NEW NAMES FOR OLD: TAXONOMIC CLARIFICATION OF SOME EARLY CRETACEOUS NANNOFOSSIL MARKER - SPECIES

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Abstract: Five new boreal Early Cretaceous calcareous nannofossil species are described and illustrated: *Clepsilithus maculosus, Nannoconus inornatus, Nannoconus pseudoseptentrionalis, Rhagodiscus gallagheri* and *Rucinolithus windleyae.* All five species have previously been misnamed or included within the concepts of other species. The more precise taxonomic concepts introduced here provide improved constraints for important marker-species events. One new combination, *Zeugrhabdotus scutula*, is introduced.

Introduction

A detailed study of calcareous nannofossils from the boreal area has shown that a number of biostratigraphically important taxa require more-precise definition. This paper describes five new species that previous workers have grouped with widely used marker-species, resulting in extended ranges and reduced biostratigraphical potential. Recognition of these new taxa enables clarification of a number of biostratigraphical ambiguities.

These observations are based on the detailed biostratigraphical study of nine sections of Ryazanian to Aptian age: three outcrop sections (two in England and a composite German section) and six cores (two from onshore England, one from the southern North Sea, one from offshore mid-Norway, and two from the Barents Sea). All of the outcrop material and some of the core material is accurately dated by means of cephalopods. The comprehensive results of this study will be presented in Rutledge & Bown (in prep.).

Systematic Palaeontology

Unless otherwise stated, all type-material is deposited in the Postgraduate Unit of Micropalaeontology, University College London.

Genus CLEPSILITHUS Crux, 1987
Type species: Clepsilithus polystreptus Crux, 1987

Clepsilithus maculosus sp. nov.
Plate 1, Figures 4-7

1982 *Stradnerlithus comptus* Black, 1971; Taylor, p.71, pl.4.6, figs 13-14 (EM).
1987 *Stradnerlithus comptus* Black, 1971; Jakubowski, p.117, pl.2, figs 23-24 (LM).
1988 *Thurmanolithion clatratum* Grün & Zweili, 1980; Applegate & Bergen, p.336, pl.17, fig.2 (EM).
1989 *Stradnerlithus comptus* Black, 1971; Crux, p.207, pl.8.13, figs 26-28 (LM).
1991 *Stradnerlithus comptus* Black, 1971; Mutterlose (not illustrated).
1991 *Stradnerlithus comptus* Black, 1971; Bralower, p.430, fig.6.41-42 (LM).

Diagnosis: Small (4.0-5.0μm), elliptical murolith with a bicyclic rim, the outer cycle of which is dextrally imbricate, and a central area occupied by about 14 short, radially-arranged bars which support a diamond-shaped central platform; in crossed-polars the bars appear as a cycle of regularly-spaced bright spots.

Description: The slightly flaring outer rim-cycle consists of about 25 dextrally-imbricate elements, and is only weakly birefringent (grey). The arrangement of elements in the inner rim-cycle is uncertain, but this cycle is highly birefringent (white) in crossed-polars. Each of the 12-16 regularly-arranged, radial bars consists of two laterally-fused elements, and exhibits white birefringence; these bars support a rather less-birefringent (grey-white), diamond-shaped platform that lies along the long axis of the central area. There is no distal process.

Dimensions: Length 4.0-5.1μm, width 3.0-3.6μm.

Remarks: This Upper Hauterivian marker species has been previously misnamed *Stradnerlithus comptus* (e.g. Jakubowski, 1987; Crux, 1989). *S. comptus* was originally described from the Kimmeridgian by Black (1971, pl.31, fig.10) and has a similar number of radially-arranged bars, but these are more delicately constructed and support a slender longitudinal bar, not a diamond-shaped platform. However, the most significant difference between the two species is their rim structure: *S. comptus* has a narrow, monocyclic-appearing rim composed of non-imbricate elements. In the light-microscope, the two are easily distinguished, *S. comptus* being weakly birefringent and inconspicuous, while *C. maculosus* has a highly birefringent inner rim-cycle and central-area bars.

Clepsilithus polystreptus differs from *C. maculosus* in having a less-developed inner rim-cycle, and fewer central bars (that are differently constructed), but this small form has not yet been observed in the light-microscope. The only contemporary species with which *C. maculosus* might be confused is the similarly proportioned *Cretarhabdus inaequalis*, but the latter species has a less-regular central structure.

Derivation of name: Latin, *maculosus* meaning spotted, referring to the brightly-spotted appearance of the cycle of central-area bars in crossed-polars.

Holotype: Pl.1, fig.4 (EM).

Paratype: Pl.1, fig.6 (LM).

Type locality & level: BGS Borehole 81/43 (southern North Sea), 32.80m (Upper Hauterivian).

Occurrence: Hauterivian of the North Sea area, occurringconsistently within the uppermost Hauterivian (above the last occurrence of *Tegulalithus septentrionalis*). The last occurrence of this species (basal variabilis Amm. Zone) provides an excellent approximation of the Hauterivian-Barremian boundary, as currently defined at Speeton.

Genus NANNOCONUS Kamptner, 1931
Type species: Nannoconus steinmannii Kamptner, 1931

Nannoconus inornatus sp. nov.
Plate 1, Figures 8-12, 14-18

1982 *Nannoconus abundans* Stradner & Grün, 1973; Taylor pl.4.6, fig.19 (EM).
1987 *Nannoconus abundans* Stradner & Grün, 1973; Thomsen, pl.6, figs 10-11 (EM).

Diagnosis: A short, biconcave, pillar-like nannoconid constructed from thin plates arranged in a very low-angled spiral, with a narrow axial canal.

Description: The sides of this nannoconid are convex, and the ends unflared, slightly concave and identical, thus apical/basal ends cannot be distinguished. The height is generally less than the diameter, often considerably less. The axial canal is very much narrower than the wall of the nannoconid. The outer surface of the wall is smooth, giving a circular profile in end view. The thin plates composing the wall are arranged in a very low-angled spiral.

Dimensions: Diameter 5.0-9.0μm, height 2.5-6.0μm.

Remarks: Several previous authors (e.g. Taylor, 1982; Thomsen, 1987) have included *Nannoconus inornatus* within their concept of *Nannoconus abundans*, and consequently recorded an anomalously early first occurrence for this marker-species. *N. inornatus* is considered to be the ancestor of *N. abundans*, but it is important to differentiate between the two species clearly, in order to maintain the biostratigraphical integrity of *N. abundans*.

N. inornatus differs from *N. abundans* in lacking a ?basal flange, from *Nannoconus circularis*, *Nannoconus globulus* and *Nannoconus inconspicuus* in having a narrower central canal, and from *Nannoconus ligius* in its non-petalloid profile.

Two varieties of this species were recorded: a larger, highly birefringent form, and a smaller, shorter variety yielding only white birefringence in end view. *N. inornatus* developed vertical ribs in the Early Barremian (late fissicostatum Amm. Zone), giving it a regularly scalloped margin in end view. These ribbed forms probably gave rise to *Nannoconus pseudoseptentrionalis sp. nov.* in the late Early Barremian (elegans Amm. Zone).

Derivation of name: Latin, *inornatus* meaning unadorned, referring to the simple, unflanged form of this species.

Holotype: Pl.1, fig.8 (EM).

Paratype: Pl.1, fig.9 (EM); Pl.1, fig.16 (LM).

Type locality & level: BGS Borehole 81/43 (southern North Sea); 14.70m (Lower Barremian).

Occurrence: Upper Hauterivian-Barremian of the North Sea area; rare through the lower part of this range, but becoming common/abundant in the Lower Barremian, just prior to the inception of N. abundans.

Nannoconus pseudoseptentrionalis sp. nov.
Plate 1, Figures 20-22

?1987 *Nannoconus quadriangulus quadriangulus* Deflandre & Deflandre-Rigaud, 1967; Thomsen, pl.6, figs 6, 7, 9 (EM).
1989 *Tegulalithus septentrionalis* (Stradner, 1963) Crux, 1986; Crux, pl.8.9, figs 5, 6 (EM).

Diagnosis: A short, flangeless nannoconid with a very narrow axial canal, and an irregular, ragged margin, as seen in end/plan view.

Description: This species is so short that it has only been seen in end/plan view. The thin, shallowly-spiralling plates composing the test overlap irregularly to give a ragged margin. This form lacks regularly-spaced vertical ribs, and thus its margin is not regularly scalloped. The axial canal is much narrower than the width of the wall. It is highly birefringent in the light-microscope.

Dimensions: Diameter: 4.5-7.0μm.

Remarks: *N. pseudoseptentrionalis* is differentiated from other similar nannoconids by its irregular, ragged margin. This renders it similar to *Tegulalithus septentrionalis* in crossed-polars, and it has been identified as such in several previous studies (e.g. Crux, 1989). These optically-similar species are readily differentiated in phase-contrast (in which *T. septentrionalis* displays regularly-spaced wall elements) and in side view (*T. septentrionalis* is commonly encountered in highly-distinctive side view). In end view, *N. pseudoseptentrionalis* lacks the weakly birefringent flanges often (but not always) seen on *T. septentrionalis* (see Pl.1, fig.23).

Derivation of name: Greek, *pseudes* meaning false, i.e. false-*septentrionalis*.

Holotype: Pl.1, fig.20 (LM).

Paratypes: Crux (1989), p.199, pl.8.9, fig.5 (EM); Crux (1989), p.199, pl.8.9, fig.6 (EM) (Otto Gott, Germany, Bed 109, 'Middle' Barremian, Aulacoteuthis Belemnite Zone).

Type locality & level: Speeton, NE England, Speeton Clay Formation, Lower Cement Bed 49, Lower Barremian, elegans Amm. Zone.

Occurrence: 'Middle' Barremian of the North Sea area. This species is common in the Lower Cement Beds of

Speeton (elegans Amm. Zone) and at a corresponding level in Germany. It is associated with common/abundant *Zeugrhabdotus scutula* nov. comb. at both localities.

Genus RHAGODISCUS Reinhardt, 1967
Type species: Discolithus asper Stradner, 1963, designated by Reinhardt, 1967

Rhagodiscus gallagheri sp. nov.
Plate 1, Figures 1-3

1987 *Rhagodiscus angustus* (Stradner, 1963) Reinhardt, 1971; Thomsen, p.77, pl.16, figs 6-8 (EM).

Diagnosis: Small (<5.0μm long), elliptical *Rhagodiscus* with a length/width ratio of <2.5, and straight or slightly convex longer sides. The central area is filled with a proximally-situated granular plate and spanned by short, transverse struts which support a relatively large, hollow spine-base.

Dimensions: Length 3.5-4.5μm.

Remarks: Previously included within the species concept of *Rhagodiscus angustus* by several authors (Thomsen, 1987; Mutterlose, 1991), *Rhagodiscus gallagheri* occurs earlier than *Rhagodiscus angustus* and is distinguished by its smaller size and more-elliptical outline. Morphologies transitional between these two species have been observed, confirming the difficulty in using *R. angustus* as a zonal marker. Note that Stradner's (1963) holotype drawing of *Rhagodiscus angustus* is parallel-sided with dimensions 5.0μm x 2.0μm. The oldest forms with these dimensions were recorded, in our study, from the Chale Clay, Isle of Wight, from the lower forbesi Amm. Zone (intra-Lower Aptian), although *R. gallagheri* is still the dominant form at this level. This first occurrence for *R. angustus* is still very much earlier than the basal Upper Aptian event recorded by previous authors, perhaps reflecting application of an even narrower species concept, i.e. very elongate forms with a length/width ratio of >3.

Derivation of name: Named in honour of Dr. Liam Gallagher, nannopalaeontologist.

Holotype: Pl.1, fig.1 (LM).

Paratype: Thomsen (1987), p.77, pl.16, fig.6 (EM) (Well E-1, Danish Sector of the North Sea, 8193', basal Aptian). Reproduced here as Pl.1, fig.3.

Type locality & level: Atherfield Point (Isle of Wight), Atherfield Clay Formation (Sample AC 13), Lower Aptian, forbesi Amm. Zone.

Occurrence: Common throughout the Aptian of the North Sea area; particularly abundant in nannofossiliferous samples from the Atherfield Clay, Isle of Wight, southern England (fissicostatus-forbesi Amm. Zones).

Genus RUCINOLITHUS Stover, 1966
Type species: Rucinolithus hayi Stover, 1966

Rucinolithus windleyae sp. nov.
Plate 1, Figures 24-29

?1987 *Lithastrinus* sp. Bralower, p.298 (not illustrated).

Diagnosis: Nannolith consisting of two inclined cycles of broad, petal-like elements: a wider ?proximal cycle of about nine regularly-imbricate elements, and a ?distal cycle formed from a lesser number of irregularly-overlapping elements.

Description: Two inclined cycles of broad, petal-like elements join at the solid centre of the nannolith; there is no central-area diaphragm structure. The wider ?proximal cycle consists of about nine sinistrally-imbricate, broadly-petalloid elements. The ?distal cycle consists of a lesser number of irregularly-arranged elements, at least one of which projects distally, overlapping the other elements of this cycle. In proximal view in the light-microscope, this form appears as a large (7.0-11.0μm), highly- birefringent rosette, with imbricating, petalloid elements; distal focusing reveals the irregular distal cycle. In side view, it exhibits a typical polycyclolith construction (*sensu* Varol, 1992), with two cycles of inclined elements. The fairly high and irregular form of this species ensure that it is often encountered in oblique view in the light-microscope, where it appears as an irregular, radiating birefringent body.

Dimensions: Diameter 7.8-11.0μm.

Remarks: This species is only tentatively assigned to *Rucinolithus*, due to its bicyclic construction. It would seem to be intermediate between previously described species of *Rucinolithus* (mostly older) and fully formed polycyclolithaceans, in which the two cycles of the nannolith are equally developed.

Differentiation: *R. windleyae* differs from *Lithastrinus* (as emended by Varol, 1992) in lacking a small central diaphragm. It is similar and possibly related to *Rucinolithus pinnatus* Bergen, 1994, but this older species (middle Tithonian to latest Berriasian) has only eight imbricate elements and lacks a well-developed, irregular ?distal cycle, having instead, a small-element cycle surrounding a central perforation. R. *windleyae* is differentiated from the light-microscopically similar *Assipetra terebrodentarius* (Pl.1, figs 30, 31) by its larger size, and petalloid, rather than globular, habit. It is important to make this distinction in order to retain the biostratigraphical integrity of the latter species, which has a first occurrence in the uppermost Hauterivian.

Derivation of name: Named in honour of Dr. Dawn E. Windley, erstwhile nannopalaeontologist.

Holotype: Pl.1, fig.25 (EM).

Paratype: Pl.1, fig.27 (EM); Pl.1, fig.28 (LM).

Type locality & level: BGS Borehole 81/43 (southern North Sea), 41.16m (Upper Hauterivian).

Occurrence: Lower/Upper Hauterivian boundary to Lower Barremian of BGS Borehole 81/43 and the Speeton section; rare through most of this range, but occasionally common in the Upper Hauterivian to basal Barremian. Bralower (1987) recorded the first occurrence of '*Lithastrinus* sp.' (which included the later-appearing *Assipetra terebrodentarius*) in the Upper Hauterivian of a number of tethyan sites.

Genus ZEUGRHABDOTUS Reinhardt, 1965
Type species: Zygolithus erectus Deflandre in Deflandre & Fert, 1954, designated by Reinhardt, 1965

Zeugrhabdotus scutula (Bergen, 1994) *comb. nov.*

Basionym: *Reinhardites scutula* Bergen, 1994 (*Journal of Nannoplankton Research*, **16**(2): 59-69, p.64, pl.1, figs 24a-c (holotype), 25a-b).

1989 *Zeugrhabdotus sisyphus* (Gartner, 1968) Crux, p.198, pl.8.7, fig.1 (EM); pl.8.12, fig.30 (LM).

1994 *Reinhardites scutula* Bergen, 1994, p.64, pl.1, figs 24a-c (holotype), 25a-b (EM and LM; same specimen).

Remarks: Previous authors have assigned this species to *Zeugrhabdotus sisyphus*, but included several other species (e.g. *Z. trivectis*) in this category, giving a much longer, composite range. We believe that this species is best classified within the genus *Zeugrhabdotus* although it may well be the ancestral species to the *Reinhardtites* lineage of the Late Cretaceous, as suggested by Bergen (1994).

Acknowledgements

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Assipetra terebrodentarius (Applegate *et al.*, 1987 in Covington& Wise, 1987) Rutledge & Bergen in Bergen, 1994
Clepsilithus maculosus sp. nov.
Clepsilithus polystreptus Crux, 1987
Cretarhabdus inaequalis Crux, 1987
Nannoconus abundans Stradner & Grün, 1973
Nannoconus circularis Deres and Achéritéguy, 1980
Nannoconus globulus Brönnimann, 1955
Nannoconus inconspicuus Deflandre *in* Deflandre & Deflandre-Rigaud, 1962
Nannoconus inornatus sp. nov.
Nannoconus pseudoseptentrionalis sp. nov.
Nannoconus ligius Applegate & Bergen, 1988
Rhagodiscus angustus (Stradner, 1963) Reinhardt, 1971
Rhagodiscus gallagheri sp. nov.
Rucinolithus windleyae sp. nov.
Stradnerlithus comptus Black, 1971
Tegulalithus septentrionalis (Stradner, 1963) Crux, 1986
Zeugrhabdotus scutula nov. comb. (= *Zeugrhabdotus sisyphus* Burnett *in* Gale *et al.* in press)

PLATE 1

Light micrographs x2112 magnification; electron micrographs, magnification as stated. Negatives are stored in the Postgraduate Unit of Micropalaeontology, University College London. Neg. - negative number; LM - light-micrograph; SEM - scanning electron micrograph; xp - crossed-polars; pc - phase-contrast.

Figs 1-3: *Rhagodiscus gallagheri sp. nov.*
Figs 1, 2: Atherfield Clay Formation (Isle of Wight), AC 13, Lower Aptian, forbesi Amm. Zone.
Fig.1: Holotype, LM-xp, Neg.5051-9.
Fig.2: LM-xp, Neg.5051-8.
Fig.3: Paratype, from Thomsen, 1987, p.77, pl.16, fig.6; Well E1, 8193', Lower Aptian.

Figs 4-7: *Clepsilithus maculosus sp. nov.*
BGS Borehole 81/43 (southern North Sea), 32.80m, Upper Hauterivian.
Fig.4: Holotype, SEM, distal view, x9180, Neg.4061-11.
Fig.5: SEM, distal oblique view, x8500, SEM, Neg.4061-12, same specimen as Fig.4.
Fig.6: Paratype, LM-xp, Neg.4071-19.
Fig.7: LM-pc, Neg.4071-21, same specimen as Fig.6.

Figs 8-12, 14-18: *Nannoconus inornatus sp. nov.*
Figs 8-12: BGS Borehole 81/43 (southern North Sea), 14.70m, Lower Barremian.
Fig.8: Holotype, SEM, oblique view, x5000, Neg.4079-17.
Fig.9: Paratype, SEM, oblique view, x5250, Neg.4079-16.
Fig.10: SEM, oblique view, x4875, Neg.4079-24.
Fig.11: SEM, oblique view, x5000, Neg.4079-22.
Fig.12: SEM, end view of Fig.11, x5000, Neg.4079-21.
Fig.14: LM-xp, side and end views, Neg.4099-6, Speeton, Bed LB5C.III, Lower Barremian, rarocinctum Amm. Zone.
Fig.15: LM-pc, Neg.4099-7, same specimens as Fig.14.
Fig.16: Paratype, LM-xp, Neg.4099-4, side view, Speeton, Bed LB5C.III, Lower Barremian, rarocinctum Amm. Zone.
Fig.17: LM-xp, Neg.3545-28, end view, Speeton, Bed LB1F (10), Lower Barremian, fissicostatum Amm. Zone.
Fig.18: LM-pc, Neg.3723-11, end view, Speeton, Bed LB5C.III, Lower Barremian, rarocinctum Amm. Zone.

Figs 13, 19: *Nannoconus abundans* Stradner & Grün, 1973.
Speeton, Bed LB1F (13), Lower Barremian, fissicostatum Amm. Zone.
Fig.13: SEM, oblique view, x4000, Neg.4069-29.
Fig.19: LM-xp, side view, Neg.3545-4.

Figs 20-22: *Nannoconus pseudoseptentrionalis sp. nov.*
Speeton, Lower Cement Bed 49, Lower Barremian, elegans Amm. Zone.
Fig.20: Holotype, LM-xp, end view, Neg.4094-20.
Fig.21: LM-pc, Neg.4094-21, same specimen as Fig.20.
Fig.22: LM-xp, end view, Neg.4065-32.

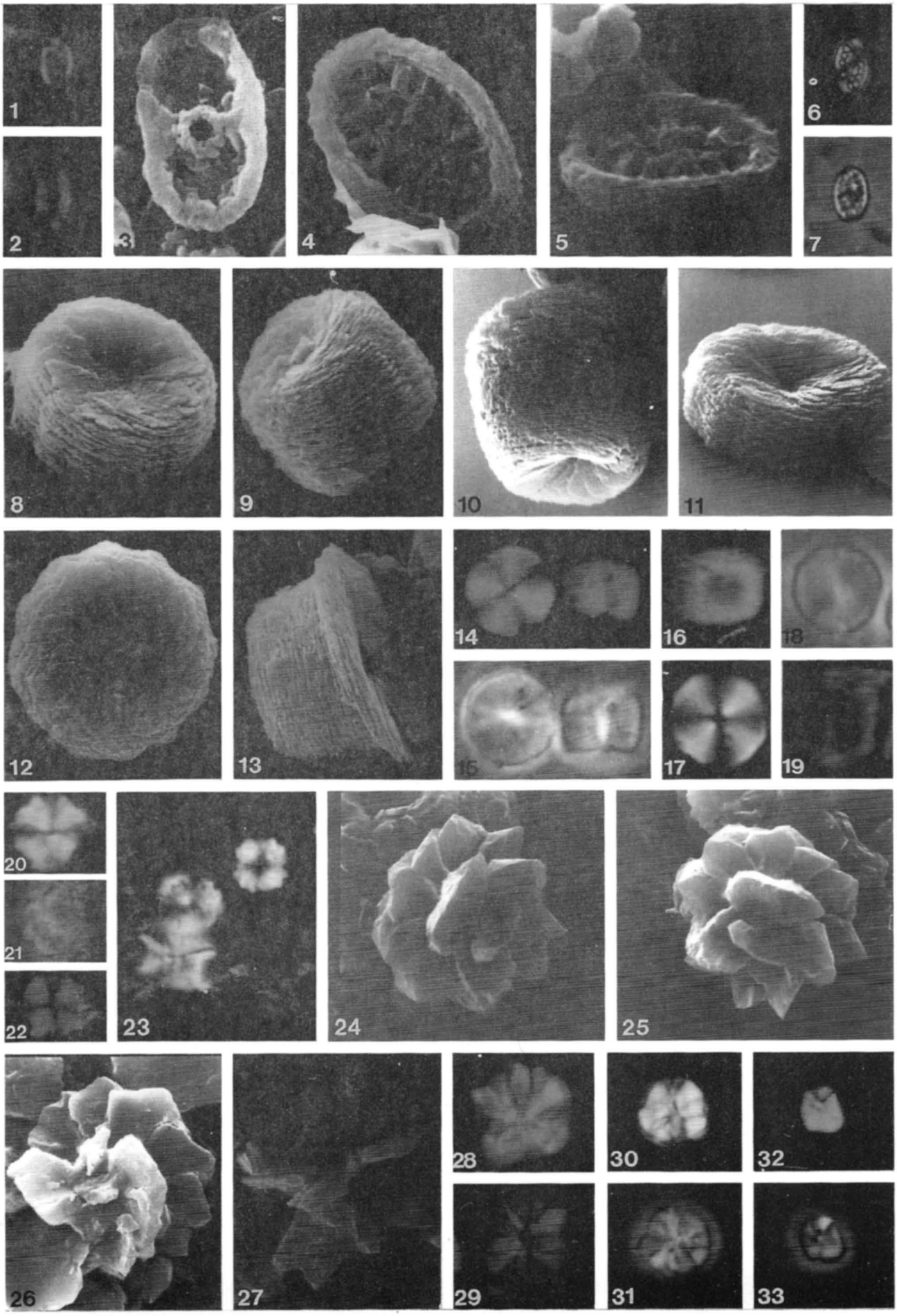
Fig.23: *Tegulalithus septentrionalis* (Stradner, 1963) Crux, 1986.
LM-xp, Neg.4023-27, side and end views, BGS Borehole 81/43 (southern North Sea), 41.16m, Upper Hauterivian.

Figs 24-29: *Rucinolithus windleyae sp. nov.*
BGS Borehole 81/43 (southern North Sea), 41.16m, Upper Hauterivian.
Fig.24: SEM, oblique view, x3875, Neg.4063-28.
Fig.25: Holotype, SEM, same specimen as Fig.24, x4000, Neg.4063-29.
Fig.26: SEM, ?distal view, x4000, Neg.4063-31.
Fig.27: Paratype, SEM, side view, x4500, Neg.4060-30.
Fig.28: Paratype, LM-xp, Neg.4023-32.
Fig.29: LM-xp, Neg.4023-24.

Figs 30, 31: *Assipetra terebrodentarius* (Applegate *et al.*, 1987 *in* Covington & Wise, 1987) Rutledge & Bergen *in* Bergen, 1994
Fig.30: LM-xp, Neg.4071-17, BGS Borehole 81/43 (southern North Sea), 11.92m, Lower Barrremian.
Fig.31: LM-pc, Neg.4071-18, same specimen as Fig.30.

Figs 32, 33: *Assipetra infracretacea* (Thierstein, 1973) Roth, 1973.
Fig.32: LM-xp, Neg.4071-2, BGS Borehole 81/43 (southern North Sea), 62.38m, Lower Hauterivian.
Fig.33: LM-pc, Neg.4071-3, same specimen as Fig.32.

PLATE 1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