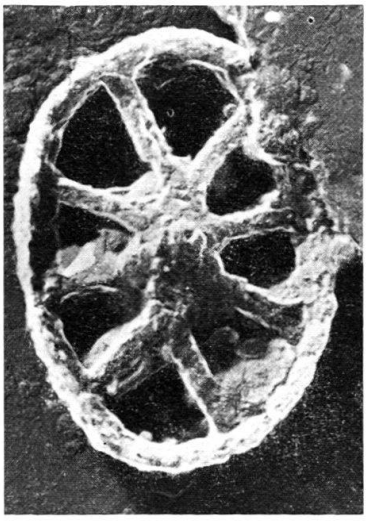

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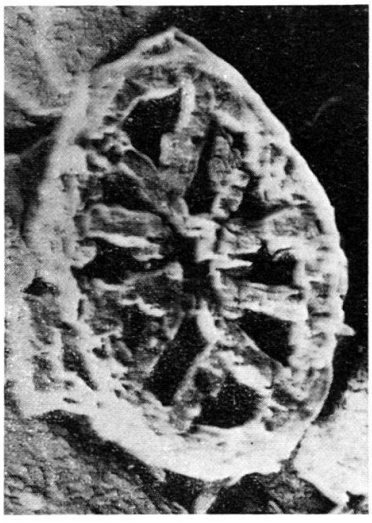

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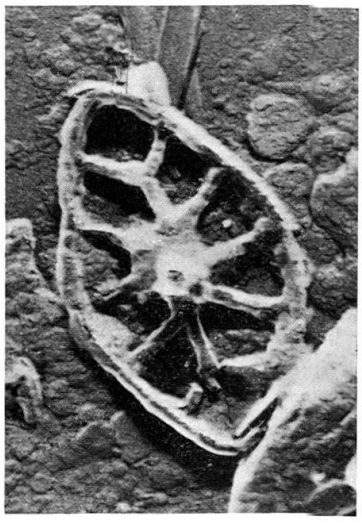

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Plate II

Fig. 1 *Diadozygus rotatus*, n. gen., n. sp., oblique view.
Holotype 29.2.2
Millbrook (Bedfordshire); *lamberti* zone (4771)
4,500 ×

Fig. 2 *Diadozygus dorsetense*, n. gen., n. sp., distal side
Holotype 27.3.2
Redcliff Point (Dorsetshire); *mariae* zone – *praecordatum* subzone (4659)
19,000 ×

Fig. 3 *Diadozygus dorsetense*, n. gen., n. sp., proximal side
Holotype 29.11.1
Redcliff Point (Dorsetshire); *mariae* zone – *praecordatum* subzone (4659)
18,000 ×

Fig. 4 *Truncatoscaphus delftensis* (STRADNER and ADAMIKER), distal side
Hypotype 27.11.2
Millbrook (Bedfordshire); *mariae* zone – *praecordatum* subzone (4941)
17,800 ×

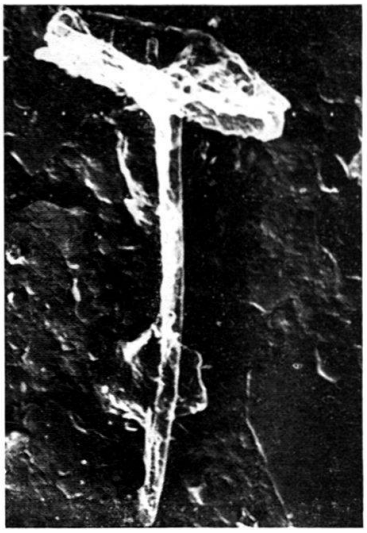
Fig. 5 *Truncatoscaphus delftensis* (STRADNER and ADAMIKER), oblique view
Hypotype 25.8.2
Millbrook (Bedfordshire); *mariae* zone – *praecordatum* subzone (4941)
18,000 ×

Fig. 6 *Diadorhombus minutus*, n. gen., n. sp., distal side
Holotype 26.11.1
Millbrook (Bedfordshire); *mariae* zone (4932)
20,300 ×

Fig. 7 *Crepidolithus crassus* (DEFLANDRE), plan view
Hypotype 27.5.1
Millbrook (Bedfordshire); *mariae* zone – *praecordatum* subzone (4941)
4,000 ×

Fig. 8 *Stephanolithion bigoti* DEFLANDRE, distal side
Hypotype 38.7.2
Millbrook (Bedfordshire); *cordatum* zone – *costicardia* subzone (4952)
4,800 ×

Fig. 9 *Podorhabdus rahla* NOEL, oblique view
Hypotype 27.2.1
Millbrook (Bedfordshire); *mariae* zone – *praecordatum* subzone (4936)
3,800 ×



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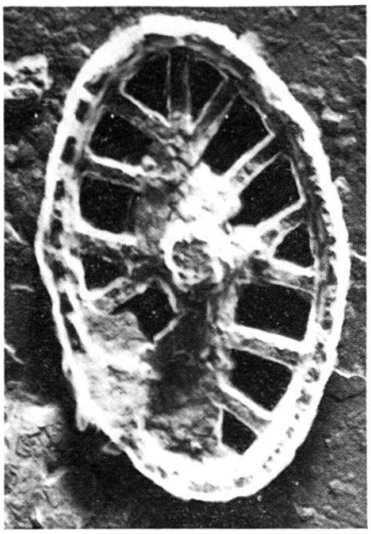

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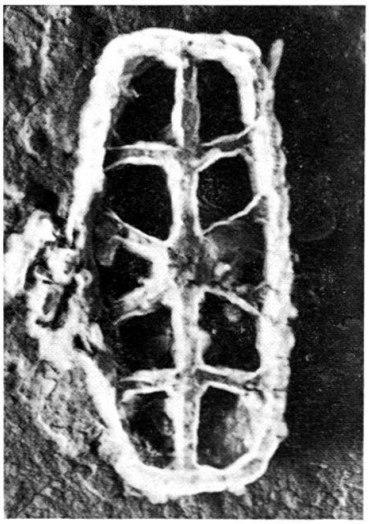

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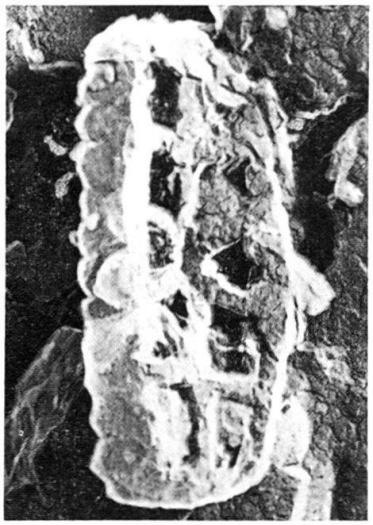

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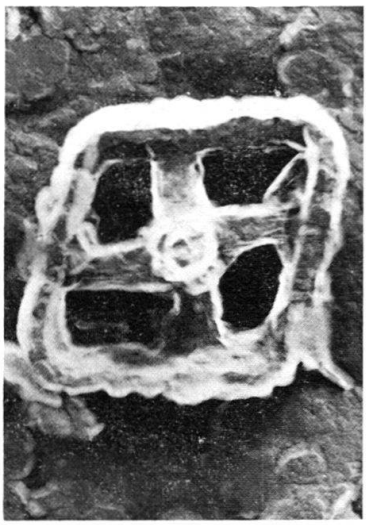

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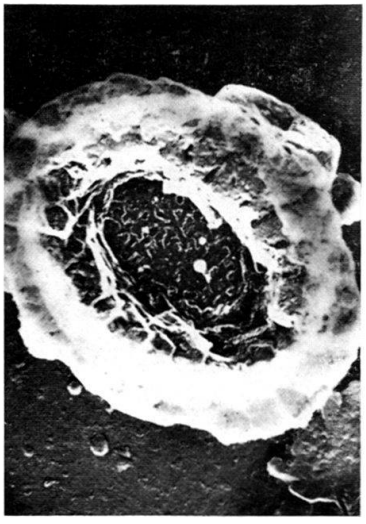

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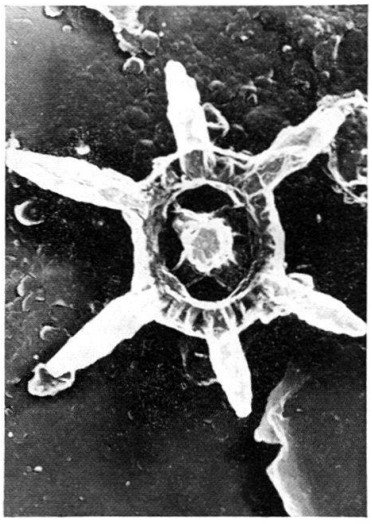

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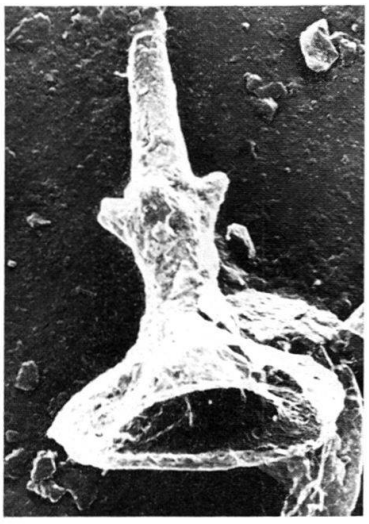

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Plate III

Fig. 1 — *Podorhabdus cylindratus* NOEL, distal side
Hypotype 31.10.2
Millbrook (Bedfordshire); *athleta* zone (4781)
6,300 ×

Fig. 2 — *Podorhabdus cylindratus* NOEL, distal side
Hypotype 32.10.1
Millbrook (Bedfordshire); *mariae* zone – *praecordatum* subzone (4941)
8,000 ×

Fig. 3 — *Hexapodorhabdus cuvillieri* NOEL, distal side
Hypotype 33.9.1
Millbrook (Bedfordshire); *cordatum* zone – *bukowskii* subzone (4945)
9,800 ×

Fig. 4 — *Octopodorhabdus decussatus* (MANIVIT), oblique proximal view
Hypotype 28.3.1
Millbrook (Bedfordshire); *mariae* zone – *praecordatum* subzone (4943)
3,700 ×

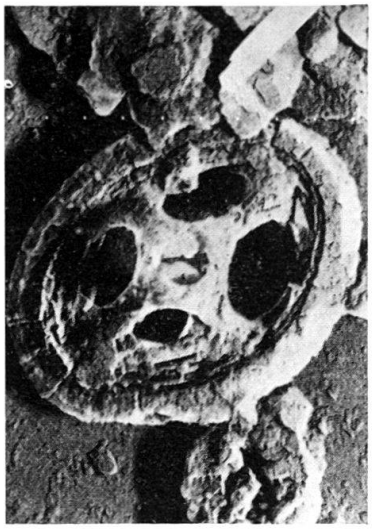
Fig. 5 — *Polypodorhabdus escaigi* NOEL, distal side
Hypotype 27.10.2
Millbrook (Bedfordshire); *cordatum* zone – *bukowskii* subzone (4945)
13,000 ×

Fig. 6 — *Polypodorhabdus escaigi* NOEL, proximal side
Hypotype 27.3.1
Millbrook (Bedfordshire); *cordatum* zone – *bukowskii* subzone (4945)
13,000 ×

Fig. 7 — *Ethmorhabdus gallicus* NOEL, distal side
Hypotype 33.2.1
Millbrook, (Bedfordshire); *cordatum* zone – *bukowskii* subzone (4945)
8,100 ×

Fig. 8 — *Ethmorhabdus anglicus* n. sp., proximal side
Holotype 36.11.1
Millbrook (Bedfordshire); *mariae* zone – *scarburgense* subzone (4780)
10,100 ×

Fig. 9 — *Sollasites horticus* (STRADNER, ADAMIKER, MARESCH) proximal side
Hypotype 28.8.2
Millbrook (Bedfordshire); *cordatum* zone – *bukowskii* subzone (4945)
19,200 ×



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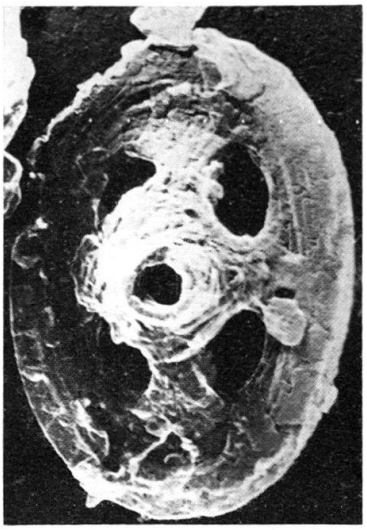

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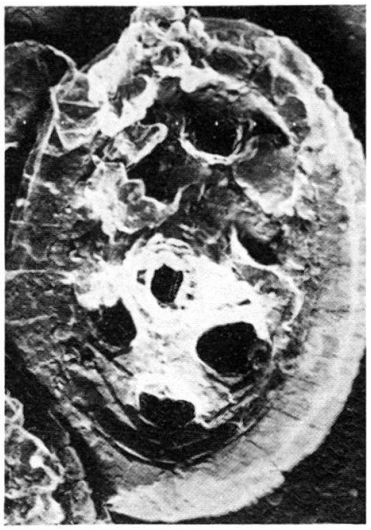

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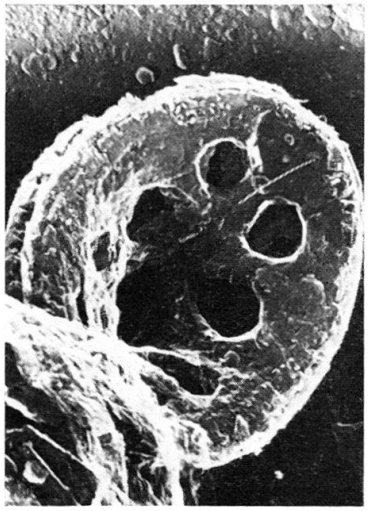

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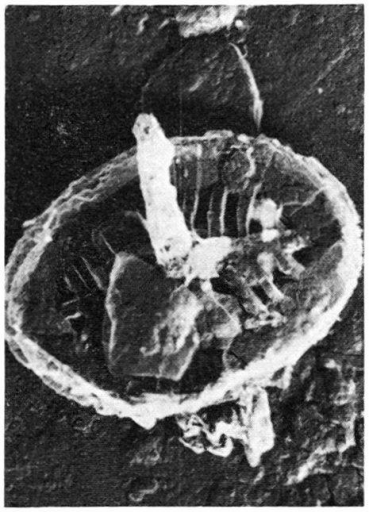

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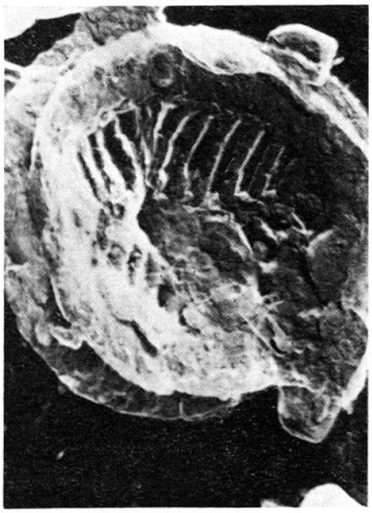

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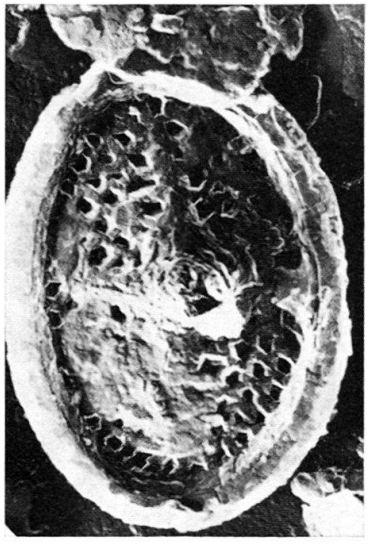

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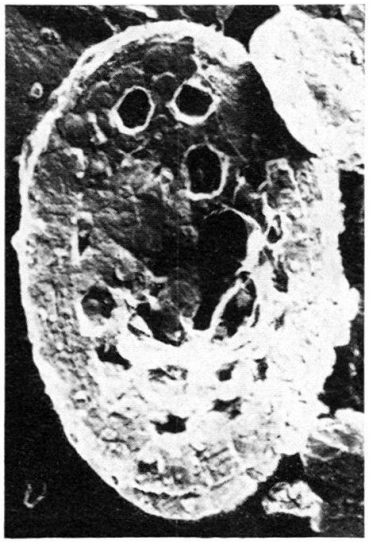

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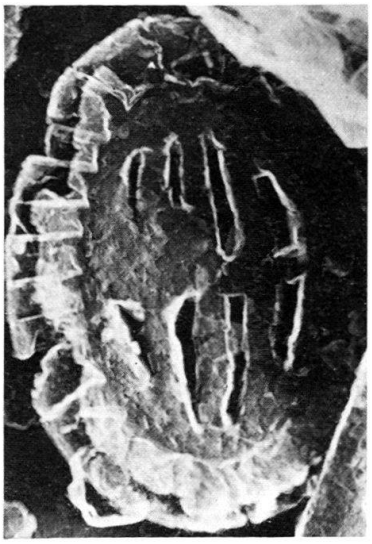

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Plate IV

Fig. 1 *Sollasites lowei* (BUKRY), distal side
Hypotype 29.8.2
Millbrook (Bedfordshire); *transversarium* zone (4959)
11,400 ×

Fig. 2 *Sollasites concentricus*, n. sp., proximal side
Holotype 27.8.2
Millbrook (Bedfordshire); *mariae* zone – *praecordatum* subzone (4941)
17,000 ×

Fig. 3 *Sollasites bipolaris*, n. sp., proximal side
Holotype 27.6.1
Millbrook (Bedfordshire); *mariae* zone – *praecordatum* subzone (4941)
13,500 ×

Fig. 4 *Discorhabdus patulus* (DEFLANDRE), coccosphere fragment. viewed obliquely
Hypotype 32.7.2
Millbrook (Bedfordshire); *mariae* zone – *praecordatum* subzone (4941)
4,500 ×

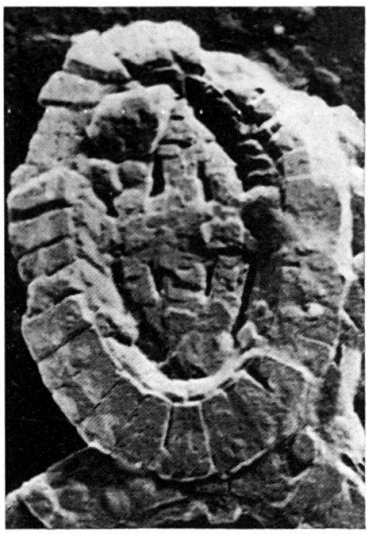
Fig. 5 *Discorhabdus jungi* NOEL, axial view
Hypotype 6.1.2
Millbrook (Bedfordshire); *mariae* zone – *scarburgense* subzone (4920)
4,800 ×

Fig. 6 *Discorhabdus jungi* NOEL, oblique view
Hypotype 25.7.1
Millbrook (Bedfordshire); *mariae* zone – *scarburgense* subzone (4920)
3,300 ×

Fig. 7 *Discorhabdus tubus* NOEL, oblique view
Hypotype 28.6.1
Millbrook (Bedfordshire); *cordatum* zone – *bukowskii* subzone (4948)
3,400 ×

Fig. 8 *Discorhabdus* sp., proximal view
Hypotype 33.12.1
Millbrook (Bedfordshire); *transversarium* zone (4959)
12,200 ×

Fig. 9 *Paleopontosphaera dubia* (NOEL), distal side
Hypotype 28.9.2
Millbrook (Bedfordshire); *mariae* zone – *praecordatum* subzone (4941)
14,700 ×



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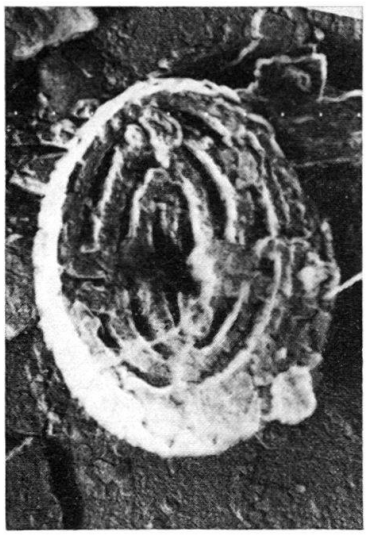

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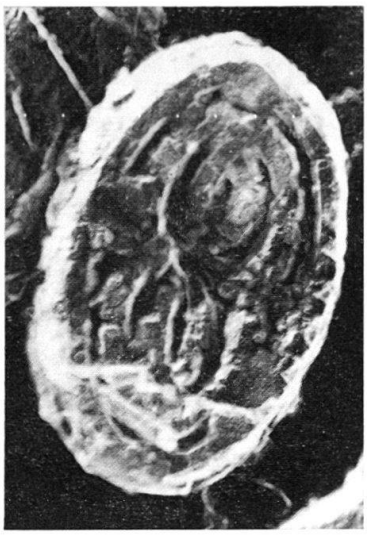

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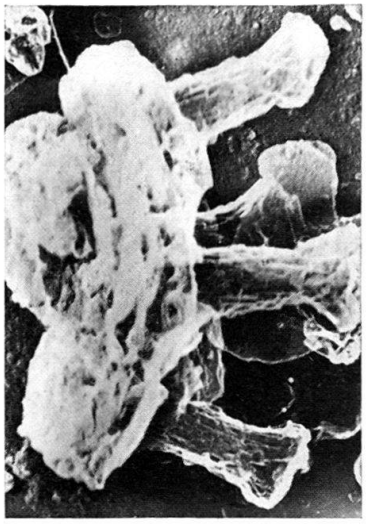

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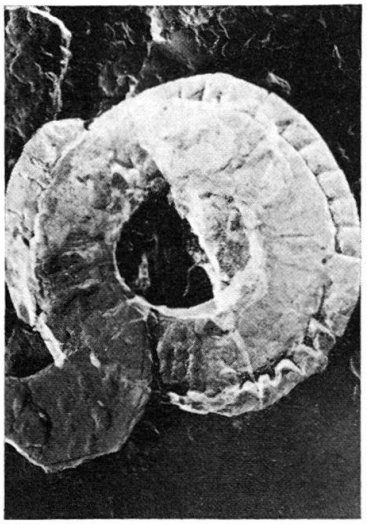

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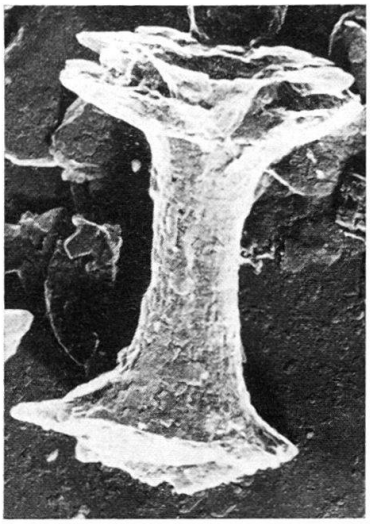

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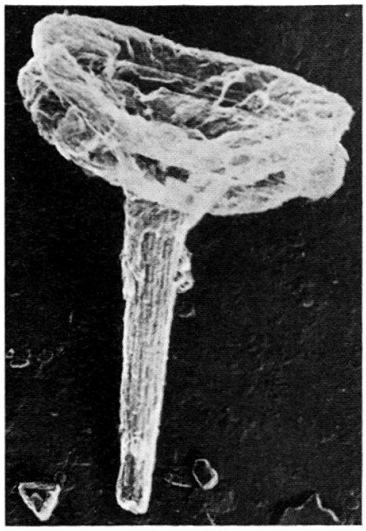

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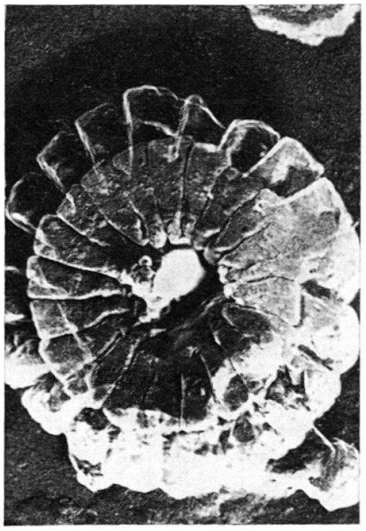

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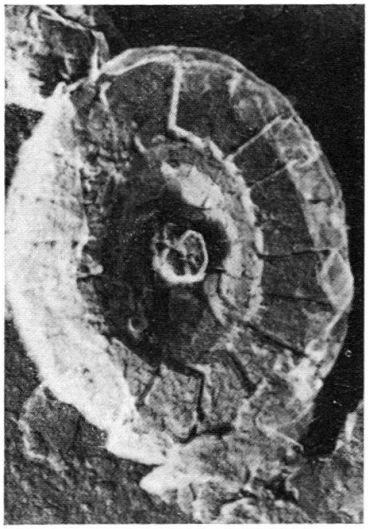

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Plate V

Fig. 1 *Watznaueria communis* REINHARDT, distal side; inner cycle of platlets missing
Hypotype 15.18.1
Jordan Cliff (Dorsetshire); *mariae* zone – *praecordatum* subzone (4657)
5,500 ×

Fig. 2 *Watznaueria communis* REINHARDT, proximal side
Hypotype 11.8.1
Jordan Cliff (Dorsetshire); *mariae* zone – *praecordatum* subzone (4654)
9,800 ×

Fig. 3 *Watznaueria communis* REINHARDT, distal side
Hypotype 28.7.1
Millbrook (Bedfordshire); *transversarium* zone (4971)
7,400 ×

Fig. 4 *Watznaueria communis* REINHARDT, proximal side
Hypotype 29.10.2
Millbrook (Bedfordshire); *transversarium* zone (4971)
8,000 ×

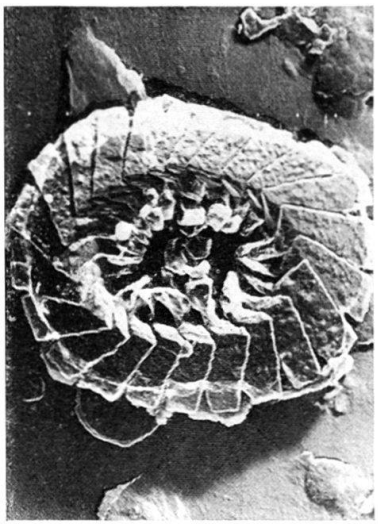
Fig. 5 *Watznaueria britannica* (STRADNER), distal side
Hypotype 20.9.1
Redcliff Point (Dorsetshire); *mariae* zone – *praecordatum* (4660)
5,800 ×

Fig. 6 *Watznaueria reinhardti*, n. sp., distal side
Hypotype 33.4.1
Millbrook (Bedfordshire); *cordatum* zone – *bukowskii* subzone (4945)
8,100 ×

Fig. 7 *Watznaueria* sp., distal side
Hypotype 33.5.1
Millbrook (Bedfordshire); *cordatum* zone – *bukowskii* subzone (4945)
7,000 ×

Fig. 8 *Cyclagelosphaera margereli* NOEL, distal side
Hypotype 34.7.2
Millbrook (Bedfordshire); *transversarium* zone (4971)
8,500 ×

Fig. 9 *Cyclagelosphaera margereli* NOEL, distal side
Hypotype 11.10.2
Jordan Cliff (Dorsetshire); *mariae* zone – *praecordatum* subzone (4654)
8,000 ×



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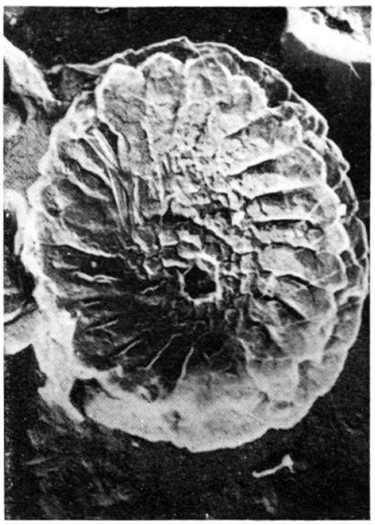

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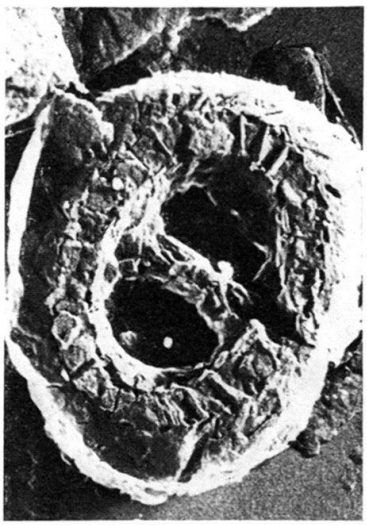

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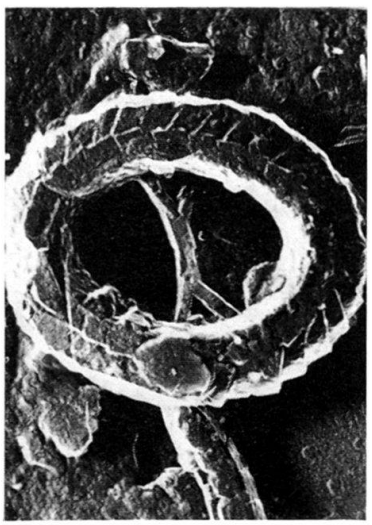

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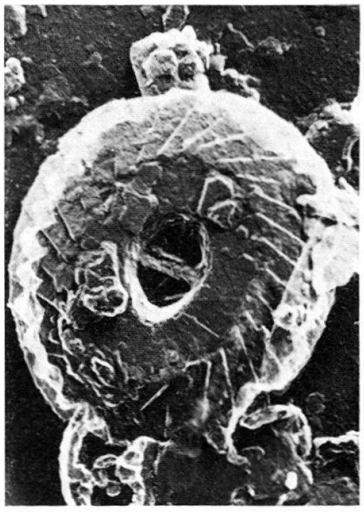

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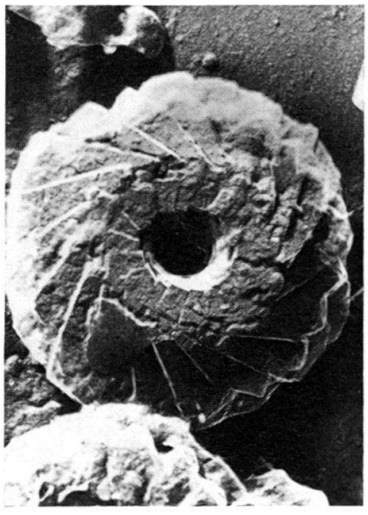

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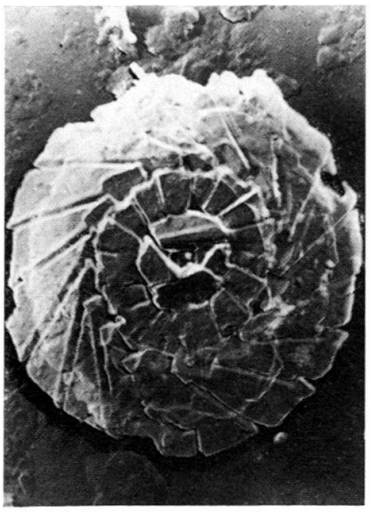

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