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Artikel: The Upper Jurassic coccoliths from the Haddenham and Gamlingay boreholes (Cambridgeshire, England)

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assumption. The number of specimens also varies within the stratigraphical interval studied; there is an increase in such numbers in the lower part of the Kimmeridge Clay, to a maximum number per unit mass of rock found for the whole of the Jurassic.

The methods of study are as stated in MEDD (1971) but a Zeiss photomicroscope II has been used for the routine optical investigations. The Nomarski interference phase contrast accessory is occasionally of help in the study of coccoliths. A TV fast scanning accessory on the scanning electron microscope has also proved to be of value for a detailed study of coccolith strew mounts; the instrument used is a Cambridge Instruments Co. Stereoscan Mark 2A, which is located at the Institute of Geological Sciences, London. The technique of NOËL (1973, p. 98) in examining the rock surface with an SEM has also been used but without her remarkable successes. Other Kimmeridgian samples examined, however, have provided excellent results, with abundant assemblages and coccospheres seen.

The problem of sample contamination is considerably diminished using borehole material and none of the problems associated with surface collected material (MEDD 1971, p. 823) was encountered. The problem of reworking of older coccoliths into the younger nannofloras has not been overcome as to its recognition, as opposed to these species having an extended range. It is difficult to envisage a method of erosion of the older sediments, which would preserve the coccoliths in such numbers as have been found at some levels in these boreholes. The relative proportions of the species are also different from that encountered in the older material. These suspect species appear most often in samples, which are already rich in numbers of indigenous species (i.e., not found in older sediments).

Figured or cited material prefixed with the letters "EM" are of micrographs taken with a Philips 75B transmission electron microscope at the Sedimentology Research Laboratory, University of Reading, and the material is lodged at that laboratory. If prefixed with the letters "SEM", the material was examined using the scanning electron microscope at IGS, London, where the material is now housed. If prefixed by the letters "MPK", the optical strew slides are stored in the MPK collection of type and figured specimens at the Institute of Geological Sciences, Leeds.

Details of the assemblages

The dominant species in all of the samples studied is *Ellipsagelosphaera britannica* (STRADNER) and particularly the small form of it. The only other species found, which occasionally constitute more than 25% of the nannoflora are: *Tetralithus gothicus* DEFLANDRE, *Palaeopontosphaera dubia* NOËL, *Zeugrhabdotus erectus* (DEFLANDRE) and small tremalith-like forms. The remainder of the species recorded can be found in varying degrees of abundance, but with no single species comprising more than 10% of the nannoflora.

Stratigraphical distribution

The distribution of the nannoflora of the Haddenham and Gamlingay boreholes are summarized in Tables 2 and 3, which record the species in the order of their incoming. A revised version of the species incoming of the Ampthill Borehole is given in Table 4 this can be compared with Table 6 of MEDD (1971). It can be seen that there is a species maximum in the *cordatum* Zone at 34.98–35.36 m. A list of the species to be found in the three boreholes is given in the Appendix (p. 82).

The Appendix also illustrates the total nannofloral ranges of those species found in the three boreholes, as they have been found up to June 1978. It is *not* intended to be a comprehensive chart of the Jurassic nannofloras. In particular, many of the Lower Jurassic forms are omitted, as are some of the newly found forms in the three boreholes.

However, from this Appendix some comparisons can be drawn with the zonal ranges given by BARNARD & HAY (1975) and with their summaries of the assemblages.

There are several major episodes of coccolith evolution in the Jurassic. The first is their introduction at the base of the Jurassic, with typical Lias assemblages being developed by the Early Sinemurian. The beginnings of the Lias extinctions and the introduction of some of the Middle–Upper Jurassic forms take place in the *falciferum* Zone of the Toarcian.

Onshore English Middle Jurassic (Bajocian) material has yielded very few coccoliths, but a borehole drilled in 1974 in Lyme Bay, Dorset [NGR SY 3515 8115] by the Institute of Geological Sciences (borehole number 50/$\overline{03}$/329) penetrated Bajocian strata to a depth of 19.30 m below the sea-bed. The contained sequence was sufficiently ammonite bearing to enable the recognition of the Bajocian sequences and together with the freshness of the material has enabled the coccolithophorid succession to be established.

The Middle Jurassic assemblages are therefore already present at the base of the Bathonian. There is only a minor evolutionary developmental phase within the Bathonian (in the *retrocostatum* Zone) and the next major coccolith change occurs as a rapid diversification of species at the base of the Oxfordian. This stage corresponds to the acme of the Jurassic coccoliths in NW Europe.

The coccolith assemblages of the overlying Kimmeridgian stage become fewer in numbers of species, although the specimen numbers are usually maintained or even increased. Many of the Jurassic species have their last known occurrences in this stage. Occasionally it is only a local disappearance and the species continue into the higher beds elsewhere. However, fewer than ten of the 134 species so far found in the Jurassic are present in the English province beyond the *pectinatus* Zone of the Kimmeridgian. Portlandian coccoliths have been recorded in a few Southern England boreholes (e.g. Fairlight, Warlingham), but have only a generalized Upper

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Explanations to Table 2

The species occurrence is plotted against borehole depth. The abundance of the species is absolute (and so is not relative to the rest of the species in the assemblage) and is represented in the tables as horizontal lines of variable width at the depth of occurrence. The key to these widths is marked: *present* = 1% or less of the total calcite in the sample (or one specimen or less in 10 fields of view); *frequent* = 2–10% of the calcite in the samples (or one specimen in each field of view); *common* = 11–29% of the calcite in the sample (about 10 specimens in each field of view); *abundant* = 30% or more of the total calcite in the sample (common, i.e. 10's of specimens, in each field of view). If marked questionable – the species identification is in doubt, irrespective of the numbers found.

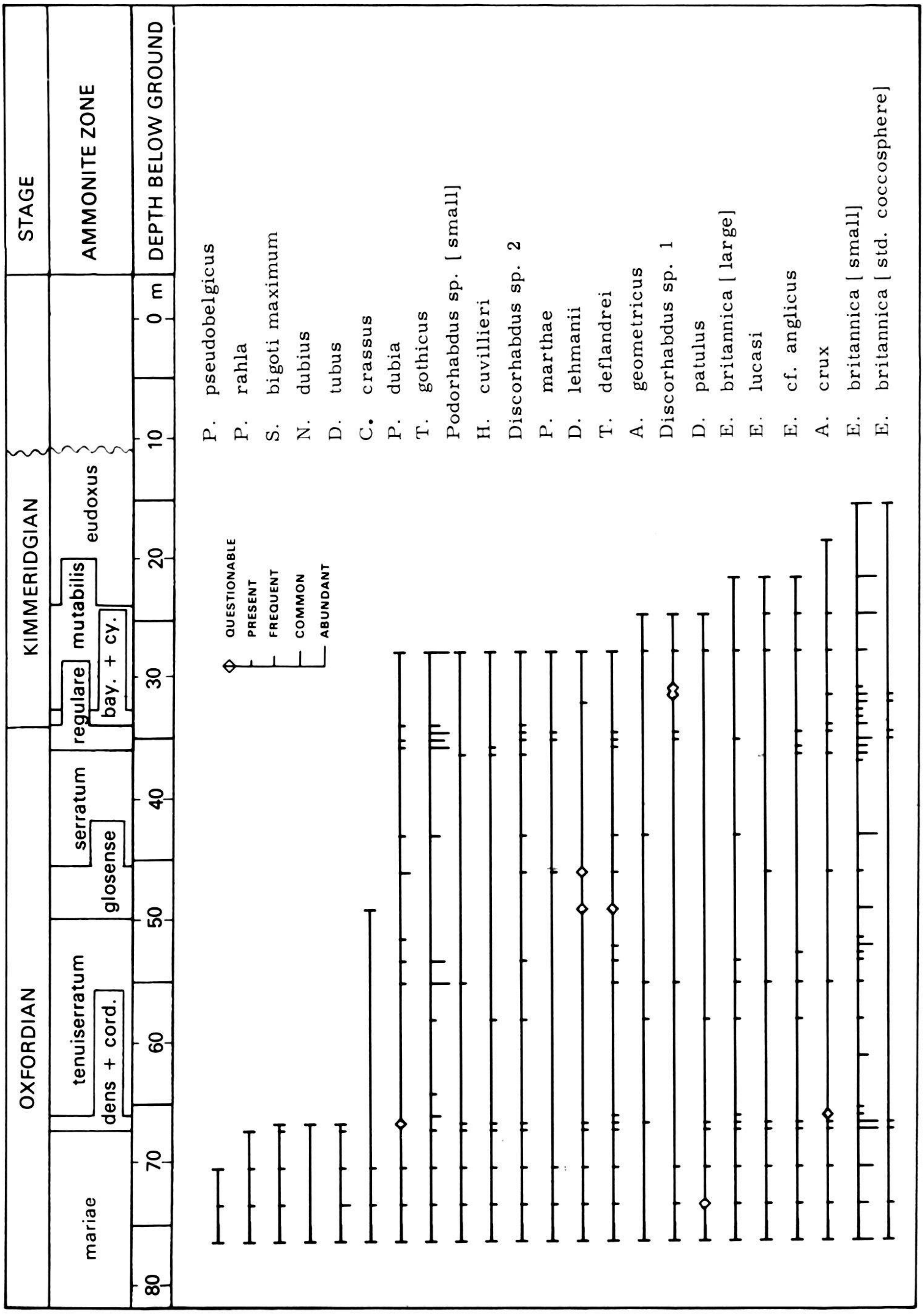


Table 2A: *Coccolith species found in the Haddenham Borehole.*

Table 2B: *Coccolith species found in the Haddenham Borehole.*

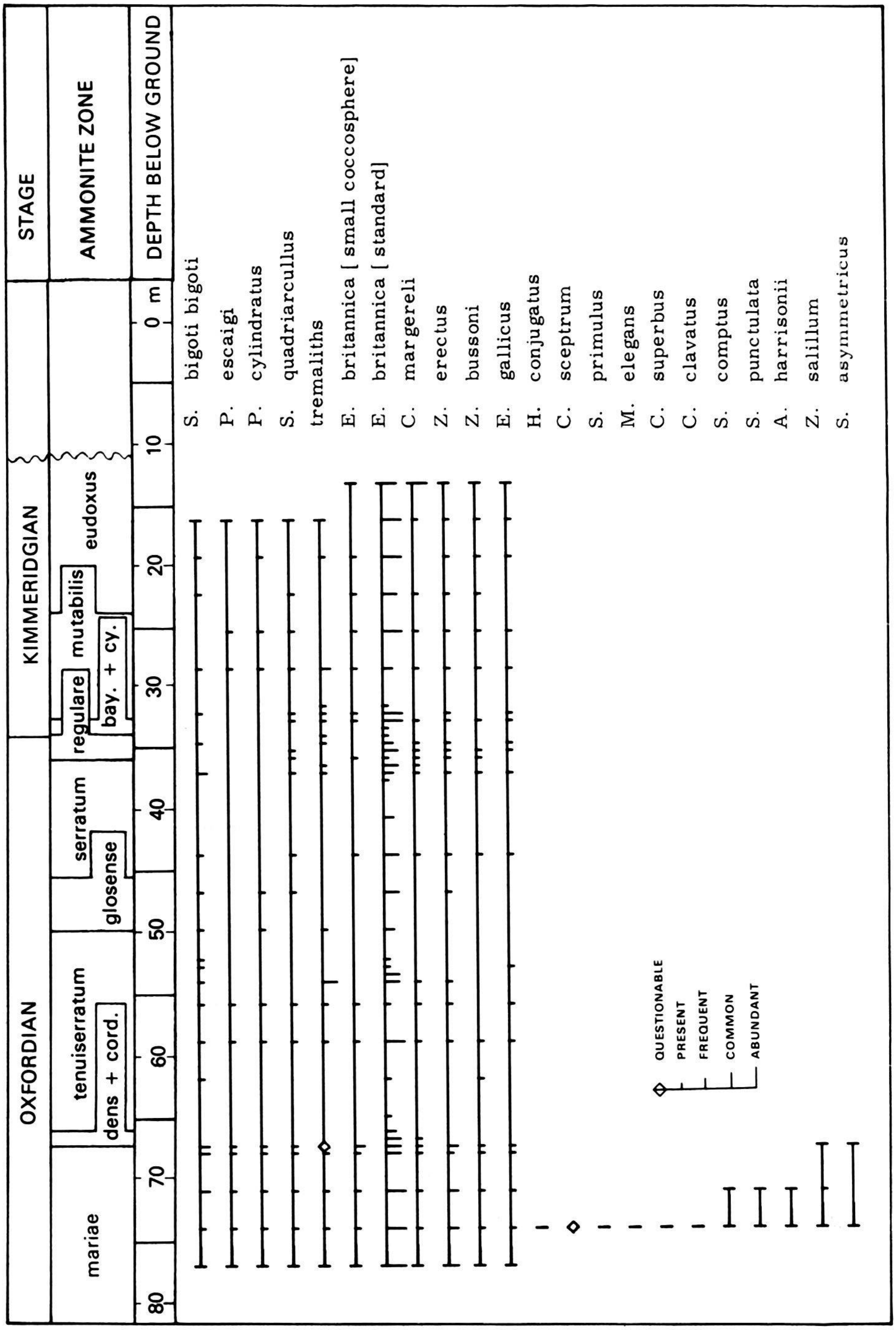


Table 2C: *Coccolith species found in the Haddenham Borehole.*

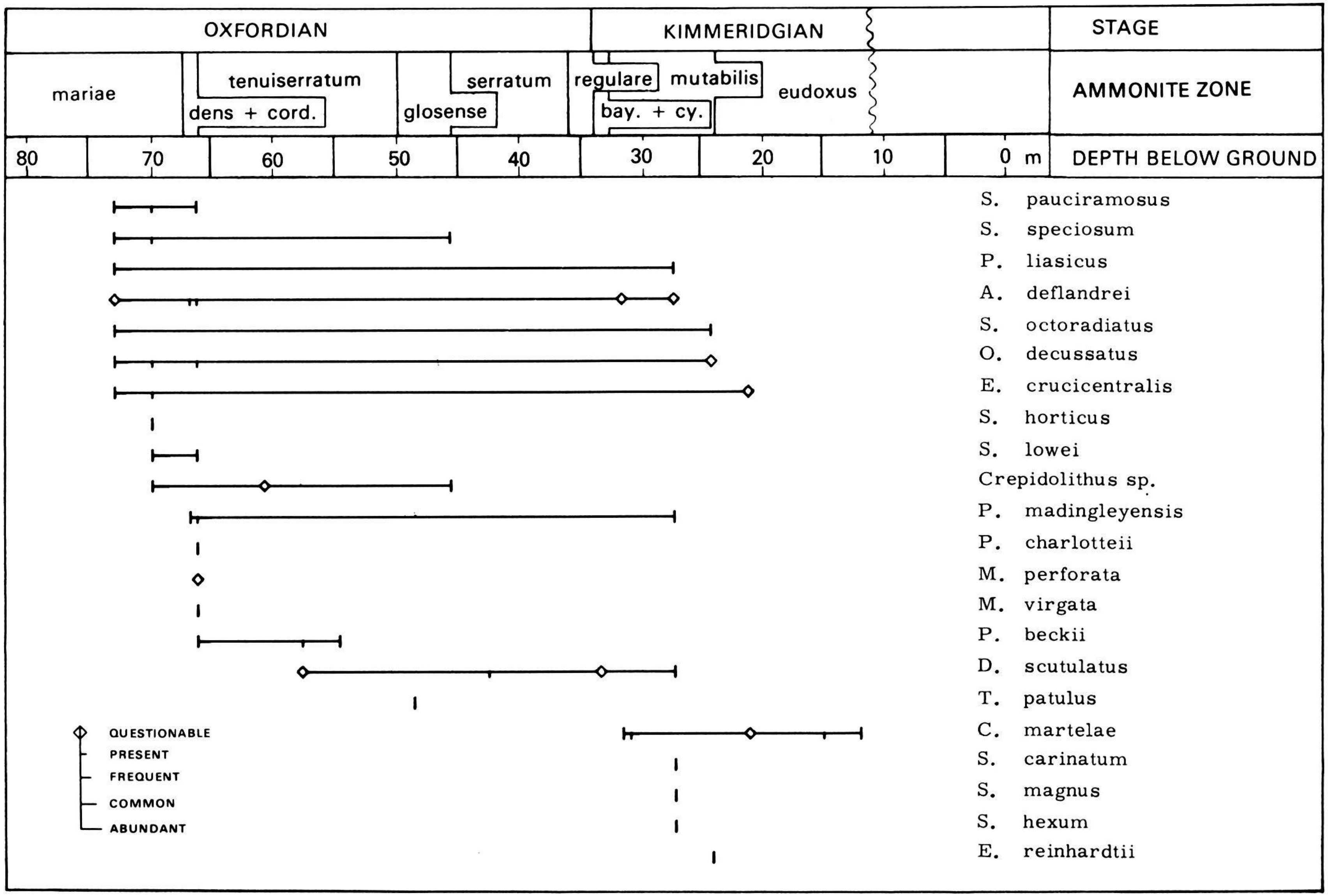


Table 3A: *Coccolith species found in the Gamlingay Borehole.*
(Explanations as for Table 2)

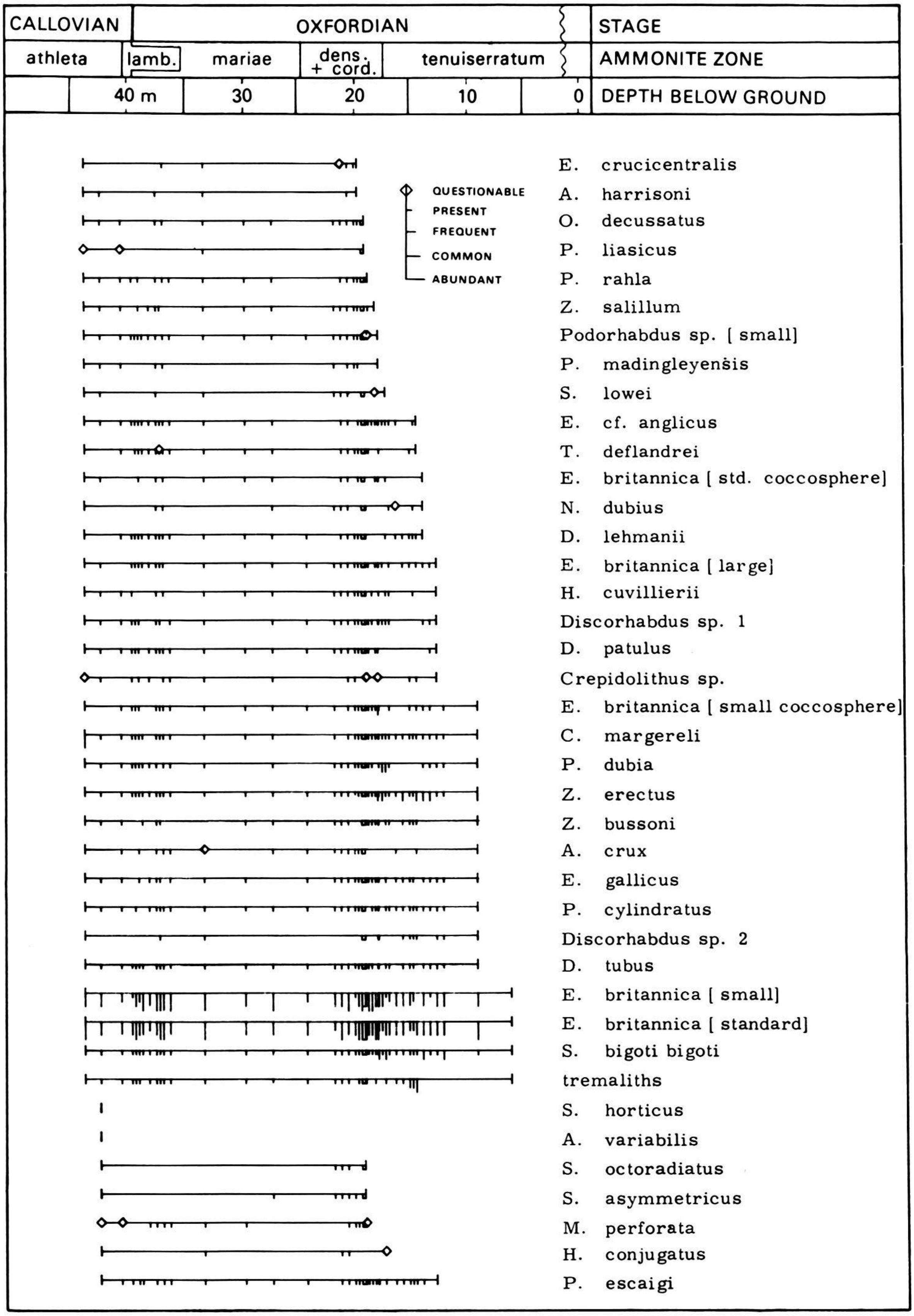


Table 3B: *Coccolith species found in the Gamlingay Borehole.*
(Explanations as for Table 2)

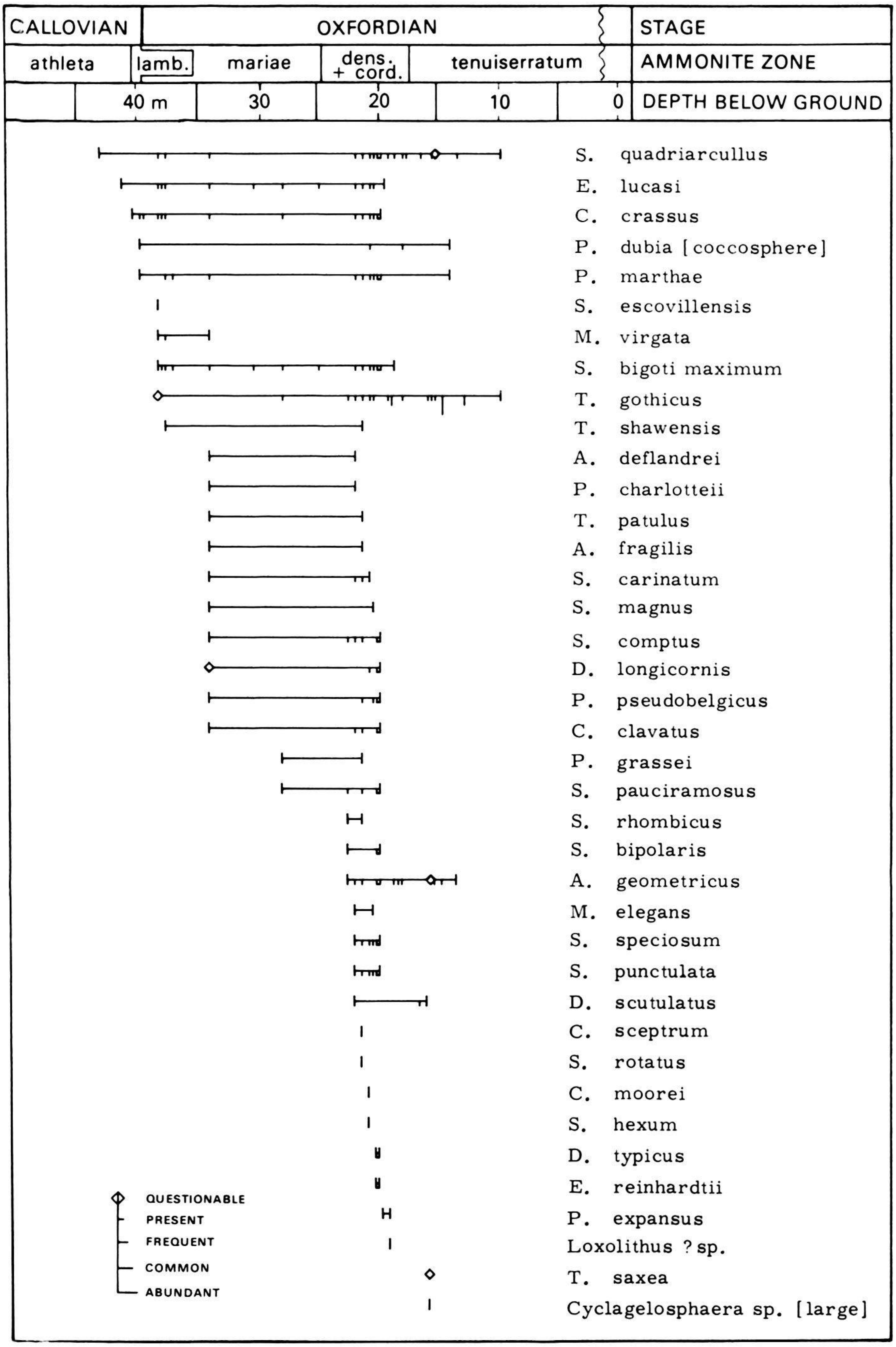
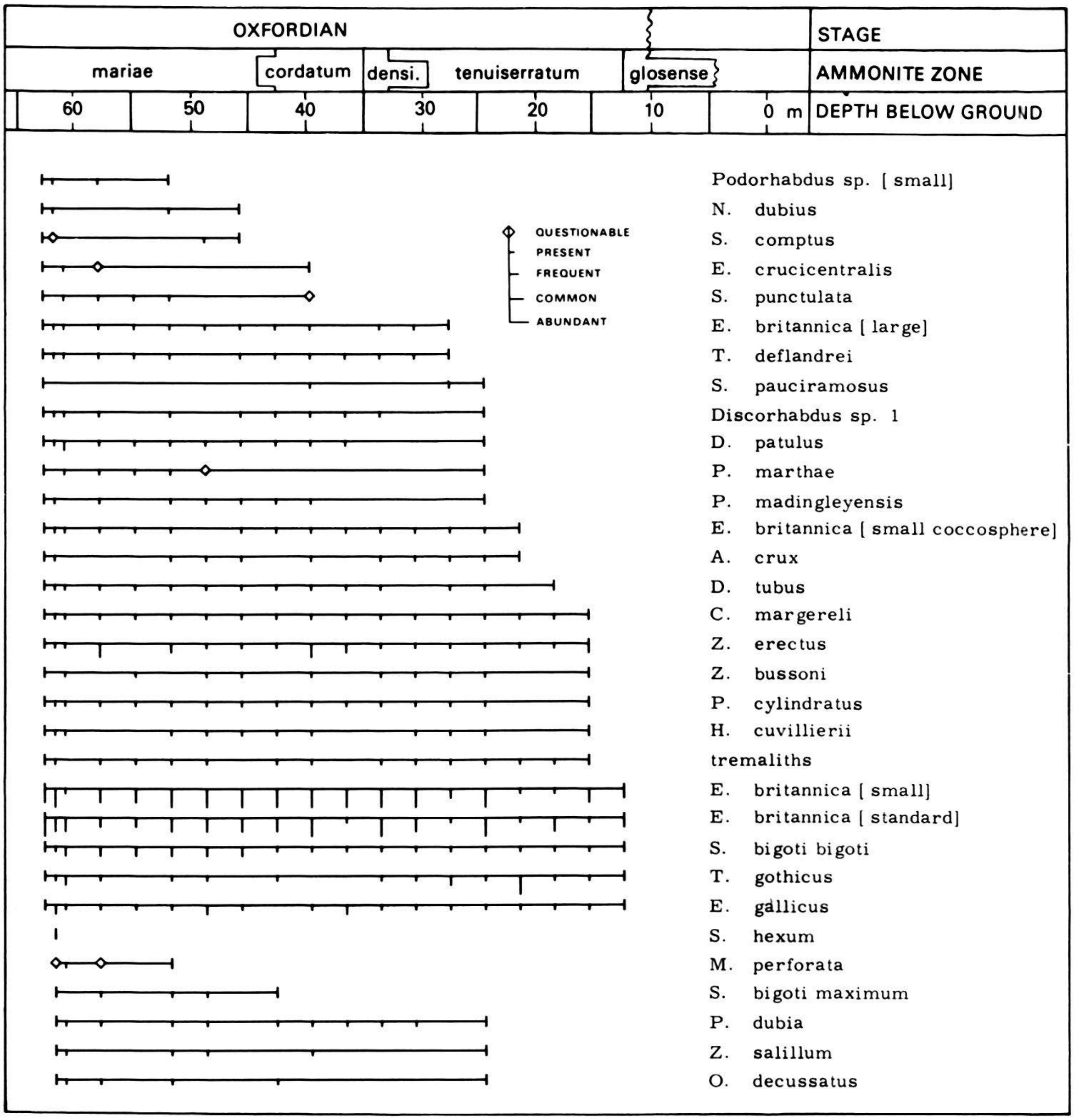


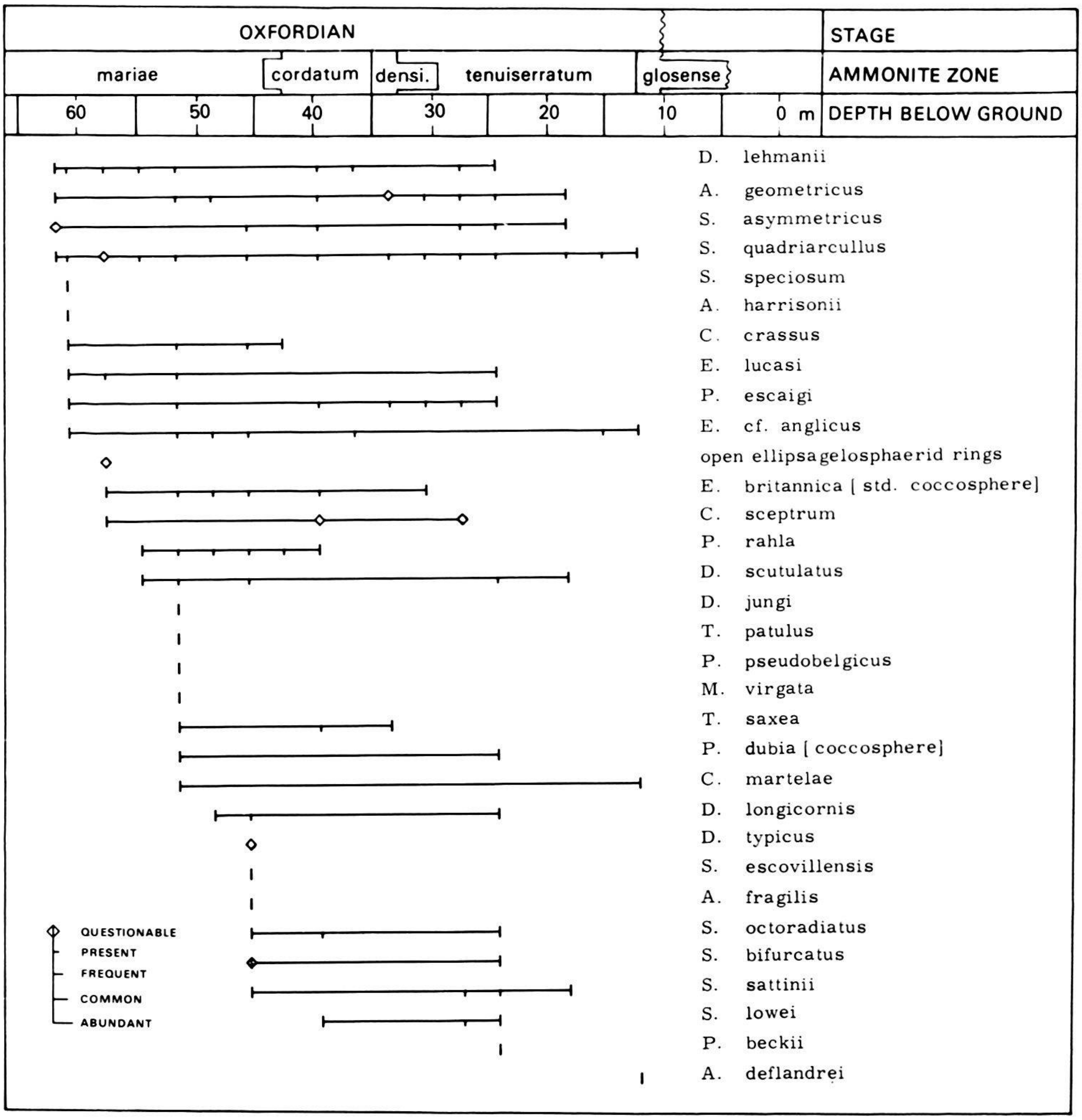
Table 4A: *Coccolith species found in the Ampthill Borehole.*
(Explanations as for Table 2)



Jurassic aspect. And so the next major evolutionary change, with the incoming of types characteristic of the Lower Cretaceous, is not found in the British material. This phase, however, has been seen in material from the DSDP Leg 11 Site 105 Borehole (drilled at 34°54′ N, 69°10′ W).

Barnard & Hay (1975) use the incoming of certain species and their associated assemblages to form the basis of a Jurassic coccolith zonation. Although it is here still regarded as a rather premature exercise, as the English and French floras are mostly restricted to boreal shelf seas, a revised zonal scheme based on English coccolith material will be published elsewhere shortly. It is still not a very satisfactory zonation in that several of the zonal forms are either very small or occur only

Table 4B: *Coccolith species found in the Ampthill Borehole.*
(Explanations as for Table 2)



rarely in the sediments. The acme and interval zones cited are also of only local importance. The Upper Kimmeridgian to Berriasian interval is not valid elsewhere, as the DSDP material examined suggests at least one further nannofossil zone to be present at the top of the Jurassic. The use of improved technology in the investigation of the samples and the examination of oceanic Jurassic sediments from DSDP (IPOD) sites may in the future give a more reliable zonation.

The problem of reworked coccoliths from older beds may be prevalent in some horizons of these boreholes (as mentioned above) and seems to be widespread in the upper part of the *mariae* and the *cordatum* zones, with the appearance of characteristic Lias forms such as *Mitrolithus elegans, Parhabdolithus liasicus* and *P. mar-*

thae. However, the ranges of these species may also be extended from that cited in the literature. An example of this is the occurrence of *Stephanolithion speciosum* DEFLANDRE in the Oxfordian of the Gamlingay Borehole, whereas it had been considered previously to be confined to below the Callovian/Oxfordian boundary.

The extinction of the Upper Jurassic coccolith species may prove to be as stratigraphically valuable as their incomings (e.g. that of *Stephanolithion bigoti* DEFLANDRE in the Kimmeridgian), and this too is reflected in the proposed zonation.

Systematic palaeontology

There is very little to add to the species descriptions given by NOËL (1965, 1973) and MEDD (1971). Only such information as supplements these descriptions is given below. Most of the additional data concerns the finding of new or rare species or additional stratigraphic information. The suprageneric arrangement has been altered from the previous papers and is based on taxonomic revisions of the Coccolithinae by ROOD, HAY & BARNARD (1971) and by BLACK (1972, 1973). This has necessitated some discussion; necessary species synonymies and other remarks are given below.

The classification is based on ICBN rules, and follows modern botanical work (BLACK 1972, p. 23), which places all coccolith groups into the Suborder Coccolithinae KAMPTNER. Many of the Mesozoic genera have structures similar to those of Tertiary forms, and by extrapolation these latter forms can be related to Recent taxa. From these analogies the proposed supra-generic classification is established.

One disadvantage of this, however, is that the major groups of coccoliths (e.g. Eiffellithales ROOD, HAY & BARNARD 1971) are restricted to the familial level, many of the defined families belonging to such groups are down-graded to subfamily status, subfamily groups now become tribe status.

Class ***Haptophyceae*** CHRISTENSEN 1962

Suborder ***Coccolithinae*** KAMPTNER 1928

Family ***Eiffellithaceae*** REINHARDT 1965

Remarks. - The classification is accepted here of all Upper Jurassic coccoliths that possess an eiffellithid rim that were placed in Eiffellithales new order by ROOD, HAY & BARNARD (1971, p. 248), but the grouping is here down-graded to family status.

The classification of these small Upper Jurassic coccoliths with such a rim and a variably developed central area is very tenuous, and no two publications are in agreement. One basis for such a classification is to consider the nature of their rim first and then to subdivide these groups on the arrangement of their central areas.

In most of the groups given below the arrangement of the crystallites of the rim is at a fairly uniform angle, with the elements of the outer ring either stacked almost vertically and so having little or no imbrication, or at an angle of 45-60 degrees with moderate imbrication. *Staurorhabdus* NOËL, considered by many workers to be the