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Autor: Barnard, Tom / Hay, William W.

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2 figures in the text and 3 tables and 6 plates Basle, Dec. 1974

On Jurassic Coccoliths: A tentative zonation of the Jurassic of Southern England and North France¹)

By Tom Barnard²) and William W. Hay³)

ABSTRACT

This paper presents the first attempt at an overall zonation of the Jurassic by use of coccoliths. The area chosen, Southern England, includes many of the classic localities of the Jurassic, with almost continuous sequences. Twenty-two zones are proposed and these are correlated with the existing ammonite zonation. The range zones, distribution of the assemblages and their relationship to the lithofacies are discussed.

The study has been carried out both optically and with the aid of an electron microscope.

Introduction and Review of previous Zonations of the Jurassic, using calcareous nannofossils

Although several studies have now been published on Jurassic coccoliths, they are mostly concerned with description, and taxomony of the flora, and no attempt has been made to produce a detailed overall zonation of the Jurassic.

Bronnimann (1955) utilizing nannoconids exclusively, proposed a three-fold subdivision of the latest Jurassic and earliest Cretaceous rocks, basing his study on samples collected mostly from Cuba. His one Jurassic unit was the *Nannoconus steinmanni* Zone, characterised by the abundant occurrence of that species, and the absence of other nannoconids. The age of the *Nannoconus steinmanni* Zone was considered to be "Tithonian" or Purbeckian.

STRADNER (1963) was the first to realize the stratigraphical importance of coccoliths through the whole of the Jurassic, in a general discussion on Mesozoic nannofossils. He established five divisions of the Jurassic (including Bronnimanni's Steinmanni zone), based on "associations", and limited by the first appearances of these "assemblages":

¹) Research supported by Oceanography Section, National Science Foundation Grant GA/ 31969 X.

²) Department of Micropalaeontology, University College London, Gower Street, London, W.C.1.

³) Division of Marine Geology and Geophysics, Rosenstiel School of Marine and Atmospheric Science, University of Miami, 10 Rickenbacher Causeway, Miami, Florida 33149.

Table 1

Purbeckian	"Nannoconus" Zone	Nannoconus associations related to Lower Cretaceous floras
Callovian-Portlandian	Bigoti association	Stephanolithion bigoti easily recognized in Callovian-Oxfordian
Bathonian	Decorus association	Double rimmed "trumpet" forms Rhabololithus decorus
Pliensbachian-Bajocian	Opacus association	Appearance of Discolithus crassus and Coccolithus opacus
Sinemurian	Liasicus association	Rhabdolithus liasicus

The authors, in the tables, have used the names given to the genera and species by STRADNER, NOËL, PRINS, etc., but have brought them up to date in the discussion.

Of Stradner's five zonal "associations" the oldest of these was the "Liasicus"-association, which he indicated was characterized by the presence of Schizosphaerella punctulata Deflandre and Parhabdolithus liasicus Deflandre. He listed the age of the "Liasicus"-association as Sinemurian. The next oldest assemblage was the "Opacus"-association, which was characterized by the presence of the two species of the underlying "Liasicus"-association and Discolithus crassus Deflandre and Coccolithus opacus Stradner.

Discolithus crassus is now known as Crepidolithus crassus, but the identity of Coccolithus opacus in terms of the species recognized by recent authors is uncertain. The age of "Opacus"-associations was given as Pliensbachian, Aalenian and Bajocian. The next higher assemblage was termed "Decorus"-association, and was indicated to be wholly different from those below. Four species were listed: Coccolithus britannicus Stradner, Hexalithus lecali Gardet, Discolithus asper Stradner, and Rhabdolithus decorus Deflandre. Coccolithus britannicus is now known as Watznaueria britannica; Discolithus asper may be conspecific with Ethmorhabdus gallicus Noël or Ethmorhabdus anglicus ROOD, HAY & BARNARD; "Rhabdolithus decorus" of STRADNER was a species of Discorhabdus; Hexalithus lecali was a nannofossil not readily identified with species recognized today. The age of the "Decorus"-association was given as Bathonian. The next higher assemblage was termed the "Bigoti"-association, recognized by an abundance of Stephanolithion bigoti Deflandre. Other species indicated to be present included Coccolithus britannicus, Discolithus asper, Zygolithus fibulus (LECAL) and Coccolithus pelagius (WALLICH). Specimens referred by STRADNER to Zygolithus fibulus would now be assigned to Zeugrhabdotus erectus (DEFLANDRE) or Zeugrhabdotus noeli ROOD, HAY & BARNARD. The specimens STRADNER identified as Coccolithus pelagicus are now termed Watznaueria communis REINHARDT. The age of the "Bigoti"-associations was given as Callovian, Oxfordian, Kimmeridgian and Portlandian. The highest Jurassic assemblage recognized by STRADNER was termed Nannoconus steinmanni-association, and indicated to include Discolithus asper, Coccolithus pelagicus and Parhabdolithus embergeri (Noël) in addition to Nannoconus steinmanni. The age of the Nannoconus steinmanni-association was given as Portlandian. Comments on the relation of STRADNER's "associations" with the zones recognized here is presented below in the discussion of each of the biostratigraphic units. Noël (1965b) in her monograph on Jurassic coccoliths presented the ranges of most species, but did not stress their stratigraphical importance, although (p. 174–177) a short discussion was given summarized as follows in Table 2:

Table 2

Portlandien – Valanginien		Rich, appearance of new Lower Cretaceous assemblages, including <i>Nannoconus</i> group		
Kimmeridgien	Malm	Poor, remnants from Oxfordien		
Oxfordien	Wiaiiii	Richest group; Stephanolithion bigoti		
Callovien	1	Poor but heralds On	xfordien acme	
Bathonien Bajocien Aalénien	Dogger	Poor, least characteristic Abundant only in the marls		
Toarcien		Characterized	Crepidolithus crassus	
Charmouthien	Lias	by "massive" coccoliths	Parhabdolithus liasicus, marthae,	
Sinémurien			robustus, Crepidolithus crassus	

Although differences occur there is a strong similarity between the divisions of STRADNER and Noël. The differences are largely due to the much more extensive study of the Jurassic coccoliths by Noël, and also to the different emphasis given by both authors, according to whether the study was made by light or electron microscopy.

Prins (1969) presented a zonation for the Lower and Middle Lias, based on study of samples from England, France and western Germany. Many of the species listed on his range chart had not been formally described, but he presented a series of useful drawings which have allowed subsequent authors, particularly Rood, Hay & Barnard (1973), to recognize and validate most of them. He concentrated on two aspects, the evolution of Liassic coccoliths and also the zonal sequence, summarized as follows (see Table 3, p. 566).

Prins recognized four zones and five subzones. The lowest unit, termed the Crucirhabdus Zone was indicated to extend from the base of the range of "Crucirhabdus primulus" to the base of the range of Parhabdolithus liasicus Deflandre. This unit was succeeded by the Parhabdolithus Zone, divided into a lower Parhabdolithus marthae Subzone and an upper Parhabdolithus liasicus Subzone. The lower subzone has the appearance of Parhabdolithus liasicus as its base, and the disappearance of Parhabdolithus marthae as its top. The upper subzone apparently has the appearance of "Paleopontosphaera veterna" as its top. In our work, we have interpreted these low occurrences of Paleopontosphaera as belonging to Paleopontosphaera dubia Noël. The next higher unit is the Crepidolithus Zone, divided into a lower Crepidolithus cavus Subzone and a Crepidolithus crassus Subzone.

Prins indicated the range of Crepidolithus cavus to begin just below the base of the Crepidolithus cavus Subzone, and that of Crepidolithus crassus to begin in the middle of the Crepidolithus cavus Subzone. It is evident that the limits of these units were marked by events other than the appearance of the name species. As noted above, the base of the Crepidolithus cavus Subzone coincides with the base of the range

Table 3

Nannoplankton Zone	Subzones	Ammonite Zone	Time Stratigraphic Zonation		
Striatococcus Zone	Striatococcus opacus	tenuicostatum	L U	Toarcian	Upper Lias
	Crepidolithus crassus	spinatum margaritatus	U	Pliensbachian	Middle Lias
Crepidolithus Zone	Crepidolithus cavus	davoei ibex jamesoni	L		
Parhabdolithus Zone	Parhabdolithus liasicus Parhabdolithus	raricostatum oxynotum obtusum turneri semicostatum	U L	Sinemurian	
Crucirhabdus Zone	marthae	bucklandi angulata Als. liasicus planorbis pre-planorbis	U L	Hettangian	Lower Lias

of "Paleopontosphaera veterna". The base of the Crepidolithus crassus Subzone coincides with the base of the range of "Lucidiella intermedia" or "Mitrolithus irregularis", two species which we have been unable to recognize. Prins' highest unit he termed the Striatococcus Zone, with a single subzone, the Striatococcus opacus Subzone. The base of this unit was clearly intended to be defined by the base of the range of "Striatococcus opacus", which we assume is Coccolithus opacus Stradner. Recent authors have been uncertain as to the identification of this species, and the name has not been used since Prins' paper appeared.

Worsley (1971) proposed a zonation for the latest Jurassic and early Cretaceous encountered in Holes 4 and 5A of the Deep Sea Drilling Project. Brief accounts of the calcareous nannofossils from the two holes, drilled just east of the Bahamas Platform, had been published by Bukry & Bramlette (1969) and Hay (1969). To each of these investigators, seven samples were available, three from Hole 4 and four from Hole 5A. The relative position of the samples from the two holes has become a matter of controversy, and because each of the samples was regarded as the type level of a zone by Worsley, some discussion is necessary. Worsley adopted a short form of referring to the samples, assigning them letters of the alphabet. This is a convenient form of terminology for the following discussion, and is utilized here. The terminology and sequence of the samples is as follows:

Sample	Hole	Barrel	Section	Depth in section	Depth below sea floor
G	4	3	1	20 cm	134 m
В	4	4	1	80 cm	191 m
\mathbf{A}^{-1}	4	5	core catcher		207 m
F	5A	3	core catcher		145 m
E	5A	4	1	30 cm	185 m
D	5A	6	core catcher		236 m
C	5A	7	core catcher		274 m

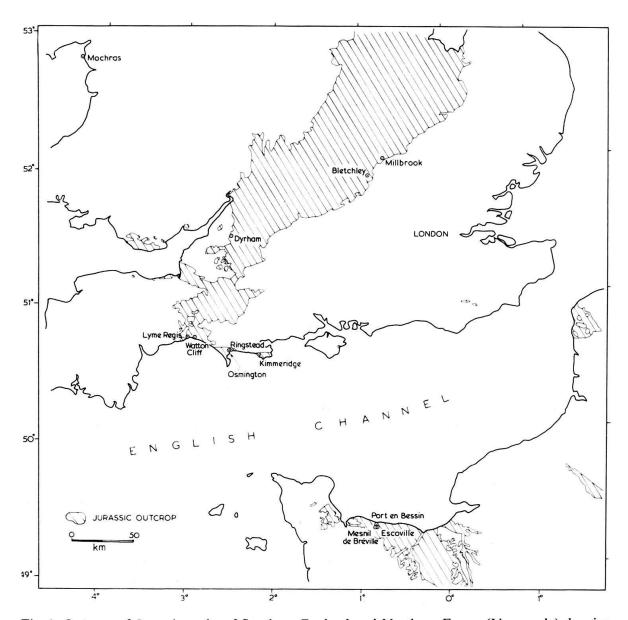


Fig. 1. Outcrop of Jurassic rocks of Southern England and Northern France (Normandy) showing position of major collecting areas.

From superposition, it is evident that in Hole 4, sample G overlies sample B, which in turn overlies sample A. In Hole 5A, the sequence, from top to bottom is F, E, D, C. In attempting to place the samples from these two holes into a single sequence, the authors arrived at somewhat different conclusions. Hay gave no age determinations for four of the samples, and his determination for the remaining three indicates the sequence, from top to bottom: G, D, B. Bukry & Bramlette provided age determination for all of the samples, suggesting a sequence, from top to bottom: F, G, E, B, D, A, C. Worsley rearranged the sequence of the samples, determining it to be, from top to bottom: G, F, E, D, C, B, A. Using this sequence, he recognized

seven zones, two of which were considered to be Jurassic. Worsley's lowest unit was termed the *Parhabdolithus embergeri* Zone, defined as extending from the lowest occurrence of *Parhabdolithus embergeri* to the lowest occurrence of *Nannoconus steinmanni*. This unit has been adopted here. Worsley considered the age of this zone to be Kimmeridgian-Portlandian, and this is consistent with our results. His highest Jurassic unit was termed the *Nannoconus steinmanni* Zone, and was defined as extending from the lowest occurrence of *Nannoconus steinmanni* to the lowest occurrence of *Diadorhombus rectus* Worsley. He considered its age to be Portlandian. This unit is also included in our zonation of the Jurassic, although we have not studied samples containing its assemblage.

THIERSTEIN (1971) questioned Worsley's zonation, proposing an almost wholly different scheme for zonation of the latest Jurassic and early Cretaceous. His results were based on studies of sections in South Western Europe, and on reinterpretation of the samples from Holes 4 and 5A of the Deep Sea Drilling Project. He rearranged the order of the samples to be, from top to bottom: G, F, E, B, A, D, C. THIERSTEIN'S sequence differs from that of Worsley in assuming that samples C and D lie below A. An interesting feature of THIERSTEIN'S sequence is that by following it, all samples are in order by depth below the sea floor. This is not an unreasonable or extraordinary circumstance, because the two sites are only 20 miles apart.

THIERSTEIN proposed a single zone which extended into the uppermost Jurassic, the Nannoconus colomi Zone. Nannoconus colomi (DE LAPPARENT) is considered to be the senior synonym of Nannoconus steinmanni, so the case of this zone defined by the earliest occurrence of Nannoconus colomi corresponds to the base of the Nannoconus steinmanni zone of Bronnimann (1955), Stradner (1963), and Worsley (1971). THIERSTEIN considered the type sample (A) of Worsley's Parhabdolithus embergeri Zone to be much younger, and assigned it to his Calcicalathina oblongata Zone, which he considered to be of Valanginian-Hauterivian age. Although THIERSTEIN stated that the assemblage of sample A was identical to that of this Calcicalathina oblongata Zone except that it lacked Nannoconus colomi and Micrantholithus hoschulzi (REINHARDT) his range chart indicated more extensive differences. Sample A lacks Rucinolithus wisei THIERSTEIN, Manivitella pemmatoidea (DEFLANDRE ex MANIVIT), Bipodorhabdus roeglii THIERSTEIN, and Diadorhombus rectus Worsley, all species considered characteristic of the Calcicalathina oblongata Zone. THIERSTEIN discounted the absence of these species and considered the absence of Nannoconus colomi and Micrantholithus hoschulzi to have been "influenced by water depth and temperature", so that "their absence should not be used exclusively for biostratigraphic correlation". This seems an unusual conclusion because of the spatial proximity of the samples from Holes 4 and 5A.

MEDD (1971) dealt with coccoliths from the Middle and Upper Jurassic, from a number of localities in S. England and N. France, giving occurrences of the various species in the different ammonite zones. No zonation however, was given.

WILCOXON (1972) reported the occurrence of calcareous nannofossils in late Jurassic and early Cretaceous strata cored at sites 99, 100, 101 and 105 by the Deep Sea Drilling Project. Although he did not propose a zonation scheme, he recognized a sequence of datum levels considered important for biostratigraphy. The Jurassic datum levels of WILCOXON are all lowest occurrences, and are indicated below:

Highest: LOS Cretarhabus splendens, Lithraphidites carniolensis, Braarudosphaera discula

LOS Nannoconids

LOS Stephanolithion lafittei

LOS Podorhabdus quadriperforatus

LOS Cyclagelosphaera margereli

Lowest: LOS Watznaueria britannica

The oldest samples studied by WILCOXON, core catcher samples from barrels 8, 9, 10 and 11 at site 100 contain relatively sparse assemblages; the lowest sample contains only four species, and must be regarded as abnormal. The sequence of other lowest and highest occurrences in the late Jurassic found by WILCOXON is particularly interesting in that the highest occurrence of *Stephanolithion bigoti* Deflandre is below the lowest occurrence of *Parhabdolithus embergeri*. WILCOXON found nannoconids to appear at the same level as *Parhabdolithus embergeri*, but on his range chart he indicated this horizon to lie below the lowest occurrence of an interesting species he referred to as *Corollithion* sp.

His illustration of *Corollithion* sp. reveals that it is identical with *Diadorhombus* rectus Worsley. Detailed examination of Wilcoxon's data reveals nothing that conflicts with Worsley's (1971) zonation. However, the ranges for a number of species in the North Atlantic, particularly *Glaukolithus diplogrammus*, *Cyclagelosphaera margereli*, *Diazomatolithus lehmani* and *Cretarhabdus crenulatus* as reported by Wilcoxon differ markedly from their ranges in South Western Europe as reported by Thierstein (1971).

THIERSTEIN'S zonation is not readily applicable to WILCOXON'S data. Comparison of the ranges indicated by WILCOXON with those by WORSLEY and THIERSTEIN suggests that WORSLEY'S interpretation of the sequence of samples from Deep Sea Drilling Holes 4 and 5A was correct.

Systematics

INCERTAE SEDIS

Genus Annulithus ROOD, HAY & BARNARD

Type: Annulithus arkelli n. sp. Rood, Hay & Barnard (Genotype: 40.5.1).

Type locality: Lyme Regis, Dorset.

Type level: Lias, Bed, Hl (LANG), Lower Hettangian, Ostrea liasica Zone.

Diagnosis: A coccolith-like object consisting of a simple ring of a few large, coarse, irregular elements.

Annulithus arkelli n. sp. Rood, Hay & Barnard

Pl. I, Fig. 1 and Pl. IV, Fig. 1

Diagnosis: As for genus.

Description: The type specimen consists of about 10 irregular elements, arranged into a circlet. The elements are apparently mostly organic and the degree of calicification is relatively light in comparison with most coccoliths.

Remarks: This coccolith has been named after the late Dr. W. J. Arkell in honour of his important contributions to Jurassic stratigraphy. The coccolith is abundant and

important enough to warrant a zone named after it. It is the oldest coccolith we have encountered and may represent the ancestral primitive form which gave rise to the coccolithophorids. A similar object was reported from Permian strata in Turkey by PIRINI RADRIZZANI (1971) as *Cricolithus* sp.

Calcareous nannofossil zones of the Jurassic

Annulithus arkelli Zone

Definition: Interval from the lowest occurrence of *Annulithus arkelli* ROOD, HAY & BARNARD to the lowest occurrence of *Crucirhabdus primulus* PRINS ex ROOD, HAY & BARNARD.

Species present: Annulithus arkelli rare to common, Crepidolithus cavus Prins ex Rood, Hay & Barnard is rare to common but its occurrence is not consistent in all samples from the interval; Tubirhabdus patulus Prins ex Rood, Hay & Barnard and Vekshinella quadriarculla (Noël) are rare in this interval; Schizosphaerella punctulata Deflandre is common to rare. The occurrence of Annulithus arkelli is consistent. It has its lowest occurrence below that of any of the other species and is present in all of the samples from this interval examined in the course of the investigation. The other species are present in only a few samples, and may be absent through dissolution from others.

Remarks: Prins (1969) indicated only a single species, Crucirhabdus primulus, to be present in the lowest Lias. Our investigation of the Dorset Lias reveals that several species are present, but that Crucirhabdus primulus does not appear at the base of the Lias. The evolutionary scheme of Prins (1969) does not appear to be an accurate reflection of the occurrences of species in the Dorset Lias. It is possible that specimens referred to by Prins as "Crucirhabdus primulus" var. "nanus" may belong to Vekshinella quadriarculla.

The Annulithus arkelli Zone corresponds to the lower part of the Crucirhabdus Zone of Prins (1969).

Crucirhabdus primulus Zone

Definition: Interval from the lowest occurrence of Crucirhabdus primulus to the lowest occurrence of Parhabdolithus liasicus DEFLANDRE.

Species present: Crucirhabdus primulus, Vekshinella quadriarculla and Zeugrhabdotus erectus (DEFLANDRE) are common; Schizosphaerella punctulata is abundant and may be the dominant species in many samples; Tubirhabdus patulus, Crepidolithus cavus, Crepidolithus crucifer Prins ex Rood, Hay & Barnard, and Annulithus arkelli are rare to common; Chiastozygus primitus Prins ex Rood, Hay & Barnard is rare and sporadic in occurrence.

Remarks: This corresponds to the upper part of the *Crucirhabdus* Zone of PRINS (1969), in which he indicated *Tubirhabdus patulus* and "*Crucirhabdus expansus*" to be present along with an abundance of *Crucirhabdus primulus*.

Parhabdolithus marthae Zone

Definition: Interval from the lowest occurrence of *Parhabdolithus liasicus* to the highest occurrence of *Parhabdolithus marthae* DEFLANDRE.

Species present: Parhabdolithus liasicus and Parhabdolithus marthae tend to dominate samples from this interval; Crucirhabdus primulus, Tubirhabdus patulus, Zeugrhabdotus erectus, Vekshinella quadriarculla and Schizosphaerella punctulata are common to rare; Crepidolithus crucifer, Crepidolithus cavus and Annulithus arkelli are rare.

Remarks: Prins (1969) indicated on his Table 1 that the lowest occurrence of *Parhabdolithus marthae* was slightly higher than the lowest occurrence of *Parhabdolithus liasicus* and the same sequence of appearance has been noted in our study of the Dorset Lias. Prins apparently intended the lower limit of his *Parhabdolithus Zone – Parhabdolithus marthae* Subzone to be marked by the lowest occurrence of *Parhabdolithus liasicus*, so that the interval as defined here corresponds exactly to the *Parhabdolithus marthae* Subzone of Prins.

Parhabdolithus liasicus Zone

Definition: Interval from the highest occurrence of *Parhabdolithus marthae* to the lowest occurrence of *Paleopontosphaera dubia* Noël.

Species present: In the Dorset Lias, Crucirhabdus primulus, Tubirhabdus patulus and Parhabdolithus liasicus are common, the latter species sometimes dominating the assemblages; Zeugrhabdotus erectus, Vekshinella quadriarculla and Crepidolithus cavus are rare to common; Annulithus arkelli is present, but always rare.

Remarks: Prins (1969) evidently intended the *Parhabdolithus liasicus* Subzone of his *Parhabdolithus* Zone to be determined by the highest occurrence of *Parhabdolithus marthae* and the upper limit by the lowest occurrence of "*Paleopontosphaera veterna*". He did not recognize *Paleopontosphaera dubia* in the Lias, but apparently included it in his concept of "*P. veterna*". *Paleopontosphaera veterna* Prins ex Rood, Hay & Barnard, is restricted to specimens which show vestiges of a central cross, and does not appear until the late Lias.

STRADNER (1963) proposed a "nannoplanktonic zone, which might be called 'Liasicus'-association", characterized by an abundance of Parhabdolithus liasicus and Schizosphaerella punctulata. It was undoubtedly intended to include the Parhabdolithus liasicus Zone as defined here, and probably portions or all of the overlying and underlying zones.

Paleopontosphaera dubia Zone

Definition: Interval from the lowest occurrence of *Paleopontosphaera dubia* to the lowest occurrence of *Crepidolithus crassus* (Deflandre).

Species present: In the Dorset Lias Crucirhabdus primulus, Parhabdolithus liasicus, Tubirhabdus patulus and Paleonpontosphaera dubia are common; Zeugrhabdotus erectus, Vekshinella quadriarculla, Crepidolithus cavus and Schizosphaerella punctulata are rare to common. The rare species Chiastozygus primitus Prins ex Rood, Hay & Barnard has its highest occurrence in this zone.

Remarks: Prins (1969) indicated that the lower limit of his *Crepidolithus* Zone – *Crepidolithus cavus* Subzone was defined by the lowest occurrence of *Paleopontosphaera* veterna. As noted above, he probably included *Paleopontosphaera dubia* in his concept of "*Paleopontosphaera veterna*".

The upper limit of his Crepidolithus cavus Subzone seems to have been defined by the lowest occurrence of "Mitrolithus irregularis" or "Lucidiella perforata", species which we have been unable to recognize. Prins indicated that Crepidolithus crassus was rare in the early part of its range, becoming more abundant in superjacent strata. Because of the differences in species interpretation which may exist, it must be assumed that the Paleopontosphaera dubia Zone here defined is only an approximate equivalent of the Crepidolithus cavus Subzone of PRINS. STRADNER (1963) stated that the "Liasicus"-association was overlain by an "Opacus"-association, "characterized by the appearance of Discolithus crassus Deflandre and Coccolithus opacus Stradner... the first coccolith with double rim." STRADNER's illustration of Coccolithus opacus indicates a placolith with a cribrate centre. We have not observed such a form in the Dorset Lias. Prins referred to "Striatococcus opacus" and indicated this species to be abundant in Upper Piensbachian and Lower Toarcian strata. PRINS' illustration of the species shows no indication of a cribrate centre. The first coccolith having typical placolith form is Paleopontosphaera dubia and subsequent re-examination of type material may reveal that Coccolithus opacus and Paleopontosphaera dubia are identical. For the present, however, the identity of Coccolithus opacus is uncertain, and it is not clear whether any of the Paleopontosphaera dubia Zone corresponds to the "Opacus"-association of STRADNER (1963).

Crepidolithus crassus Zone

Definition: Interval from the lowest occurrence of Crepidolithus crassus to the lowest occurrence of Podorhabdus cylindratus Noël.

Species present: Crepidolithus crassus, Crepidolithus cavus, Paleopontosphaera dubia, Tubirhabdus patulus and Schizosphaerella punctulata are common; Crucirhabdus primulus may be common in the base of this zone, but becomes rare and has its highest occurrence within this interval; Parhabdolithus liasicus is abundant in the lower part of this zone but becomes less abundant near the top; Zeugrhabdotus erectus and Vekshinella quadriarculla are rare to common.

Remarks: This zone cannot be regarded as a strict equivalent of the *Crepidolithus* crassus Subzone of Prins' (1969) Crepidolithus Zone, but may approximate the lower part of Prins' unit.

This interval is probably the closest approximation to the "Opacus"-association of STRADNER (1963). On his range chart he indicated that Parhabdolithus liasicus was a constituent of the assemblage, and this interval occupies the upper part of the range of that species.

Podorhabdus cylindratus Zone

Definition: Interval from the lowest occurrence of *Podorhabdus cylindratus* to the lowest occurrence of *Discorhabdus tubus* Noël.

Species present: Podorhabdus cylindratus is rare, and must be carefully sought to determine its lowest occurrence. Tubirhabdus patulus, Zeugrhabdotus erectus, Vekshinella quadriarculla, Crepidolithus crassus, Crepidolithus cavus, Paleopontosphaera dubia and Schizosphaerella punctulata are all present in samples from this interval in the Dorset Lias, but all tend to be rare. Parhabdolithus liasicus has its highest occurrence in this interval.

Remarks: This unit corresponds to part or all of Prins' (1969) Crepidolithus crassus Subzone of his Crepidolithus Zone and the Striatococcus opacus Subzone of his Striatococcus Zone. As noted above, the identity of Striatococcus opacus is uncertain, so that detailed correlation with Prins' zonation is not possible. The lower part of the Podorhabdus cylindratus Zone might belong to the "Opacus"-association of Stradner (1963), because Parhabdolithus liasicus indicated on his range chart to be typical of that unit, has its highest occurrence in this zone.

Discorhabdus tubus Zone

Definition: Interval from the lowest occurrence of *Discorhabdus tubus* to the lowest occurrence of *Stephanolithion speciosum* DEFLANDRE.

Species present: Discorhabdus tubus, Zeugrhabdotus erectus, Vekshinella quadriarculla, Crepidolithus crassus, Podorhabdus cylindratus and Paleopontosphaera dubia, all having their lowest occurrence below this interval, are common in it at Dorset but tend to be rare in samples from Mochras (Wales). In contrast, Tubirhabdus patulus is rare in Dorset samples but common in one from Mochras. In addition to Discorhabdus tubus, Podorhabdus macrogranulatus PRINS ex ROOD, HAY & BARNARD, Striatomarginis primitivus ROOD, HAY & BARNARD, Alvearium dorsetense BLACK and Paleopontosphaera veterna PRINS ex ROOD, HAY & BARNARD all appear at the base of this unit and are common in it so that assemblages of this zone have a strikingly different aspect from the subjacent units.

Remarks: This zone does not correspond directly to any of the units of Prins (1969) or Stradner (1963).

Stephanolithion speciosum Zone

Definition: Interval from the lowest occurrence of Stephanolithion speciosum s. str. to the lowest occurrence of Diazomatolithus lehmani Noël.

Species present: In samples from Port-en-Bessin (France), Zeugrhabdotus erectus, Podorhabdus cylindratus, Striatomarginis primitivus and Paleopontosphaera dubia are common in this zone; Tubirhabdus patulus, Vekshinella quadriarculla, Crepidolithus cavus, Paleopontosphaera veterna and Discorhabdus tubus are rare. All of these species are rare in samples from Dyrham (England). In addition to Stephanolithion speciosum s. str., Hexapodorhabdus cuvillieri Noël, Octopodorhabdus decussatus (Manivit), Watznaueria communis Reinhardt, and Discorhabdus biperforatus Rood, Hay & Barnard appear at the base of this zone and are common in samples from both England and France. Alvearium dorsetense has its highest occurrence within this zone, being present in the sample from Dyrham.

Diazomatolithus lehmani Zone

Definition: Interval from the lowest occurrence of *Diazomatolithus lehmani* to the lowest occurrence of *Stephanolithion speciosum* var. octum ROOD & BARNARD.

Species present: Zeugrhabdotus erectus, Stephanolithion speciosum s. str. and Watznaueria communis are consistently common in this interval; Vekshinella quadriarculla, Crepidolithus crassus, Paleopontosphaera dubia, Discorhabdus tubus, Ethmorhabdus gallicus, Hexapodorhabdus cuvillieri, Schizosphaerella punctulata and Discorhabdus biperforatus are common to rare; Tubirhabdus patulus, Crepidolithus cavus, Octopodorhabdus decussatus and Paleopontosphaera veterna are rare. Striatomarginis primitivus and Discorhabdus biperforatus both have their highest occurrence within this interval; Diadozygus asymmetricus and Cyclagelosphaera margereli have their lowest occurrence in this unit, all of these species being generally rare.

Stephanolithion speciosum var. octum Zone

Definition: Interval from the lowest occurrence of Stephanolithion speciosum var. octum to the lowest occurrence of Stephanolithion hexum ROOD & BARNARD.

Species present: At Watton Cliff, Zeugrhabdotus erectus, Vekshinella quadriar-culla, Stephanolithion speciosum s. str. and Watznaueria communis are common; Paleopontosphaera dubia, Discorhabdus tubus, Ethmorhabdus gallicus and Cyclagelo-sphaera margereli are common to rare; Tubirhabdus patulus, Crepidolithus cavus, Podorhabdus cylindratus, Diazomatolithus lehmani, Hexapodorhabdus cuvillieri, Octo-podorhabdus decussatus, Diadozygus asymmetricus and Schizosphaerella punctulata are rare. The sample of this zone from Dyrham resembles those from Watton Cliff, but contains fewer species. Watznaueria britannica has its lowest occurrence in this interval and is rare.

Stephanolithion hexum Zone

Definition: Interval from the lowest occurrence of Stephanolithion hexum to the lowest occurrence of Stephanolithion bigoti Deflandre.

Species present: Watznaueria communis generally dominates the assemblages. Crepidolithus crassus, Stephanolithion hexum, and Stephanolithion speciosum var. octum are common; Zeugrhabdotus erectus, Paleopontosphaera dubia, Discorhabdus tubus, Ethmorhabdus gallicus and Diazomatolithus lehmani are common to rare; Vekshinella quadriarculla, Hexapodorhabdus cuvillieri, Octopodorhabdus decussatus, Diadozygus assymmetricus, Watznaueria britannica and Cyclagelosphaera margereli are rare. Stephanolithion speciosum s.str. has its highest occurrence in the lower part of this unit; Tubirhabdus patulus disappears near the top. Schizosphaerella punctulata becomes rare and its occurrence sporadic in this interval.

Remarks: STRADNER (1963) described what he termed "Decorus"-associations from Bathonian samples. The species he listed as characteristic were Coccolithus britannicus, Hexalithus lecali, Discolithus asper and Rhabdolithus decoratus. Coccolithus britannicus STRADNER is now Watznaueria britannica (STRADNER) and has its lowest occurrence in the Stephanolithion speciosum var. octum Zone.

We have been unable to correlate any of the coccoliths in our samples with that identified by Stradner as Hexalithus lecali Gardet. Discolithus asper Stradner seems to be a species of Ethmorhabdus, but from the illustration it is not possible to determine with certainty whether it is the senior synonym of Ethmorhabdus gallicus Noël, Ethmorhabdus anglicus Rood, Hay & Barnard, or is a distinct species. Examination of Stradner's type material would be necessary to settle this question. Specimens illustrated by Stradner as Rhabdolithus decorus Deflandre represent Discorhabdus patulus or some other flaring species of that genus. From a consideration of the range of the species, it seems likely that Stradner's "Decorus"-associations probably represent the upper part of the Stephanolithion hexum Zone.

Stephanolithion bigoti Zone

Definition: Interval from the lowest occurrence of *Stephanolithion bigoti* to the lowest occurrence of *Podorhabdus escaigi* Noël.

Species present: Watznaueria communis tends to dominate the assemblages. Zeugrhabdotus erectus, Paleopontosphaera dubia and Stephanolithion bigoti are common; Crepidolithus cavus, Crepidolithus crassus, Podorhabdus cylindratus, Stephanolithion hexum and Cyclagelosphaera margereli are common to rare; Vekshinella quadriarculla, Discorhabdus tubus, Ethmorhabdus gallicus, Diazomatolithus lehmani, Hexapodorhabdus cuvillieri, Octopodorhabdus decussatus, Paleopontosphaera veterna, Diadozygus asymmetricus, Watznaueria britannica and Stephanolithion speciosum var. octum are rare. Discorhabdus patulus Noël has its lowest occurrence at the base of this unit, and is common to rare. Schizosphaerella punctulata occurs sporadically. Zeugrhabdotus noeli Rood, Hay & Barnard has its lowest occurrence near the top of this zone.

Remarks: STRADNER (1963) named a unit the "Bigoti"-Zone ("Bigoti-associations" on his chart I) for assemblages "dominated by double rimmed coccoliths" with abundant Stephanolithion bigoti. STRADNER's unit may correspond to the Stephanolithion bigoti Zone as defined here or to any of the superjacent units up to the Vekshinella stradneri Zone.

Podorhabdus escaigi Zone

Definition: Interval from the lowest occurrence of *Podorhabdus escaigi* to the lowest occurrence of *Podorhabdus rahla* Noël.

Species present: Watznaueria communis dominates assemblages of this zone. Stephanolithion bigoti is common; Zeugrhabdotus erectus, Podorhabdus cylindratus, Paleopontosphaera dubia, Ethmorhabdus gallicus, Diadozygus asymmetricus and Cyclagelosphaera margereli are common or rare. Zeugrhabdotus noeli, Octopodorhabdus decussatus, Schizosphaerella punctulata, Watznaueria britannica and Vekshinella quadriarculla occur sporadically.

Podorhabdus rahla Zone

Definition: Interval from the lowest occurrence of *Podorhabdus rahla* to the lowest occurrence of *Discorhabdus jungi* Noël.

Species present: Watznaueria communis dominates the assemblages. Stephanolithion hexum and Stephanolithion bigoti are common; Zeugrhabdotus erectus, Crepidolithus crassus, Podorhabdus cylindratus, Hexapodorhabdus cuvillieri and Cyclageosphaera margereli are common to rare; Discorhabdus tubus, Ethmorhabdus gallicus, Diazomatolithus lehmani, Diadozygus asymmetricus, Stephanolithion speciosum var. octum, Watznaueria britannica and Zeugrhabdotus noeli are rare.

Remarks: This unit is represented by the upper part of the section at Bletchley and extends into the interval between the sections at Bletchley and Millbrook. It is not known whether the highest occurrence of *Stephanolithion hexum* is above or below the lowest occurrence of *Discorhabdus jungi*.

Discorhabdus jungi Zone

Definition: Interval from the lowest occurrence of *Discorhabdus jungi* to the lowest occurrence of *Diadozygus dorsetense* ROOD, HAY & BARNARD.

Species present: Watznaueria communis dominates; Zeugrhabdotus erectus, Podorhabdus cylindratus, Discorhabdus tubus, Discorhabdus jungi, Podorhabdus escaigi, and Stephanolithion bigoti are common; Vekshinella quadriarculla, Paleopontosphaera dubia, Ethmorhabdus gallicus, Hexapodorhabdus cuvillieri, Octopodorhabdus decussatus, Diadozygus asymmetricus, Cyclagelosphaera margereli, Zeugrhabdotus noeli and Watznaueria britannica are common to rare. Diadozygus minutus and Truncatoscaphus delftensis appear near the top of this unit and are rare.

Remarks: Stephanolithion hexum has its highest occurrence in the interval between the Bletchley and Millbrook sections, so it is uncertain whether it ranges into this zone.

Diadozygus dorsetense Zone

Definition: Interval from the lowest occurrence of *Diadozygus dorsetense* to the lowest occurrence of *Actinozygus geometricus* (GORKA).

Species present: Watznaueria communis dominates; Zeugrhabdotus erectus and Stephanolithion bigoti are common. Vekshinella quadriarculla, Podorhabdus cylindratus, Paleopontosphaera dubia, Discorhabdus tubus, Ethmorhabdus gallicus, Hexapodorhabdus cuvillieri, Discorhabdus jungi, Zeugrhabdotus noeli, Discorhabdus patulus and Podorhabdus escaigi are common to rare; Octopodorhabdus decussatus, Watznaueria britannica, Diadozygus asymmetricus, Diadozygus minutus and Truncatoscaphus delftensis are rare.

Actinozygus geometricus Zone

Definition: Interval from the lowest occurrence of Actinozygus geometricus to the lowest occurrence of Vekshinella stradneri ROOD, HAY & BARNARD.

Species present: Watznaueria communis dominates the assemblages; Zeugrhabdotus erectus, Paleopontosphaera dubia, Discorhabdus tubus, Cyclagelosphaera margereli and Stephanolithion bigoti are common; Podorhabdus cylindratus, Ethmorhabdus gallicus, Hexapodorhabdus cuvillieri, Octopodorhabdus decussatus, Diadozygus asymmetricus, Diadozygus minutus, Diadozygus dorsetense, Podorhabdus escaigi and Watznaueria britannica are rare.

Vekshinella stradneri Zone

Definition: Interval from the lowest occurrence of Vekshinella stradneri to the highest occurrence of Stephanolithion bigoti.

Species present: Watznaueria communis dominates the assemblages; Zeugrhabdotus erectus, Paleopontosphaera dubia, Cyclagelosphaera margereli, Podorhabdus escaigi and Stephanolithion bigoti are generally common; Vekshinella quadriarculla, Podorhabdus cylindratus, Discorhabdus tubus, Ethmorhabdus gallicus, Hexapodorhabdus cuvillieri, Zeugrhabdotus noeli, Vekshinella stradneri and Diadozygus dorsetense are common to rare; Diadozygus asymmetricus, Watznaueria britannica and Truncatoscaphus delftensis are rare. Octopodorhabdus decussatus, Podorhabdus rahla and Diadozygus minutus are rare and have their highest occurrence in this unit.

Remarks: This unit is represented by samples from Millbrook and by the Nothe Clay. A sample from Ringstead (R-1) belongs to this zone, but contains an impoverished assemblage.

Watznaueria communis Zone

Definition: Interval from the highest occurrence of *Stephanolithion bigoti* to the lowest occurrence of *Parhabdolithus embergeri* (NOËL).

Species present: Watznaueria communis dominates; Paleopontosphaera dubia and Cyclagelosphaera margereli are common; Zeugrhabdotus erectus is rare.

Remarks: This unit is represented in the lowest part of the sampled section at Kimmeridge. The assemblage is generally poor.

The existence of this unit might be questioned, because Worsley (1971) shows that Stephanolithion bigoti and Parhabdolithus occur together in Deep Sea Drilling Holes 4 and 5A off the Bahamas. However, the data of Wilcoxon (1972) show a gap between the highest occurrence of Stephanolithion bigoti and the lowest occurrence of Parhabdolithus embergeri in Deep Sea Drilling Hole 105 in the western North Atlantic off North Carolina. The data of Noël (1965) are also consistent with the presence of this unit.

Parhabdolithus embergeri Zone

Definition: Interval from the lowest occurrence of *Parhabdolithus embergeri* to the lowest occurrence of *Nannoconus colomi* (DE LAPPARENT).

Species present: Watznaueria communis dominates the assemblages; Zeugrhabdotus erectus, Vekshinella quadriarculla, Paleopontosphaera dubia, Cyclagelosphaera margereli, Podorhabdus escaigi, Vekshinella stradneri, Diadozygus dorsetense and Parhabdolithus embergeri are common to rare; Ethmorhabdus gallicus, Diadozygus asymmetricus and Truncatoscaphus delftensis are rare. Crepidolithus crassus and Podorhabdus cylindratus have their highest occurrence in this interval.

Remarks: Most of the Kimmeridgian section at Kimmeridge, and at Ringstead belongs to this zone. In definition, this corresponds exactly to the *Parhabdolithus* embergeri Zone of Worsley (1971).

Nannoconus colomi Zone

Definition: Interval from the lowest occurrence of *Nannoconus colomi* to the lowest occurrence of *Diadorhombus rectus* WORSLEY.

Species present: See Worsley (1971) and Thierstein (1971).

Remarks: This unit corresponds exactly to the *Nannoconus steinmanni* Zone of Worsley (1971). Thierstein noted that *Nannoconus colomi* is a senior synonym of *Nannoconus steinmanni* Deflandre, according to Farinacci (1964).

Coccolith distribution related to the Jurassic stages and existing Ammonite Zonation

The coccolith zones described earlier in the paper do not relate directly to the existing ammonite zonation and subsequent definition of the stages, it was, therefore, necessary to record this and briefly discuss the lithologies prevalent in these stages.

From the coccolith distribution chart (Fig. 2) it is clear that with minor differences there are three major floras: 1) a Liassic flora dominant in Lower and Middle Lias, with reduced number of species and individuals in the lower part of the Upper Lias; 2) this is replaced in the Upper Lias by a flora remaining dominant through the Middle Jurassic, and being reinforced by a second burst of species at the beginning of the Middle Jurassic. This flora continues, with significant reduction in the overall number of species, except for the addition of several new forms in the Cornbrash. 3) a new flora characteristic of the Upper Jurassic is introduced in the Callovian and early Oxfordian. This continues until a marked reduction of species occurs in the Corallian and throughout the Kimmeridgian.

Some of these changes are clearly related to major changes in facies. The largely clay facies of the Lias is replaced by a wide range of shallow water deposits including sands, clays, skeletal limestones of the Middle Jurassic, some of which are barren, but many still contain a considerable number of individual coccoliths as well as new species, so that a connection with open seas was maintained.

The Cornbrash deposits in England are for the most part thin hard limestones with no recovery of coccoliths, so the clay-facies of the North French equivalent of this "stage" was used.

These shallow water deposits were gradually replaced by the clay facies of the Callovian to Oxfordian and the third flora is common. However, a marked diminution of both individuals and species occurs with the shallow water, sands, skeletal limestones and oolites of the "Corallian" of Southern England. On the whole this period marks the decline of the Upper Jurassic floras, which continues sporadically throughout the Kimmeridgian.

The absences and reoccurrences of certain of the species throughout the Kimmeridgian may possibly be explained by the turbid environment, followed by the elimination

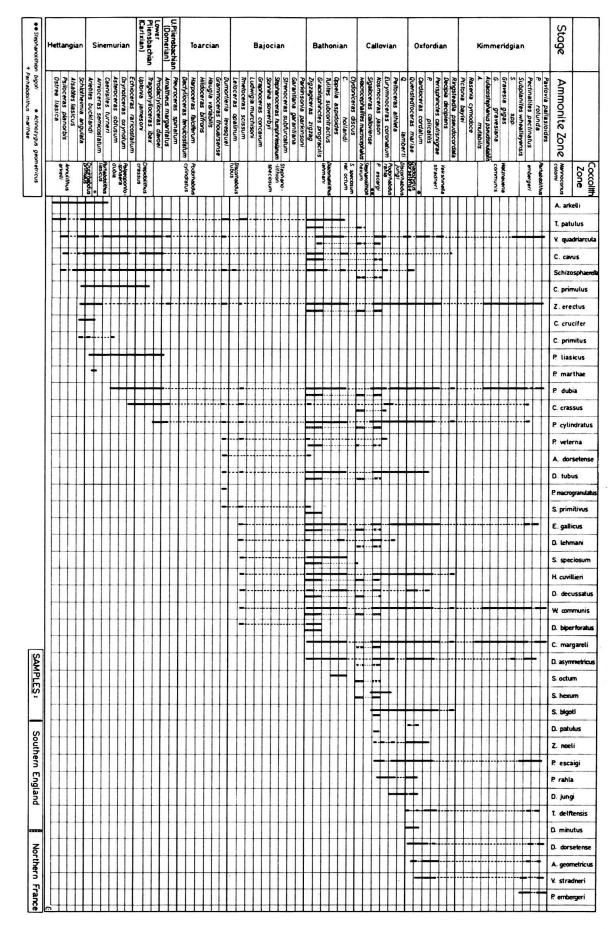


Fig. 2. Chart showing the distribution of Jurassic coccoliths, and a new coccolith zonation related to that of the ammonites.

of most of the calcareous flora and fauna by the action of organic acids at certain levels where bituminous remains are abundant. The obvious non-recovery of coccoliths from many of the shallow water skeletal limestones, oolites, sands of both the Middle Jurassic and "Corallian" emphasise these lithofacies changes.

LOWER JURASSIC

Stage HETTANGIAN

Zones liasica-angulata

The lithologies of the early part of this stage in Southern England consist of rapid alternation of dark shales and tabular limestones. The shales are often paper shales and a considerable amount of redistribution of the calcium carbonate has taken place subsequent to consolidation of the sediment. This factor contributes to what appears to be a slow introduction of the Liassic coccolith flora.

Ostrea liasica Zone

Is characterized by only two coccolith species: Annulithus arkelli, which is rare at the start of the zone, becoming established and abundant later, and Tubirhabdus patulus, which occurs in the upper part of the zone only.

Planorbis Zone

Annulithus arkelli is the most persistent and abundant coccolith, accompanied by sporadic occurrences of Tubirhabdus patulus, Crepidolithus cavus, Vekshinella quadriarculla.

Liasicus Zone

Apart from *Annulithus arkelli* which occurred throughout the zone, but sporadically at times, no other coccoliths were recorded.

Angulata Zone

Although Annulithus arkelli occurs throughout this zone, only sporadic horizons are abundant, and it is no longer the dominant species. This zone marks the introduction of most of the main elements of the Liassic flora. Some initially are rare and sporadic, but most become abundant and rapidly established. Crucirhabdus primulus, Zeugrhabdotus erectus, Crepidolithus crucifer occur for the first time, and Crepidolithus cavus and Vekshinella quadriarculla which occured in the planorbis Zone, but were absent from the liasicus Zone, recur and are much more abundant becoming main elements of the flora. Although rarer than the other species Chiastozygus primitus occurs sporadically.

Stage SINEMURIAN

Zones bucklandi-raricostatum

The lithologies for the most part are dark clays except for a few isolated thin tabular and nodular limestones. This more uniform lithology and conditions are reflected to a large extent in the abundance and persistence of the coccoliths. Crucirhabdus primulus, Tubirhabdus patulus, Zeugrhabdotus erectus, Vekshinella quadriarculla and Crepidolithus cavus occur throughout all the zones of the stage.

Bucklandi-semicostatum Zones

Two important species occur near the top of the bucklandi Zone, Parhabdolithus liasicus which remains abundant thoughout the rest of the Sinemurian, and Parhabdolithus marthae a short ranged but abundant coccolith which also occurs at the beginning of the semicostatum Zone only.

Obtusum Zone

Apart from *Parhabdolithus marthae* all other Sinemurian species occur with the addition of *Paleopontosphaera dubia*.

The non-sequence in Southern England between the *obtusum* Zone, *stellare* Subzone and *raricostatum* Zone, *densinodulum* Subzone, which eliminates the *denotatus*, *simpsoni* and *oxynotum* Subzones, does not seem to affect the distribution of the coccoliths, all Sinemurian species range through the gap, except the short range forms.

Stage PLIENSBACHIAN

Zones jamesoni-spinatum

In the early part of the stage, *ibex-davoei* Zones, the flora is abundant and a continuation of the Sinemurian. However later zones, *margaritatus-spinatum*, show a decline in the number of species and individuals. This is largely due to the sandy and silty clay facies that exists in Dorset at this age, the peculiar conditions are not conducive to coccoliths.

Stage TOARCIAN

Zones tenuicostatum-levesquei

This part of the succession in Dorset is characterised by condensed sequences and in general shallow water deposits, heralding the Middle Jurassic sedimentation. However at certain clay horizons an abundance of coccoliths occur, together with several important new species. Tubirhabdus patulus, Zeugrhabdotus erectus, Vekshinella quadriarculla, Crepidolithus crassus and Paleopontosphaera dubia still occur. Podorhabdus macrogranulatus, Striatomarginis primitivus, Discorhabdus tubus and Alvearium dorsetense are new.

MIDDLE JURASSIC

Stages BAJOCIAN-BATHONIAN

Zones opalinum-discus

The Middle Jurassic in S. England and N. France presents considerable problems for detailed zoning by coccoliths, as unfavourable lithologies, sand and oolitic limestones, and condensed sequences do not allow a continuous succession to be studied. So for the most part only isolated samples were taken, those from the Bajocian were barren. However in the Bathonian good clay horizons occur in the Fullers Earth sequence.

Tubirhabdus patulus, Zeugrhabdotus erectus, Vekshinella quadriarculla, Crepidolithus cavus, Podorhabdus cylindratus, Striatomarginis primitivus, Paleopontosphaera

dubia, Discorhabdus tubus continue into and through the Bathonian from the Toarcian. New Bathonian species are Ethmorhabdus gallicus, Dizomatolithus lehmani, Stephanolithion speciosum, Hexapodorhabdus cuvillieri, Octopodorhabdus decussatus, Watznaueria communis, Discorhabdus biperforatus, Diadozygus asymmetricus, Cyclagelosphaera margereli.

Watznaueria communis dominates most Middle Jurassic samples. Stephanolithion speciosum var. octum occurs in the upper Bathonian.

Stage CALLOVIAN

Zones macrocephalus-lamberti

The early part of the Callovian is represented in Southern England by skeletal and oolitic limestones of the Cornbrash from which coccoliths are impossible to extract, however in Normandy these horizons are represented by clays. The Kellaways Clay also has a reduced flora, the residues contain much silt size quartz grains and a considerable amount of secondary iron. It is only high up in this stage and the subsequent Oxfordian that coccolith floras become extremely abundant. The Callovian stage has therefore not been separated out into zones.

Tubirhabdus patulus rare, Zeugrhabdotus erectus common, Crepidolithus cavus sporadic, Crepidolithus crassus, Podorhabdus cylindratus common, Paleopontosphaera dubia common, Discorhabdus tubus rare, Ethmorhabdus gallicus rare, Diazomatolithus lehmani rare, Hexapodorhabdus cuvillieri rare, Octopodorhabdus decussatus rare and sporadic. Watznaueria communis dominant, Stephanolithion hexum common to rare, Diadozygus asymmetricus sporadic to rare, Stephanolithion speciosum var. octum sporadic to rare, Cyclogelosphaera margereli persistent but rare, Discorhabdus patulus occurs near the end of the Callovian, Stephanolithion bigoti, common near the end of the Callovian, Podorhabdus rahla common in the late part of the stage, Polypodorhabdus escaigi is common.

UPPER JURASSIC

Stage OXFORDIAN

Zones mariae-pseudocordata

The clay facies of the later part of the Callovian is continued into the Oxfordian until late in the stage when in the *pseudocordata* Zone shallow water sediments dominate in the Corallian.

Zeugrhabdotus erectus common, Vekshinella quadriarculla sporadic, Podorhabdus cylindratus common, Paleopontosphaera dubia common, Discorhabdus tubus common at most horizons, Ethmorhabdus gallicus common to rare, Hexapodorhabdus cuvillieri common in earlier part of the stage becoming extinct later, Watznaueria communis dominant, Diadozygus asymmetricus rare to common but persistent, Cyclagelosphaera margereli common, Podorhabdus rahla extends into the lower part of the stage, Discorhabdus jungi confined to the earlier part of the stage, Zeugrhabdotus noeli common to rare, Polypodorhabdus escaigi common, Stephanolithion bigoti common, Actinozygus geometricus common in late stage, Vekshinella stradneri common in late

stage, Diadozygus dorsetense common in late stage, Truncatoscaphus delftensis rare but persistent, Diadozygus minutus rare but persistent in the lower part of the stage.

Stage KIMMERIDGIAN

Zones baylei-pallasioides

The changes of lithology towards the end of the Oxfordian eliminate most of the Oxfordian flora, only a few species persisting in any numbers into the Kimmeridgian. Zeugrhabdotus erectus common, Vekshinella quadriarculla common but sporadic, Podorhabdus cylindratus dies out in lower part of the stage, Paleopontosphaera dubia sporadic, Ethmorhabdus gallicus rare but persistent, Watznaueria communis common, Diadozygus asymmetricus sporadic, Cyclagelosphaera margereli common, Polypodorhabdus escaigi common, Parhabdolithus embergeri common but confined to Kimmeridgian; Vekshinella stradneri, Diadozygus dorsetense, Truncatoscaphus delftensis are all rare but sporadic.

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REFERENCES

- ARKELL, W. J. (1930): A Comparison between the Jurassic rocks of the Calvados Coast and those of Southern England. Proc. Geologists' Assoc. 41, 396.
- (1933): The Jurassic system in Great Britain. Clarendon Press, Oxford.
- (1947): The geology of the country around Weymouth, Swanage, Corfe and Lulworth. Mem. geol. Surv. G.B. 1947, 1-386.
- BLACK, M. (1967): New names for some Coccolith taxa. Proc. geol. Soc. London 1640, 139-145.
- (1968): Taxonomic problems in the study of Coccoliths. Palaeontology 2/5, 793-813.
- (1971a): Coccoliths of the Speeton Clay and Sutterby Marl. Yorkshire geol. Soc. 28, 381-424.
- (1971 b): The systematics of Coccoliths in relation to the palaeontological record. In: Funnell,
 B.M. & Riedel, W.R. (Ed.): The Micropalaeontology of the Oceans (Univ. Press, Cambridge),
 p. 611-620.
- Bramlette, M. N., & Martini, E. (1964): The great change in Calcareous Nannoplankton Fossils between the Maestrichtian and Danian. Micropaleontology 10/3, 291-322.
- Bramlette, M. N., & Wilcoxon, J. A. (1967): Middle Tertiary Calcareous Nannoplankton of the Cipero Section, Trinidad, W.I. Tulane Stud. Geol. 5, 93-131.
- Bronnimann, P. (1955): Microfossils incertae sedis from the Upper Jurassic and Lower Cretaceous of Cuba. Micropaleontology 1/1, 28-51.
- Bukry, D. (1969): Upper Cretaceous Coccoliths from Texas and Europe. Univ. Kansas paleont. Contr., Art. 51 (Protista 2), 1-79.
- BUKRY, D., & Bramlette, M. N. (1969): Some new and stratigraphically useful calcareous nanno-fossils of the Cenozoic. Tulane Stud. Geol. 7/3-4.
- CALLOMON, J. H. (1962): Notes on the Callovian and Oxfordian stages. Colloq. Jurassique Luxembourg 1962, 269-291.

- ČEPEK, P., & HAY, W. W. (1969): Calcareous Nannoplankton and biostratigraphic subdivision of the Upper Cretaceous. Trans. Gulf Coast Assoc. geol. Soc. 19, 323-335.
- DEFLANDRE, G. (1939): Les stephanolithes, représentants d'un type nouveau de coccolithes du Jurassique supérieur. C. R. Acad. Sci. 208, 1331-1333.
- Deflandre, G., & Fert, C. (1954): Observations sur les Coccolithophoridés actuels et fossiles en microscopie ordinaire et électronique. Ann. Paléont. 40, 115-176.
- FARINACCI, A. (1964): Microorganismi dei calcari «Maiolica» e «Scaglia» osservati al microscopio elettronico (nannoconi e coccolithophoridi). Boll. Soc. paleont. ital. 3/2, 172–181.
- GARTNER, S., Jr. (1968): Coccoliths and related Calcareous Nannofossils from Upper Cretaceous Deposits of Texas and Arkansas. Univ. Kansas paleont. Contr. 48 (Protista 1), 1-56.
- GORKA, H. (1957): Coccolithophoridae z gornego mastrychtu Polski srodkowej. (Les Coccolithophoridés du Maestrichtien supérieur de Pologne). Acta palaeont. pol. 2, 235-284.
- HAY, W. W., & MOHLER, H.P. (1967): Calcareous Nannoplankton from Early Tertiary Rocks at Pont Labau, France, and Paleocene-Early Eocene Correlations. J. Paleont. 41, 1505-1541.
- HAY, W. W., MOHLER, H. P., ROTH, P. H., SCHMIDT, R. R., & BOUDREAUX, J. E. (1967): Calcareous Nannoplankton Zonation of the Cenozoic of the Gulf Coast and Caribbean-Antillean area and Transoceanic correlation. Trans. Gulf Coast Assoc. geol. Soc. 17, 428-480.
- Huxley, T. H. (1868): On some organisms living at great depths in the North Atlantic Ocean. Quart. J. microsc. Sci. 2/8, 203-212.
- KAMPTNER, E. (1937): Neue und bemerkenswerte Coccolithineen aus dem Mittelmeer. Arch. Protistenkd. 89, 279-316.
- (1941): Die Coccolithineen der Südwestküste von Istrien. Ann. nathist. Mus. Wien 51, 54-149.
- (1963): Coccolithineen-Skelettreste aus Tiefseeablagerungen des östlichen Pazifischen Ozeans. Ann. nathist. Mus. Wien 66, 139-204.
- LAMPLUGH, G. W. (1889): On the Subdivisions of the Speeton Clay. Quart. J. geol. Soc. London 45, 575-618.
- LANG, W. D. (1924): The Blue Lias of the Devon and Dorset Coasts. Proc. Geologists' Assoc. 35, 169. LOEBLICH, A. R., Jr., & TAPPAN, H. (1963): Type fixation and validation of certain calcareous Nannoplankton Genera. Proc. biol. Soc. Washington 76, 191-196.
- (1966): Annoted index and bibliography of the Calcareous Nannoplankton. Phycologia 5, 81–216.
- (1969): Annoted index and bibliography of the Calcareous Nannoplankton III. J. Paleont. 43, 568-588.
- LYUL'EVA, S. A. (1967): Kokolitoforidi turons'kikh vidkladiv Dniprovsko-Donets'koy zapadini. (Coccolithophoridae in the Turonian strata of the Dnieper-Don Basins.) Geol. Ž. 27, 91-98.
- Manivit, H. (1959): Contribution d'étude des coccolithes de l'Eocène. Publ. Serv. Carte géol. Algér. 2/25, 331-382 (published 1961).
- MASLOV, V. P. (1963): Klass Chrysomonadineae, Krizomonady. In: Orlov, Yu. A.: Osnovy Paleontologii 14, Vodorosli mojhoobrazny, psilofitovye, plaunovidnye, chlenistostebel'nye paporotniki. Izdat. Akad. Nauk SSSR, 152-161.
- MEDD, A. W. (1971): Some Middle and Upper Jurassic Coccolithophoridae from England and France. Proc. II. planct. Conf. Rome 1970, 821-844.
- Noël, D. (1965a): Note préliminaire sur les coccolithes jurassiques. Cah. Micropaléont. 1/1, 1-12.
- (1965b): Sur les coccolithes du Jurassique Européen et d'Afrique du Nord. Essai de classification des coccolithes fossiles. Ed. Cent. natl. Rech. sci., 1-209.
- PIRINI RADRIZZANI, C. (1971): Coccoliths from Permian deposits of eastern Turkey. Proc. II. planct. Conf. Rome 1970, 993–995.
- Prins, B. (1969): Evolution and stratigraphy of Coccolithinids from the Lower and Middle Lias. Proc. I. int. Conf. plankt. Microfoss. Geneva. E. J. Brill, Leiden 2, 547-558.
- REINHARDT, P. (1964): Einige Kalkflagellaten-Gattungen (Coccolithophoriden, Coccolithineen) aus dem Mesozoikum Deutschlands. Mber. dtsch. Akad. Wiss. Berlin 6, 749-759.
- (1965): Neue Familien für fossile Kalkflagellaten (Coccolithophoriden, Coccolithineen). Mber. dtsch. Akad. Wiss. Berlin 7, 30-40.
- (1966): Zur Taxionomie und Biostratigraphie des fossilen Nannoplanktons aus dem Malm, der Kreide und dem Alttertiär Mitteleuropas. Freiberger Forschh. (C) 196, 5-109.
- ROOD, A. P., & BARNARD, T. (1972): On Jurassic Coccoliths: Stephanolithion, Diadozygus and Related Genera. Eclogae geol. Helv. 65/2, 327-342.

- ROOD, A. P., HAY, W. W., & BARNARD, T. (1971): Electron microscope studies of Oxford Clay Coccoliths. Eclogae geol. Helv. 64/2, 245–272.
- (1973): Electron microscope studies of Lower and Middle Jurassic Coccoliths. In press.
- STRADNER, H. (1963): New contributions to Mesozoic stratigraphy by means of Nannofossils. Proc. 6th World Petroleum Congr. Frankfurt a. M., Sect. 1, 167.
- STRADNER, H., & ADAMIKER, D. (1966): Nannofossilien aus Bohrkernen und ihre elektronenmikroskopische Bearbeitung. Erdöl-Erdgas-Z. 8, 330-341.
- STRADNER, H., ADAMIKER, D., & MARESCH, O. (1968): Electron microscope studies on Albian Calcareous Nannoplankton from Delft 2 and Leidschendam 1 Deepwells Holland. Verh. k. nederl. Akad. Wetensch., Afd. Natkd. (1) 24/4, 1-107.
- THIERSTEIN, H. R. (1971): Tentative Lower Cretaceous Calcareous Nannoplankton Zonation. Eclogae geol. Helv. 64/3, 459 488.
- WILCOXON, J. A. (1972): Upper Jurassic Lower Cretaceous Nannoplankton from the western North Atlantic Basin (in: C. E. HOLLISTER et al.). Init. Rep. Deep Sea Drill. Proj. 11, 427-457.
- Wood, A., & Woodland, A. W. (1968): Borehole at Mochras, West of Llanbedr, Merionethshire. Nature 219/5161, 1352-1354.
- WORSLEY, T. R. (1971): Calcareous Nannofossil Zonation of Upper Jurassic and Lower Cretaceous sediments from the Western Atlantic. Proc. II. planct. Conf. Rome 1970, 1301-1322.

Plate I

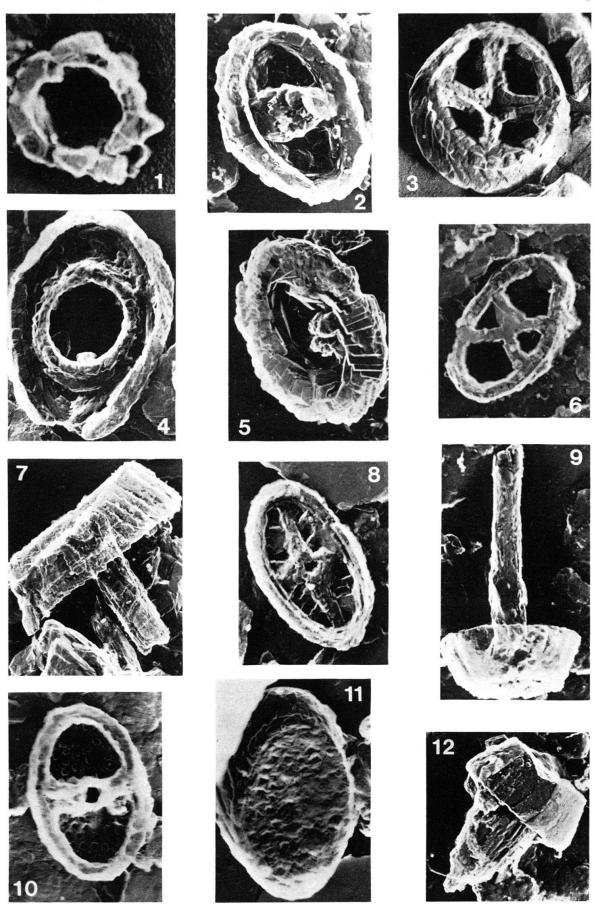
All transmission electron micrographs

Fig. 1	Annulithus arkelli n. gen. n. sp.; Genotype 40.5.1. Lyme Regis (Dorset); Lias, Bed Number H1 (LANG), Zone Ostrea liasica. × 16,000
Fig. 2	Crepidolithus cavus Prins ex Rood, Hay & Barnard; Hypotype 42.3.2. Lyme Regis (Dorset); Lias, Bed Number 90a (Lang), zone raricostatum, subzone densinodulum. × 10,000
Fig. 3	Vekshinella quadriarculla (Noël); Hypotype 34.8.1. Millbrook (Bedfordshire); Ampthill Clay, zone transversarium. × 14,000
Fig. 4	Tubirhabdus patulus Prins ex Rood, Hay & Barnard; Hypotype 56.10.2. Escoville (Northern France); Cornbrash, zone macrocephalus. × 8,000
Fig. 5	Crepidolithus crucifer Prins ex Rood, Hay & Barnard; Hypotype 43.1.1. Eype (Dorset); Upper Lias, Downcliff Clay, zone levesquei. × 4,500
Fig. 6	Chiastozygus primitus PRINS; Hypotype 42.7.1. Lyme Regis (Dorset); Lias, Bed Number 90a (LANG), zone raricostatum, subzone densinodulum. × 14,000
Fig. 7	Crucirhabdus primulus Prins ex Rood, Hay & Barnard; Hypotype 44.1.2. Golden Cap (Dorset); Lias, Bed Number 122a (Lang), zone davoei, subzone maculatum. × 9,000
Fig. 8	Crucirhabdus primulus Prins ex Rood, Hay & Barnard; Hypotype 42.8.1. Lyme Regis (Dorset); Lias, Bed Number 90a (Lang), zone raricostatum, subzone densinodulum. × 14,000
Fig. 9	Parhabdolithus liasicus (DEFLANDRE); Hypotype 41.7.2. Lyme Regis (Dorset); Lower Lias; Bed Number 48 (Lang), zone semicostatum, subzone reynesi. × 7,000
Fig. 10	Zeugrhabdotus erectus (Deflandre); Hypotype 32.6.2. Millbrook (Bedfordshire); Upper Oxford Clay, zone mariae, subzone praecordatum. × 18,000
Fig. 11	Crepidolithus crassus (Deflandre); Hypotype 29.8.1. Millbrook (Bedfordshire); Ampthill Clay, zone transversarium. × 12,000
Fig. 12	Parhabdolithus marthae Deflandre; Hypotype 41.8.1. Lyme Regis (Dorset); Lower Lias, Bed Number 48 (Lang), zone semicostatum, subzone reynesi. × 4,500

Eclogae geologicae Helvetiae Vol. 67/3, 1974

T. BARNARD and W. W. HAY: Jurassic Coccoliths (S. England and N. France)

PLATE I



ECLOGAE GEOL. HELV. 67/3-1974

Plate II

All transmission electron micrographs

Fig. 1	Podorhabdus cylindratus Noël; Hypotype 56.10.1. Escoville (Northern France); Cornbrash, zone macrocephalus. × 5,000
Fig. 2	Paleopontosphaera dubia Noël; Hypotype 42.10.2. Golden Cap (Dorset); Lias, Bed Number 120d (Lang), zone davoei, subzone valdani. × 9,000
Fig. 3	Striatomarginis primitivus Rood, Hay & Barnard; Hypotype 44.10.1. Eype (Dorset); Upper Lias, Downcliff Clay, zone levesquei. × 12,000
Fig. 4	Paleopontosphaera veterna PRINS ex ROOD, HAY & BARNARD; Hypotype 55.11.1. Port en Bessin (Normandy); Fullers Earth, zone progracilis. × 12,000
Fig. 5	Podorhabdus macrogranulatus Prins ex Rood, Hay & Barnard; Hypotype 43.10.2. Eype (Dorset); Upper Lias, Downcliff Clay, zone levesquei. × 10,500
Fig. 6	Ethmorhabdus gallicus Noël; Hypotype 55.7.1. Escoville (Northern France); Cornbrash, zone macrocephalus. × 5,000
Fig. 7	Watznaueria britannica (STRADNER); Hypotype 52.2.1. Redcliff Point (Dorset); Oxford Clay, zone mariae, subzone praecordatum. × 8,500
Fig. 8	Stephanolithion speciosum Deflandre; Hypotype 56.1.1. Port en Bassin (Normandy); Fullers Earth, zone progracilis. × 8,000
Fig. 9	Hexapodorhabdus cuvillieri Noël; Hypotype 38.8.1. Millbrook (Bedfordshire); Ampthill Clay, zone transversarium. × 10,000
Fig. 10	Cyclagelosphaera margereli Noël; Hypotype 30.7.1. Tidmoor Point (Dorset); Oxford Clay, zone mariae. × 9,500
Fig. 11	Diazomatolithus lehmani Noël; Hypotype 6.1.2. Redcliff Point (Dorset); Oxford Clay, zone mariae, subzone praecordatum. × 5,000
Fig. 12	Diadozygus asymmetricus Rood, HAY & BARNARD; Hypotype 33.7.1. Millbrook (Bedfordshire); Oxford Clay, zone cordatum, subzone bukowskii. × 13,000

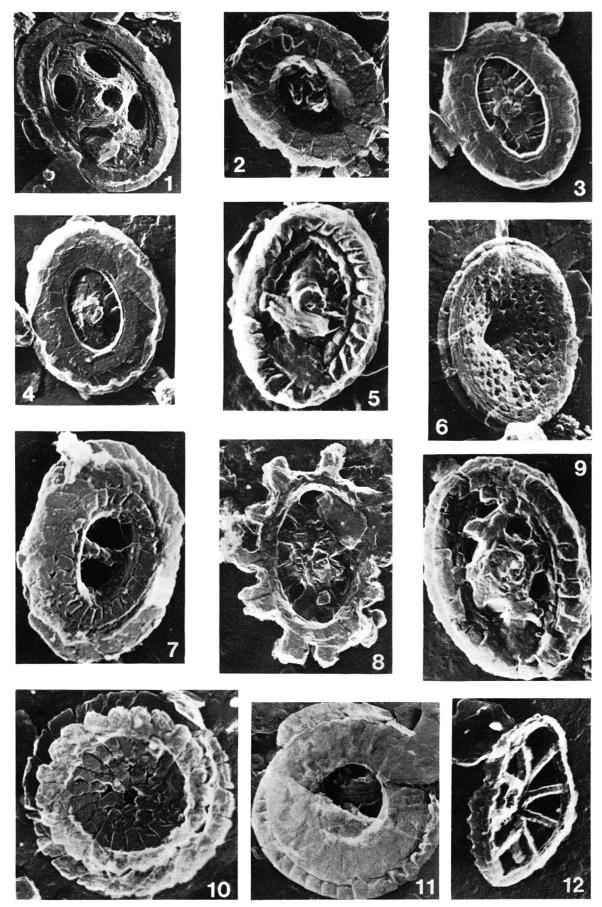


Plate III

All transmission electron micrographs

Fig. 1	Stephanolithion hexum Rood & Barnard; Hypotype 55.8.1. Escoville (Northern France); Cornbrash, zone macrocephalus. × 5,500
Fig. 2	Stephanolithion speciosum var. octum Rood & Barnard; Hypotype 57.4.2. Escoville (Northern France): Cornbrash, zone macrocephalus. × 4,500
Fig. 3	Podorhabdus rahla Noël; Hypotype 32.1.1. Millbrook (Bedfordshire); Oxford Clay, zone athleta. × 8,000
Fig. 4	Watznaueria communis Reinhardt; Hypotype 55.3.1. Port en Bessin (Normandy); Fullers Earth, zone progracilis. × 10,000
Fig. 5	Discorhabdus jungi Noël; Hypotype 27.7.2. Millbrook (Bedfordshire); Oxford Clay, zone mariae, subzone praecordatum. × 5,000
Fig. 6	Stephanolithion bigoti Deflandre; Hypotype 28.12.1. Millbrook (Bedfordshire); Oxford Clay, zone mariae, subzone praecordatum. × 2,000
Fig. 7	Actinozygus geometricus (GORKA); Hypotype 26.9.1. Millbrook (Bedfordshire); Upper Oxford Clay, zone mariae, subzone scarburgense. × 13,000
Fig. 8	Zeugrhabdotus noeli Rood, Hay & Barnard; Hypotype 32.11.1. Millbrook (Bedfordshire); Upper Oxford Clay, zone mariae, subzone praecordatum. × 24,000
Fig. 9	Vekshinella stradneri Rood, Hay & Barnard; Hypotype 34.5.1. Millbrook (Bedfordshire); Ampthill Clay, zone transversarium. × 14,000
Fig. 10	Polypodorhabdus escaigi Noël; Hypotype 53.12.1. Hounstout Cliff (Dorset); Kimmeridge Clay, zone pallasioides. × 8,000
Fig. 11	Diadozygus dorsetense Rood, Hay & Barnard; Hypotype 29.11.1. Millbrook (Bedfordshire); Upper Oxford Clay, zone cordatum, subzone costicardia. × 13,000
Fig. 12	Discorhabdus patulus (Deflandre); Hypotype 24.6.1. Millbrook (Bedfordshire); Middle Oxford Clay, zone athleta. × 5,000
Fig. 13	Parhabdolithus embergeri (Noël); Hypotype 33.11.1. Millbrook (Bedfordshire); Oakley Beds, zone transversarium. × 6,000

T. BARNARD and W. W. HAY: Jurassic Coccoliths (S. England and N. France)

PLATE III

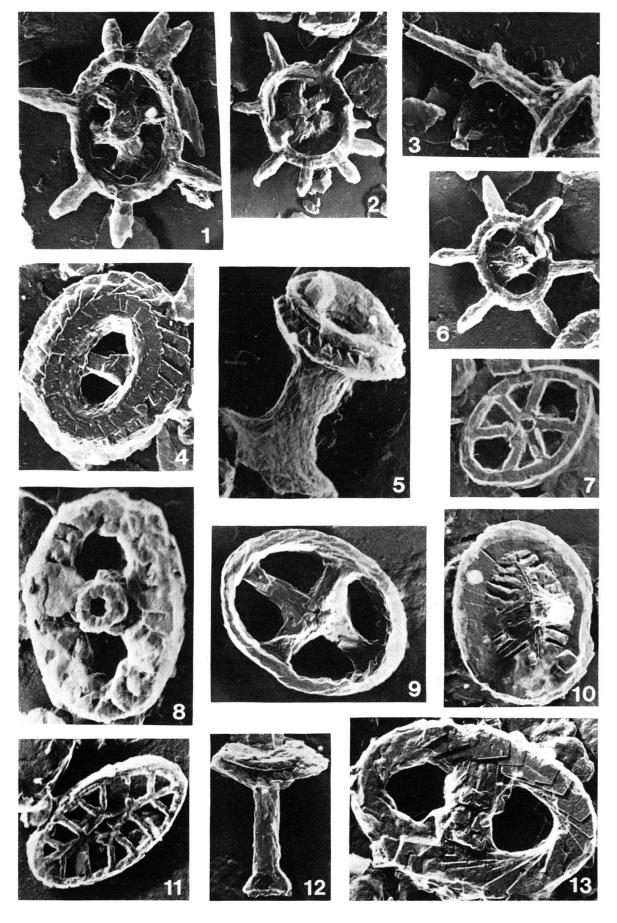


Plate IV

All phase contrast light micrographs \times 4,000

Fig. 1	Annulithus arkelli n. gen. n. sp. Lyme Regis (Dorset); Lias, Bed Number H. 75 (LANG), zone angulata, subzone extranodosa.
Fig. 2	Crepidolithus cavus Prins ex Rood, Hay & Barnard Lyme Regis (Dorset); Lias, Bed Number 74s (Lang), zone turneri, subzone birchi.
Fig. 3	Vekshinella quadriarculla (Noël) Lyme Regis (Dorset); Lias, Bed Number H41 (Lang), zone planorbis, subzone planorbis.
Fig. 4	Tubirhabdus patulus Prins ex Rood, Hay & Barnard Burton Bradstock (Dorset); Fullers Earth, zone progracilis.
Fig. 5	Crepidolithus crucifer Prins ex Rood, Hay & Barnard Lyme Regis (Dorset); Lias, Bed Number 97 (Lang), zone raricostatum, subzone densinodulum.
Fig. 6	Chiastozygus primitus PRINS Lyme Regis (Dorset); Lias, Bed Number 83g (LANG), zone obtusum, subzone obtusum.
Fig. 7	Crucirhabdus primulus PRINS ex ROOD, HAY & BARNARD Lyme Regis (Dorset); Lias, Bed Number 30e-f (LANG), zone bucklandi, subzone rotiforme.
Fig. 8	Crucirhabdus primulus PRINS ex ROOD, HAY & BARNARD Lyme Regis (Dorset); Lias, Bed Number 26 (LANG), zone bucklandi, subzone conybeari.
Fig. 9	Parhabdolithus liasicus Deflandre Lyme Regis (Dorset); Lias, Bed Number 30 e-f (Lang), zone bucklandi, subzone rotiforme.
Fig. 10	Zeugrhabdotus erectus (Deflandre) Port en Bessin (Normandy); Fullers Earth, zone progracilis.
Fig. 11	Crepidolithus crassus (Deflandre) Lyme Regis (Dorset); Lias, Bed Number 97 (Lang), zone raricostatum, subzone densinodulum.
Fig. 12	Parhabdolithus marthae Deflandre Lyme Regis (Dorset); Lias, Bed Number 36b (Lang), zone bucklandi, subzone rotiforme.
Fig. 13	Podorhabdus cylindratus Noël Eype (Dorset): Upper Lias, Downcliff Clay, zone levesquei.

Eclogae geologicae Helvetiae Vol. 67/3, 1974

T. Barnard and W. W. Hay: Jurassic Coccoliths (S. England and N. France)

PLATE IV

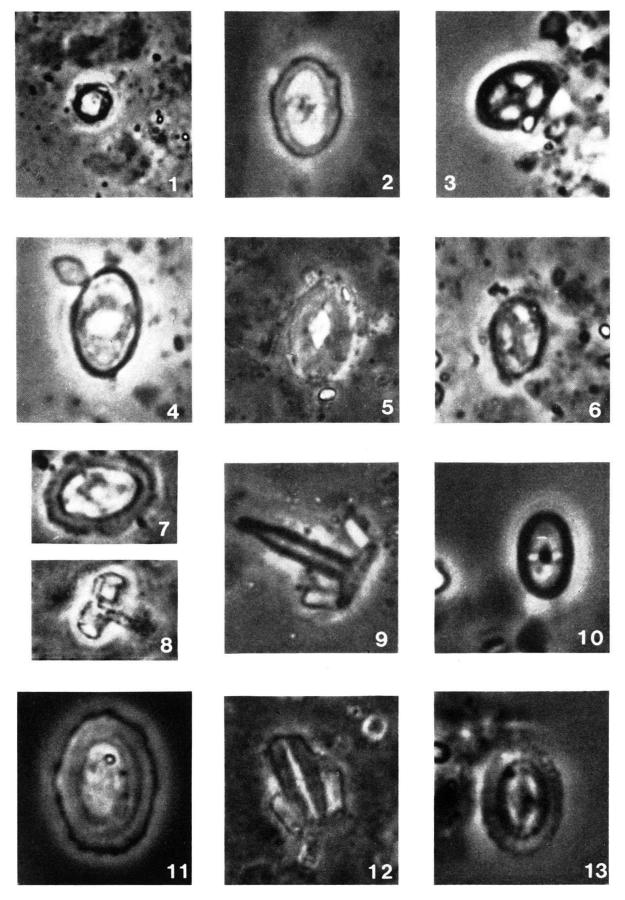


Plate V

All phase contrast light micrographs × 4,000

Fig. 1	Paleopontosphaera dubia Noël Lyme Regis (Dorset); Lias, Bed Number 121 (LANG), zone davoei, subzone luridum.
Fig. 2	Striatomarginis primitivus ROOD, HAY & BARNARD Millbrook (Bedfordshire); Oxford Clay, zone athleta.
Fig. 3	Paleopontosphaera veterna PRINS ex ROOD, HAY & BARNARD Eype (Dorset); Downcliff Clay, Upper Lias, zone levesquei.
Fig. 4	Podorhabdus macrogranulatus Prins ex Rood, Hay & Barnard Eype (Dorset); Downcliff Clay, Upper Lias, zone levesquei.
Fig. 5	Ethmorhabdus gallicus Noël Millbrook (Bedfordshire); Oxford Clay, zone cordatum, subzone bukowskii.
Fig. 6	Watznaueria britannica (STRADNER) Bletchley (Buckinghamshire); Oxford Clay, zone athleta.
Fig. 7	Stephanolithion speciosum Deflandre Burton Bradstock (Dorset); Fullers Earth, zone zigzag.
Fig. 8	Hexapodorhabdus cuvillieri Noël Millbrook (Bedfordshire); Oxford Clay, zone cordatum, subzone bukowskii.
Fig. 9	Cyclagelosphaera margereli Noël Eype (Dorset); Downcliff Clay, Upper Lias, zone levesquei.
Fig. 10	Diazomatolithus lehmani Noël Millbrook (Bedfordshire); Oxford Clay, zone mariae, subzone scarburgense.
Fig. 11	Diadozygus asymmetricus ROOD, HAY & BARNARD Millbrook (Bedfordshire); Oxford Clay, zone mariae, subzone scarburgense.
Fig. 12	Stephanolithion hexum ROOD & BARNARD Escoville (Northern France), Cornbrash, zone macrocephalus.

Eclogae geologicae Helvetiae Vol. 67/3, 1974

T. Barnard and W. W. Hay: Jurassic Coccoliths (S. England and N. France)

PLATE V

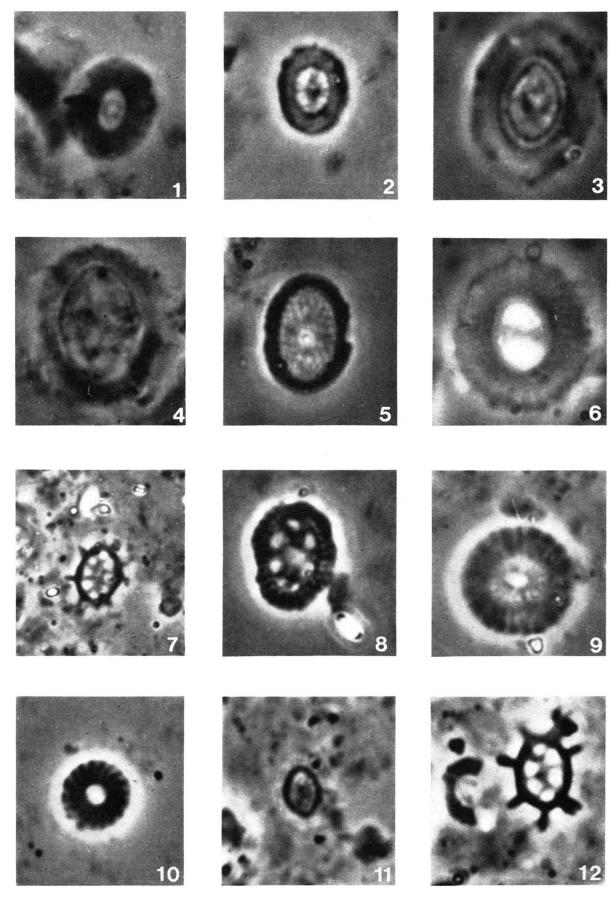


Plate VI

All phase contrast light micrographs × 4,000

Fig. 1	Stephanolithion speciosum var. octum Rood & BARNARD Escoville (Northern France); Cornbrash, zone macrocephalus.
Fig. 2	Podorhabdus rahla Noël Millbrook (Bedfordshire); Oxford Clay, zone mariae, subzone praecordatum.
Fig. 3	Watznaueria cummunis Reinhardt Millbrook (Bedfordshire); Oxford Clay, zone cordatum, subzone bukowskii.
Fig. 4	Discorhabdus jungi Noël Millbrook (Bedfordshire); Oxford Clay, zone mariae, subzone scarburgense.
Fig. 5	Stephanolithion bigoti Deflandre Millbrook (Bedfordshire); Oxford Clay, zone athleta.
Fig. 6	Actinozygus geometricus (GORKA) Millbrook (Bedfordshire); Oxford Clay, zone mariae, subzone praecordatum.
Fig. 7	Zeugrhabdotus noeli ROOD, HAY & BARNARD Dyrham (Gloucestershire); Lower Fullers Earth Clay, zone zigzag.
Fig. 8	Vekshinella stradneri Rood, Hay & Barnard Lyme Regis (Dorset); Bed Number 30e-f(Lang), zone bucklandi, subzone rotiforme.
Fig. 9	Polypodorhabdus escaigi Noël Millbrook (Bedfordshire); Oxford Clay, zone cordatum, subzone bukowskii.
Fig. 10	Diadozygus dorsetense Rood, Hay & Barnard Millbrook (Bedfordshire); Oxford Clay, zone mariae, subzone scarburgense.
Fig. 11	Discorhabdus patulus (DEFLANDRE) Mesnil de Bréville (Northern France); Callovian, zone jason.
Fig. 12	Parhabdolithus embergeri (Noël) Hounstout Cliff (Dorset); Kimmeridgian, zone pectinatites.

Eclogae geologicae Helvetiae Vol. 67/3, 1974

T. Barnard and W. W. Hay: Jurassic Coccoliths (S. England and N. France)

PLATE VI

