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Early Jurassic calcareous nannofossils from Portugal and their biostratigraphic use

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ABSTRACT

The ranges of 23 of calcareous nannofossils from 25 samples of the Brenha Road section, Portugal, are given. Four zones and five subzones are proposed and compared with the ammonite stage and zone system and with existing calcareous nannofossil zonations.

ZUSAMMENFASSUNG

Die Verbreitung von 23 Nannoplankton-Arten, aus 25 Proben des Profils «Brenha Road» (Portugal) stammend, wird angegeben. Die im vorliegenden Artikel vorgeschlagenen vier Zonen und fünf Subzonen werden einerseits mit den Ammoniten-Zonen und anderseits mit bereits bestehenden Nannoplankton-Zonierungen korreliert.

Introduction

This paper is the first part of a biostratigraphic study of Jurassic calcareous nannofossils from sections in Portugal. In this part a zonation for the Lower Jurassic of the Brenha Road section is tentatively proposed. The zonation is compared with the Jurassic stage and zone system and with existing biozonations based on calcareous nannofossils. It is intended that subsequent papers will cover Middle and Upper Jurassic sections so that when complete the work will form a comprehensive and detailed study of the Jurassic of Portugal.

Previous work

Past publications on Jurassic calcareous nannofossils have been mainly concerned with the taxonomy of the group (NOËL 1965*a*, 1965*b*, 1972; MEDD 1971; ROOD, HAY & BARNARD 1971, 1973; GRÜN, PRINS & ZWEILLI 1974). More recently, authors have begun to adopt a biostratigraphic approach (PRINS 1969; THIERSTEIN 1971, 1973; WORSLEY 1971; WILCOXON 1972; BARNARD & HAY 1974). However, the Lower Jurassic remains a comparatively little studied period. This might be due to the lack of suitable Lower Jurassic samples, particularly at Deep Sea Drilling Project sites and also due to the great interest and debate that surrounds the Jurassic-Cretaceous boundary and its correlation (BRÖNNIMANN 1955; THIERSTEIN, WORSLEY and WILCOXON). Amongst those who have included the Lower Jurassic in their biozonations STRADNER (1963) proposed a fivefold subdivision for the whole

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Jurassic. BARNARD & HAY, working on sections from Southern England and north-west France, proposed a more detailed subdivision with 22 coccolith zones for the whole Jurassic system. The Lower Jurassic part of their zonation will be considered in greater detail later in this paper. PRINS' zonation of the Lower and Middle Lias, also considered further in this paper, incorporates an evolutionary interpretation of Liassic coccoliths.

Location and stratigraphy

The Brenha Road section is in the region of Figueira da Foz which lies to the north of Lisbon and north-west of the Tagus River in Portugal. Samples were

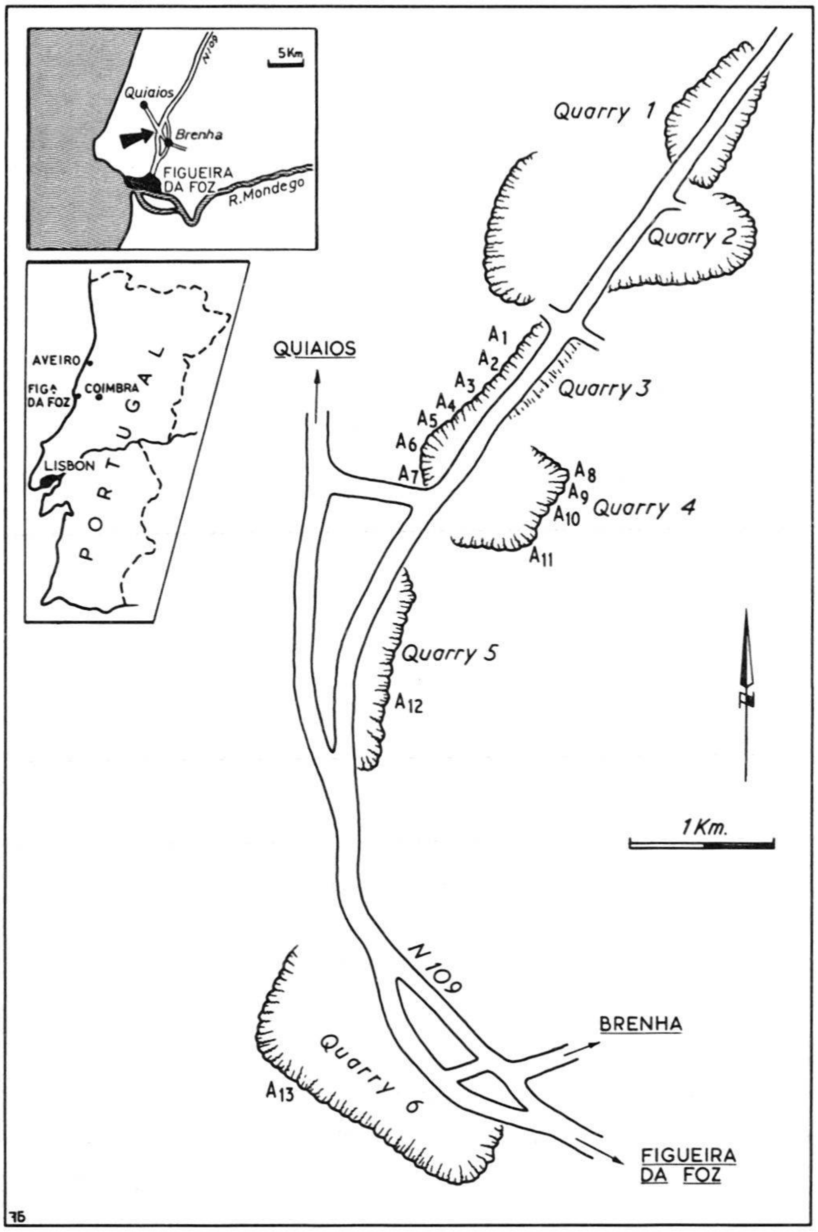

Fig. 1. The location of the Brenha Road section, Portugal. $A_1 - A_{13}$ indicate sites with identified zonal ammonites.

collected in 1969 from the section which was then in a recently exposed cutting just north of Brenha on the new road between Aviero and Figueira da Foz (see Fig. 1). In a study of the Coimbra area SCHOTT & STAESCHE (1957) give a detailed account of the old Brenha Road section. Their work serves as a useful guide to the newer section.

The Brenha Road section is an almost complete sequence from the Lias to the top of the Bathonian. The Lower Jurassic part of the section may be subdivided into two parts on the basis of lithology. Limestones and marls with thin bands of mudstone and shale comprise the lower part, while the Upper Lias consists of a more uniform sequence of clays. Quarry 1 (see Fig. 1) exposes massive dolomites and limestones which constitute SCHOTT's Coimbra Beds, thought to be Lower Sinemurian in age. Quarry 2 contains fossiliferous horizons. In the northern face, which is also thought to be Lower Sinemurian, a bed of cidaroid echinoderms is found and in the south face there is an *Ostrea* horizon which contains fragments of lamellibranchs, gastropods and oysters. The *Ostrea* horizon constitutes SCHOTT's Gryphaea-obliqua-Beds which are Upper Sinemurian in age. Quarry 3, on the west side of the road, exposes mudstones, shales and marls with limestone bands. On the opposite side of the road a finely banded shale-limestone sequence is exposed. A duplicate set of samples was collected from this part of the section. In the northern part of Quarry 4 massive limestones are exposed and these pass up into shaly beds in the southern part. Quarry 5 is an exposure of thin nodular limestone and marl bands and Quarry 6 is in uniform grey mudstones of Toarcian age.

All sample data is available on request from the British Library, Boston Spa as a Supplementary Publication (Code No. SUP 90020).

Using ammonites collected from sites $A_1 - A_{13}$ in Quarries 3-6, J.H. Callomon (unpublished information) was able to recognize the following stratigraphy, which has provided a basis for the development of a biozonation using calcareous nannofossils.

Section notation	*Stage and Zone*
A_{13}	Toarcian
$A_9 - A_{12}$	Upper Pliensbachian (Spinatum Zone)
A_8	Upper Pliensbachian (Margaritatus Zone)
A_7	Lower Pliensbachian (Davoei Zone)
$A_5 - A_6$	Lower Pliensbachian (Ibex Zone)
$A_2 - A_4$	Lower Pliensbachian (Jamesoni Zone)
A_1	Upper Sinemurian

Method

While the scanning electron microscope has been of great value for taxonomic investigation, the proposed biozonation has been developed mainly from work done under the light microscope. Where specific identification is possible only with the scanning electron microscope the specimens have been grouped together under their generic name. Thus, for example, *Calyculus pugnatum* and *Calyculus cribrum* are recorded as *Calyculus* spp.

Following the recommendation of the "Round Table on Calcareous Nannoplankton" (FARINACCI 1971) that "the relative abundance of species used in defining a zone be indicated", the author has adopted the method described by HAY (1970) which suggests that "species abundance is recorded as the logarithm of abundance in a simple smear slide ...". In this study the smear slides were viewed at 1600×. Three hundred fields of view were examined and the species abundance was recorded as follows:

1 = 10's of specimens in each field of view	= abundant
0 = 1 specimen in each field of view	= very common
-1 = 1 specimen in 10 fields of view	= common
-2 = 1 specimen in 100+ fields of view	= rare

In this form the results are readily available for reproduction in tables, graphs and range charts.

Paleontology

The samples collected from the Brenha Road section generally produced a good abundance of coccoliths. Preservation of the specimens was found to be variable. The Toarcian sediments gave assemblages with a wide range of well preserved coccoliths. However, the Pliensbachian and Sinemurian sediment contained assemblages with a predominance of more robust forms and very few complete specimens of the more delicately constructed forms. In some samples the more robust specimens were found to be highly altered, so that identification was made mainly on the basis of outline. In these altered samples delicately constructed coccoliths were absent or rare.

The ranges of 23 species of calcareous nannofossils, their relative abundance and the proposed biozonation are given in Figure 2. It can be seen that several species are found throughout the section. *Schizosphaerella punctulata* is abundant or very common throughout and *Crepidolithus crassus* is also generally common. *Tubirhabdus patulus* and *Zeugrhadotus erectus* are quite common while *Vekshinella quadriarcula* has a more sporadic occurrence throughout the section. These particular species will not be included in the following discussion of each zone although their presence should be remembered.

Calcareous nannofossil zonation

Biscutum ellipticum Zone

Limits: From the first appearance of *Biscutum ellipticum* to the first appearance of *Podorhabdus cylindratus.*

Species present: Apart from those species that are found throughout the section there are present throughout the zone *Parhabdolithus liasicus, Crucirhabdus primulus, Crepidolithus cavus, Crepidolithus crucifer, Discorhabdus ignotus, Ethmorhabdus* aff. *E. gallicus, Biscutum ellipticum* and *Calyculus* spp.

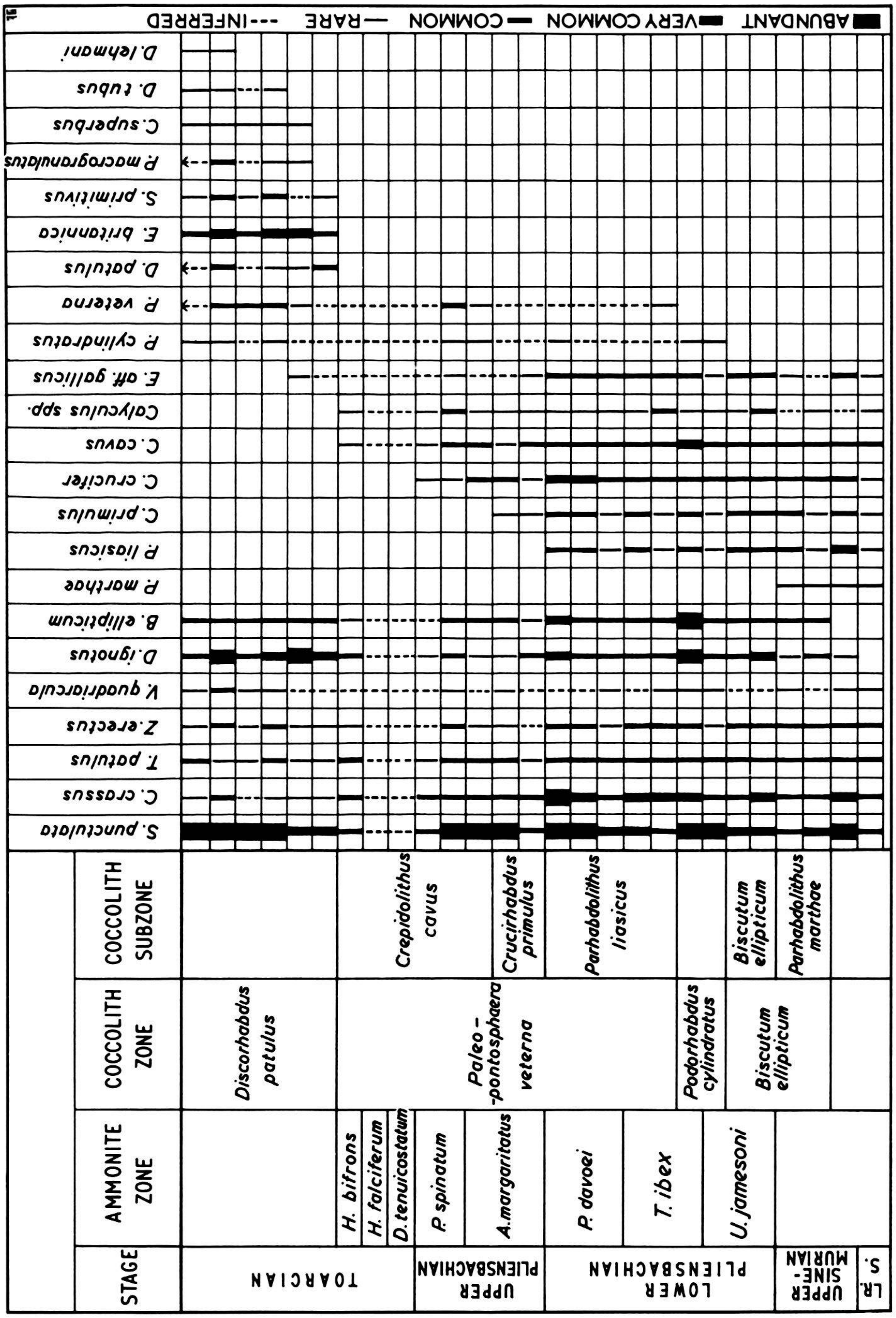

Fig. 2. Stratigraphic distribution of Lower Jurassic coccoliths and the proposed zonation of the Brenha Road section. Each horizontal line represents one assemblage.

Comparison with Jurassic stage and zone system: This zone occupies the period from the middle of the Upper Sinemurian to the upper part of the Lower Pliensbachian Jamesoni Zone.

Parhabdolithus marthae Subzone

Limits: From the last occurrence of *Parhabdolithus marthae* to the first appearance of *Podorhabdus cylindratus*.
Index species: The presence of *Parhabdolithus marthae* defines the subzone.
Comparison with Jurassic stage and zone system: The upper limit of the subzone is found at the top of the Sinemurian.

Biscutum ellipticum Subzone

Limits: From the last occurrence of *Parhabdolithus marthae* to the first appearance of *Podorhabdus cylindratus*.
Index species: *Parhabdolithus marthae* is absent.
Comparison with Jurassic stage and zone system: The subzone is found from the top of the Sinemurian to the upper part of the Lower Pliensbachian Jamesoni Zone.

Podorhabdus cylindratus Zone

Limits: From the first appearance of *Podorhabdus cylindratus* to the first appearance of *Paleopontosphaera veterna*.
Species present: There are *Parhabdolithus liasicus, Crucirhabdus primulus, Crepidolithus cavus, Crepidolithus crucifer, Discorhabdus ignotus, Biscutum ellipticum, Ethmorhabdus* aff. *E. gallicus, Podorhabdus cylindratus* and *Calyculus* spp.
Comparison with Jurassic stage and zone system: The zone occupies the top of the Lower Pliensbachian Jamesoni Zone and the lower part of the Lower Pliensbachian Ibex Zone.

Paleopontosphaera veterna Zone

Limits: From the first appearance of *Paleopontosphaera veterna* to the first appearance of *Discorhabdus patulus*.
Species present: *Crepidolithus cavus, Discorhabdus ignotus, Biscutum ellipticum, Podorhabdus cylindratus, Paleopontosphaera veterna, Ethmorhabdus* aff. *E. gallicus* and *Calyculus* spp. are found throughout the zone. *Crepidolithus crucifer* does not occur at the top of the zone.
Comparison with Jurassic stage and zone system: The zone ranges from the middle of the Lower Pliensbachian Ibex Zone to the top of the Toarcian Bifrons Zone.

Parhabdolithus liasicus Subzone

Limits: From the first appearance of *Paleopontosphaera veterna* to the last occurrence of *Parhabdolithus liasicus*.
Index species: *Parhabdolithus liasicus*.

Comparison with Jurassic stage and zone system: The subzone occupies the period from the middle of the Lower Pliensbachian Ibex Zone to the top of the Lower Pliensbachian Davoei Zone.

Crucirhabdus primulus Subzone

Limits: From the last occurrence of *Parhabdolithus liasicus* to the last occurrence of *Crucirhabdus primulus.*

Index species: *Crucirhabdus primulus.*

Comparison with Jurassic stage and zone system: This subzone is restricted to the lower part of Upper Pliensbachian Margaritatus Zone.

Crepidolithus cavus Subzone

Limits: From the last occurrence of *Crucirhabdus primulus* to the first appearance of *Discorhabdus patulus.*

Index species: *Crepidolithus cavus* and *Calyculus* spp.

Comparison with Jurassic stage and zone system: This subzone occupies the rest of the Upper Pliensbachian Margaritatus Zone and continues to the top of the Toarcian Bifrons Zone.

Discorhabdus patulus Zone

Limits: From the first appearance of *Discorhabdus patulus* to the top of the section.

Species present: *Podorhabdus cylindratus, Paleopontosphaera veterna, Biscutum ellipticum, Discorhabdus ignotus, Discorhabdus patulus, Ellipsagelosphaera britannica* and *Striatomarginis primitivus. Ethmorhabdus* aff. *E. gallicus* is found at the base of the zone but soon disappears. *Podorhabdus macrogranulatus, Carinolithus superbus, Discorhabdus tubus* and *Diazomatolithus lehmani* have their first appearances within this zone.

Comparison with Jurassic stage and zone system: The zone occupies the Variabilis, Thouarsense and Levesquei Zones of the Toarcian.

Comparison of the proposed zonation with existing calcareous nannofossil zonations

There have been only two papers (Prins 1969; Barnard & Hay 1974) which have proposed zonations based on calcareous nannofossils for the Lower Jurassic (see Table). A comparison of the proposed zonation for the Brenha Road section with Prins' zonation for Lower and Middle Lias coccoliths from England, France and Western Germany shows little similarity. Those species found by Prins that may be directly compared with the ones given in Figure 2 are generally shown as having different ranges. *Tubirhabdus patulus* is the only species which has the same range in both charts but, since it is found throughout the Lower Jurassic, it is considered to be of little biostratigraphic importance. Other species, such as *Crepidolithus crucifer, Parhabdolithus liasicus* and *Parhabdolithus marthae,* have compar-

Table: *Comparison of the proposed zonation for the Brenha Road section with existing Lower Jurassic calcareous nannofossil zonations* (* this paper).

Stage	Ammonite Zonation	Calcareous Nannofossil Zonation: PRINS 1969	Calcareous Nannofossil Zonation: BARNARD and HAY 1974	Calcareous Nannofossil Zonation: BRENHA ROAD ZONE*	Calcareous Nannofossil Zonation: BRENHA ROAD SUBZONE*
Aalenian	*L. opalinum*		Discorhabdus tubus	Discorhabdus patulus	
Toarcian	*D. levesquei*				
	G. thouarsense		Podorhabdus cylindratus		
	H. variabilis				
	H. bifrons			Paleopontosphaera veterna	Crepidolithus cavus
	H. falciferum				
	D. tenuicostatum	Striatococcus opacus			
Upper Pliensbachian	*P. spinatum*				
	A. margaritatus	Crepidolithus crassus			Crucirhabdus primulus
Lower Pliensbachian	*P. davoei*	Crepidolithus cavus			Parhabdolithus liasicus
	T. ibex		Crepidolithus crassus	P. cylindratus	
	U. jamesoni			Biscutum ellipticum	Biscutum ellipticum
Sinemurian	*E. raricostatum*	Parhabdolithus liasicus			Parhabdolithus marthae
	O. oxynotum		Paleopontosphaera dubia		
	A. obtusum				
	C. turneri		Parhabdolithus liasicus		
	A. semicostatum	Parhabdolithus marthae	Parhabdolithus marthae		
	A. bucklandi		Crucirhabdus primulus		
Hettangian	*S. angulata*	Crucirhabdus primulus	Annulithus arkelli		
	A. liasicus				
	P. planorbis				
Rhaetian					

able first appearances but differing upper limits. Since the correlation of species ranges is so poor it is not surprising to find that PRINS' zonation cannot be applied to the Brenha Road section. PRINS does not fully employ species first appearances in defining the limits of his zones but rather describes these limits on the basis of species abundance. The author suggests that this method is unsatisfactory since species abundance may vary over different geographic areas and is also subject to the errors inherent in measurement. The author also considers that the wide variety and large number of species found at the base of the Brenha Road section, in the Lower Sinemurian, renders unlikely the possible evolution of these species from the single Hettangian species, *Crucirhabdus primulus*, as proposed by PRINS.

Detailed comparison of the species ranges given in Figure 2 with those found by BARNARD & HAY (1974, Fig. 2, p. 579) gives a good correlation (see Fig. 3). Direct stratigraphic comparison can be made between the Portuguese section and those of BARNARD & HAY using ammonites in the Pliensbachian and early Toarcian. However, in the Sinemurian and Upper Toarcian of the Portuguese section the ammonite zones were not identified in the field although the boundary between the Lower and Upper Sinemurian was located. Thus, stratigraphic correlation, using ammonites, between the two areas is, in part, tentative.

Of the 16 species common to both areas, 6 species have the same ranges. A further 7 species, that is *Crucirhabdus primulus, Parhabdolithus marthae, Crepidolithus crassus, Podorhabdus cylindratus, Striatomarginis primitivus, Podorhabdus macrogranulatus* and *Discorhabdus tubus*, have ranges which differ only within a particular stage. The differences in the ranges given for the final 3 species, *Crepidolithus crucifer, Crepidolithus cavus* and *Paleopontosphaera veterna*, are very much more distinct. The author suggests that this may be due to the problems of the identification of these species under the light microscope. In addition to the species mentioned above the author also finds *Ellipsagelosphaera britannica* and *Discorhabdus patulus* in the Toarcian while these species are not found by BARNARD & HAY until the Bajocian and Callovian, respectively. The author considers that the species name *Watznaueria communis*, used by BARNARD & HAY, should be *Ellipsagelosphaera britannica*. This follows the definition proposed by GRÜN & ALLEMANN that *Ellipsagelosphaera* is used for forms in which "the central area is surrounded by an additional cycle of abcentrally sloping, unimbricated, flat elements (which) form a tube ...". *Watznaueria*, on the other hand, although essentially similarly constructed, differs in the lack of the additional cycle of elements which surrounds the central area.

Comparison of the proposed coccolith zonation with that of BARNARD & HAY shows that the two are essentially similar. Dissimilarity arises where the ranges of critical zonal species differ. Despite range variations it has been necessary to use certain species because they were the only ones suitable. This is because in this part of Lower Jurassic there are only a few species available upon which to base a zonation since this was an early stage in coccolith development. It is an unfortunate result that in some cases a zone defined on a particular species in Portugal is not apparently contemporaneous with a zone based on the same species in North-Western Europe. Also, BARNARD & HAY were able to suggest a more detailed subdivision since they had a complete set of samples from the Sinemurian and most of the

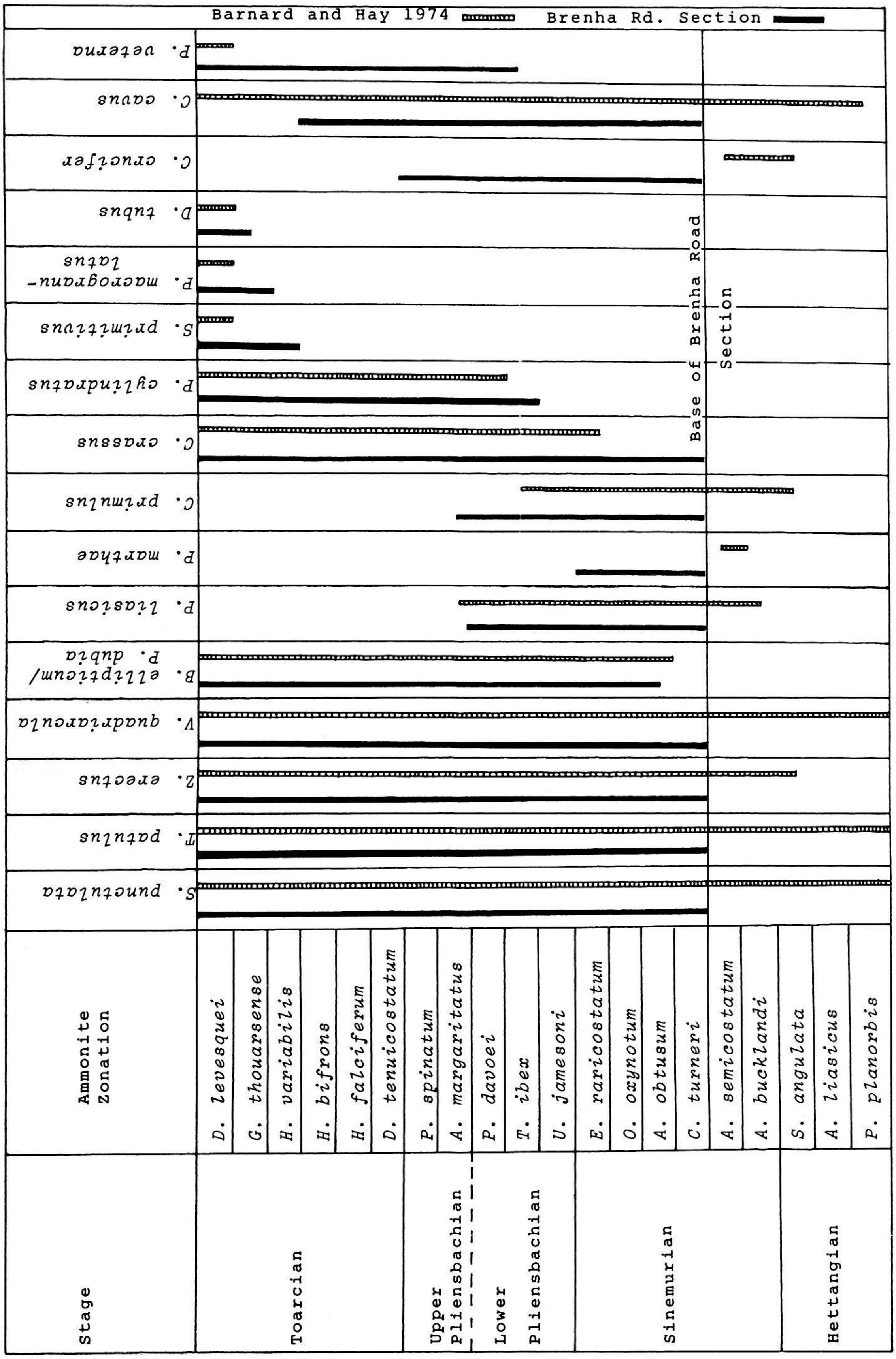

Fig. 3. Comparison of the Lower Jurassic coccolith distribution from the Brenha Road section with that from Southern England and North France.

Hettangian. Thus, their *Annulithus arkelli*, *Crucirhabdus primulus*, *Parhabdolithus marthae* and *Parhabdolithus liasicus* Zones are not represented in the Brenha Road section although the species used by BARNARD & HAY to define the zones are certainly present (except *Annulithus arkelli*) at the base of the Portuguese section. The *Palaeopontosphaera dubia* Zone of BARNARD & HAY and the *Biscutum ellipticum* Zone proposed here have essentially similar lower limits in both charts. The first appearance at the top of the Upper Sinemurian of *Crepidolithus crassus* in North-Western France and Southern England resulted in the erection of the *Crepidolithus crassus* Zone which cannot be applied in Portugal due to the earlier appearance there of that species. In contrast, the earlier appearance in Portugal of *Podorhabdus cylindratus* resulted in the formation of the *Podorhabdus cylindratus* Zone at the top of the Lower Pliensbachian Jamesoni Zone while in England and Northern France the zone is not introduced until later in the Pliensbachian. Again, the earlier appearance in Portugal of *Paleopontosphaera veterna* has enabled a further subdivision of the Pliensbachian and early Toarcian to be made. BARNARD & HAY'S *Podorhabdus cylindratus* Zone ranges from the Lower Pliensbachian Davoei Zone to the Upper Toarcian Thouarsense Zone. In the Portuguese section the lower limit of the uppermost zone, the *Discorhabdus patulus* Zone, is strongly defined at the top of the Toarcian Bifrons Zone by the appearance of *Discorhabdus patulus*, *Striatomarginis primitivus* and *Ellipsagelosphaera britannica*. Other species such as *Podorhabdus macrogranulatus*, *Discorhabdus tubus*, *Carinolithus superbus* and *Diazomatolithus lehmani* appear within the zone. BARNARD & HAY do not record the influx of new species until the top of the Toarcian. It is likely that a more complete representation of the Toarcian from England and Northern France would result in a closer correlation in this part of the column.

The author considers that the introduction of subzones, defined largely on the last occurrences of selected species, is valuable since it enables finer subdivision of the Lower Jurassic. This is particularly apparent in the Pliensbachian and Lower Toarcian where the lack of new species would normally result in the formation of a long ranging zone with a resultant loss of detail. Thus, the *Paleopontosphaera veterna* Zone ranges from the middle of the Lower Pliensbachian Ibex Zone to the top of the Toarcian Bifrons Zone. No new species are recorded within this zone but subdivision may be made on the basis of the discontinuation of certain distinctive species such as *Parhabdolithus liasicus* and *Crucirhabdus primulus*.

The ages and ranges of the coccoliths from the Brenha Road section and from the sections in Southern England and North France have been based on ammonite dating and a comparison of the two areas has shown some dissimilarity. It could be suggested that the discrepancy, attributed in this paper to poor coccolith correlation, may instead be a result of regional variations in ammonite ranges.

Summary of coccolith distribution in the Lower Jurassic

The Lower Jurassic of the Brenha Road section may be subdivided into two parts on the basis of its calcareous nannofossils. The first part is characterized by a wide variety of coccoliths which are found at the base of the Lower Sinemurian and continue to be present through the Sinemurian and Pliensbachian. Towards the top of the Pliensbachian the number of species and the number of specimens decreases so that in the Lower Toarcian both are reduced. The Upper Toarcian, on the other hand, is characterized by a large influx of new species. This floral change correlates quite closely with a facies change from shallow water limestones and mudstones of Sinemurian and Pliensbachian age to the more uniform, deeper water clays of the Toarcian. A causal relationship appears likely in terms of the oceanography of the times.

The floral and sedimentary changes recorded above may be closely correlated with those described by BARNARD & HAY (1974). The pattern also corresponds with that described in the literature for the Pliensbachian–Toarcian boundary. HALLAM (1967, 1972) describes a pattern of transgressions and regressions which might well be applied to the Brenha Road section. He also suggests that the faunal break at the Pliensbachian–Toarcian boundary in North-Western Europe is largely attributable to the Lower Toarcian bituminous shale facies. The absence in South-Western Europe of this facies is thought to have resulted in the survival of some bivalves into the Middle Toarcian. He does, however, find a marked influx of new bivalves in the Toarcian Bifrons Zone and concludes that in South-Western Europe the faunal change between the late Pliensbachian and the Toarcian is still considerable although less abrupt than in North-Western Europe. The calcareous nannofossils of the Brenha Road section accord with this model.

Systematic paleontology

Since this paper is essentially biostratigraphic in nature and in view of the extent of the relevant literature dealing with taxonomy, the author considers that the inclusion of a list of species together with references to the most recent, relevant publications is adequate.

List of species

[Most recent reference in square brackets]

Biscutum ellipticum (GORKA 1957) GRÜN & ALLEMANN 1975 [GRÜN & ALLEMANN 1975, Pl. 1, Fig. 5-7, 154-156].

Calyculus cribrum NOËL 1972 [GRÜN, PRINS & ZWEILLI 1974, Pl. 15, Fig. 4-6, Textfig. 11, 311-312].

Calyculus pugnatum GRÜN, PRINS & ZWEILLI 1974 [GRÜN, PRINS & ZWEILLI 1974, Pl. 19, Fig. 5, Textfig. 12, 312-313].

Carinolithus superbus PRINS 1969 [PRINS 1969, Pl. 1, Fig. 7, 552].

Crepidolithus cavus PRINS 1969 [ROOD, HAY & BARNARD 1973, Pl. 2, Fig. 5, 375].

Crepidolithus crassus (DEFLANDRE 1954) NOËL 1965*a* [GRÜN, PRINS & ZWEILLI 1974, Pl. 20, Fig. 1-3, 310].

Crepidolithus crucifer PRINS 1969 [ROOD, HAY & BARNARD 1973, Pl. 2, Fig. 4, 374-375].

Crucirhabdus primulus PRINS 1969 [ROOD, HAY & BARNARD 1973, Pl. 1, Fig. 1-2, 367-368].

Diazomatolithus lehmani NOËL 1965*b* [THIERSTEIN 1971, Pl. 3, Fig. 11-15, 479].

Discorhabdus ignotus (GORKA 1957) PERCH-NIELSEN 1968 [GRÜN & ALLEMANN 1975, Pl. 1, Fig. 8-10, Textfig. 4, 157-158].

Discorhabdus patulus (DEFLANDRE 1954) NOËL 1965*a* [ROOD, HAY & BARNARD 1971, Pl. 4, Fig. 4, 266-267].

Discorhabdus tubus NOËL 1965*b* [ROOD, HAY & BARNARD 1971, Pl. 4, Fig. 7, 267].

Ellipsagelosphaera britannica (STRADNER 1963) PERCH-NIELSEN 1968 [GRÜN & ALLEMANN 1975, Pl. 1, Fig. 11-12, Pl. 2, Fig. 1-4, Textfig. 5, 159-160].

Ethmorhabdus aff. *E. gallicus* NOËL 1965*b* [NOËL 1965*b*, Pl. 10, Fig. 3-4, 112].
Paleopontosphaera veterna PRINS 1969 [ROOD, HAY & BARNARD 1973, Pl. 3, Fig. 2-3, 378-379].
Parhabdolithus liasicus DEFLANDRE 1952 [ROOD, HAY & BARNARD 1973, Pl. 2, Fig. 1, 372-373].
Parhabdolithus marthae DEFLANDRE 1954 [ROOD, HAY & BARNARD 1973, Pl. 2, Fig. 2, 373].
Podorhabdus cylindratus NOËL 1965*b* [ROOD, HAY & BARNARD 1973, Pl. 2, Fig. 6, 377].
Podorhabdus macrogranulatus PRINS 1969 [ROOD, HAY & BARNARD 1973, Pl. 2, Fig. 7, 377].
Schizosphaerella punctulata DEFLANDRE & DANGEARD 1938 [GRÜN, PRINS & ZWEILLI 1974, Pl. 22, Fig. 4-6, 314-315].
Striatomarginis primitivus ROOD, HAY & BARNARD, 1973 [ROOD, HAY & BARNARD 1973, Pl. 3, Fig. 4, 379-380].
Tubirhabdus patulus PRINS 1969 [ROOD, HAY & BARNARD 1973, Pl. 2, Fig. 3, 373-374].
Vekshinella quadriarcula (NOËL 1965*b*) ROOD, HAY & BARNARD 1971 [GRÜN, PRINS & ZWEILLI 1974, Pl. 19, Fig. 6, 307-308].
Zeugrhabdotus erectus (DEFLANDRE 1954) REINHARDT 1965 [ROOD, HAY & BARNARD 1973, Pl. 1, Fig. 3, 252].

Further discussion is merited in respect of two of the above species. *Discorhabdus ignotus:* The author follows the synonomy of GRÜN & ALLEMANN (1975) but does not use the name *Bidiscus ignotus* (GORKA 1957) HOFFMANN 1970 since the description of the new genus *Bidiscus* in BUKRY (1969) does not differ from the earlier description of the genus *Discorhabdus* in NOËL (1965*b*). The figured specimens (Pl. 2, Fig. 1-11, Pl. 4, Fig. 10-11) illustrate the great variety found in this species in the Brenha Road section. *Ethmorhabdus* aff. *E. gallicus:* The specimens (Pl. 1, Fig. 4-6, Pl. 3, Fig. 4-5) have been assigned to this species since they are similar to those figured in NOËL (1965*b*, Pl. 10, Fig. 1-5). The specimen (Pl. 3, Fig. 5) is also very similar to that described by BARNARD & HAY (1974, Pl. 5, Fig. 5) as *Ethmorhabdus gallicus* NOËL.

Acknowledgments

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Plate 1

All specimens from Brenha Road section

Fig. 1 *Schizosphaerella punctulata* DEFLANDRE & DANGEARD
Oblique view
Hypotype UCL-67-18
Upper Toarcian, × 1200

Fig. 2 *Schizosphaerella punctulata* DEFLANDRE & DANGEARD
Proximal side
Hypotype UCL-61-10
Upper Toarcian, × 2100

Fig. 3 *Schizosphaerella punctulata* DEFLANDRE & DANGEARD
Oblique view
Hypotype UCL-61-12
Upper Toarcian, × 2800

Fig. 4 *Ethmorhabdus* aff. *E. gallicus* NOËL
Distal side
Hypotype UCL-63-22
Pliensbachian (Ibex Zone), × 5900

Fig. 5 *Ethmorhabdus* aff. *E. gallicus* NOËL
Proximal side
Hypotype UCL-57-2
Pliensbachian (Ibex Zone), × 5900

Fig. 6 *Ethmorhabdus* aff. *E. gallicus* NOËL
Distal side
Hypotype UCL-57-3
Pliensbachian (Ibex Zone), × 8500

Fig. 7 *Biscutum ellipticum* (GORKA) GRÜN & ALLEMANN
Distal side
Hypotype UCL-64-35
Pliensbachian (Spinatum Zone), × 8600

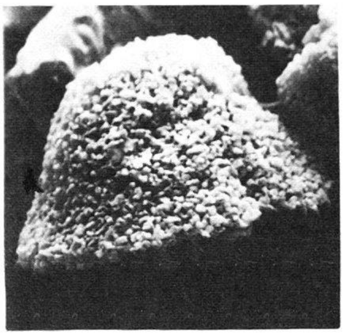
Fig. 8 *Calyculus pugnatum* GRÜN, PRINS & ZWEILLI
Proximal side
Hypotype UCL-64-2
Pliensbachian (Margaritatus Zone), × 4000

Fig. 9 *Calyculus cribrum* NOËL
Proximal side
Hypotype UCL-63-9
Pliensbachian (Ibex Zone), × 6000

Fig. 10 *Parhabdolithus marthae* DEFLANDRE
Oblique view
Hypotype UCL-56-29
Upper Sinemurian, × 5900

Fig. 11 *Podorhabdus cylindratus* NOËL
Proximal side
Hypotype UCL-60-10
Upper Toarcian, × 4300

Fig. 12 *Discorhabdus patulus* (DEFLANDRE) NOËL
Oblique view
Hypotype UCL-66-15
Upper Toarcian, × 4500



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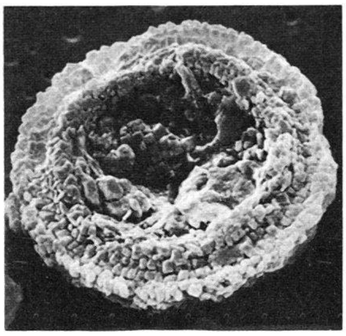

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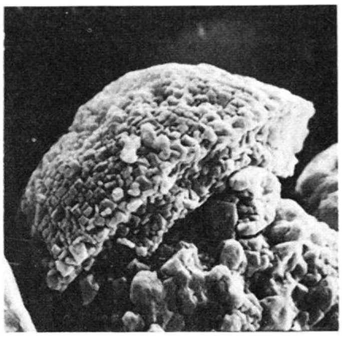

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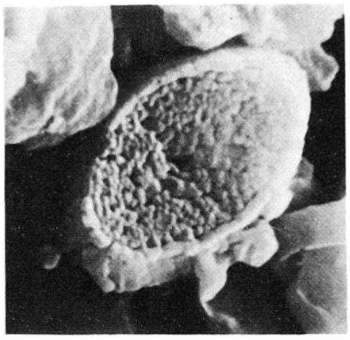

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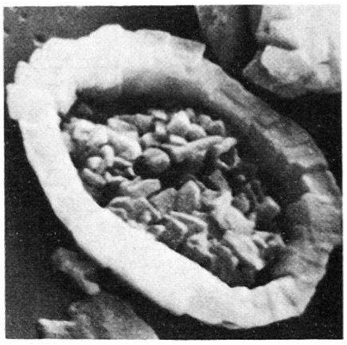

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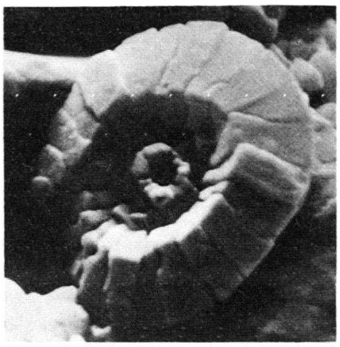

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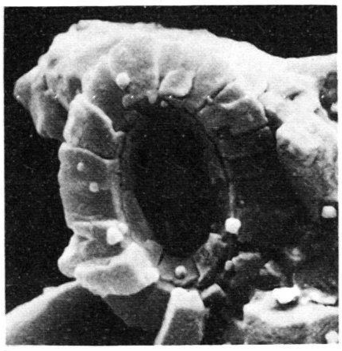

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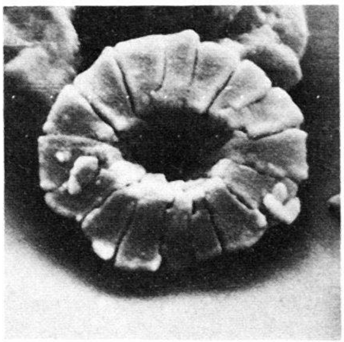

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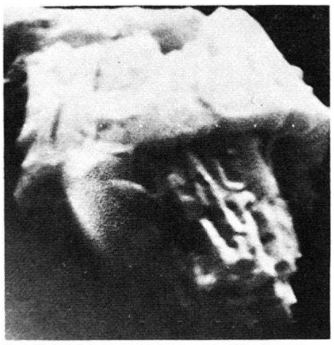

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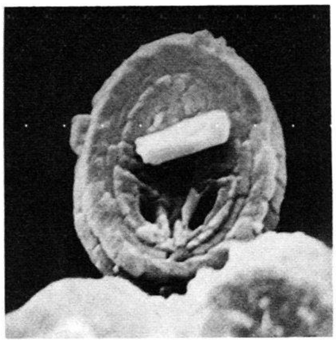

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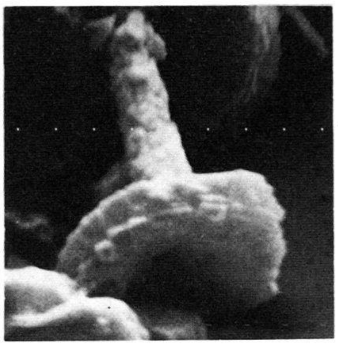

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Plate 2

All specimens from Brenha Road section

Discorhabdus ignotus (Gorka) Perch-Nielsen

Fig. 1 Proximal side
Hypotype UCL-65-19
Upper Toarcian, × 6400

Fig. 2 Proximal side
Hypotype UCL-56-8
Pliensbachian (Ibex Zone), × 5500

Fig. 3 Proximal side
Hypotype UCL-65-26
Upper Toarcian, × 9500

Fig. 4 Proximal side
Hypotype UCL-66-30
Upper Toarcian, × 5800

Fig. 5 Proximal side
Hypotype UCL-66-11
Upper Toarcian, × 6600

Fig. 6 Proximal side
Hypotype UCL-67-19
Upper Toarcian, × 6000

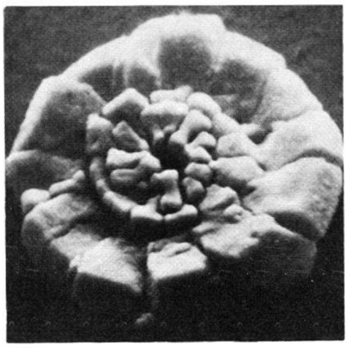
Fig. 7 Distal side
Hypotype UCL-56-32
Upper Toarcian, × 5500

Fig. 8 Proximal side
Hypotype UCL-67-20
Upper Toarcian, × 6600

Fig. 9 Proximal side
Hypotype UCL-63-26
Pliensbachian (Ibex Zone), × 6500

Fig. 10 Oblique view
Hypotype UCL-60-22
Upper Toarcian, × 5700

Fig. 11 Oblique view
Hypotype UCL-61-4
Upper Toarcian, × 6200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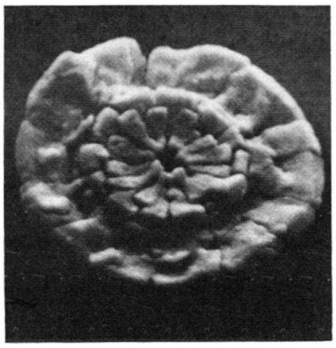
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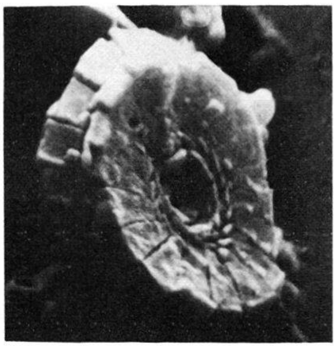
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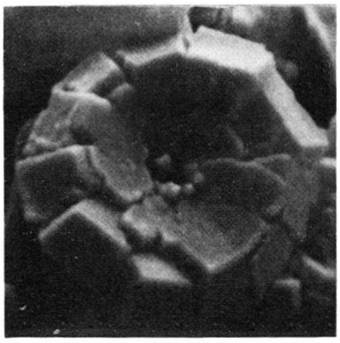
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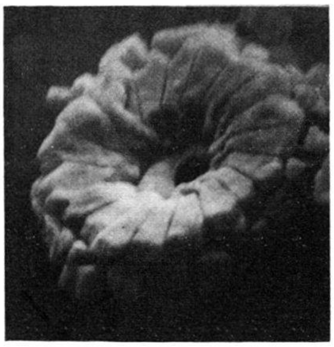
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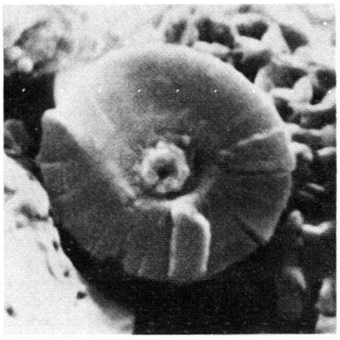
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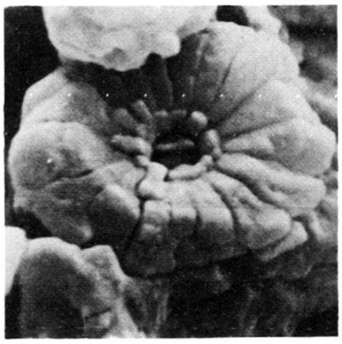
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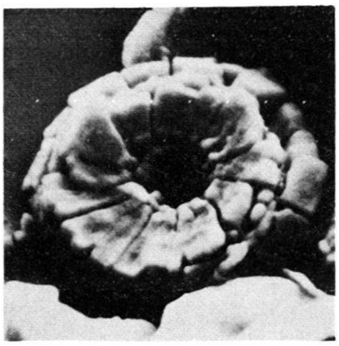
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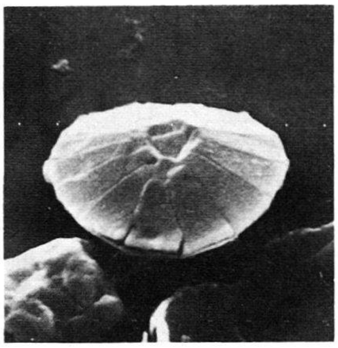
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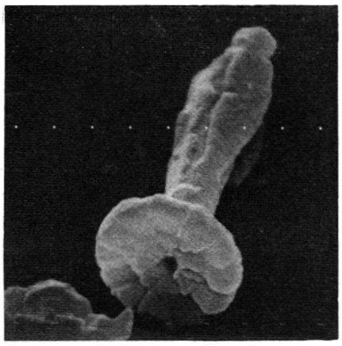
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Plate 3

All specimens from Brenha Road section
All light micrographs × 1300

Fig. 1 — *Schizosphaerella punctulata* DEFLANDRE & DANGEARD
Hypotype UCL-81-4
Upper Toarcian

Fig. 2 — *Schizosphaerella punctulata* DEFLANDRE & DANGEARD
Hypotype UCL-74-31
Pliensbachian (Margaritatus Zone)

Fig. 3 — *Podorhabdus macrogranulatus* PRINS
Hypotype UCL-77-5
Upper Toarcian

Fig. 4 — *Ethmorhabdus* aff. *E. gallicus* NOËL
Hypotype UCL-78-25
Pliensbachian (Davoei Zone)

Fig. 5 — *Ethmorhabdus* aff. *E. gallicus* NOËL
Hypotype UCL-80-4
Pliensbachian (Davoei Zone)

Fig. 6 — *Vekshinella quadriarcula* (NOËL) ROOD, HAY & BARNARD
Hypotype UCL-80-7
Pliensbachian (Davoei Zone)

Fig. 7 — *Biscutum ellipticum* (GORKA) GRÜN & ALLEMANN
Hypotype UCL-79-2
Upper Toarcian

Fig. 8 — *Calyculus* spp.
Hypotype UCL-80-11
Pliensbachian (Margaritatus Zone)

Fig. 9 — *Calyculus* spp.
Hypotype UCL-78-28
Pliensbachian (Davoei Zone)

Fig. 10 — *Crepidolithus crucifer* PRINS
Hypotype UCL-78-24
Pliensbachian (Ibex Zone)

Fig. 11 — *Crepidolithus crassus* (DEFLANDRE) NOËL
Hypotype UCL-79-16
Upper Sinemurian

Fig. 12 — *Crepidolithus cavus* PRINS
Hypotype UCL-78-29
Pliensbachian (Ibex Zone)

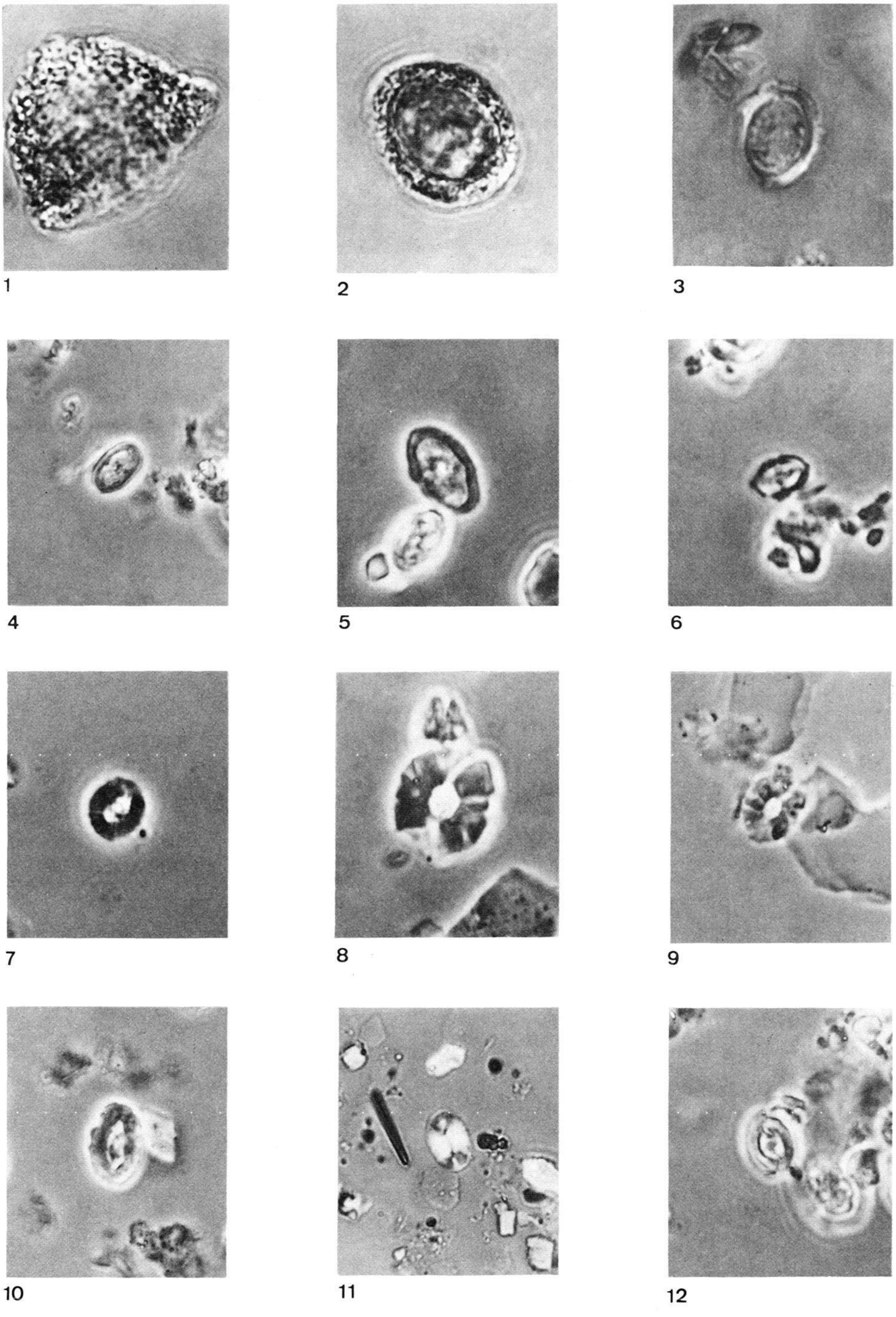
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Plate 4

All specimens from Brenha Road section
All light micrographs × 1300

Fig. 1 *Discorhabdus tubus* NOËL
Hypotype UCL-77-2
Upper Toarcian

Fig. 2 *Carinolithus superbus* PRINS
Hypotype UCL-78-13
Upper Toarcian

Fig. 3 *Carinolithus superbus* PRINS
Hypotype UCL-81-11
Upper Toarcian

Fig. 4 *Crucirhabdus primulus* PRINS
Hypotype UCL-75-19
Pliensbachian (Ibex Zone)

Fig. 5 *Discorhabdus patulus* (DEFLANDRE) NOËL
Hypotype UCL-82-31
Upper Toarcian

Fig. 6 *Parhabdolithus marthae* DEFLANDRE
Hypotype UCL-73-25
Upper Sinemurian

Fig. 7 *Parhabdolithus liasicus* DEFLANDRE
Hypotype UCL-71-22
Pliensbachian (Jamesoni Zone)

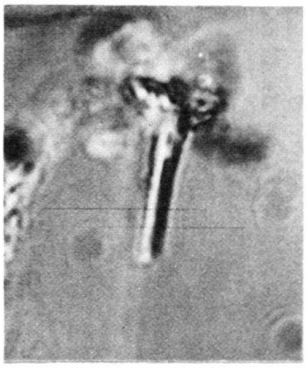
Fig. 8 *Parhabdolithus liasicus* DEFLANDRE
Hypotype UCL-79-15
Upper Sinemurian

Fig. 9 *Diazomatolithus lehmani* NOËL
Hypotype UCL-82-35
Upper Toarcian

Fig. 10 *Discorhabdus ignotus* (GORKA) PERCH-NIELSEN
Hypotype UCL-82-33
Pliensbachian (Spinatum Zone)

Fig. 11 *Discorhabdus ignotus* (GORKA) PERCH-NIELSEN
Hypotype UCL-73-30
Pliensbachian (Jamesoni Zone)

Fig. 12 *Tubirhabdus patulus* PRINS
Hypotype UCL-73-22
Pliensbachian (Jamesoni Zone)



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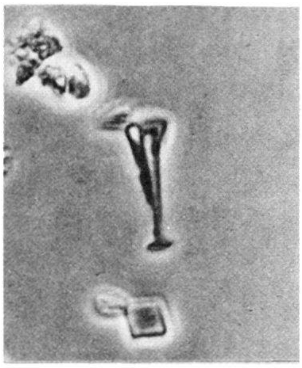

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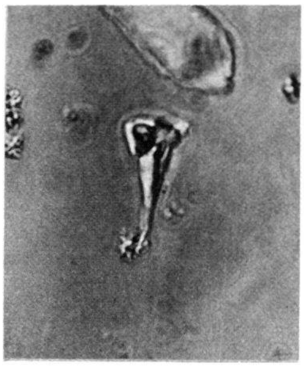

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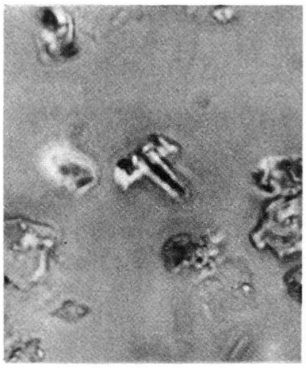

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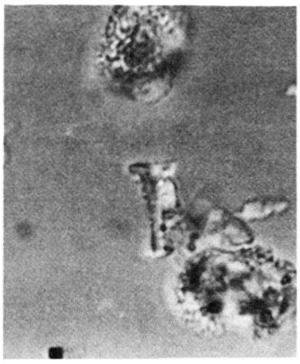

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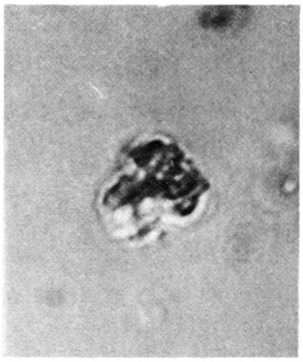

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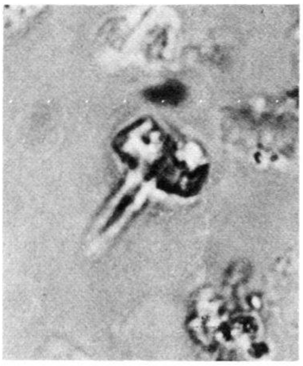

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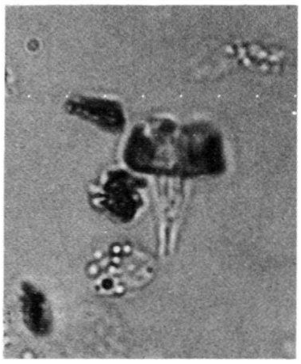

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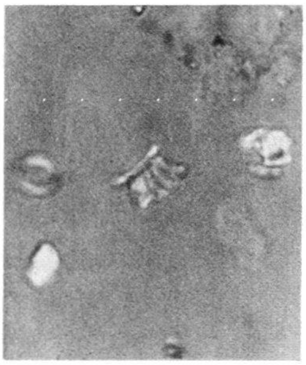

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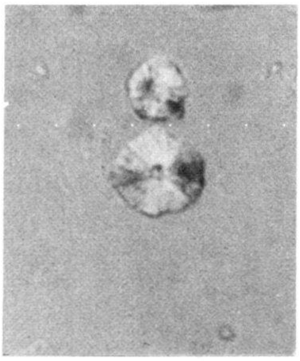

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