NEW SPECIES AND NEW COMBINATIONS OF CRETACEOUS NANNOFOSSILS, AND A NOTE ON THE ORIGIN OF *PETRARHABDUS* (DEFLANDRE) WIND & WISE

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Abstract: In order to standardise the taxonomy which accompanies the Upper Cretaceous illustrations in a forthcoming book, 23 new combinations are introduced: *Biscutum melaniae, Chiastozygus antiquus, C. trabalis, Lapideacassis asymmetrica, L. hispinosa, L. magnifica, Marthasterites bramlettei, M. crassus, M. simplex, Retecapsa ficula, Staurolithites aachena, S. dentata, S. dorfii, S. elongatus, S. glabra, S. imbricatus, S. integra, S. parma, Tortolithus polygonatus, Zeugrhabdotus biperforatus, Z. burwellensis, Z. ponticulus* and *Z. spiralis*.

In addition, a number of taxa were identified which have apparently not yet been formally named. Twenty-four new taxa are described here: *Arkhangelskiella antecessor, A. confusus, A. maastrichtiensis, Biscutum thurowii, Chiastozygus stylesii, Cylindralithus? nieliae, Diloma galei, Eiffellithus? hancockii, E. pospichalii, Laguncula montrisouensis, Micrantholithus quasihoschulzii, Micula adumbratus, Neocrepidolithus ruegenensis, Petrarhabdus vietus, Petrobrastella? bownii, Quadrum bengalensis, Q. svabenickae, Rhagodiscus indistinctus, Semiholollithus dens, Staurolithites? aenigma, S. flavus, S. minutus, S. zoensis* and *Zeugrhabdotus praesigmoides*. The search for an SEM illustration of *P. vietus* led to the discovery of a possible link between *Prediscosphaera* and *Petrarhabdus*, and a short note concerning this is also presented here.

Introduction

Whilst illustrating the Upper Cretaceous chapter for a book on nannofossils and biostratigraphy (Burnett *in* Bown, in press), it became apparent that a number of taxa required naming, whilst a further 23 needed to be recombined in order to present a standardised taxonomy and to reflect the recent ideas on higher taxonomy presented in Bown & Young (1997).

Among the new species is *P. vietus*. The search for an SEM photomicrograph of this form also revealed possible evidence for the origins of the genus, from *Prediscosphaera*. A brief comparison of the genera, and a discussion of the possible origins of *Petrarhabdus*, appear below.

New combinations and names herein appear in alphabetical order, according to genus. FO = first occurrence, LO = last occurrence, LM = light microscope, PC = phase-contrast, XPL = crossed-polarised light, Amm. = Ammonite, Ech. = Echinoid.

Genus *ARKHANGELSKIELLA* Vekshina, 1959

Type species: *Arkhangelskiella cymbiformis* Vekshina, 1959

This species has been used to include a variety of forms possessing a range of coccolith lengths, differing rim:central area width ratios, with/without central axial crosses, and with/without central-area perforations. Distinctions between the species below were made on the basis of length and rim-width only because no other features could be consistently determined with accuracy in routine LM examination of a range of preservational states, and such features as axial crosses and perforations seem to be common to each species, but inconsistently occurring. These distinctions have been made because some of the forms have a FO or LO which has been found to be biostratigraphically useful.

Arkhangelskiella antecessor sp. nov.

1996 *Arkhangelskiella*? sp. Burnett *in* Gale *et al.*: p.523, fig.4d.

Derivation of name: Latin *antecessor* = forerunner. This form is possibly the ancestor to the Late Cretaceous *Arkhangelskiella*s.

Diagnosis: A medium- to large-sized form of *Arkhangelskiella* with a narrow rim, an apparently imperforate central-area plate which shows the typical arkhangelskiellid segmentation, and a thin axial cross.

Remarks: This form differs from species of *Crucicribrum* in Black, 1973 possessing an imperforate central-area plate, reminiscent of later *Arkhangelskiella*s, rather than the grille which typifies *Crucicribrum*. The new species has a restricted range in the Upper Albian in the expanded section at Mont Risou, and may have been previously overlooked for that reason. *Arkhangelskiella* has not been reported from the Albian before.

Holotype: Fig.4d (XPL), p.523 *in* Gale *et al.* (1996); Neg.# UCL-5183-4.

Holotype dimensions: 8.4µm long, 6.0µm wide, 0.7µm rim width.

Type location: Mont Risou, near Rosans, Drôme, SE France.

Type level: Sample RI-120m, Schloenbachia (Praeschloenbachia) briacensis Amm. Subzone, Stoliczkaia dispar Amm. Zone, Upper Albian Marnes Bleues Formation, CC9b.

Range: Upper Albian.

Arkhangelskiella confusus sp. nov.

1989a *Arkhangelskiella cymbiformis* Vekshina, 1959 var. N Varol: p.132, pl.1, figs 5-8.

Derivation of name: Latin *confusus* = mingle. Its early range, from the Coniacian, can be easily confused with that of *Broinsonia parca expansa* in material which is less than well-preserved.

Diagnosis: Small- to medium-sized *Arkhangelskiella* with a <1.5µm thick rim.

Remarks: This species first appears around the Coniacian, and is thus stratigraphically differentiated from the species of *Arkhangelskiella* described below which appear,

respectively, in the Campanian and Maastrichtian. This form typically has a rim which is intermediate (1.0-1.5μm) in width between the rim thicknesses of *A. cymbiformis sensu stricto* and *A. maastrichtiensis*, and also includes small (down to ~4μm long) forms of the genus.
Holotype: Pl.1, figs 5-8 (PC/XPL) *in* Varol (1989a).
Holotype dimensions: 7.7μm long, 5.7μm wide, 1.1μm rim width.
Type location: North Sea.
Type level: Campanian-Maastrichtian (not given precisely).
Range: Coniacian-Upper Maastrichtian.

Arkhangelskiella cymbiformis Vekshina, 1959

1989a *Arkhangelskiella cymbiformis* Vekshina, 1959 var. NT Varol: p.132, pl.1, figs 9-12.

Description: Strictly, a large *Arkhangelskiella* with a <1.5μm thick rim.
Remarks: This species first occurs near the base of the Campanian, and can be used as a marker here at most latitudes. Its large form (>8μm long) and relatively narrow rim (<1μm wide) distinguish it from all other *Arkhangelskiella*s.
Illustration: Pl.1, figs 9-12 *in* Varol (1989a).
Illustration dimensions: 8.0μm long, 6.3μm wide, 0.9μm rim width.
Range: Lower Campanian-Upper Maastrichtian.

Arkhangelskiella maastrichtiensis sp. nov.

1989a *Arkhangelskiella cymbiformis* Vekshina, 1959 var. W Varol: p.132, pl.1, figs 1-4.

Derivation of name: This form is common in the Maastrichtian, particularly at high latitudes.
Description: Large *Arkhangelskiella* with a >1.5μm thick rim.
Remarks: The large size (>10μm) and thick rim (>1.5μm) distinguish this from other *Arkhangelskiella*s. It becomes common in the Upper Maastrichtian in high latitudes, and can be used as a marker there.
Holotype: Pl.1, figs 1-4 (PC/XPL) *in* Varol (1989a).
Holotype dimensions: 10.9μm long, 8μm wide, 1.7μm rim width.
Type location: North Sea.
Type level: Maastrichtian (not given precisely).
Range: Campanian?-Upper Maastrichtian.

Genus *BISCUTUM* Black *in* Black & Barnes, 1959
Type species: *Biscutum ellipticum* (Górka, 1957) Grün *in* Grün & Allemann, 1975 (= *Biscutum testudinarium* as designated by Grün *in* Grün & Allemann 1975)

Biscutum thurowii sp. nov.
Plate 1, Figures 34-35

1996 *Biscutum gartneri* Black, 1971a: Burnett *in* Gale *et al.*: p.527, fig.6s.

Derivation of name: After Dr. Jürgen Thurow, in recognition of his micropalaeontological and sedimentological work on the Upper Cretaceous.
Diagnosis: Small *Biscutum* with a small central area lined with blocks and two central-area perforations separated by a transverse bar aligned with the short ellipse axis.
Remarks: The holotype description/illustration of *B. gartneri* was simply of a very small *Biscutum*, although Black's (1972, pl.2, figs 3, 4) later illustrations appear to show a bar and perforations. Since neither the holotype nor the original description of *B. gartneri* refer to these features, a new name was deemed necessary. Distinguished from other species of *Biscutum* by the blocky lining to the central area, and the bar separating the two distinct perforations.
Holotype: Plate 1, Figures 34-35 (SEM); Neg.# UCL-3842-30/31.
Holotype dimensions: 4.0μm long, 2.3μm wide.
Type location: Mont Risou, near Rosans, Drôme, SE France.
Type level: Sample RI-104m, Schloenbachia (Praeschloenbachia) briacensis Amm. Subzone, Stoliczkaia dispar Amm. Zone, Upper Albian Marnes Bleues Formation, CC9b.
Range: Upper Albian-Lower Cenomanian.

Biscutum melaniae (Górka, 1957) *comb. nov.*

1957 *Tremalithus melaniae* Górka: p.245, 270; pl.1, fig.12.
1966 *Coccolithus oregus* Stover: p.139, pl.1, figs 8, 9; pl.8, fig.4.
1989b *Biscutum harrisonii* Varol: p.297, pl.12.1, fig.1; pl.12.4, figs 16-20.

Basionym: *Tremalithus melaniae* Górka, 1959: p.245, 270; pl.1, fig.12 (holotype). (Górka, H. 1957. Les Coccolithophoridés du Maestrichtien supérieur de Pologne. *Acta Palaeontologica Polonica*, **2**(2/3): 239-284.)
Remarks: Medium to large, broadly elliptical *Biscutum* with a wide dark shield and a small, highly birefringent central area. Particularly frequent in high latitude locations.
Range: Upper Turonian-Lower Paleocene.

Genus *CHIASTOZYGUS* Gartner, 1968
Type species: *Chiastozygus amphipons* (Bramlette & Martini, 1964) Gartner, 1968

Chiastozygus antiquus (Perch-Nielsen, 1973) *comb. nov.*

Basionym: *Neochiastozygus antiquus* Perch-Nielsen: p.319, pl.3, figs 1 (holotype), 3, 5. (Perch-Nielsen, K. 1973. Neue Coccolithen aus dem Maastrichtien von Dänemark, Madagaskar und Ägypten. *Bulletin of the Geological Society of Denmark*, **22**: 306-333.)
Remarks: The rim construction in this species is similar to that found in other members of *Chiastozygus* and is thus different to that found in *Neochiastozygus*. This species is a distinctive component of some Upper Maastrichtian assemblages, being medium-sized and highly birefringent.
Range: Upper Maastrichtian.

Chiastozygus stylesii sp. nov.
Plate 1, Figures 9a-b

Derivation of name: After Mr. Toby Stiles, photographic technician at UCL.
Diagnosis: A distinctive species of *Chiastozygus* with an elongated, elliptical rim with a narrow dark outer and wider bright inner cycle. The 45° cross is thick, each arm apparently composed of a single calcite block, and is reminiscent of a propeller blade. Opposite arms go into extinction together.
Remarks: The new species is distinguished from other species of *Chiastozygus* by its distinctive elongated-ellipse outline and its highly birefringent propeller-like cross.
Holotype: Plate 1, Figures 9a-b (XPL); Neg.# UCL-5759-9/10.
Holotype dimensions: 9.1µm long, 6.1µm wide.
Type location: DSDP Site 258, Naturaliste Plateau, E Indian Ocean.
Type level: Sample DSDP 258-6-5, 119-120cm, Coniacian, CC14-?15.
Range: Coniacian.

Chiastozygus trabalis **(Górka, 1957)** ***comb. nov.***

1957 *Discolithus trabalis* Górka: p.252, 275, pl.3, fig.2.
1996 *Chiastozygus* sp.2 Burnett *in* Gale *et al.*: p.523, figs 4s-t.

Basionym: *Discolithus trabalis* Górka, 1957: p.252, 275, pl.3, fig.2 (holotype). (Górka, H. 1957. Les Coccolithophoridés du Maestrichtien supérieur de Pologne. *Acta Palaeontologica Polonica*, 2(2/3): 239-284.)
Remarks: This species is distinctive in having a fragile-looking, generally highly-birefringent, ragged inner rim and cross, the latter with a perforation at the centre.
Range: Upper Albian-Upper Maastrichtian.

Genus *CYLINDRALITHUS* Bramlette & Martini, 1964
Type species: *Cylindralithus serratus* Bramlette & Martini, 1964

Cylindralithus ? nieliae sp. nov.
Plate 1, Figures 13-14, 17a-19

Derivation of name: After Dr. Brigitta van Niel, in recognition of her work on *Nannoconus*.
Diagnosis: A form composed of five to six stacked rims of imbricating elements. The lowest, widest rim particularly has a median constriction which gives the form a slight 'figure-of-eight' outline in the LM. This constriction may or may not be apparent in succeeding rims. The uppermost rim is the narrowest.
Remarks: This is a distinctive taxon, being highly birefringent in the LM and having a distinctive 'figure-of-eight' outline when focusing on the widest rim. The taxon is tentatively placed in *Cylindralithus* because of its almost cylindrical nature but it is sufficiently different to species such as *C. serratus* and *C. nudus* for this assignment to be questionable. The form bears a passing resemblance to the Eocene genus *Hayella* Gartner, 1969.
Holotype: Plate 1, Figures 13-14 (SEM); Neg.# UCL-5043-24/25.
Holotype dimensions: 5.3µm long, 4.3µm wide, ~3.3µm high. (LM dimensions: 6.5µm long, 5.2µm wide.)
Type location: ODP Hole 761B, Wombat Plateau, E Indian Ocean.
Type level: Sample ODP 761B-22X-5, 18-19cm, Upper Maastrichtian, CC25c.
Range: Upper Campanian-Upper Maastrichtian.

Genus *DILOMA* Wind & Čepek, 1979
Type species: *Diloma primitiva* (Worsley, 1971) Wind & Čepek, 1979

Diloma galei sp. nov.
Plate 1, Figures 10a-b

Derivation of name: After Prof. Andy Gale, in recognition of his works on the stratigraphy of the Upper Cretaceous.
Diagnosis: A species of *Diloma* with a wide central area filled with numerous fine bars arranged about the long ellipse axis. No axial cross is visible.
Remarks: Differs from *D. placinum* and *D. primitiva* in apparently not possessing an axial cross. These two species have ranges in the Hauterivian.
Holotype: Plate 1, Figures 10a-b (XPL); Neg.# UCL-5755-26/25.
Holotype dimensions: 7.0µm long, 5.2µm wide.
Type location: Abbots Cliff, near Folkestone, Kent, UK.
Type level: Sample AC5, Mantelliceras dixoni Amm. Zone, Lower Cenomanian Chalk Marl Formation, CC9c.
Range: Lower Cenomanian.

Genus *EIFFELLITHUS* Reinhardt, 1965
Type species: *Eiffellithus turriseiffelii* (Deflandre *in* Deflandre & Fert, 1954) Reinhardt, 1965

Eiffellithus ? hancockii sp. nov.
Plate 1, Figures 3a-b

1996 *Staurolithites*? sp.2 Burnett *in* Gale *et al.*: p.523, fig.4z.

Derivation of name: After Prof. Jake Hancock, in recognition of his work on the stratigraphy of the Upper Cretaceous.
Diagnosis: A small- to medium-sized, elliptical coccolith with a thick bicyclic rim. The outer rim is relatively wide and dark and the inner rim is broader and highly birefringent. A very small, axial cross completely occupies the central area of the coccolith.
Remarks: This form is only tentatively assigned to *Eiffellithus* because, although it has a dark outer rim and bright inner rim, it does not seem to have the inner rim construction seen in other forms of *Eiffellithus* (compare this form with *E. pospichalii*). The species is distinctively different from any other species of either *Eiffellithus* or *Staurolithites*.
Holotype: Plate 1, Figures 3a-b (XPL); Neg.# UCL-5762-28/29.
Holotype dimensions: 4.8µm long, 3.7µm wide.

Type location: Lydden Spout, near Folkestone, Kent, UK.
Type level: Sample LYS5, Acanthoceras rhotomagense Amm. Zone, Middle Cenomanian Chalk Marl Formation, CC10a.
Range: Upper Albian-Middle Cenomanian.

Eiffellithus pospichalii sp. nov.
Plate 1, Figures 11a-b

Derivation of name: After Dr. Jim Pospichal, in recognition of his work, particularly on the K/T boundary.
Diagnosis: A large species of *Eiffellithus* which has a broad, thick 45° cross completely filling the central area.
Remarks: This form is distinct from other species of *Eiffellithus* in being large, very highly birefringent, and having a broad thick cross filling the central area. The new species also has a restricted range in the Campanian, and has not been observed outside the Indian Ocean basin and immediate environs.
Holotype: Plate 1, Figures 11a-b (XPL/PC); Neg.# UCL-5599-2/1.
Holotype dimensions: 11.3µm long, 7.8µm wide.
Type location: DSDP Site 217, Bay of Bengal, N Indian Ocean.
Type level: Sample DSDP 217-29-4, 95-97cm, Upper/Lower Campanian, CC20-21.
Range: Lower-Upper Campanian.

Genus *LAGUNCULA* Black, 1971b
Type species: *Laguncula dorotheae* Black, 1971b

Laguncula montrisouensis sp. nov.
Plate 1, Figures 31a-c

Derivation of name: After the section at Mont Risou from which this species was first identified.
Diagnosis: A species of *Laguncula* with a subdiamond-shaped outline and a thin basal plate situated at the neck of the form.
Remarks: The new species is distinct from *L. dorotheae* in having a subangular outline and a basal plate.
Holotype: Plate 1, Figures 31a-c (XPL/PC); Neg.# UCL-5202-8/7/19.
Holotype dimensions: 10.4µm long, 8.7µm at widest point, 5.7µm plate width.
Type location: Mont Risou, near Rosans, Drôme, SE France.
Type level: Sample RI-24m, Neostlingoceras carcitanense Amm. Subzone, Mantelliceras mantelli Amm. Zone, Upper Albian Marnes Bleues Formation, CC9b.
Range: Upper Albian.

Genus *LAPIDEACASSIS* Black, 1971b
Type species: *Lapideacassis mariae* Black, 1971b

Lapideacassis Black, 1971b differs from *Scampanella* Forchheimer & Stradner, 1973 emend. Perch-Nielsen & Franz, 1977 in possessing >1 distal tier. In *Scampanella*, this single distal tier comprises >50% of the body length. This differentiation is not considered to be a particularly useful generic distinction and is often difficult to determine. Since the genera are obviously closely related, *Scampanella* is considered to be synonymous with *Lapideacassis*.

Lapideacassis asymmetrica* (Perch-Nielsen *in* Perch-Nielsen & Franz, 1977) *comb. nov.

Basionym: *Scampanella asymmetrica* Perch-Nielsen *in* Perch-Nielsen & Franz, 1977: p.853, pl.2, figs 3-6, 9-10 (9, 10 = holotype); pl.6, figs 7-9, text-fig.3.16. (Perch-Nielsen, K. & Franz, H.E. 1977. *Lapideacassis* and *Scampanella*, calcareous nannofossils from the Paleocene at Sites 354 and 356, DSDP Leg 39, southern Atlantic. *IRDSDP*, **39**: 849-862.)

Lapideacassis bispinosa* (Perch-Nielsen *in* Perch-Nielsen & Franz, 1977) *comb. nov.

Basionym: *Scampanella bispinosa* Perch-Nielsen *in* Perch-Nielsen & Franz, 1977: p.853, pl.3, figs 1-7 (4-7 = holotype); pl.6, figs 12-14, 15-17.; text-fig.3.14. (Perch-Nielsen, K. & Franz, H.E. 1977. *Lapideacassis* and *Scampanella*, calcareous nannofossils from the Paleocene at Sites 354 and 356, DSDP Leg 39, southern Atlantic. *IRDSDP*, **39**: 849-862.)

Lapideacassis magnifica* (Perch-Nielsen *in* Perch-Nielsen & Franz, 1977) *comb. nov.

Basionym: *Scampanella magnifica* Perch-Nielsen *in* Perch-Nielsen & Franz, 1977: p.853, pl.1 figs 1-5 (1-4 = holotype); pl.6, figs 4-6; text-fig.3.6. (Perch-Nielsen, K. & Franz, H.E. 1977. *Lapideacassis* and *Scampanella*, calcareous nannofossils from the Paleocene at Sites 354 and 356, DSDP Leg 39, southern Atlantic. *IRDSDP*, **39**: 849-862.)

Genus *MARTHASTERITES* Deflandre, 1959
Type species: *Marthasterites furcatus* (Deflandre *in* Deflandre & Fert, 1954) Deflandre 1959

Marthasterites bramlettei* (Deflandre, 1959) *comb. nov.

Basionym: *Marthasterites furcatus* var. *bramlettei* Deflandre, 1959: p.139-140, pl.3, fig.2 (holotype). (Deflandre, G. 1959. Sur les nannofossiles calcaires et leur systématique. *Revue de Micropaléontologie*, **2**(3): 127-152.)
Remarks: This variety has been elevated to species status because its morphology is distinct from that of *M. furcatus*, and since it also has a slightly different stratigraphical range.

Marthasterites crassus* (Deflandre, 1959) *comb. nov.

Basionym: *Marthasterites furcatus* var. *crassus* Deflandre, 1959: p.139, pl.2, fig.17 (holotype); pl.3, figs 3, 4. (Deflandre, G. 1959. Sur les nannofossiles calcaires et leur systématique. *Revue de Micropaléontologie*, **2**(3): 127-152.)
Remarks: This variety has been elevated to species status because its morphology is distinct from that of *M.*

furcatus, and since it also has a slightly different stratigraphical range.

Marthasterites simplex* (Bukry, 1969) *comb. nov.

Basionym: *Marthasterites furcatus* subsp. *simplex* Bukry, 1969: p.66, pl.39, figs 6 (holotype), 7. (Bukry, D. 1969. Upper Cretaceous coccoliths from Texas and Europe. *University of Kansas Paleontological Contributions*, **Article 51** (Protista 2), 79pp..)
Remarks: This variety has been elevated to species status because its morphology is distinct from that of *M. furcatus*, and since it also has a slightly different stratigraphical range.

Genus *MICRANTHOLITHUS* Deflandre *in* Deflandre & Fert, 1954
Type species: *Micrantholithus flos* Deflandre *in* Deflandre & Fert, 1954

Micrantholithus quasihoschulzii sp. nov.
Plate 1, Figures 15a-b

Derivation of name: Latin *quasi* = simulating, referring to the similarity between the new species and *M. hoschulzii*, which has a LO in the Aptian.
Diagnosis: A species of *Micrantholithus* in which the pentalith segments have a V-shaped depression along their outer edges.
Remarks: Only a few sightings of *Micrantholithus* have been made in the Upper Cretaceous. Gartner (*in* Robaszynski *et al.*, 1990) found a form of *Micrantholithus* in the Turonian of Tunisia which has crenulate outer edges, whilst the author has only found rare specimens of the new species in the Coniacian of the Trunch BH (Norfolk, UK) and in the southern English Chalk.
Holotype: Plate 1, Figure 15a (XPL); Neg.# UCL-5764-8.
Holotype dimensions: 8.7µm widest dimension (6.5µm other figured specimen).
Type location: Langdon Stairs, near Folkestone, Kent, UK.
Type level: Sample LAS17, cortestudinarium/coranguinum Ech. Zones, Coniacian Ramsgate Chalk Formation, CC14.
Range: Coniacian.

Genus *MICULA* Vekshina, 1959
Type species: *Micula decussata* Vekshina, 1959

Micula adumbratus sp. nov.
Plate 1, Figures 23a-d

Derivation of name: Latin *adumbratus* = false, represented in outline, referring to the similarity of the new species to *M. staurophora*, to which it is believed to be ancestral.
Diagnosis: In plan view in the LM, the new species appears similar to *M. staurophora* in one orientation but when rotated reveals a more complex morphology than the triangular blocks which comprise *M. staurophora*. It is difficult to discern whether the sutures between the constituent blocks of the new species cut the corners of a square (as in *Micula*) or the edges (as in *Quadrum*). In PC, there appear to be four smaller blocks situated between and/or below the main, highly birefringent ones which provide the *Micula*-like form.
Remarks: This new species is believed to constitute an intermediate form between *Quadrum* and *Micula* but is placed in *Micula* because it occurs just below the FO of *M. staurophora* and because its interference figure is reminiscent of this species. The form is dissimilar to any species of *Quadrum* (compare with Varol's (1992) plates 6 and 7).
Holotype: Plate 1, Figures 23a-d (XPL/PC); Neg.# UCL-5757-7/6/9/8.
Holotype dimensions: 4.4µm edge to edge; 5.7µm point to point.
Type location: Březno BH, Czech Republic.
Type level: BRE3 (38.5m) Upper Turonian, CC13a.
Range: Upper Turonian-Coniacian.

Genus *NEOCREPIDOLITHUS* Romein, 1979
Type species: *Neocrepidolithus neocrassus* (Perch-Nielsen, 1968) Romein, 1979

Neocrepidolithus ruegenensis sp. nov.
Plate 1, Figure 12

Derivation of name: After the section on the Island of Rügen from which the species is described.
Diagnosis: A large species of *Neocrepidolithus* which contains a thick inner cycle of elements, which leave a narrow central opening which is unoccupied.
Remarks: Differs from other species of the genus in being larger, with a narrow central opening.
Holotype: Plate 1, Figure 12; Neg.# UCL-5757-15.
Holotype dimensions: 7.6µm long, 5.7µm wide.
Type location: Rügen Island, Jasmund, E Germany.
Type level: Sample RÜG46, Upper Maastrichtian, CC25a.
Range: Upper Maastrichtian.

Genus *PETRARHABDUS* (Deflandre, 1959) Wind & Wise *in* Wise, 1983
Type species: *Petrarhabdus copulatus* (Deflandre, 1959) Wind & Wise *in* Wise, 1983

Petrarhabdus vietus sp. nov.
Plate 2, Figures 9-10

Derivation of name: Latin *vietus* = shrunken, referring to the nature of the spine relative to the coccolith.
Diagnosis: A species of *Petrarhabdus* in which the spine is remarkably smaller than the coccolith. In the LM, the image is very highly birefringent. It has >17 rim elements and a small central area which contains a complex cross composed of multiple laths. In the SEM, the spine appears to be composed of three stacks of calcite blocks, as opposed to the two stacks observed in *P. copulatus*. In *P. copulatus*, the rim elements do not imbricate as much as in *P. vietus*.
Remarks: The structure of *Petrarhabdus* has been remarked on previously by, for example, Wind (1975; who illustrated a number of 'varied morphologies'), Wind &

Wise (*in* Wise, 1983) and Bralower & Siesser (1992; who illustrated the distal view without the spine), but its origins have remained obscure. However, a form of *Prediscosphaera* (*P.* cf. *P. majungae*: Plate 2, Figures 5, 6) has been found which suggests a link between *Prediscosphaera* and *Petrarhabdus*. Both genera have placolith rims, the two shields composed of the same crystal unit. The shields typically fuse with overgrowth in *Prediscosphaera*, and this can also be seen in *Petrarhabdus* (compare Plate 2, Figures 2 and 3 with Figure 6). Peg-like R-units can be seen, inserted between the rim elements in proximal views of *Prediscosphaera* (just visible on Plate 2, Figure 6), and these are also present in *Petrarhabdus* (Plate 2, Figure 8). A distinctive difference between the rims of the two genera is that *Prediscosphaera* typically has 16 elements in the rim, whilst *Petrarhabdus* has 17 or more. The *Petrarhabdus* spine is extremely distinctive, being angular and rosette-like. The *Prediscosphaera* specimen illustrated here has a bulbous tier of elements adjoining the coccolith, with a second, smaller tier lying above (and possibly inserted between) these. This specimen is possibly overgrown, but it is possible to envisage that this arrangement might well have evolved into the *Petrarhabdus* spine construction. Thus, *Petrarhabdus* may have evolved from *Prediscosphaera*.
Holotype: Plate 2, Figure 10 (XPL); Neg.# UCL-5599-9.
Holotype dimensions: 14.4µm diameter.
Type location: DSDP Site 217, Bay of Bengal, N Indian Ocean.
Type level: Sample DSDP 217-23-2, 67-68cm, Lower/Upper Maastrichtian, CC24/25a.
Range: Upper Campanian-Upper Maastrichtian.

Genus *PETROBRASIELLA* Troelsen & Quadros, 1971
Type species: *Petrobrasiella venata* Troelsen & Quadros, 1971

Petrobrasiella? bownii sp. nov.
Plate 1, Figures 32-33f

Derivation of name: After Dr. Paul Bown, in recognition of his work on Mesozoic nannofossils.
Diagnosis: A form comprising a basal plate composed of elements which form an indistinct rim (probably a preservational feature) and a perforated distal part. The perforations are subhexagonal. In the LM, focusing on the distal part shows the reticulated nature of this. Focusing on the base, the perforations can be seen to extend into the core of the form. The LM side-view again reveals the extensive perforations and a coccolith-like base with a cavate central area.
Remarks: This form is tentatively placed in *Petrobrasiella* (= *Athenagalea* Hattner & Wise, 1980) which differs in having irregularly-spaced perforations on the outside which, in LM side-view, can be seen to branch from a central core rather than extend in a straight line, and no discernible coccolith base. Also, *Petrobrasiella* has affinities with *Lucianorhabdus* Deflandre, 1959, which the new species does not appear to share.
Holotype: Plate 1, Figure 32 (SEM); Neg.# UCL-5048-3.
Holotype dimensions: 7.0µm diameter, 6.7µm high. (LM illustrations: 7.4µm diameter, 6.5µm high.)
Type location: DSDP Site 249, Mozambique Ridge, W Indian Ocean.
Type level: Sample DSDP 249-17-2, 109-110cm, Campanian/Maastrichtian, CC22a-23b.
Range: Upper Campanian/Lower Maastrichtian.

Genus *QUADRUM* Prins & Perch-Nielsen *in* Manivit *et al.*, 1977
Type species: *Quadrum gartneri* Prins & Perch-Nielsen *in* Manivit *et al.*, 1977

Quadrum bengalensis sp. nov.
Plate 1, Figures 26a-b

Derivation of name: After the Bay of Bengal from which it is described.
Diagnosis: A form of *Quadrum* which has one cycle larger then the other. The larger cycle appears to be slightly flared, and the elements slightly separated from one another.
Remarks: Differs from other *Quadrum* species with four elements per face in being distinctly wider at one end.
Holotype: Plate 1, Figures 26a-b (XPL); Neg.# UCL-5763-25/24.
Holotype dimensions: 4.4µm ?long, 3.0-3.9µm ?wide.
Type location: DSDP Site 217, Bay of Bengal, N Indian Ocean.
Type level: Sample DSDP 217-17-1, 86-88cm, uppermost Maastrichtian, CC26.
Range: Upper Maastrichtian.

Quadrum svabenickae sp. nov.
Plate 1, Figures 22a-b

Derivation of name: After Dr. Lilian Švábenická, in recognition of her work on Upper Cretaceous nannofossils in particular.
Diagnosis: A species of *Quadrum* which has an excavated central area and elements which appear to be particularly thickened at the edges.
Remarks: Differs from other species in the genus with four elements per face in possessing an excavated central area and thick outer corners.
Holotype: Plate 1, Figure 22a (XPL); Neg.# UCL-4055-9.
Holotype dimensions: 6.5µm face to face, 8.7µm corner to corner. (Other illustration: 4.8µm face to face, 5.7µm corner to corner.)
Type location: DSDP Site 249, Mozambique Ridge, W Indian Ocean.
Type level: Sample DSDP 249-21-6, 80-81cm, Upper Campanian, CC21.
Range: Lower-Upper Campanian.

Genus *RETECAPSA* Black, 1971a
Type species: *Retecapsa brightoni* Black, 1971a

Retecapsa ficula* (Stover, 1966) *comb. nov.

Basionym: *Coccolithites ficula* Stover, 1966: p.138, pl.5, figs 5 (holotype), 6; pl.9, fig.11. (Stover, L.E. 1966. Creta-

ceous coccoliths and associated nannofossils from France and the Netherlands. *Micropaleontology*, **12**(2): 133-167.)

Genus *RHAGODISCUS* Reinhardt, 1967
Type species: *Rhagodiscus asper* (Stradner, 1963) Reinhardt, 1967

Rhagodiscus indistinctus sp. nov.
Plate 1, Figures 16a-b

Derivation of name: Latin *indistinctus* = obscure, dim, referring to its appearance in XPL.
Diagnosis: A medium-sized, elliptical coccolith with a moderately broad rim, and a narrow central area which contains a spine(-base). It is unclear whether the central area contains a floor or not. The coccolith is of low birefringence, and the spine-base often difficult to discern, which gives it an overall appearance of indistinction.
Remarks: The indistinct appearance of this form differentiates it from other species of *Rhagodiscus*. Although this form may appear to be simply a poorly-preserved specimen, it has a well-defined distribution in a number of locations, in material with a range of preservational states, and is thus believed to represent a definite species.
Holotype: Plate 1, Figure 16a (XPL); Neg.# UCL-5654-13.
Holotype dimensions: 8.7µm long, 5.7µm wide. (Other illustration: 9.1µm long, 6.5µm wide.)
Type location: DSDP Site 217, Bay of Bengal, N Indian Ocean.
Type level: DSDP 217-20-1, 114-115cm, Upper Maastrichtian, CC25b.
Range: Lower Campanian-Upper Maastrichtian.

Genus *SEMIHOLOLITHUS* Perch-Nielsen, 1971
Type species: *Semihololithus biskayae* Perch-Nielsen, 1971

Semihololithus dens sp. nov.
Plate 1, Figures 20-21, 24-25

Derivation of name: Latin *dens* = tooth, because the new species resembles a tooth.
Diagnosis: A species of *Semihololithus* which has a basal plate divided into two, each part having a process extending from it, such that the form resembles a tooth.
Remarks: In the LM, this species is highly birefringent. It differs from other species of the genus in bearing two thin processes.
Holotype: Plate 1, Figures 20, 21, 25 (SEM); Neg.# UCL-5046-27/29/28.
Holotype dimensions: 5.7µm high, 4.7µm basal plate length, 3.2µm basal plate width. (LM illustration: 6.3µm high, 6.5µm basal plate length.)
Type location: DSDP Site 249, Mozambique Ridge, W Indian Ocean.
Type level: Sample DSDP 249-17-5, 111-112cm, Upper Campanian-Lower Maastrichtian, CC22a-23b.
Range: Upper Campanian-Lower Maastrichtian.

Genus *STAUROLITHITES* Caratini, 1963
Type species: *Staurolithites laffittei* Caratini, 1963
Staurolithites Caratini, 1963 is considered to be the senior synonym of *Vekshinella* Loeblich & Tappan, 1963, *Vagalapilla* Bukry, 1969 and *Staurorhabdus* Noël, 1973. All species have a murolith rim, axially-aligned cross, and may/may not bear a spine.

Staurolithites aachena* (Bukry, 1969) *comb. nov.

Basionym: *Vagalapilla aachena* Bukry, 1969: p.55-56, pl.31, figs 6-9 (7 = holotype). (Bukry, D. 1969. Upper Cretaceous coccoliths from Texas and Europe. *University of Kansas Paleontological Contributions*, **Article 51** (Protista 2): 79pp..)

Staurolithites? aenigma sp. nov.
Plate 1, Figures 1a-b

1996 *Staurolithites*? sp.1 Burnett *in* Gale *et al.*: p.523, figs 4l-m.

Derivation of name: Latin *enigma* = enigma, something obscure, referring to the atypical overall appearance of this staurolithitid coccolith.
Diagnosis: Small- to medium-sized, elliptical coccolith with a bicyclic rim. The rims are equally narrow, the outer one being dark and the inner one bright. The central area contains a plate: this is unclear from LM observation but has been observed in the SEM. The axial cross is composed of laths and sits partially within the plate. This cross tends to be highly birefringent in the LM.
Remarks: The new species is tentatively placed in *Staurolithites* but is dissimilar to other species in this genus because of the unusual situation of the cross sitting in a central plate. It is easily distinguishable from other species of the genus because of this feature.
Holotype: Plate 1, Figures 1a-b (XPL); Neg.# UCL-5733-34/35.
Holotype dimensions: 4.6µm long, 3.5µm wide.
Type location: Mont Risou, near Rosans, Drôme, SE France.
Type level: Sample RI+8m, Neostlingoceras carcitanense Amm. Subzone, Mantelliceras mantelli Amm. Zone, Lower Cenomanian, CC9b.
Range: Upper Albian-Lower Cenomanian.

Staurolithites dentata* (Bukry, 1969) *comb. nov.

Basionym: *Vagalapilla dentata dentata* Bukry, 1969: p.56, pl.32, figs 1-3 (3 = holotype). (Bukry, D. 1969. Upper Cretaceous coccoliths from Texas and Europe. *University of Kansas Paleontological Contributions*, **Article 51** (Protista 2): 79pp..)
Remarks: Bukry (1969) described two subspecies, *V. dentata dentata* and *V. dentata aperta*. These are believed to represent preservational morphotypes, thus the taxon is elevated to species status herein.

Staurolithites dorfii* (Bukry, 1969) *comb. nov.

Basionym: *Vagalapilla dorfii* Bukry, 1969: p.57, pl.32, figs 7, 8 (8 = holotype). (Bukry, D. 1969. Upper Cretaceous coccoliths from Texas and Europe. *University of Kansas Paleontological Contributions*, **Article 51** (Protista 2): 79pp..)

Staurolithites elongatus* (Bukry, 1969) *comb. nov.

Basionym: *Vagalapilla imbricata elongata* Bukry, 1969: p.58, pl.33, figs 3 (holotype), 4. (Bukry, D. 1969. Upper Cretaceous coccoliths from Texas and Europe. *University of Kansas Paleontological Contributions*, **Article 51** (Protista 2): 79pp..)
Remarks: Bukry (1969) described two subspecies of *V. imbricata* (Gartner, 1968) (see below). The subspecies are dissimilar enough to belong to separate species. *V. imbricata elongata* is thus, herein, elevated to species status.

Staurolithites flavus sp. nov.
Plate 1, Figures 2a-b

Derivation of name: Latin *flavus* = yellow, referring to the distinctive appearance of the axial cross in the LM.
Diagnosis: A simply-constructed species of *Staurolithites* which possesses a distinctively highly-birefringent axial cross.
Remarks: This medium-sized species has a unicyclic murolith rim. An axial cross spans the open central area. The bars of the cross appear to be composed of single blocks of calcite and, in the LM, these are highly birefringent. It is not clear whether the species bears a spine or not.
Holotype: Plate 1, Figure 2a (XPL); Neg.# UCL-5599-7.
Holotype dimensions: 4.8μm long, 3.5μm wide.
Type location: DSDP Site 217, Bay of Bengal, N Indian Ocean.
Type level: Sample DSDP 217-23-2, 78-79cm, Lower/ Upper Maastrichtian, CC24-25a..
Range: Lower Cenomanian-Upper Maastrichtian.

Staurolithites glabra* (Jeremiah, 1996) *comb. nov.

Basionym: *Bownia glabra* Jeremiah, 1996: p.125, pl.3, fig.20 (holotype). (Jeremiah, J. 1996. A proposed Albian to Lower Cenomanian nannofossil biozonation for England and the North Sea Basin. *Journal of Micropalaeontology*, **15**(2): 97-129.)

Staurolithites imbricatus* (Gartner, 1968) *comb. nov.

Basionym: *Vekshinella imbricata* Gartner, 1968: p.30-31, pl.9, figs 16 (holotype), 17; pl.13, figs 8, 9. (Gartner, S. 1968. Coccoliths and related calcareous nannofossils from Upper Cretaceous deposits of Texas and Arkansas. *University of Kansas Paleontological Contributions*, **48**: 56pp..)
Remarks: Bukry (1969) described two subspecies, *Vagalapilla imbricata imbricata* and *V. imbricata elongata*. These subspecies are not considered to be similar to Gartner's *V. imbricata*. The former is more similar to *Staurolithites mielnicensis* (Górka, 1957) Perch-Nielsen, 1968, whilst the latter is herein elevated to species status (see above).

Staurolithites integra* (Bukry, 1969) *comb. nov.

Basionym: *Vagalapilla compacta integra* Bukry, 1969: p.56, pl.31, fig.12 (holotype). (Bukry, D. 1969. Upper Cretaceous coccoliths from Texas and Europe. *University of Kansas Paleontological Contributions*, **Article 51** (Protista 2): 79pp..)
Remarks: This taxon has been elevated to species status because the two original subspecies, *V. compacta compacta* and *V. compacta integra* are distinctly different. The former has been moved into *Helicolithus* (*H. compactus* (Bukry, 1969) Varol & Girgis, 1994), and the latter is now placed into *Staurolithites* because it comprises a simple murolith rim and an axial cross.

Staurolithites minutus sp. nov.
Plate 1, Figures 4a-b

Derivation of name: Latin *minutus* = small, referring to the size of the species.
Diagnosis: A very small species of *Staurolithites* which is distinctively highly-birefringent with a virtually closed central-area and an indistinct, extremely small axial cross.
Remarks: The very small size of the new species, its virtually closed central area and extremely small cross differentiate it from other *Staurolithites* species.
Holotype: Plate 1, Figures 4a-b (XPL); Neg.# UCL-5731-18/19.
Holotype dimensions: 3.7μm long, 2.2μm wide.
Type location: Bluffs on Chattahoochee River, near Georgia railroad crossing, Quitman County, Georgia, USA.
Type level: Sample USA44, Coon Creek Tongue, Ripley Formation.
Range: Cenomanian?-Maastrichtian.

Staurolithites parma* (Wind & Wise *in* Wise & Wind, 1977) *comb. nov.

Basionym: *Vekshinella? parma* Wind & Wise *in* Wise & Wind, 1977: p.307, pl.42, figs 1, 2 (2 = holotype). (Wise, S.W. & Wind, F.H. 1977. Mesozoic and Cenozoic calcareous nannofossils recovered by DSDP Leg 36 drilling on the Falkland Plateau, southwest Atlantic sector of the Southern Ocean. *IRDSDP*, **36**: 269-492.)

Staurolithites zoensis sp. nov.
Plate 1, Figures 5-7b

Derivation of name: From the Zoe C BH, from which the species is described.
Diagnosis: A medium-sized, slightly elongated species of *Staurolithites* in which the inner rim-cycle and thin, axial cross are highly birefringent. The inner and outer rims are similarly narrow. The bars of the axial cross bend slightly at the junction with the rim. A spine-base is apparent.
Remarks: The new species is differentiated from other species of *Staurolithites* by the bicyclic rim, and the way in which the highly birefringent axial cross twists slightly where it attaches to the rim.
Holotype: Plate 1, Figure 5 (XPL); Neg.# UCL-5657-32.
Holotype dimensions: 6.5μm long, 4.8μm wide. (Other illustrations: 6.1-6.7μm long, 3.5-4.4μm wide.)
Type location: Zoe C Borehole, S Africa.
Type level: Sample ZC1155, uppermost Campanian, CC23a.
Range: Santonian-Upper Maastrichtian.

Genus *TORTOLITHUS* Crux *in* Crux *et al.*, 1982
Type species: *Tortolithus caistorensis* Crux *in* Crux *et al.*, 1982

Tortolithus polygonatus* (Górka, 1963) *comb. nov.

Basionym: *Discolithus polygonatus* Górka, 1963: p.14, text-pl.1, figs 8, 9; pl.1, figs 5 (holotype), 6. (Górka, H. 1963. Coccolithophoridés, dinoflagellés, hystrichosphaeridés et microfossiles *Incertae sedis* du Crétacé supérieur de Pologne. *Acta Palaeontologica Polonica*, **8**(1): 3-87.)

Genus *ZEUGRHABDOTUS* Reinhardt, 1965
Type species: *Zeugrhabdotus erectus* (Deflandre *in* Deflandre & Fert, 1954) Reinhardt, 1965

Zeugrhabdotus biperforatus* (Gartner, 1968) *comb. nov.

Basionym: *Zygodiscus biperforatus* Gartner, 1968: p.31-32, pl.14, figs 15, 16 (16 = holotype); pl.17, figs 1, 2; pl.18, figs 20, 21; pl.19, fig.4; pl.20, figs 19, 20; pl.21, fig.5; pl.26, fig.5. (Gartner, S. 1968. Coccoliths and related calcareous nannofossils from Upper Cretaceous deposits of Texas and Arkansas. *University of Kansas Paleontological Contributions*, **48**: 56pp..)

Zeugrhabdotus burwellensis* (Black, 1972) *comb. nov.

Basionym: *Crepidolithus burwellensis* Black, 1972: p.29, pl.3, figs 1 (holotype), 2. (Black, M. 1972. British Lower Cretaceous coccoliths. I. Gault Clay, Part 1. *Palaeontographical Society Monograph*, **126**: 1-48.)

Zeugrhabdotus ponticulus* (Deflandre *in* Deflandre & Fert, 1954) *comb. nov.

Basionym: *Discolithus ponticulus* Deflandre *in* Deflandre & Fert, 1954: p.144, pl.13, figs 18, 19; text-figs 32, 54. (Deflandre, G. & Fert, C. 1954. Observations sur les coccolithophoridés actuels et fossiles en microscopie ordinaire et électronique. *Annales de Paléontologie*, **40**: 117-176.)

Zeugrhabdotus praesigmoides sp. nov.
Plate 1, Figures 8a-c

Derivation of name: Latin *prae* = before, referring to the probable ancestral relationship between this species and *Z. sigmoides*.
Diagnosis: A medium-sized species of *Zeugrhabdotus* in which the inner cycle is bright, and opposite quadrants go into extinction together on rotation. A small, twisted bridge, composed of small blocks, spans the narrow, open central area.
Remarks: This form is smaller, and the inner cycle is broader, than in *Z. sigmoides*. The inner cycle is distinctively birefringent and the bar has a sigmoidal appearance similar to that seen in *Z. sigmoides* but dissimilar to other species of *Zeugrhabdotus*.
Holotype: Plate 1, Figures 8a-c (XPL). Neg.# UCL-5795-4/5/3.
Holotype dimensions: 6.5µm long, 4.8µm wide.
Type location: DSDP Site 249, Mozambique Ridge, W Indian Ocean.
Type level: Sample DSDP 249-19-2, 137-138cm, Upper Campanian-Lower Maastrichtian, CC22a-23b.
Range: Santonian?-Maastrichtian.

Zeugrhabdotus spiralis* (Bramlette & Martini, 1964) *comb. nov.

Basionym: *Zygodiscus spiralis* Bramlette & Martini, 1964: p.303, pl.4, figs 6-8 (6, 7 = holotype). (Bramlette, M.N. & Martini, E. 1964. The great change in calcareous nannoplankton fossils between the Maestrichtian and Danian. *Micropalaeontology*, **10**, 291-322.)

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PLATE 1

All LM illustrations x2300

All negatives are stored in the Micropalaeontology Unit, UCL

Figs 1a-b: ***Staurolithites? aenigma***. XPL (holotype, b rotated); sample RI+8m, Lower Cenomanian; UCL-5733-34/35.

Figs 2a-b: ***Staurolithites flavus***. XPL (a holotype); samples DSDP 217-23-2 (a), Miss-76-5 (b), Lower Maastrichtian; UCL-5599-7/5732-28.

Figs 3a-b: ***Eiffellithus? hancockii***. XPL (holotype, b rotated); sample LYS5, Middle Cenomanian; UCL-5762-28/29.

Figs 4a-b: ***Staurolithites minutus***. XPL (holotype, b rotated); sample USA44, Maastrichtian; UCL-5731-18/19.

Figs 5-7b: ***Staurolithites zoensis***. XPL (5 holotype, 6a, 7b rotated); samples ZC1155 (5), Upper Campanian, Miss-76-1L (6a, b), Santonian, USA81 (7a, b), Campanian; UCL-5657-32/5730-8/9/5731-28/29.

Figs 8a-c: ***Zeugrhabdotus praesigmoides***. XPL (holotype, b, c rotated); sample DSDP 249-19-2, Upper Campanian-Lower Maastrichtian; UCL-5795-4/5/3.

Figs 9a-b: ***Chiastozygus stylesii***. XPL (holotype, b rotated); sample DSDP 258-6-5, Coniacian; UCL-5759-9/10.

Figs 10a-b: ***Diloma galei***. XPL (a), PC (b rotated) (holotype); sample AC5, Lower Cenomanian; UCL-5755-26/25.

Figs 11a-b: ***Eiffellithus pospichalii***. XPL (a), PC (b) (holotype); sample DSDP 217-29-4, Upper Campanian; UCL-5599-2/1.

Fig.12: ***Neocrepidolithus ruegenensis***. XPL (holotype); sample RÜG46, Upper Maastrichtian; UCL-5757-15.

Figs 13-14, 17a-19: ***Cylindralithus? nieliae***. SEM (13, 14, 18, 19), XPL (17a focus on base, 17b focus on top) (13, 14 holotype); samples ODP 761B-22X-5, Upper Maastrichtian, DSDP 249-22-5, Lower Campanian; UCL-5043-24/25/5200-22/23/5048-28/29.

Figs 15a-b: ***Micrantholithus quasihoschulzii***. XPL (a holotype); sample LAS17, Coniacian; UCL-5764-9/8.

Figs 16a-b: ***Rhagodiscus? indistinctus***. XPL (a holotype); samples DSDP 217-20-1, Upper Maastrichtian, DSDP 249-20-3, Upper Campanian-Lower Maastrichtian; UCL-5654-13/4054-19.

Figs 20-21, 24-25: ***Semihololithus dens***. SEM (20, 21, 25 holotype), XPL (24); samples DSDP 249-17-5, 249-19-3, Upper Campanian-Lower Maastrichtian; UCL-5046-27/29/4054-20/5046-28.

Figs 22a-b: ***Quadrum svabenickae***. XPL (a holotype); samples DSDP 249-21-6, ODP 761B-25X-4, Upper Campanian; UCL-4055-9/5704-24.

Figs 23a-d: ***Micula adumbratus***. XPL (a, b rotated), PC (c, d rotated) (holotype); sample BRE3, Upper Turonian; UCL-5757-7/6/9/8.

Figs 26a-b: ***Quadrum bengalensis***. XPL (b rotated) (holotype); sample DSDP 217-17-1, Upper Maastrichtian; UCL-5763-25/24.

Fig.27: Curved spine. XPL; sample A-76-10D, Upper Campanian; UCL-5758-23. Such spines possibly belong to *Reinhardtites*, although *Reinhardtites* also possesses thick spines with flared terminations. They are very distinctive and have a restricted range in the Campanian.

Figs 28-30: ***Rucinolithus?* sp.**. SEM (28, 30), XPL (29); samples ODP 765C-24R-1, DSDP 249-23-1, Lower Campanian; UCL-5043-9/5763-33/5043-10. This form is possibly the flared end of a *Reinhardtites* spine.

Figs 31a-c: ***Laguncula montrisouensis***. XPL (a focus on interior, b focus on exterior), PC (c) (holotype); sample RI-24m, Upper Albian; UCL-5202-8/7/19.

Figs 32-33f: ***Petrobrasiella? bownii***. SEM (32 holotype), XPL (33a, e), PC (33b-d, f); Samples DSDP 249-17-2, Upper Campanian-Lower Maastrichtian; UCL-5048-3/5795-23/24/29/35/31/30.

Figs 34-35: ***Biscutum thurowii***. SEM (holotype); sample RI-104m, Upper Albian; UCL-3842-30/31.

PLATE 1

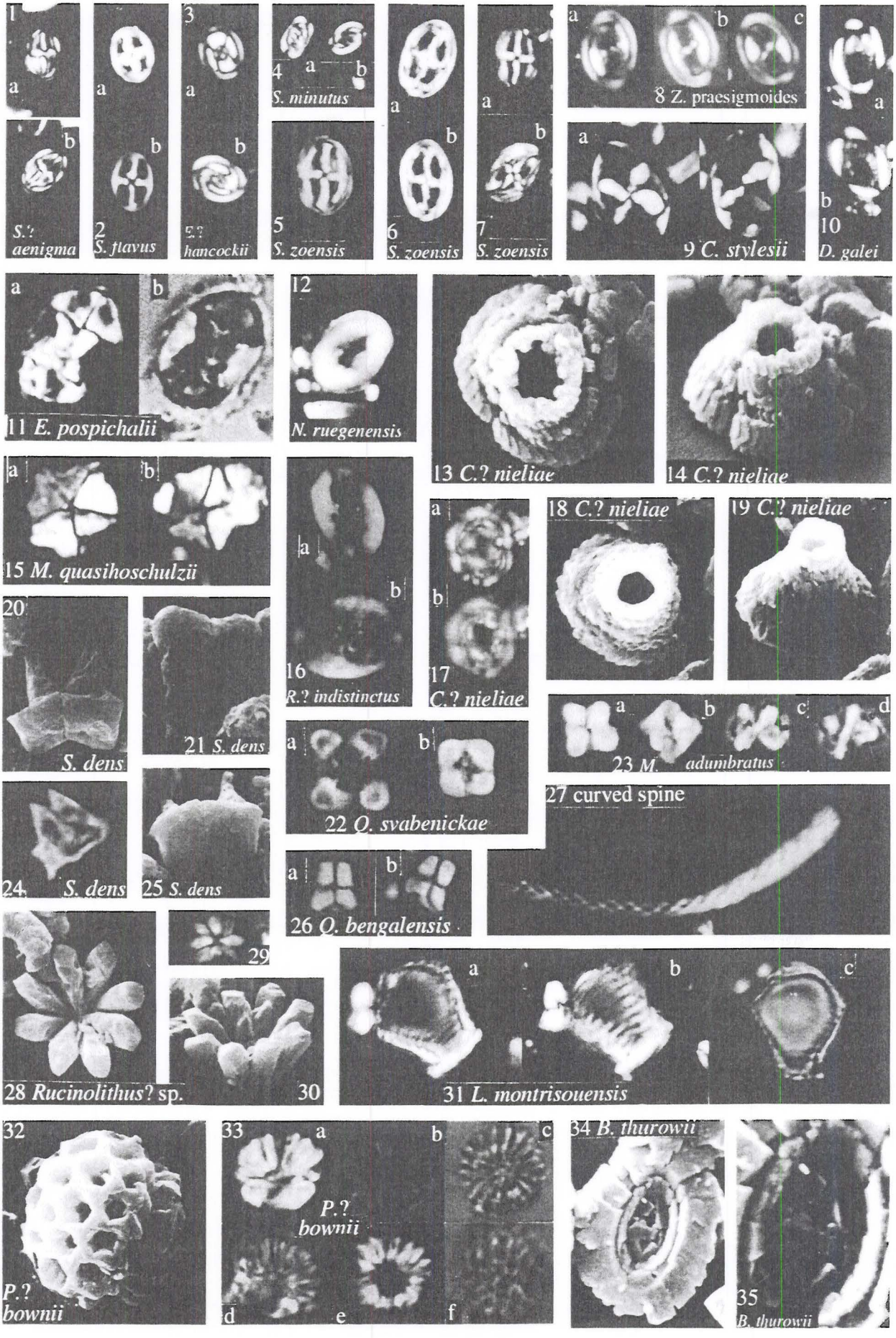
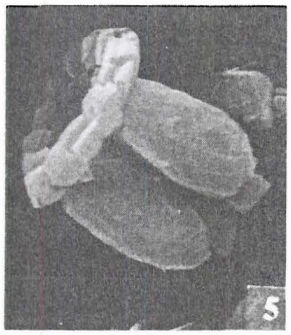
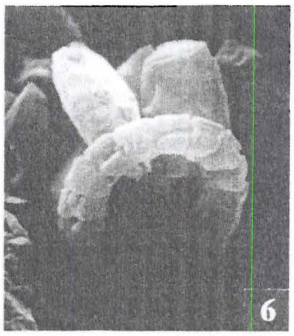

1 a b S.? aenigma
2 S. flavus
3 S.? hancockii
4 S. minutus
5 S. zoensis
6 S. zoensis
7 S. zoensis
8 Z. praesigmoides
9 C. stylesii
10 D. galei
11 E. pospichalii
12 N. ruegenensis
13 C.? nieliae
14 C.? nieliae
15 M. quasihoschulzii
16 R.? indistinctus
17 C.? nieliae
18 C.? nieliae
19 C.? nieliae
20 S. dens
21 S. dens
22 O. svabenickae
23 M. adumbratus
24 S. dens
25 S. dens
26 O. bengalensis
27 curved spine
28 Rucinolithus? sp.
29
30
31 L. montrisouensis
32 P.? bownii
33 P.? bownii
34 B. thurowii
35 B. thurowii

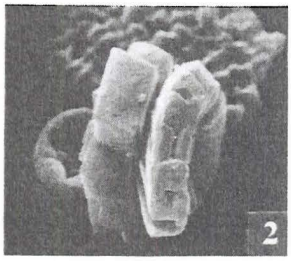
PLATE 2

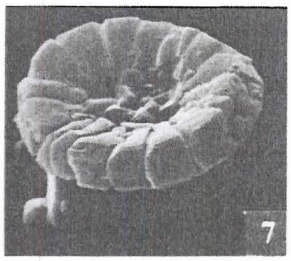
Petrarhabdus copulatus

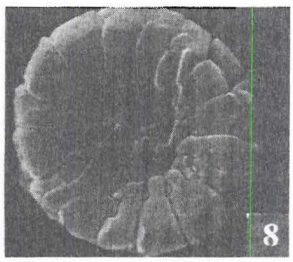




Prediscosphaera cf. *P. majungae*

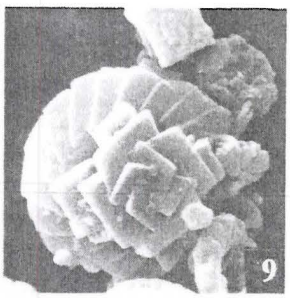


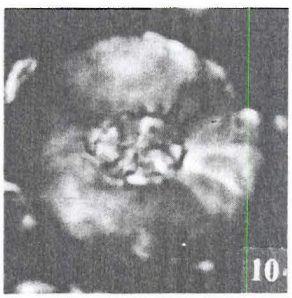




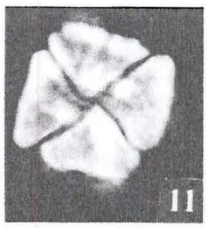
Petrarhabdus copulatus

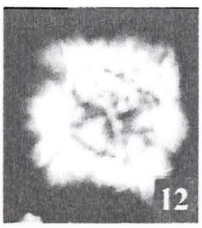
Petrarhabdus copulatus

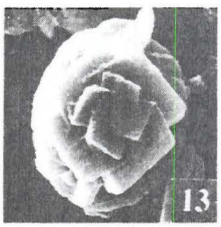




Petrarhabdus vietus







Petrarhabdus copulatus

Petrarhabdus copulatus

Figs 1-4 (UCL-5044-19/20/21/23) are rotated views of *P. copulatus*, illustrating the nature of the spine, and its size in relation to the coccolith, which has 17 rim elements. Figs 1-3 particularly show the *Prediscosphaera*-like way in which the placolith shields (which are formed from a single crystal V-unit) fuse together with overgrowth. **Figs 5-6** (UCL-5043-35/5044-2) show both the side and proximal views of *P.* cf. *P. majungae*. The main part of the spine is more bulbous than in the holotype but this may be a preservational effect. The spine construction is reminiscent of the *Petrarhabdus* spine. The shields in Fig.6 are partially fused. The rim has the 16 elements typical of *Prediscosphaera*. **Figs 7-8** (UCL-5044-5/6) again show fused shields in *Petrarhabdus*, and also the arrangement of the R-units which appear like pegs at the inner edge of the rim (Fig.8), demonstrating beautifully the alternation of V- and R-units in the rim. This is the arrangement typical in *Prediscosphaera*, although they cannot be seen so well in Fig.6. **Figs 9-10** (UCL-5022-30/5599-9). The thickness of the *P. vietus* coccolith makes it impossible to focus on the spine in the LM (Fig.10). The smaller size of the spine in relation to the coccolith, and the imbricate nature of the rim elements (which number >18) can be seen in Fig.9. **Figs 11-13** (UCL-5659-27/26/5048-25) illustrate typical *P. copulatus*.