

**Calcareous Nannofossil Type Specimens
 in the Collection of the Geological Survey of Austria:
 A Taxonomic and Stratigraphic Update**

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211 Text-Figures

*Nannoplankton
 Taxonomy
 Cenozoic
 Mesozoic
 Type Specimens
 Palaeontological collection*

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**Kalkige Nannofossilien (Typenmaterial) in der Sammlung der Geologischen Bundesanstalt:
 Eine taxonomische und stratigraphische Neubearbeitung**

Zusammenfassung

Eine taxonomische und stratigraphische Revision aller von Herbert STRADNER – allein oder mit Kollegen – beschriebenen Arten und Gattungen von kalkigem Nannoplankton (haptophyte Algen) wurde durchgeführt. Die Originalbeschreibungen und -illustrationen aus diversen Publikationen werden wiedergegeben. Da die Beschreibungen oft nur in deutscher Sprache vorlagen und viele Arten ursprünglich nur mit Zeichnungen dokumentiert waren, wurden diese jetzt mit Übersetzungen in die englische Sprache und neuen Mikrophotographien ergänzt. Vierundsiebzig känozoische (9 Gattungen und 65 Arten) und 43 mesozoische (5 Gattungen und 38 Arten) Taxa wurden bearbeitet und im aktuellen taxonomischen System positioniert. Das Typenmaterial wird in den Sammlungen der Geologischen Bundesanstalt (Wien) aufbewahrt.

Abstract

This document constitutes a taxonomic reference for the collection of calcareous nannoplankton (Haptophytes) type specimens designated by one of us (HS), alone or with colleagues, and deposited at the Geological Survey of Austria. The original descriptions and illustrations of the 117 described taxa are reproduced, accompanied when necessary of a literal English translation, and often complemented by the first photographic illustrations of their holotypes and paratypes. Thus 74 Cenozoic (9 genera and 65 species) and 43 Mesozoic (5 genera and 38 species) taxa are considered. The taxonomy is updated and replaced by a current and comprehensive high rank taxonomy. A new family and several new combinations are introduced.

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Introduction

A sound taxonomic framework is at the core of geological studies that rely upon the paleontological record, whether biostratigraphic, evolutionary or paleoenvironmental. In the early days of discovery of the living and extinct coccolithophorids it was acceptable to accompany the formal descriptions of new taxa solely with interpretative hand-drawn illustrations of holotypes and paratypes. Subsequent publications of photographs in the optical and/or electron microscope have usually helped clarify the concept of such species, but rarely have photographs of hand-drawn holotypes been published.

As part of an initiative of the Geological Survey of Austria, this paper compiles all taxa (103 species and 14 genera) described by one of us (HS) over the years, placing them in a current and comprehensive taxonomic framework. As part of our work, all slides containing holotypes described by STRADNER were incorporated now into the collections of the Geological Survey of Austria. To make the material retrievable, the new collection numbers replace the old designations mentioned in the original papers of STRADNER. As conceived, this document constitutes a taxonomic reference for the collection of holotypes designated by STRADNER and deposited at the Geological Survey. The description of all taxa and their original illustrations (for species) are republished herein, and photographs of many holotypes (and paratypes) are published for the first time.

The new photographs were taken with a Zeiss Axioplan light microscope at a magnification of 1000x. They support the original documentation of the type specimens, which were figured by hand-drawings in the early papers of HS. Some of these drawings show idealized figures of the type specimens, which have been made using the features of a number of syntypes or by reconstruction of incomplete specimens. Thus, for taking the photographs of this type material, it was necessary to select a lectotype out of a number of syntypes. In the more recent papers of HS, the holotypes are defined by photographs or electron micrographs. In the latter case, the collection number of the micrograph is given with the description of the holotype.

The generic names under which several species were first described have changed, a logical consequence of improved bases for generic taxonomy. Thus we have selected the most sound, generally accepted recombinations. We have indicated synonymies and we discuss the taxonomic status of several taxa. A number of taxa have been described based on overgrown specimens. This is especially true of those described from the lower Eocene of Cuba. Overcalcification of nannofossils in the Cuba samples makes it difficult to discern between specific features and secondary alteration due to overgrowth. Accordingly we suggest suppression of some names (e.g., *Discoaster trinus*; *Heliorthus fallax*), either because they designate clear artifacts of recrystallization (e.g., dicoasters with arms associated in two triplets), or because original ambiguity has prevented their use, and other valid names are available (albeit without historical priority) for the same taxa. In contrast, we maintain the usefulness of the lower Eocene marker *Tribrachiatulus bramlettei*, a species that has been docu-

mented worldwide and by many authors since its description in 1960. Other species were described from specimens reworked in much younger rocks. For these taxa the correct stratigraphic distribution is given. The biostratigraphic frameworks referred to are those of AUBRY (1996), MARTINI (1971) and OKADA & BUKRY (1980) for the Cenozoic taxa; SISSINGH (1977), PERCH-NIELSEN (1985), BOWN et al. (1998), BURNETT (1998) for the Mesozoic taxa. Some of the taxa discussed herein have been poorly cited. This is largely because they were described from shallow water deposits, resulting in their biostratigraphic range being poorly established. A broad zonal distribution is given for these taxa.

The original German or English descriptions of species are given *verbatim*. If only German descriptions existed they were translated into English. We have not attempted to redescribe the taxa using the current terminology. On occasions, the same type levels and type localities were referred to differently in different publications.

Finally, we have included all taxa in a high rank taxonomy, involving families and orders. However the coccoliths referred to as *holococcoliths* (composed of tightly packed tiny rhombs, not of the cycles of modified rhombs that characterize *heterococcoliths*) are excluded because in the living coccolithophores hetero- and holococcoliths are secreted sequentially, representing, respectively, the diploid and haploid phases of the life cycle. Consequently, the taxonomic names that have been given to holococcoliths are taxonomically irrelevant and synonymous with the names given to heterococcoliths associated in the same cycle. Although it is reasonable to assume that holococcoliths represent the haploid stage in extinct species, it is not possible to determine which heterococcolith and holococcolith are parts of the same cycle. It cannot be excluded either that some species are represented only by the calcified haploid stage (a valid concern for living species as well, although no such case has been reported). Although it is important to retain the holococcolith name for extinct taxa, inclusion in a separate order or family would be meaningless, whereas inclusion in existing such taxa is an impossible task. Holococcolith taxa described by STRADNER (and co-authors) are thus treated separately from the current classification.

The high rank taxonomy of the Mesozoic coccolithophores has been in a continuous state of flux, with substantial disagreements among authors as to the generic content of families (see AUBRY, 1998). We provisionally use here the classification established by BOWN (1998). Mesozoic taxa (*Braarudosphaera africana*, *Micrantholithus obtusus*, *Scampanella cornuta*), which may be classified in Cenozoic taxonomy are treated in these families.

An e-book of this publication with complementary data is prepared to be published at the end of 2010. It will contain to more taxa (e.g. *Trochastrites* nov. gen., STRADNER 1961, p. 114 and *Tetralithus gothicus* DEFLANDRE *trifidus* n. ssp. STRADNER 1961, 124 and 126), which will be also documented in an extra publication.

Taxonomy CENOZOIC

Order: Biscutales AUBRY (in press)
Family: Prinsiaceae HAY & MOHLER 1967

Genus: *Prinsius* HAY & MOHLER, 1967

Type species: *Coccolithus bisulcus* STRADNER, 1963 (in GOHRBRANDT et al.), p. 72, Text-Fig. 1a, b, Pl. 8, Figs. 3–6.

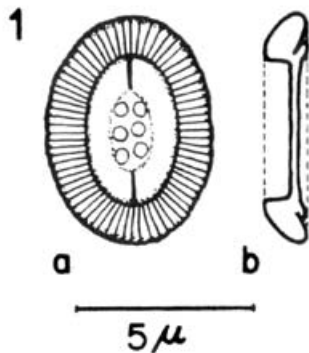
Original description of *Coccolithus bisulcus* STRADNER, 1963

Holotypus: GBA 2009/058/0062.

Derivatio nominis: *bisulcus* (Lat.) = zweigefurcht.

Locus typicus: Nußdorf am Haunsberg, Salzburg (Station 63/2/263/1 bei GOHRBANDT, 1963).

Stratum typicum: Paleozän, tiefere Zone E bei GOHRBANDT (1963).



Text-Fig. 1a.
Original drawing of *Coccolithus bisulcus*.

Beschreibung: Ovale Gehäuseelemente mit doppelter Randscheibe; Binnenraum längsoval bis zweispitzig, in Richtung der Längsachse durch zwei schmale Furchen unterteilt. Zwischen den Furchen sind bei Phasenkontrastbeleuchtung Poren in unregelmäßiger Anordnung zu erkennen. Letztere können besonders bei größeren Exemplaren fehlen oder infolge der Fossilisation nicht mehr erkennbar sein. Die sehr fein gerieften Randscheiben bestehen aus radiär angeordneten Kalklamellen.

Dimensionen: Längsachse 4–6,5 µm, Querachse 3–5 µm, Höhe 1–1,5 µm.

Beziehungen: *Coccolithus bisulcus* n. sp. ist nahe mit *Coccolithus pelagicus* (WALLICH) SCHILLER verwandt, von welchem er sich durch die andersartige Gestaltung des Binnenraumes unterscheidet. *Coccolithus pelagicus* hat zwei nahe dem Zentrum befindliche Poren, *Coccolithus bisulcus* jedoch zwei bis an die Randscheiben sich erstreckende Schlitze mit einem im Zentrum dazwischenliegenden Porenfeld.

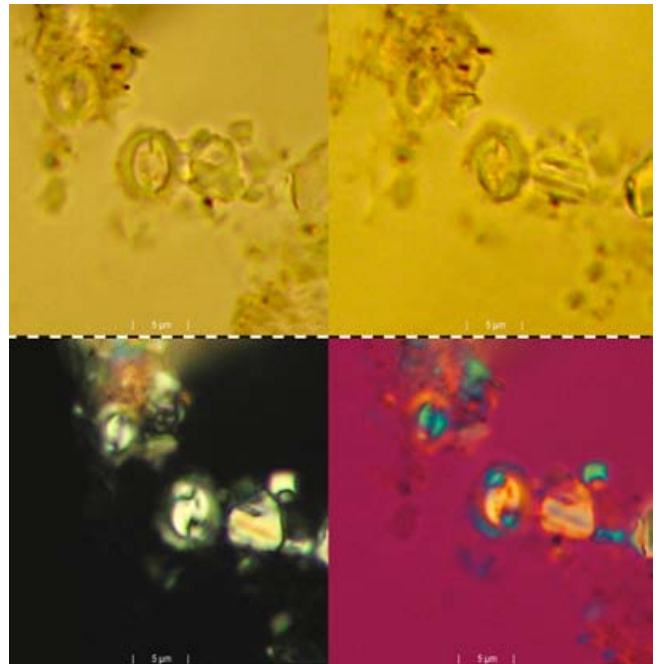
Bemerkungen: Diese Art konnte in den meisten Proben der paleozänen Schichten vereinzelt angetroffen werden; am Locus typicus ist sie sogar sehr häufig.

English translation:

Holotype: GBA 2009/058/0062.

Derivation of name: *bisulcus* (Lat.) = with two slits.

Type locality: Nußdorf at Haunsberg, Salzburg (Station 63/2/263/1 in GOHRBANDT et al., 1963).



Text-Fig. 1b.
Placoliths in normal light and in polarized light.

Level: Paleocene, Zone E of GOHRBANDT (1963).

Diagnosis: Oval coccoliths with double peripheral shield, central area oval or slightly pointed in the longer axis. Two grooves in main direction enclose the centre of the coccolith, which is perforated by a small number of irregularly orientated holes. These also can be missing (or not be observable). The peripheral plates show a delicate striation of calcite lamellae.

Size: Length 4–6.5 µm, width 3–5 µm, height 1–1.5 µm.

Relations: *Coccolithus bisulcus* is closely related to *C. pelagicus*, from which it differs by the different design of the central area. The two grooves enclosing several pores between them makes it easy to differentiate from *C. pelagicus* with only two pores.

Occurrence: In Paleocene samples rare to common, at the type locality even frequent.

Comments:

Biostratigraphic distribution: Upper Paleocene – lowermost Eocene. Zone NP3 through Zone NP10.

Genus: *Toweius* HAY & MOHLER, 1967

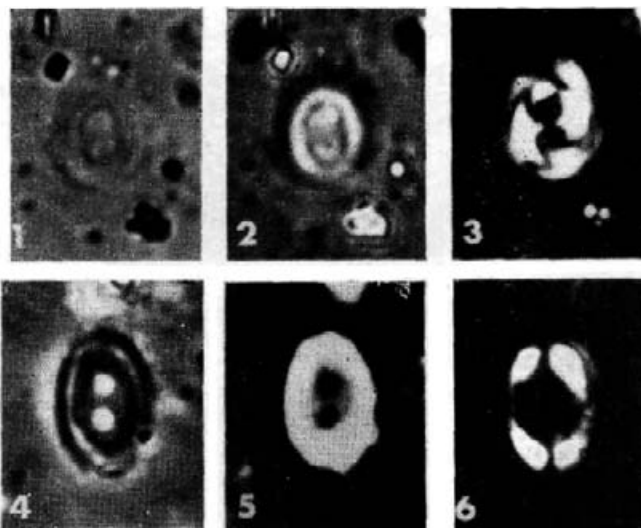
Comments:

Taxonomic status: *Coccolithus petrinus* STRADNER, 1969, p. 413, Pl. 84, Figs. 1–6, is most likely a junior synonym of *Toweius occultatus* (LOCKER) PERCH-NIELSEN, 1971 (= *Coccolithus occultatus* LOCKER, 1967, p. 764, 765, Pl. 1, Fig. 5, Pl. 2, Figs. 9, 10).

Original description of *Coccolithus petrinus* STRADNER, 1969

Holotype: GBA 2009/058/0064.

Derivation of name: *petrinus* (Lat.) = from the rocks.



Text-Fig. 2.
Original photographs of the holotype of *Coccolithus petrinus*.

Type locality: Hagenbach Valley, Lower Austria, Stat. 4.
Level: Lower Eocene.

Synonym: *Coccolithus* cf. *pelagicus* (WALLICH); BOUCHÉ, 1962, p. 83, Pl. 1, Fig. 24.

Diagnosis: Elliptical placoliths with proximal and distal plate, the central area perforated by two circular pores. Transversal bridge not as pronounced as in the larger *Coccolithus crassipons* BOUCHÉ. Rare.

Order: Chiastozygales AUBRY (in press)
Family: Neococcolithaceae AUBRY (in press)

Genus: Chiphragmalithus BRAMLETTE & SULLIVAN, 1961

Type species: *Chiphragmalithus calathus* BRAMLETTE & SULLIVAN 1961, p. 156, Pl. 10, Figs. 7a, b, 8–10.

Synonym: *Heliorthus* BRONNIMANN & STRADNER 1960, p. 368.

Type species: *Heliorthus fallax* BRONNIMANN & STRADNER 1960, p. 368, Figs. 8–10.

Comments:

Taxonomic status: *Chiphragmalithus calathus* BRAMLETTE & SULLIVAN 1961 being a junior synonym of *Heliorthus fallax* (type of the genus *Heliorthus* BRONNIMANN & STRADNER 1960) the name *Heliorthus* should have priority over the name *Chiphragmalithus* BRAMLETTE & SULLIVAN 1961 (see AUBRY, in press). However, the taxon *fallax* (and the corresponding genus *Heliorthus*) is based on an overgrown specimen, which would justify rejection of the name *fallax* and conservation of the name *calathus*.

Stratigraphic distribution: Zone NP12.

**Original description of
Heliorthus BRONNIMANN & STRADNER, 1960**

Derivatio nominis: Kombiniert aus Heliolithae und Ortholithae.

Locus typicus: Universidad-Formation, Stat. 489, Kuba.

Diagnose: Ein Coccolith, dessen Binnenraum von einem dicken, nach Art der Gattung *Tetralithus* gebauten Kreuz er-

füllt ist. Im polarisierten Lichte verhält sich dieses Kreuz ortholithisch, die schmale Randscheibe hingegen heliolithisch. Es scheint also die Textur der Randscheibe radialstrahlig, die des Kreuzes parallelstrahlig zu sein.

Größe: 8–13 µm.

Beziehungen: *Heliorthus* ist nahe verwandt mit *Tetralithus copulatus* DEFLANDRE, von dem er sich aber durch die kleineren Dimensionen des „Tetralithus“-Kreuzes unterscheidet.

English translation:

Derivation of name: word combination of parts of: Heliolithae and Ortholithae.

Diagnosis: Coccoliths, the central area of which is filled by a central cross behaving under crossed nicols like a *Tetralithus*, that is ortholithical. The marginal plate however behaves heliolithical. The microcrystal texture of the marginal plate is radially orientated, while the central cross seems to be parallelly orientated.

Size: 8–13 µm.

Remarks: *Heliorthus* is closely related to *Tetralithus copulatus* DEFLANDRE, from which it can be distinguished by the smaller size of the central cross.

**Original description of the
type species *Heliorthus fallax* STRADNER, 1960
(in BRONNIMANN & STRADNER)**

Lectotypus: GBA 2009/058/0017/1.

Derivatio nominis: *fallax* (Lat.) = trügerisch.

Locus typicus: Universidad-Formation, Stat. 489, Kuba.

Diagnose: Die Beschreibung dieser einstweilen einzigen Art der neuen Gattung *Heliorthus* fällt mit der des Genotypus zusammen. Die Ansichten der beiden Flachseiten zeigen ein etwas unterschiedliches Bild. Fig. 3a/9 scheint der distalen Fläche zu entsprechen.

Größe des Holotypus: 10–13 µm.

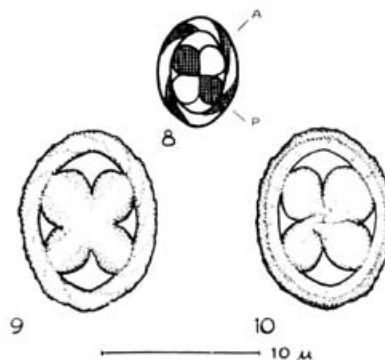
English translation:

Lectotype: GBA 2009/058/0017/1.

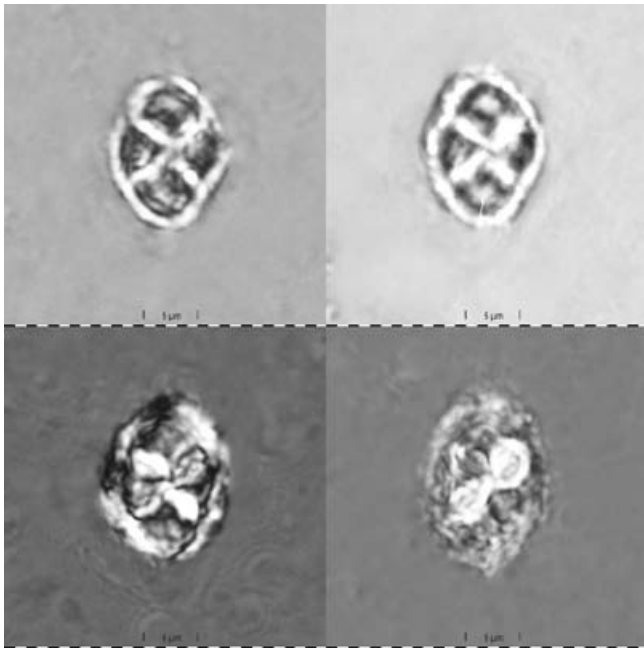
Derivation of name: *fallax* (Lat.) = deceitful.

Type locality: The description of this species corresponds to that of the genus; the two flat sides differ; Fig. 3a/9 shows the distal side.

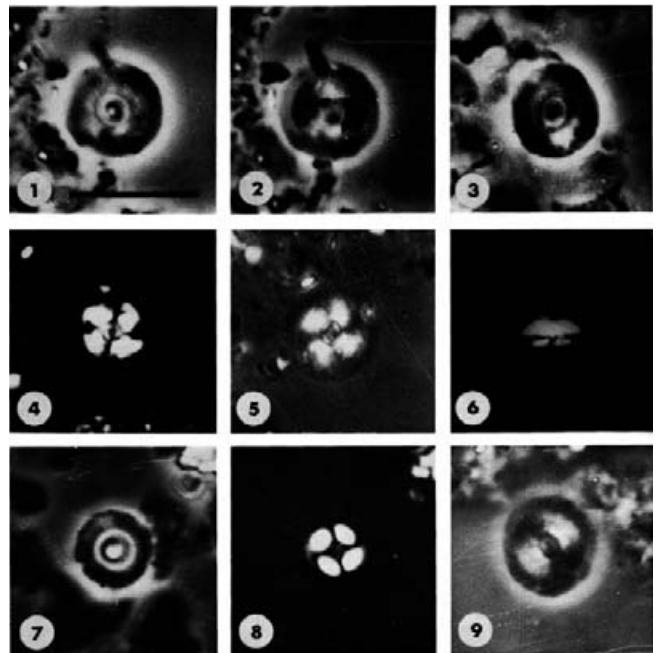
Size: 10–13 µm.



Text-Fig. 3a.
Original drawing of *Heliorthus fallax*.



Text-Fig. 3b.
Lectotype of *Heliorthus fallax* in normal light at different focus levels and in polarized light.



Text-Fig. 4b.
Original photographs of *Cyclococcolithus leptoporus* ssp. *centrovalis*.
Scale = 5 μm.

**Order: Cocosphaerales HAECKEL, 1894 emend.
YOUNG & BOWN, 1997**

Family: Calcidiscaceae YOUNG & BOWN, 1997

Genus: Calcidiscus KAMPTNER, 1950

Type species: *Calcidiscus leptoporus* (MURRAY & BLACKMAN) KAMPTNER *centrovalis* (STRADNER & FUCHS) PERCH-NIELSEN 1984 (= *Cyclococcolithus leptoporus* (MURRAY & BLACKMAN) KAMPTNER *centrovalis* STRADNER & FUCHS, 1980, p. 255, 256, Pl. 5, Figs. 1–9, Pl. 6, Figs. 2–6, Pl. 7, Figs. 1–6, Text-Figs. 2 A, B

**Original description of
Cyclococcolithus leptoporus (MURRAY & BLACKMAN)
KAMPTNER centrovalis STRADNER & FUCHS, 1980**

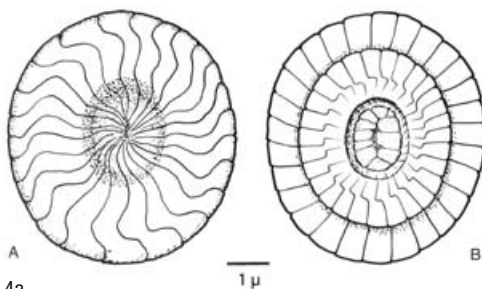
Holotypus: TEM-Platte Nr. 13581, Taf. 6, Fig. 4 und 5. Distalansicht.

Paratypus: TEM-Platte Nr. 13568, Taf. 7, Fig. 1. Proximalansicht.

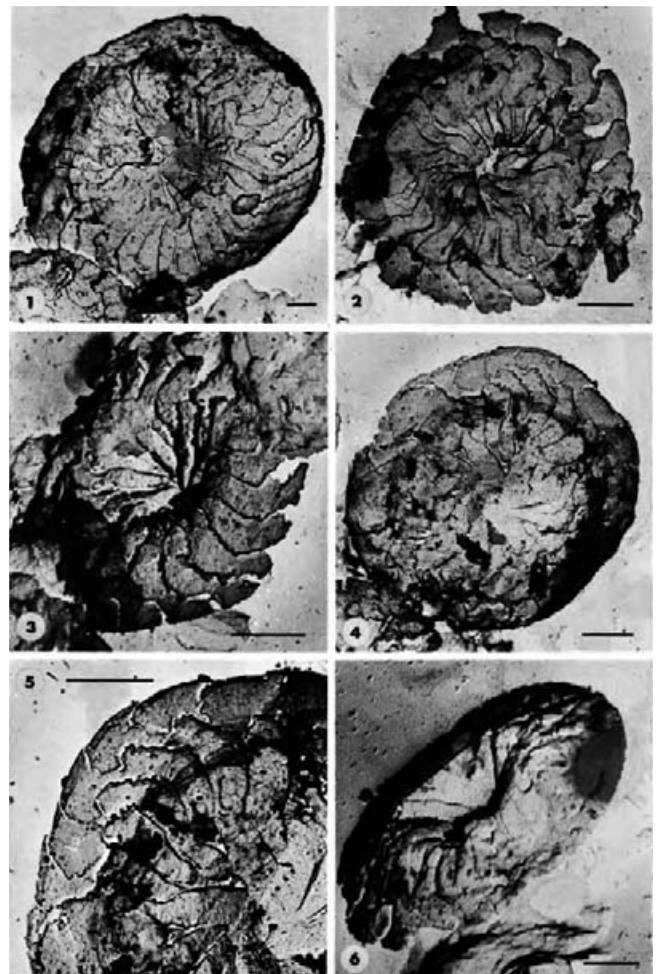
Derivatio nominis: *centrum* (Lat.) = Mitte; *ovalis* (Lat.) = eiförmig; Wortkombination: in der Mitte länglich rund.

Locus typicus: Tiefbohrung Laxenburg 1 der ÖMV-AG, Kern 350–355 m, Kiste 3 oben.

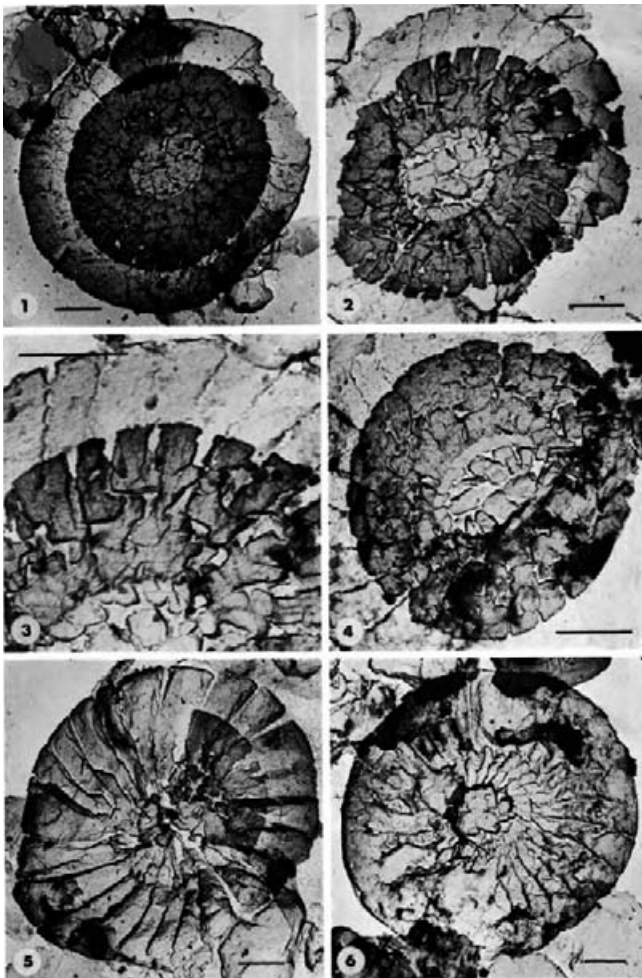
Stratum typicum: Höheres Untersarmatium (Ober-Miozän).



Text-Fig. 4a.
Original drawing of the distal (A) and proximal (B) side.



Text-Fig. 4c.
Distal view of etched specimens (2, 3); distal view of the holotype TEM Micrograph 13581 (4); detail of the holotype specimen (5); oblique view of the distal side (6).
Scale = 1 μm.



Text-Fig. 4d.
View of the proximal side: a well preserved specimen (1), a slightly etched specimen (2), detail of the elements (3). Distal side with elliptical central area (4), proximal view of a distal plate, proximal plate largely destroyed (5), proximal view of the distal plate without proximal plate (6).
Scale = 1 µm.

Beschreibung: Placolithen, die aufgrund ihrer allgemeinen Form und Konstruktion der Art *Cyclococcolithus leptoporus* zugeordnet werden, von der sie sich aber durch folgende Merkmale unterscheiden: Die Mittelfläche (central area) ist breitelliptisch oder breitoval, die Anzahl der Elemente liegt zwischen derjenigen von *Cyclococcolithus leptoporus* var. B (31 ± 2) und var. C (19 ± 2) nach MCINTYRE et al. (1967). Die Einzelelemente sind auf der Distalseite durch S-förmig gekrümmte Suturen getrennt. Bei gekreuzten Nikols erscheint die Distalscheibe dunkel, nur die Proximalscheibe zeigt ein deutliches Löschkreuz.

Dimensionen: Holotypus: Länge 6 µm, Breite 5,5 µm, Höhe ca. 3 µm.

Paratypus: Länge 6 µm, Breite 5 µm, Höhe ca. 3 µm.

Größenvariation: 3–7 µm.

English translation:

Holotype: TEM plate no.13581. Paratype: TEM plate no. 13568.

Derivation of name: *centrum* (Lat.) = centre, *ovalis* (Lat.) = oval.

Type locality: OMV deepwell Laxenburg 1, core 350–355 m.
Level: Upper part of Lower Sarmatian (Upper Miocene).

Diagnosis: Broad elliptical placoliths, which according to their general features have to be assigned to *Cyclococcolithus leptoporus leptoporus*, from which they differ by their overall geometry: The central area is broad elliptical, the same as the outer circumference. The suture lines of the distal and also of the proximal side are curved. In polarized light the proximal shield appears dark, while the distal shield shows a distinct extinction cross.

Size: Length 6 µm, width 5.5 µm, height approximately 3 µm.

Amplitude of size variations: 3–7 µm.

Comments:

Biostratigraphic distribution: Upper Miocene (Tortonian); Zone NN11.

Family: Coccolithaceae POCHE, 1913 emend. YOUNG & BOWN, 1997

Genus: *Cruciplacolithus* HAY & MOHLER in HAY, MOHLER, ROTH, SCHMIDT & BOUDREAUX, 1967

Type species: *Cruciplacolithus tenuis* (STRADNER) HAY & MOHLER in HAY et al. 1967 (= *Heliorthus tenuis* STRADNER, 1961, p. 84, Text-Figs. 64–65; = *Coccolithus helis* STRADNER, 1963 (nom. substit. pro *Coccolithus (Heliorthus) tenuis* STRADNER, non *Coccolithus tenuis* KAMPTNER, 1937) in GOHRBANDT, 1963, p. 74, Pl. 8, Fig. 16, Pl. 9, Figs. 1–2]).

Original description of *Heliorthus tenuis* STRADNER, 1961

Lectotypus: GBA 2009/058/0003/1.

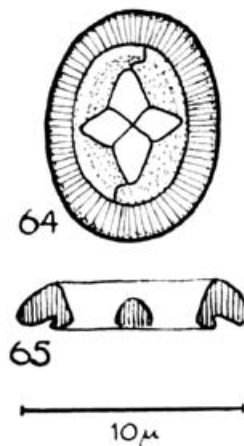
Derivatio nominis: *tenuis* (Lat.) = zart.

Locus typicus: Haidhof bei Ernstbrunn, Niederösterreich. Häufig.

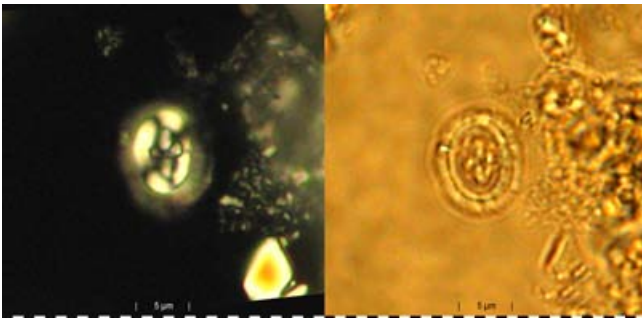
Stratum typicum: Oberste Kreide (Danien).

Diagnose: Elliptischer Coccolith, dessen Randscheibe sehr schmal ist und einen großen mit einem entlang der Hauptachsen orientierten flachen Tetralithuskreuz geschmückten Binnenraum umschließt. Die periphere Randscheibe ist zart gerieft und verhält sich bei gekreuzten Nikols heliolithisch, das Kreuz des Binnenraumes hingegen ortholithisch.

Größe: 8–12 µm.



Text-Fig. 5a.
Original drawing of *Heliorthus tenuis*.



Text-Fig. 5b.
Lectotype of *Heliorthus tenuis* in normal light and in polarized light.

English translation:

Lectotype: GBA 2009/058/003/1.

Derivation of name: *tenuis* (Lat.) = delicate

Type locality: Haidhof near Ernstbrunn, Lower Austria.
Common.

Level: Danian.

Description: Elliptical coccoliths with narrow marginal plate and a large central cross oriented in the directions of the main axes of the wide central area. The peripheral plate shows a heliolithical structure, the cross of the central area however an ortholithical one.

Size: 8–12 µm.

Comments:

Stratigraphic distribution: Paleocene (Danian–Thanetian). The lowest occurrence of *C. tenuis* defines the NP2/NP3 zonal boundary (MARTINI, 1971) and the CP1/CP2 (Okada & Bukry, 1980). Highest occurrence in Subzone NP9a.

Family: Markaliaceae AUBRY (in press)

Genus: *Markalius* BRAMLETTE & MARTINI, 1964

Type species: *Markalius inversus* (DEFLANDRE) BRAMLETTE & MARTINI, 1964 (= *Cyclococcolithus leptoporus* (MURRAY & BLACKMANN, 1898) KAMPTNER 1941 var. *inversus* DEFLANDRE, in DEFLANDRE & FERT, 1954, p. 150, Pl. 9, Figs. 4–7).

**Original description of
Cyclococcolithus astroporus STRADNER, 1963
(in GOHRBRANDT et al.)**

Holotypus: GBA 2009/058/0063.

Derivatio nominis: *aster* (Gr.) = Stern; *poros* (Gr.) = Pore.

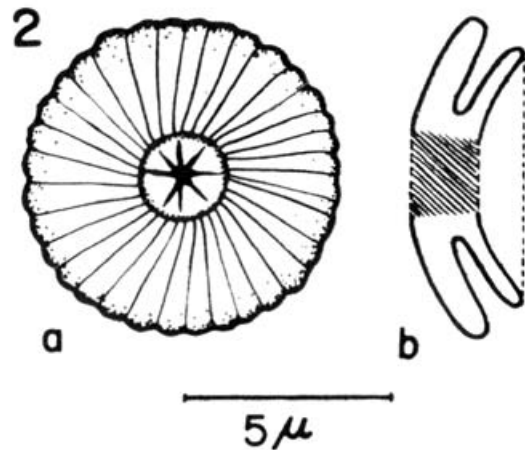
Locus typicus: Nußdorf am Haunsberg (Station 63/2/30/4 in GOHRBANDT, 1963).

Stratum typicum: Paleozän, Zone A.

Beschreibung: Im Umriss kreisrunde Gehäuseelemente mit doppelter Randscheibe, welche aus stark gekurvten Lamellen zusammengesetzt ist. Der runde Binnenraum ist von einer zarten, aus radiären Elementen zusammengesetzten Membran erfüllt, welche von sternförmig angeordneten Schlitzen durchbrochen wird.

Dimensionen: Durchmesser 5–7 µm; Binnenraum 1–1,5 µm; Höhe 2,5 µm.

Beziehungen: *Cyclococcolithus astroporus* ist eng mit *Cyclococcolithus leptoporus* (MURRAY & BLACKMAN) KAMPTNER verwandt.



Text-Fig. 6a.
Original drawing of *Cyclococcolithus astroporus*.

Zur Unterscheidung beider Arten dient die Struktur der Binnenraum-Membran, welche bei letzterer Art von Poren durchbrochen ist.

Erstauftreten: Zone A of GOHRBANDT et al. (1963); Station 63/2/165–166/6).

English translation:

Holotype: GBA 2009/058/0063.

Derivaton of name: *aster* (Gr.) = star, *poros* (Gr.) = pore.

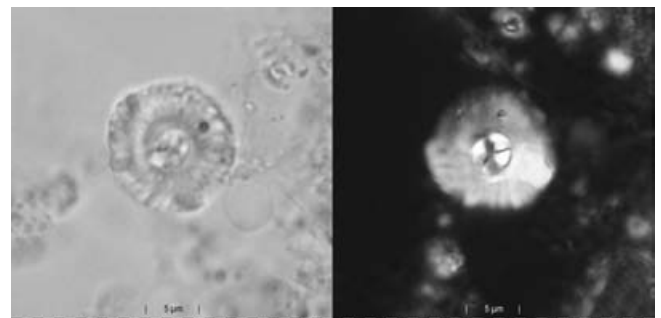
Type locality: Nußdorf at Haunsberg, Salzburg (Station 63/2/30/4 in GOHRBANDT, 1963).

Level: Lower Paleocene.

Diagnosis and description: Circular coccoliths with double rim plates, which are composed of curved lamellae. The circular central area is filled with a membrane composed of radial elements. Narrow slits between them form a slender dark star.

Relations: *Cyclococcolithus astroporus* is closely related to *Cyclococcolithus leptoporus* (MURRAY & BLACKMAN) KAMPTNER, from which it differs by the lack of an open central pore and by its central “star”.

Size: 7–9 µm in diameter.



Text-Fig. 6b.
Original photographs of the holotype in normal light and polarized light.

Comments:

Taxonomic status: *Markalius astroporus* (STRADNER) HAY & MOHLER in HAY et al., 1967, p. 434 (= *Cyclococcolithus astroporus* STRADNER 1963 (in Gohrbrandt et al.), p. 75, Text-Figs. 3, 2a, b, Pl. 9, Figs. 5–7) is a junior synonym of *Markalius inversus* (DEFLANDRE).

Order: Discoasterales HAY, 1977
Family: Biantholithaceae AUBRY (in press)

Genus: *Biantholithus* BRAMLETTE & MARTINI, 1964

Biantholithus astralis STEINMETZ & STRADNER, 1984, p. 676, Pl. 52, Figs. 1, 4, Pl. 53, Figs. 1, 2.

**Original description of
Biantholithus astralis STEINMETZ & STRADNER, 1984**

Holotype: Plate 53, Figure 1. Negative 2/92/007.

Derivation of name: *astra* (Lat.) = stars.

Type locality: Southeast Atlantic Ocean, Angola Basin, DSDP 530A-50-1, 6–7 cm.

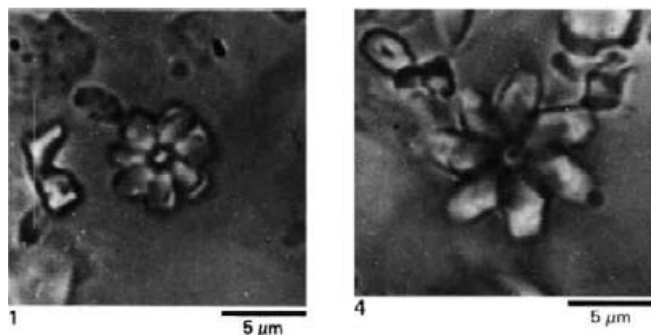
Level: Danian (*Cruciplacolithus tenuis* Zone (MARTINI, 1971), *Cruciplacolithus tenuis* Subzone (BUKRY, 1973a, 1975).

Description: This new species consists of seven to eight segments radiating from a common center. The segments are slightly imbricate and slightly tilted, as are the blades of a windmill. Each segment is in contact with adjacent segments for a little more than half its length. Beyond the point of contact, the segments taper slightly and end with rounded tips. A small hole is present in the center where the segments meet.

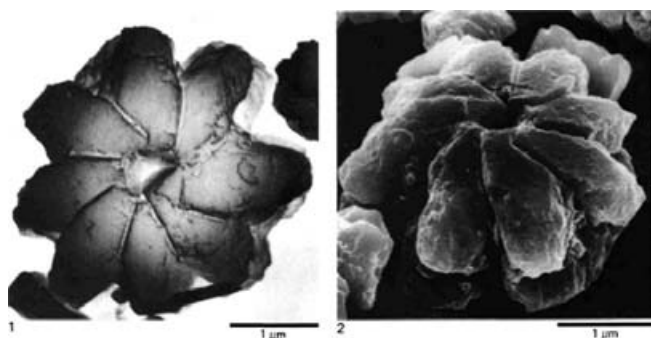
Remarks: *Biantholithus sparsus* BRAMLETTE & MARTINI differs from *Biantholithus astralis* nov. spec., in that it has eight to twelve segments which are in contact for almost their entire length.

Comments:

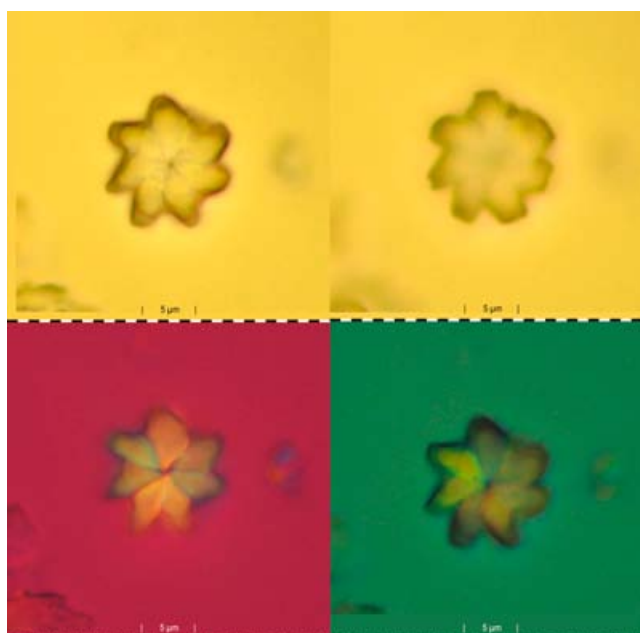
Stratigraphic distribution: Lower Paleocene (Danian); Zone NP1–NP3.



Text-Fig. 7a.
Original photographs of syntypes of *Biantholithus astralis*.



Text-Fig. 7b.
Original photograph of the holotype.



Text-Fig. 7c.
Photographs of a syntype in normal and polarized light at different focus levels.

Family: Discoasteraceae TAN SIN HOK, 1927
orth. mut. VEKSHINA, 1959

Comments:

STRADNER & PAPP's study (1961) of the shape of the sutures on either sides of discoasters is at the basis of THEODORIDIS's reintroduction with emendation (1983, 1984) of the genera *Eudiscoaster* TAN SIN HOK 1927 and *Heliodiscoaster* TAN SIN HOK 1927. This taxonomic revision is rarely followed, the all encompassing genus name *Discoaster* being preferred for pragmatic reasons. We provisionally follow AUBRY (in press) in accepting the scientific validity of these two genera.

Genus: *Eu-discoaster* TAN SIN HOK, 1927 emended
THEODORIDIS, 1984

Comments:

Four species described by STRADNER have been/are reassigned to *Eudiscoaster*:

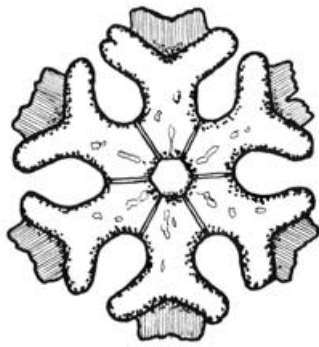
- *Eu-discoaster icarus* (STRADNER) FLORES VILLAJERO 1986 (= *Discoaster icarus* STRADNER, 1973, p. 1138, Pl. 41, Figs. 10, 11).
- *Eu-discoaster musicus* (STRADNER) THEODORIDIS 1983 (= *Discoaster musicus* STRADNER, 1959, p. 1088, Text-Fig. 28).
- *Eu-discoaster perforatus* (STRADNER) AUBRY & STRADNER n. c. (= *Discoaster perforatus* STRADNER 1959a, p. 1087, Text-Fig. 27).

Original description of *Discoaster icarus*
STRADNER, 1973

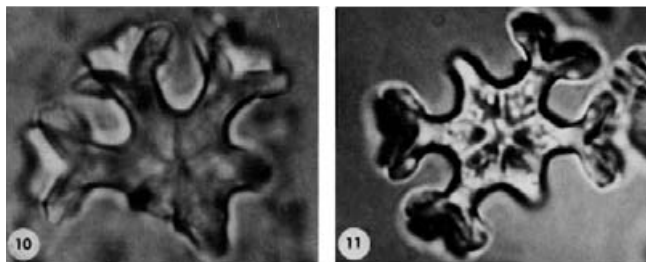
Holotype: Plate 41, Figure 10 in STRADNER, 1973 (slide: GBA 2009/058/0068).

Paratypes: Plate 41, Figure 11.

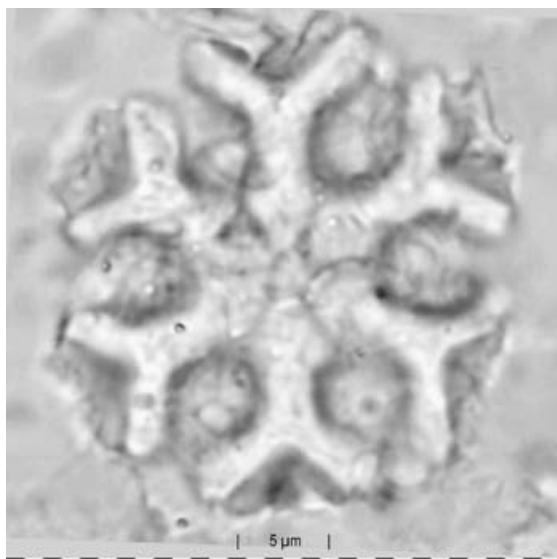
Derivation of name: *Ikaros* (Gr.) = son of Daedalus; in Latin *Icarus*.



Text-Fig. 8a.
Original drawing of *Discoaster icarus*.



Text-Fig. 8b.
Original photographs of the holotype of *Discoaster icarus*.



Text-Fig. 8c.
Photograph of a syntype.

Type locality: DSDP 13-134-7, CC, Balearic Abyssal Plain/Sardinian Margin, lat. 30° 11.70'N, long. 7° 18.25'E.

Level: Upper Miocene, Messinian.

Diagnosis: A discoaster of the *D. variabilis* group with rays terminating in a wide-angle of bifurcating branches with "flaps" between the branches. Larger asteroliths with a diameter to about 30 µm, as well as small specimens, show these flap-like extensions. The center of the convex or distal side of *Discoaster icarus* n. sp. is decorated with a hexagonal prismatic knob and the rays are separated by straight suture lines. The concave or proximal side also shows straight suture lines but lacks a central knob. The

membranes of the "flaps" are bent toward the concave side and are best seen in oblique side view. In some asteroliths they are bent so sharply that they can hardly be seen in plain view.

Comments:

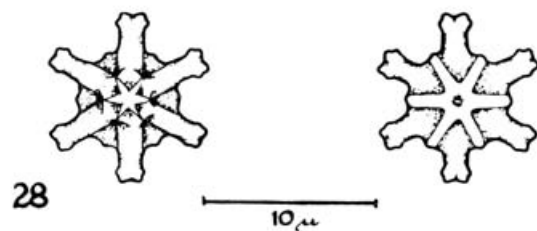
Stratigraphic distribution: Upper Miocene (Tortonian); Upper Zone NN11.

**Original description of *Discoaster musicus*
STRADNER, 1959a**

Lectotype: GBA 2009/058/0004/1.

Derivation of name: *musicus* (Lat.) = musical. Dedicated to my dear music-loving parents.

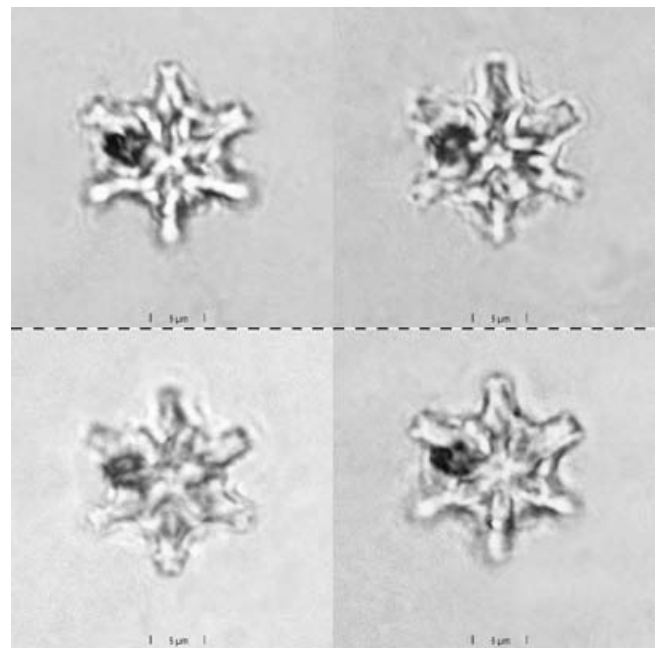
Type locality: Frättingsdorf.



Text-Fig. 9a.
Original drawing of *Discoaster musicus*.

Level: Miocene, Lower Tortonium (Lower Lagenid Zone).

Description: Asteroliths with six short rays and a richly decorated central area. The rays have slightly enlarged ends with a shallow terminal notch and two lateral knots resembling those of slender asteroliths of *Discoaster distinctus*. The tips of the large central star of the convex face can be seen as extra interstitial corners of the central disc. On the concave face the rays reach as broad ridges to the centre. The central area of this face can be decorated by an additional star.



Text-Fig. 9b.
Holotype in normal light at different focus levels.

Comments:

Taxonomic status: *Discoaster sanmiguelensis* BUKRY 1981, p. 462, Pl. 2, Figs. 7–10, Pl. 3, Figs. 1–14, is a junior synonym of *E. musicus*.

Stratigraphic distribution: Upper lower to upper middle Miocene (Upper Burdigalian to Lower Tortonian); Zone NN4 to lower NN8 (rare).

Original description of *Discoaster perforatus* STRADNER, 1959a

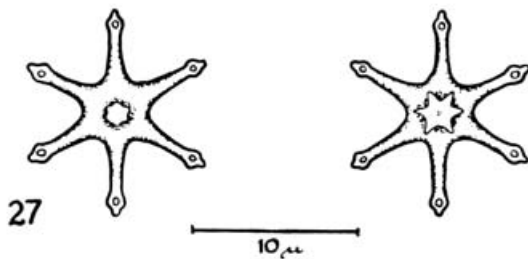
Lectotype: GBA 2009/058/0006.

Derivation of name: *perforatus* (Lat.) = perforated.

Type locality: Frättingsdorf.

Level: Miocene, Tortonian (Lower Lagenid Zone).

Description: Asterolith six-rayed with slender asteroradii, which shortly before their pointed endings are enlarged to give space to a round perforation. The central disc is resembling that of *Discoaster challengeri* with which it is found co-occurring.



Text-Fig. 10a.
Original drawing of *Discoaster perforatus*.



Text-Fig. 10b.
Holotype in normal light at different focus levels.

Comments:

Stratigraphic distribution: Middle Miocene (Upper Langhian to Lower Serravallian); Zone NN5–NN6.

Genus: *Heliodiscoaster* TAN SIN HOK, 1927 emended THEODORIDIS, 1984

Comments:

Ten species of discoasters have been recombined to *Heliodiscoaster*:

- *Heliodiscoaster aecus* (BRONNIMANN & STRADNER) AUBRY & STRADNER n. c. (= *Discoaster aecus* BRONNIMANN & STRADNER, 1960, p. 366, Pl. 1, Figs. 1–3).

- *Heliodiscoaster bronnimanni* (STRADNER) AUBRY & STRADNER n. c. (= *Discoaster bronnimanni* STRADNER 1961, p. 85, Text-Fig. 82).
- *Heliodiscoaster currens* (STRADNER) AUBRY & STRADNER n. c. (= *Discoaster currens* STRADNER, 1959a, p. 3, Fig. 6).
- *Heliodiscoaster gemmeus* (STRADNER & PAPP) THEODORIDIS 1983 (= *Discoaster gemmeus* STRADNER 1959a, p. 6, Fig. 21).
- *Heliodiscoaster gemmifer* (STRADNER) AUBRY & STRADNER n. c. (= *Discoaster gemmifer* STRADNER, 1961, p. 86, Text-Fig. 83).
- *Heliodiscoaster kuepperi* (STRADNER) THEODORIDIS 1983 (= *Discoaster kuepperi* STRADNER 1959b, p. 478, Figs. 17, 21).
- *Heliodiscoaster martinii* (STRADNER) AUBRY & STRADNER n. c. (= *Discoaster martinii* STRADNER 1959b, p. 479, Figs. 45, 47).
- *Heliodiscoaster munitus* (STRADNER) AUBRY & STRADNER n. c. (= *Discoaster munitus* STRADNER 1961, p. 85, Text-Fig. 81).
- *Heliodiscoaster ornatus* (STRADNER) THEODORIDIS 1983 (= *Discoaster ornatus* STRADNER, 1959a, p. 8, Fig. 30, not *Discoaster tani* BRAMLETTE & RIEDEL subsp. *ornatus* BRAMLETTE & WILCOXON 1967, p. 112, Pl. 7, Figs. 7–8).
- *Heliodiscoaster salisburgensis* (STRADNER) AUBRY & STRADNER n. c. (= *Discoaster salisburgensis* STRADNER 1961, p. 8, Text-Figs. 77, 78).
- *Heliodiscoaster strictus* (STRADNER) AUBRY & STRADNER n. c. (= *Discoaster strictus* STRADNER 1961, p. 85, Text-Fig. 80).
- *Heliodiscoaster wemmelenensis* (ACHUTHAN & STRADNER) THEODORIDIS 1983 (= *Discoaster wemmelenensis* ACHUTHAN & STRADNER, 1967, p. 5, Pl. 4, Figs. 3, 4).

Three other taxa based on poorly preserved material are regarded as superfluous, and are therefore not recombined to *Heliodiscoaster* herein:

- *Discoaster geometricus* BRONNIMANN & STRADNER 1960, p. 366, Pl. 1, Figs. 4, 5.
- *Discoaster trinus* STRADNER 1961, p. 9, Text-Fig. 79.
- *Discoaster uncinatus* BRONNIMANN & STRADNER 1960, p. 366, Pl. 1, Figs. 6, 7.

We recommend suppression of these names.

Original description of *Discoaster aecus* BRONNIMANN & STRADNER, 1960

Lectotypus: GBA 2009/058/0015.

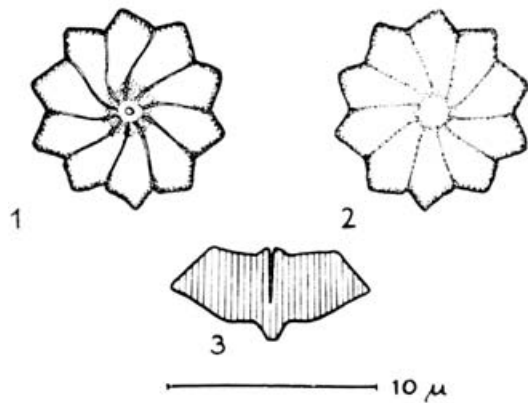
Derivatio nominis: *aecus* (Lat.) = flach, eben.

Locus typicus: Universidad-Formation, BR-Stat. 858, Kuba.

Beschreibung: Ein rosettenförmiger Discoaster, dessen Flachseiten weitgehend an *Discoaster barbadiensis* erinnern, von welchem er sich aber durch einen völlig andersartigen Querschnitt unterscheidet. Der Asterolith hat auf der Facies superior zentral einen dünnen Kanal, der weit ins Innere des verhältnismäßig sehr dicken Kalkkörperchens hineinreicht. Der Stiel ist im Gegensatz zu *Discoaster barbadiensis* kurz.

Größe: 10–15 µm.

Beziehungen: *Discoaster aecus* steht zwischen den beiden Arten *Discoaster salisburgensis* STRADNER (1961, Fig. 27) aus dem Paläozän und *Discoaster barbadiensis* TAN SIN HOK aus dem mittleren und oberen Eozän.



Text-Fig. 11.
Original drawing of *Discoaster aecus*.

English translation:

Lectotype: GBA 2009/058/0015.

Derivation of name: *aecus* (Lat.) = flat, even.

Description: Rosette-shaped discoasters, which in plan view resemble *Discoaster barbadiensis* Tan Sin Hok by the similar number of rays or sectors. One side, which is corresponding to the convex side of *D. barbadiensis* is flat or slightly concave and has a tiny central canal. The other side has a short knob or stem. *Discoaster aecus* is considered an intermediary taxon between *Discoaster salisburgensis* and *Discoaster barbadiensis*.

Size: 10–15 μm.

Comments:

Stratigraphic distribution: Middle Eocene (Lutetian); Subzone NP14b to Zone NP15

**Original description of *Discoaster bronnimanni*
STRADNER, 1961**

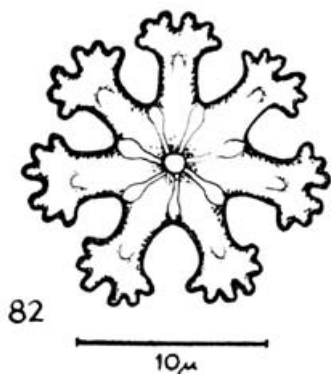
Derivatio nominis: Herrn Dr. Paul BRÖNNIMANN, Tripolis, Libya, zugeeignet.

Locus typicus: Aragon, Mexiko. Selten.

Stratum typicum: Mitteleozän.

Ein Discoaster, dessen Strahlen distal in sechs kurze, zu je dreien gebündelte Ästchen aufgespalten sind. Die Unterteilungslinien der Facies superior sind linkswendig geknickt, die der Facies inferior sind gerade.

Größe: 12–16 μm.



Text-Fig. 12.
Original drawing of *Discoaster bronnimanni*.

English translation:

Derivatio nominis: dedicated to Dr. Paul BRÖNNIMANN, Tripolis, Libya.

Type locality: Aragon, Mexico. Selten.

Type level: Middle Eocene.

Description: Discoasters with bifurcated arms ending with trilobate knobs. Sutures are straight on the proximal side and curved on the distal side.

Size: 12–16 μm.

Comments:

Syntypes lost due to corrosion of the embalming medium in slide GBA 2009/058/0025.

Stratigraphic distribution: Middle Eocene (Lutetian); Zone NP15.

**Original description of *Discoaster currens*
STRADNER, 1959a**

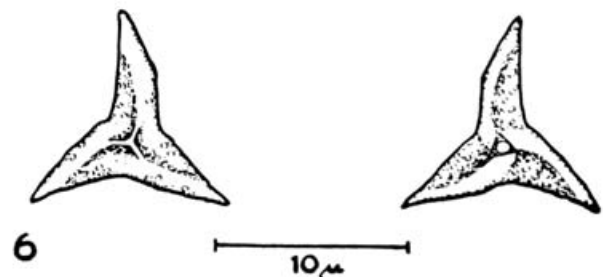
Lectotype: GBA 2009/058/0001.

Derivatio nominis: *currens* (Lat.) = running.

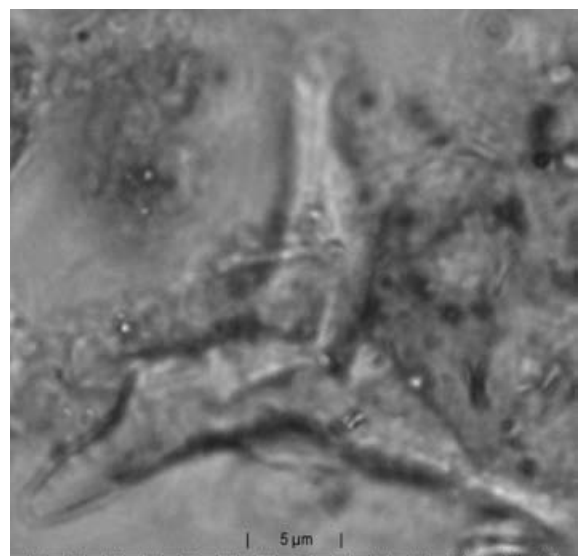
Type locality: Mattsee, Station 133.

Level: Paleocene (Thanetian).

Description: Asteroliths of triradiate shape, the rays resembling those of *Discoaster lodoensis*. On one face of the



Text-Fig. 13a.
Original drawing of *Discoaster currens*.



Text-Fig. 13b.
Lectotype of *Discoaster currens* in normal light.

asterolith the ridges of the curved rays run together to a little triradiate star; on the other face there is a tiny knob. This new form-species seems to be closely related to *Discoaster lodoensis*, from which it was separated because there are no regular four-radiate links between the two form-species in the Austrian material. For the type series and its variability see STRADNER (1959).

Comments:

Taxonomic status: this morphotype may represent a 3-rayed variety of *E. lodoensis*.

Stratigraphic distribution: The original stratigraphic assignment does not represent the actual stratigraphic level, which is Lower Eocene (NP12).

**Original description of *Discoaster gemmeus*
STRADNER, 1959a**

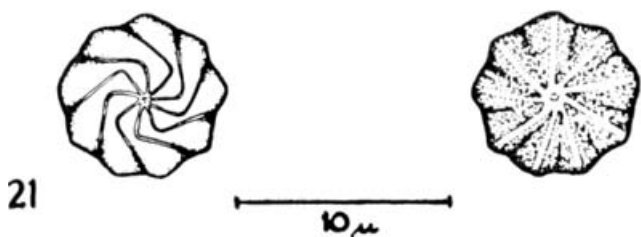
Lectotype: GBA 2009/058/0003.

Derivatio nominis: *gemmeus* (Lat.) = gleaming.

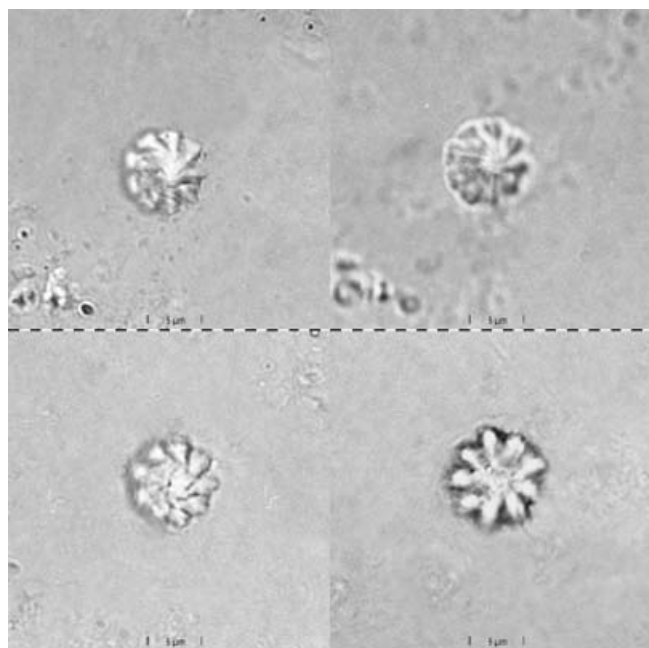
Type locality: Mattsee, station 133.

Level: Middle Paleocene (Thanetian).

Description: Asteroliths with eight or nine rounded rays that are united most of their length. The superior face has crooked suture-lines as in *Discoaster mirus*, the inferior face has high ridges which unite in the centre to a cone-shaped structure. Between these ridges suture lines only can be



Text-Fig. 14a.
Original drawing of *Discoaster gemmeus*.



Text-Fig. 14b.
Syntypes in normal light at different focus levels.

seen near the periphery. Sometimes a central pore is visible. This new form-species is easily found because of its strong light-fraction in low magnification. The asteroliths appear to have a gleaming emerald colour because of their considerable thickness.

Comments:

Taxonomic status: Because of the broad definition, the concept of *gemmeus* is applicable to Paleocene and Eocene morphotypes. The name *mohleri* was introduced by BUKRY & PERCIVAL (1971, p. 128) for the Paleocene morphotypes. It is possible that the early Eocene concept of *gemmeus* overlaps with the concept of *H. robustus* (HAQ) AUBRY & STRADNER n. c. (= *Discoaster robustus* HAQ, 1970, p. 12, Pl. 15, Fig. 7). Possibly a morphotype of *D. mirus* DEFLANDRE 1954.

Stratigraphic distribution: Lower Eocene (the original stratigraphic assignment does not represent the actual stratigraphic level).

**Original description of *Discoaster gemmifer*
STRADNER & PAPP, 1961**

Lectotypus: GBA 2009/058/0037.

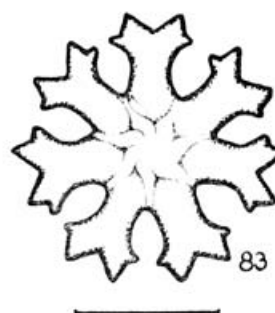
Derivatio nominis: *gemmifer* (Lat.) = Perlen tragend.

Locus typicus: Mattsee, Salzburg. Häufig.

Stratum typicum: Mitteleozän.

Weiteres Vorkommen: Aragon, Mexiko.

Größe: 8–20 μm.



Text-Fig. 15a.
Original drawing of *Discoaster gemmifer*.

Etiam: Die vom Verfasser 1959a als *Discoaster distinctus* MARTINI beschriebenen Discoasteriden. Asterolithen, deren Arme distal einen annähernd 90°igen Öffnungswinkel haben und an deren aufgespaltenen Strahlenenden laterale Knötchen („Perlen“) zu erkennen sind. Diese Art ist eng mit *Discoaster distinctus* MARTINI und *Discoaster nivalis* MANIVIT verwandt, von welchen sie sich aber durch die Art ihrer Strahlenendigungen unterscheidet.

English translation:

Lectotype: GBA 2009/058/0037.

Derivation of name: *gemmifer* (Lat.) = wearing pearls.

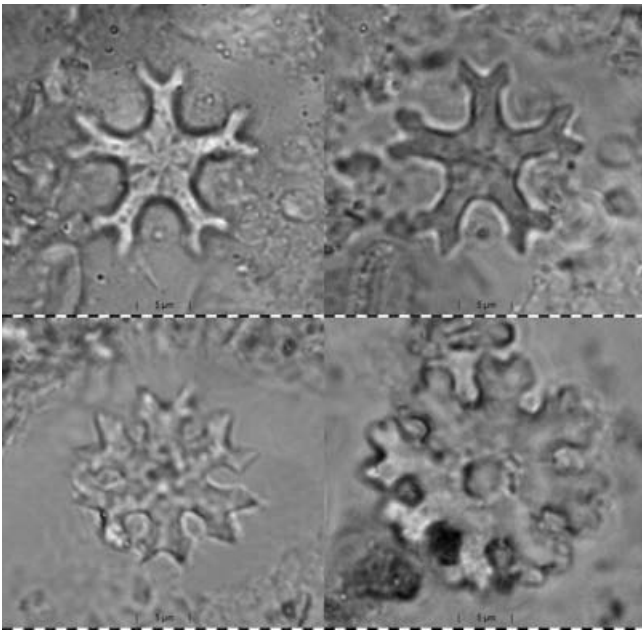
Type locality: Mattsee, Salzburg, Sta. 130, common.

Level: NP12, Lower Eocene.

Size: 8–20 μm.

Other occurrence: Aragon Formation, Mexico. There are also those Discoasters, which in 1959 were assigned to *Discoaster distinctus* MARTINI by the author.

Discoasters with five to nine free rays that at their distal ends have a widely opened bifurcation, 90 degrees or more, and at both lateral sides of their broadened ends



Text-Fig. 15b.
Syntypes of *Discoaster gemmifer* in normal light at different focus levels.

possess small knobs. Closely related to *Discoaster deflandrei*, *D. distinctus* and *D. nivalis* MANIVIT, from which they differ by their characteristic distal ends of the rays.

Comments:

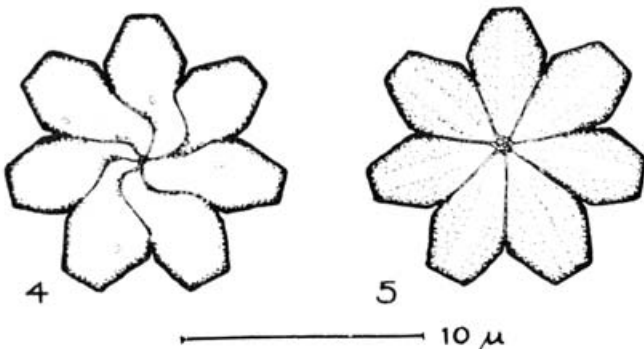
Taxonomic status: STRADNER & PAPP (1961, p. 69, Pl. 8, Figs. 1–10, Pl. 11, Figs. 4, 5) broadened considerably STRADNER'S concept (1961) of the taxon, by accepting a considerable morphologic variability, which led to taxonomic overlaps with other taxa, most notably with *D. cruciformis* MARTINI, 1958, p. 357, Pl. 2, Figs. 9a, b. We restrict here the concept of this taxon to the holotype that exhibits the characteristic angular and uneven terminations of the rays. Stratigraphic distribution: Lower and Middle Eocene (Ypresian–Lutetian); Zone NP12–NP16.

**Original description of *Discoaster geometricus*
BRÖNNIMANN & STRADNER, 1960**

Lectotypus: GBA 2009/058/0016/1.

Derivatio nominis: *geometricus* (Lat.) = geometrisch.

Locus typicus: Universidad-Formation, BR-Stat. 489, Kuba.



Text-Fig. 16.
Original drawing of *Discoaster geometricus*.

Diagnose und Beschreibung: Ein Discoaster, dessen gekürzte Strahlen von annähernd geradlinigem Umriss sind. Die Unterteilungslinien der Facies superior sind nur leicht geschwungen, die Unterteilungslinien der Facies inferior sind besonders bei den sechsstrahligen Asterolithen zu je zweien bogenförmig verbunden, so dass die sogenannte „Hemidiscoaster“-Struktur entsteht. Asterolithen 4- bis 8-strahlig.

Größe: 7–12 μm.

Beziehungen: Dieser *Discoaster* ist in die Verwandtschaft von *Discoaster deflandrei* BRAMLETTE & RIEDEL einerseits und *Discoaster molengraaffi* TAN SIN HOK andererseits zu stellen. Möglicherweise stellt *Discoaster geometricus* eine Übergangsform zwischen den beiden genannten Arten dar.

English translation:

Lectotype: GBA 2009/058/0016/1.

Derivatio nominis: *geometricus* (Lat.) = geometrical.

Locus typicus: Universidad Formation, BR-Stat. 489, Kuba.

Diagnose and description: Asteroliths with 4–8 straight rays. On one of the flat sides the suture lines are curved, on the other side two of these can be united in such a way as to show the so called “hemidiscoaster” appearance.

Size: 7–12 μm.

Relations to *Discoaster deflandrei* BRAMLETTE & RIEDEL and *Discoaster molengraaffi* TAN SIN HOK are indicated.

Comments:

Taxonomic status: probably a superfluous taxon based on an overgrown discoaster.

**Original description of *Discoaster kuepperi*
STRADNER, 1959b**

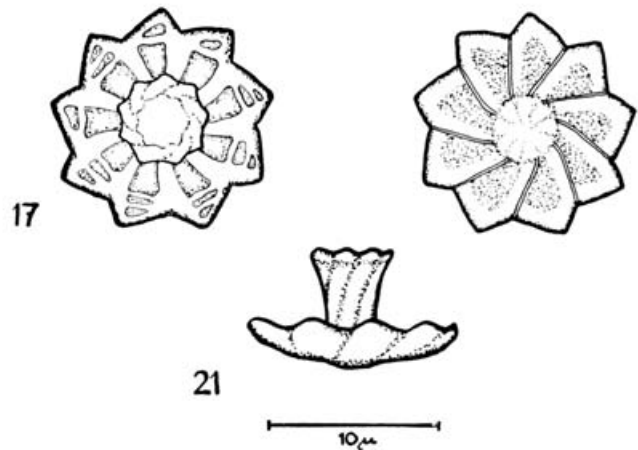
Lectotype: GBA 2009/058/0009.

Derivatio nominis: Herrn Dir. Prof. Dr. H. KÜPPER, Wien, in Dankbarkeit gewidmet.

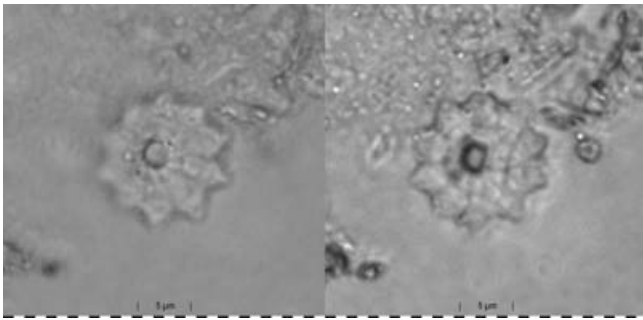
Stratum typicum: Mittleres Paläozän (Thanetium).

Locus typicus: Mattsee, Salzburg, Stat. 130; selten.

Asterolithen mit meist neun keilförmigen, in distaler Richtung stumpfwinkelig zugespitzten Asteroradien. Diese sind nach der Art von *Discoaster lodoensis* BRAMLETTE & RIEDEL geschwungen und mit Verstärkungsrippen versehen. Die



Text-Fig. 17a.
Original drawing of *Discoaster kuepperi*.



Text-Fig. 17b.
Lectotype of *Discoaster kuepperi* in normal light.
View of the concave side at different focus.

Strahlen dieser Formart sind meist mehr als drei Viertel ihrer Länge miteinander verwachsen. Auf der Facies superior sind sie mit je ein oder zwei Querrippen verziert, welche langgestreckte Grübchen umschließen, ein Merkmal, das sonst bei keiner anderen Art vorkommt. Ein weiteres sehr charakteristisches Merkmal ist die zu einer gedrehten und kannelierten Säule ausgebildete Bulla centralis, die an ihrem oberen Ende trichterförmig erweitert ist. Der Öffnungswinkel dieses Trichters beträgt etwas weniger als 90°.

Größe: 9–12 µm.

English translation:

Lectotype: GBA 2009/058/0009.

Derivation of name: Thankfully dedicated to Dr. Prof. Dr. H. KÜPPER, Vienna.

Type level: NP12, lower Eocene.

Type locality: Mattsee, Salzburg, Stat. 130, rare.

Asteroliths with 9 wedge-shaped, bluntly pointed rays. These are curved the same way as in *Discoaster lodoensis* BRAMLETTE & RIEDEL and also with reinforcing ribs joined together to about three fourth of their length. The concave face shows a striation cross to the sutures with elongate dips in between. A remarkable feature of this species is the funnel-shaped proximal bulla centralis, in other species only a knob, here however a flaring column with an opening angle less than 90 degrees.

Size: 9–12 µm.

Comments:

Stratigraphic range: Lower Eocene (Ypresian; Zone NP11 – Subzone NP14a).

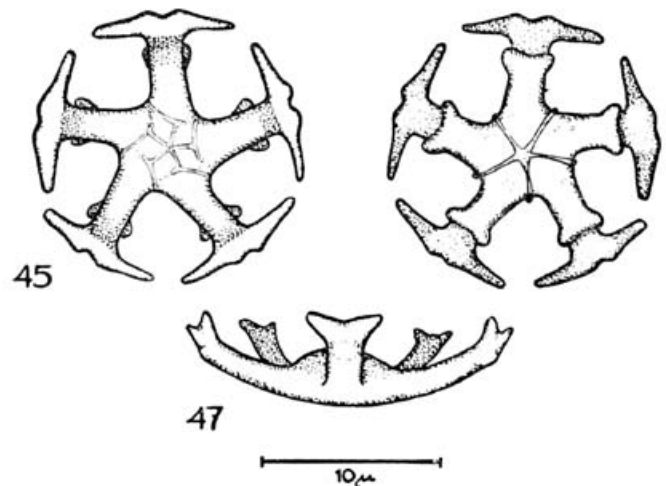
The stratigraphic age of the type level from which *H. kuepperi* was described was thought to be middle Paleocene (Thanetian) at the time of publication. Subsequent studies (see references) have indicated a lower Eocene (Ypresian) age, which is in agreement with the known stratigraphic range of *H. kuepperi* outside of Austria.

**Original description of *Discoaster martinii*
STRADNER, 1959b**

Synonym *Discoaster pentaradiatus* TAN SIN HOK not MARTINI, 1958, S. 359, Pl. 3, Figs. 12 a, b. Not *Discoaster pentaradiatus* TAN SIN HOK of BRAMLETTE & RIEDEL, 1954, p. 401, Text-Fig. 2 b, Pl. 39, Fig. 11.

Lectotypus: GBA 2009/058/0010/1.

Derivatio nominis: Herrn Dr. E. MARTINI, Frankfurt, der diese Formart als erster beschrieb, gewidmet.

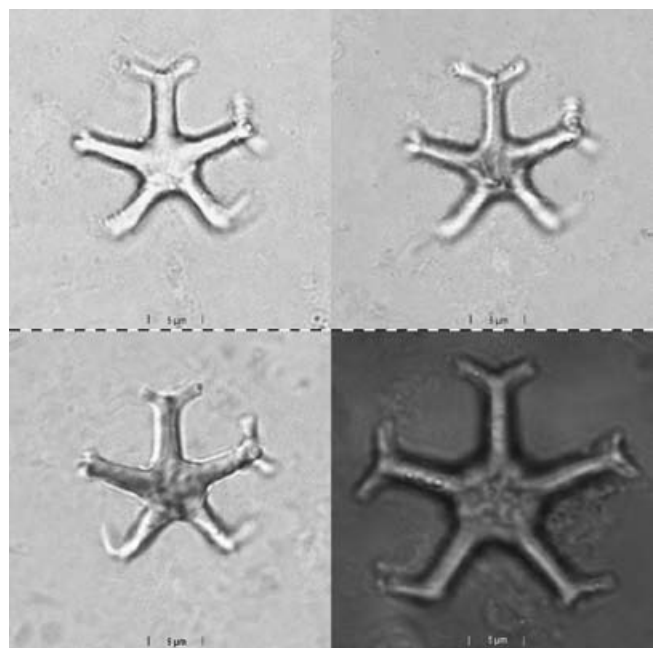


Text-Fig. 18a.
Original drawing of *Discoaster martinii*.

Locus typicus: Aragon, Mexiko.

Stratum typicum: Unteres Eozän.

Fünfstrahlige Asterolithen, deren Strahlen ähnlich wie die von *Discoaster tani* BRAMLETTE & RIEDEL stark gewölbt sind und in zwei lange abstehende Enden gespalten sind. Die Achsen der Strahlen treffen nicht im Mittelpunkt zusammen, sondern gehen an diesem nahe vorbei. Nahe der Stelle, an der sich die Strahlen mit einem sehr stumpfen Winkel gabeln, sind große breite Höcker ausgebildet. Diese überragen auf der konvex gewölbten Facies inferior die Breite der Strahlen, so dass sie auch von der Facies superior, der konkaven Flachseite, her sichtbar sind. Dies trifft aber nur auf ausgesprochen robuste Exemplare zu, wie ein solches in Abb. 45 dargestellt wurde. Die Mehrzahl der gefundenen Asterolithen entspricht MARTINI'S Mikrofoto 12 b. Unterteilungslinien wie bei *Discoaster tani* BRAMLETTE & RIEDEL.



Text-Fig. 18b.
Two syntypes in normal light at different focus levels.

English translation:

Lectotype: GBA 2009/058/0010/1.

Derivation of name: Dedicated to Dr. Erlend MARTINI, Frankfurt/Main, who first has described this form-species.

Type Locality: Aragon, Mexico.

Level: Lower Eocene.

Diagnosis: Four or five-rayed asteroliths, the rays of which are similar to those of *Discoaster tani* BRAMLETTE & RIEDEL; all curved in one direction and with split endings. The axes of the rays do not meet in the centre of the asterolith, they pass by it.

The bifurcations of the rays are spreading widely, up to 180 degrees, and are distinctly thinner than the rays themselves. In some specimens there are also small knobs proximal of the bifurcations as shown in the drawing (Fig. 45).

The majority of the asteroliths correspond to the microphoto 12 b in MARTINI'S paper.

Comments:

Stratigraphic distribution: Middle Eocene (Lutetian); Zone NP15.

Original description of *Discoaster munitus* STRADNER, 1961

Lectotypus: GBA 2009/058/0026.

Derivatio nominis: *munitus* (Lat.) = befestigt.

Locus typicus: Aragon, Mexiko. Selten.

Stratum typicum: Mitteleozän.

Asterolithen mit sehr großer Zentralscheibe und sehr gedrungenen, kurzen Strahlen, die lateral verbreitert und distal dachartig abgeflacht sind.

Größe: 12–15 µm.

English translation:

Lectotype: GBA 2009/058/0026.

Derivation of name: *munitus* (Lat.) = fortified.

Type locality: Aragon, Mexico.

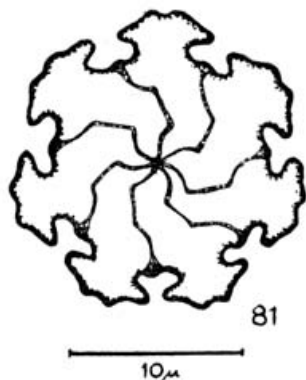
Level: Middle Eocene. Rare.

Size: 12–15 µm.

Diagnosis: Asteroliths with large central area and short sturdy rays, which are laterally broadened and flattened in the shape of a roof.

Comments:

Stratigraphic distribution: Middle Eocene (Lutetian); Zone NP13. Closely related to *Discoaster mirus* DEFLANDRE 1954.



Text-Fig. 19. Original drawing of *Discoaster munitus*.

Original description of *Discoaster ornatus* STRADNER, 1959a

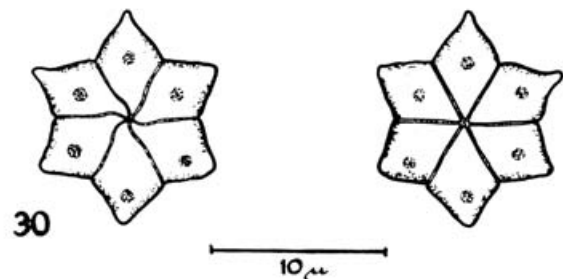
Lectotype: GBA 2009/058/0005/1.

Derivation of name: *punctis "ornatus"* (Lat.) = "decorated" with dots.

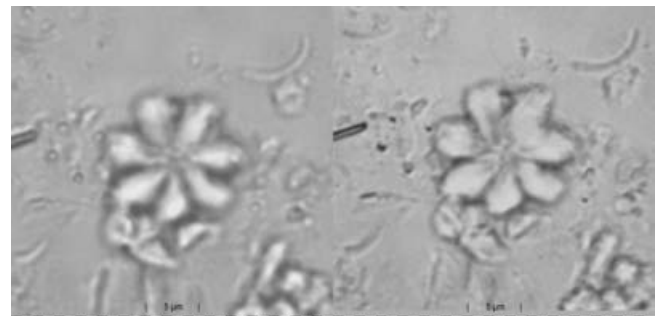
Type locality: Matzen oilfield.

Level: Miocene, Tortonian.

Diagnosis: Asteroliths 6 to 9-rayed with pointed ends and a pore at the distal half of the ray. The rays are rather broad; the incisions between them are acute. The smaller the asterolith the bigger the pore. The pores are similar to those of *Pemma rotundum* Klumpp (Braarudosphaeridae DEFLANDRE), but they are not so near the centre as with *Pemma*. The superior face has curved or crooked suture-lines, the inferior face straight ones.



Text-Fig. 20a. Original drawing of *Discoaster ornatus*.



Text-Fig. 20b. Syntype in normal light at different focus levels.

Comments:

Taxonomic status: The irregular outline of this discoaster implies strong overgrowth. This taxon is likely based on an artifact of preservation and is superfluous. However, the shapes of the sutures between rays imply that it belongs to *Helio-discoaster*.

Stratigraphic range: Lower Oligocene (Rupelian); Zone NP21–NP23.

Original description of *Discoaster salisburgensis* STRADNER, 1961

Lectotypus: GBA 2009/058/0027.

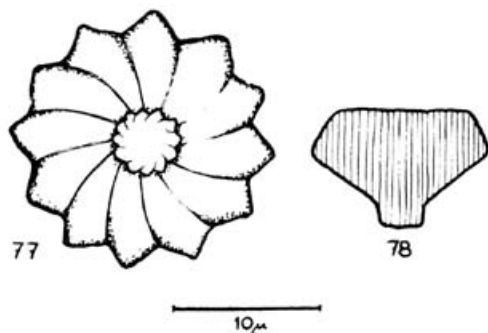
Derivatio nominis: *salisburgensis* (Lat.) = aus Salzburg.

Locus typicus: Kühlgraben, Untersberg bei Salzburg. Häufig.

Stratum typicum: Paläozän.

Ein vielstrahliger Discoaster von laibchenförmiger Gestalt, dessen eine Flachseite etwas konisch erhöht ist und einen

kurzen, aber kräftigen Stiel trägt. Zur Unterscheidung dieser Art von dem in der Flachansicht sehr ähnlichen *Discoaster barbadiensis* TAN SIN HOK emend. BRAMLETTE & RIEDEL ist unbedingt die Seitenansicht des Asterolithen erforderlich. Größe: 8–15 µm.



Text-Fig. 21a.
Original drawing of *Discoaster salisburgensis*.

English translation:

Lectotype: GBA 2009/058/0027.

Derivation of name: *salisburgensis* = from Salzburg, Austria.

Type locality: Kühlgraben, Untersberg, south of Salzburg.

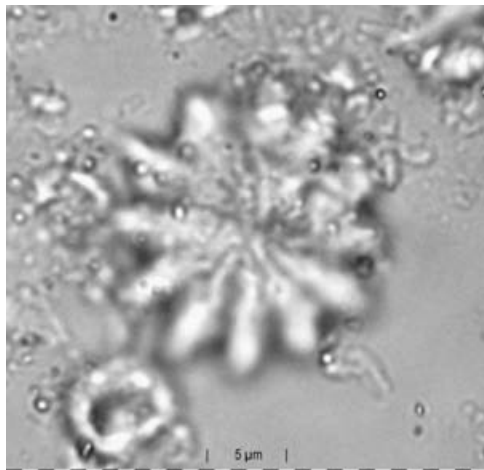
Level: Paleocene.

Description: A many-rayed discoaster of bulky shape, with one of the flat sides conical and mounted by a short stub. To distinguish this species from the similar but more slender *Discoaster barbadiensis* TAN SIN HOK emend. BRAMLETTE & RIEDEL the asteroliths have to be observed in side view.

Size: 8–15 µm.

Comments:

Stratigraphic distribution: Upper Paleocene to Lower Eocene (Thanetian–Ypresian); Zone NP9 to Zone NP12.



Text-Fig. 21b.
Lectotype in normal light.

**Original description of *Discoaster strictus*
STRADNER, 1961**

Lectotypus: GBA 2009/058/0028.

Derivatio nominis: *strictus* (Lat.) = straff.

Locus typicus: Aragon, Mexiko. Mäßig häufig.

Stratum typicum: Mitteleozän.

Asterolithen meist sechsstrahlig mit geraden, gegen die Spitze sich verjüngenden Strahlen. Die Unterteilungslinien der Facies superior sind zweimal geknickt und stellen ein wichtiges Unterscheidungsmerkmal gegenüber *Discoaster tani* BRAMLETTE & RIEDEL dar.

Größe: 12–20 µm.

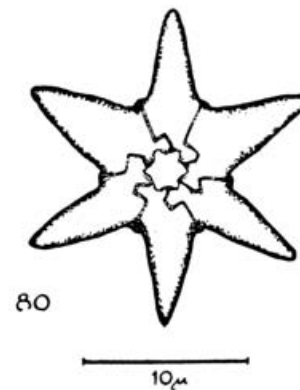
English translation:

Lectotype: GBA 2009/058/0028.

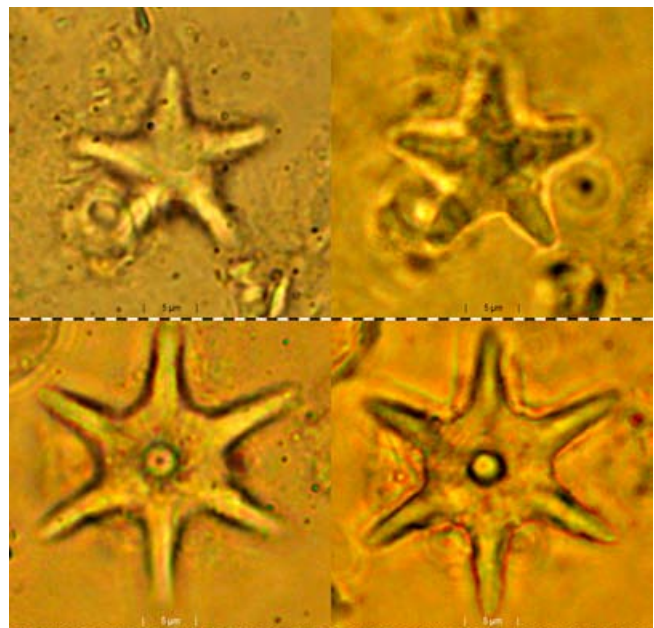
Derivation of name: *strictus* (Lat.) = tight.

Type locality: Aragon, Mexico, moderately common.

Level: Middle Eocene.



Text-Fig. 22a.
Original drawing of *Discoaster strictus*.



Text-Fig. 22b.
Lectotype in normal light.

Diagnosis: Asteroliths with usually six tapering straight rays. The sutures between the rays are bent twice. They differ from *Discoaster tani* BRAMLETTE & RIEDEL by their larger size and their sutures.

Size: 12–20 µm.

Comments:

Taxonomic status: regarded by some as a synonym of *H. subloboensis* BRAMLETTE & SULLIVAN, 1961, (e.g. Theodoridis, 1984), this is a rare but distinct taxon.

Stratigraphic distribution: Middle Eocene (Lutetian); Zone NP14b to lower Zone NP16.

**Original description of *Discoaster trinus*
STRADNER, 1961**

Lectotypus: GBA 2009/058/0029.

Derivatio nominis: *trinus* (Lat.) = je drei.

Locus typicus: Holzmannberg, Oberösterreich. Häufig.

Stratum typicum: Mitteleozän.

Ein Discoaster, dessen sechs Strahlen auf beiden Flachseiten zu je dreien verwachsen sind, und zwar so, dass die Winkel zwischen den verwachsenen Strahlen 120 Grad betragen und je ein Strahl, der auf der gegenüberliegenden Flachseite verwachsen ist, ausgelassen wird. Die Enden der Strahlen sind gekerbt. Diese Art ist eng mit *Discoaster molengraaffi* Tan Sin Hok aus dem Jungtertiär der Insel Rotti verwandt.

Größe: 10–16 µm.

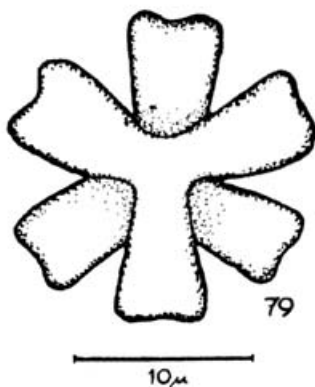
English translation:

Lectotype: GBA 2009/058/0029.

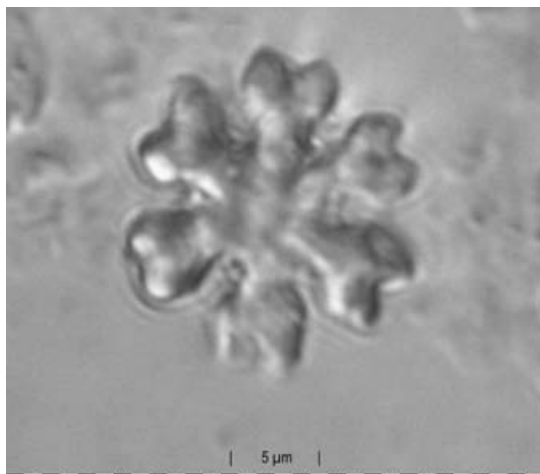
Derivation of name: *trinus* (Lat.) = three each.

Type locality: Holzmannberg, Upper Austria.

Level: Middle Eocene.



Text-Fig. 23a.
Original drawing of *Discoaster trinus*.



Text-Fig. 23b.
Discoaster trinus in normal light.

Six-rayed discoasters in which three rays are united to form angles of 120 degrees. The tips of the broad rays are slightly notched.

Size: 10–16 µm.

Comments:

Taxonomic status: superficial taxon based on a strongly overgrown discoaster.

**Original description of *Discoaster uncinatus*
STRADNER, 1960**

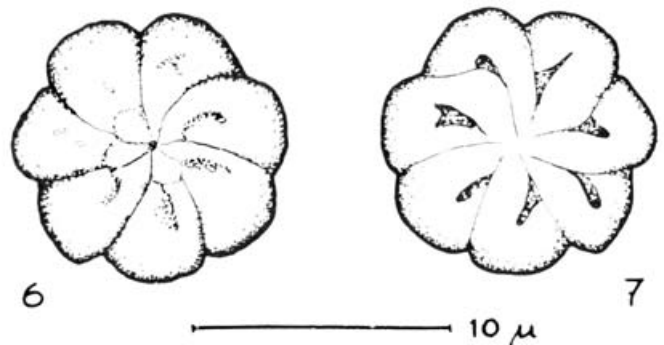
Lectotypus: GBA 2009/058/0016/2.

Derivatio nominis: *uncinatus* (Lat.) = hakig.

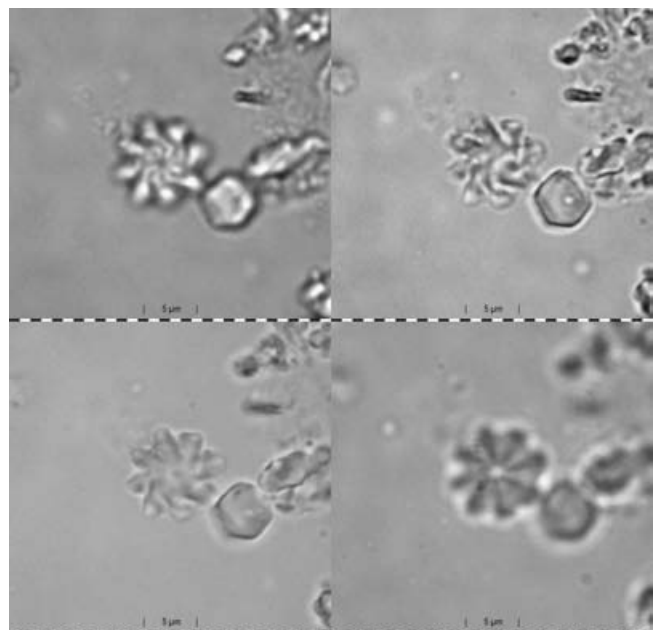
Locus typicus: Universidad-Formation, BR-Stat. 489, Kuba.

Diagnose und Beschreibung: Ein Discoaster, dessen Strahlen auf der Facies inferior eine hakenförmige Struktur zeigen. Die Strahlen haben keine freien Enden, sondern beteiligen sich nur mit ihrer runden Biegungskante an der Bildung der Umrisslinie.

Größe: 10–14 µm.



Text-Fig. 24a.
Original drawing of *Discoaster uncinatus*.



Text-Fig. 24b.
Lectotype in normal light at different focus levels.

Beziehungen: *Discoaster uncinatus* n. sp. gehört wegen seiner stark gebogenen Strahlen in die engere Verwandtschaft von *Discoaster lodoensis* BRAMLETTE & RIEDEL.

English translation:

Lectotype: GBA 2009/058/0016/2.

Derivation of name: *uncinatus* (Lat.) = hook-shaped.

Type locality: BR-Stat. 489, Cuba.

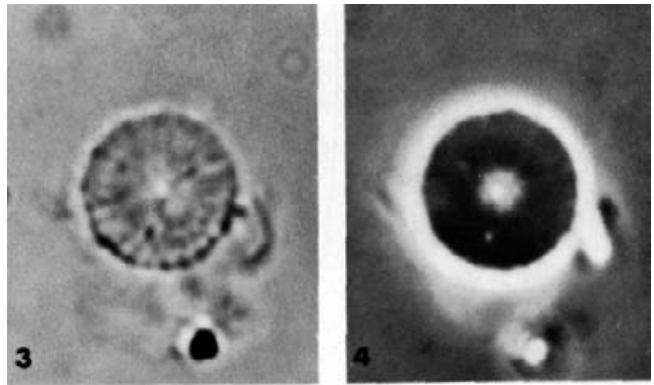
Diagnosis: Discoasters with rays bent like hooks on one of their flat side. These have no free ends, but with their curved parts form the outline of the discoaster.

Size: 10–14 µm.

Relations: *Discoaster uncinatus* is possibly related to *Discoaster lodoensis* BRAMLETTE & RIEDEL.

Comments:

Taxonomic status: A superfluous taxon based on a corroded discoaster.



3. *Discoaster wemmelenis* nov. spcc.
4. Same specimen

Text-Fig. 25b.
Original photographs in phase contrast.

**Original description of *Discoaster wemmelenis*
ACHUTHAN & STRADNER, 1969**

Holotype: GBA 2009/058/0066.

Derivation of name: from “Wommel”, Belgium.

Type locality: Wommel, Belgium; Sands of Wommel.

Level: “Wommelian”.

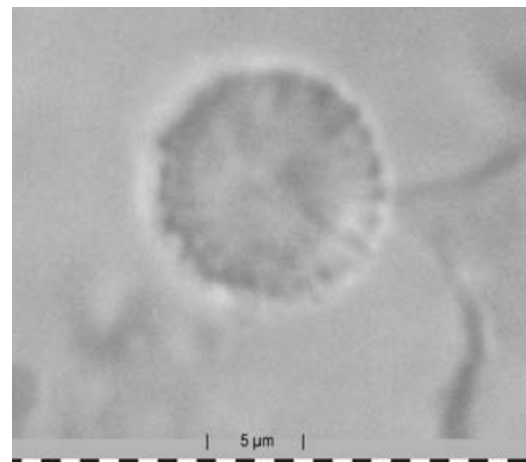
Diagnosis: Heliodiscoasters consisting of 20 to 30 wedge-shaped rays, which are packed in a radial arrangement. Outline in plane view slightly serrate. The side view shows that both faces are centrally depressed, one of the faces being more convex than the other. The sloping margin of the former (distal) face is more pronounced than that of the latter (proximal). No central knob.

Size: Diameter: 5 µm or less, height: half the diameter.

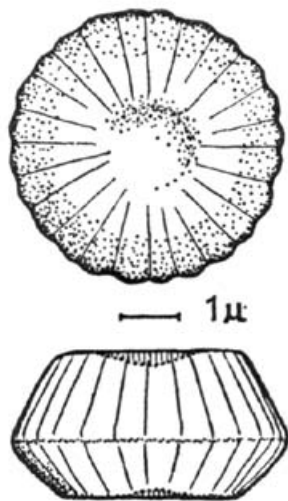
Discussion: *Discoaster wemmelenis* differs from *Discoaster lenticularis* by its smaller diameter and greater thickness as well as by the lacking of any central boss or knob.

Comments:

Stratigraphic distribution: Middle Eocene (Lutetian; Subzone NP14b – Zone NP16).



Text-Fig. 25c.
Lectotype in normal light at different focus levels.



Text-Fig. 25a.
Original drawing of *Discoaster wemmelenis*.

**Family: Sphenolithaceae DEFLANDRE, 1952 orth.
mut. VEKSHINA, 1959**

Genus: *Iselithina* STRADNER, 1966

Type species: *Iselithina iris* STRADNER, 1966, p. 339, Text-Figs. 12–15.

Comments:

Coccoliths assigned to *Iselithina* are strongly modified from an original type. They may be derived from sphenoliths (thus placement of the genus in the Family Sphenolithaceae) or from placoliths (in which case they should be placed in the Family Calcidiscaceae) (see AUBRY, in press).

Original description of *Iselithina* STRADNER, 1966

Derivation nominis: Ilse = Name einer weiblichen Wasser-gottheit (altgerm. Mythologie), lithos (Gr.) = Stein.

Diagnose: Coccolithen, welche aus einem zentralen, aus schraubig angeordneten Kristallplatten aufgebauten Kernstück und zwei verschiedenartig ausgebildeten, im Umriss kreisrunden, durch charakteristische Poren gekennzeichneten Randscheiben bestehen. Die flach kegelförmige proximale Randscheibe hat zwischen den peripher schwach

gerundeten, in der Mitte leicht gekerbten Kristallplatten schlitzförmige Poren, welche vom Kernstück aus in fast radialer Richtung verlaufen und nur eine sehr geringe Inklinatation der Kristallplatten erkennen lassen. Das Kernstück kann zentral vollkommen verschlossen sein oder ringförmig ausgebildet. Die zu seinem Aufbau verwendeten Platten laufen in Richtung zur distalen Randscheibe hin zu speichenförmigen Gebilden aus. Die distale Randscheibe besteht in der Regel aus weniger Einzelementen als die proximale Randscheibe. Ihre abgerundet-trapezförmigen, gewölbten Kristallplatten sitzen pilzhutartig auf den vom Kernstück ausgehenden Speichen. Das Niveau der distalen Randscheibe liegt über und somit außerhalb dem des Kernstückes. Die äußere und innere Mantelfläche der distalen Randscheibe sind kegelmantelförmig geneigt.

English translation:

Derivation of name: Ilse = name of a water goddess (German mythology); an allusion to the first name of Ilse STRADNER (1927–2003); *lithos* (Gr.) = stone.

Diagnosis and description: Circular coccoliths consisting of a proximal ring composed of mushroom-shaped elements, which are supported by thin stems emanating from a twisted and perforated central core. The proximal circular shield consists of straight wedge-shaped elements with rounded tips. These elements are touching each other near the periphery leaving open elongate slots between them. The proximal shield consists of about twice as many elements as compared to the distal ring. The orientation of the distal crystal plates, which are lifted by tiny spokes in distal direction, corresponds to the mantle of a flat cone. They are held above the central core.

Comments:

Taxonomic status: The genus *Hayella* ROTH, 1969, p. 464 is a junior synonym of *Ilselithina* STRADNER, 1966.

Original description of *Ilselithina iris* STRADNER, 1966 (in STRADNER & ADAMIKER)

Holotypus: Stereo-Platten Nr. 2 595/2 596/65, 4.800 fach.

Paratypus: Stereo-Platten Nr. 2 533/2 534/65, 9.800 fach.

Derivatio nominis: Iris = Augensterne; Göttin des Regenbogens (griech. Mythologie).

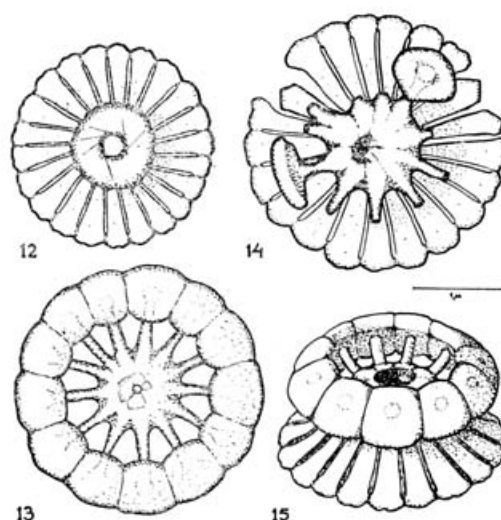
Locus typicus: Oamaru, Neuseeland; Diatomit von Williams Bluff.

Stratum typicum: Obereozän.

Diagnose: Die Art diagnose dieser bis jetzt einzigen Art der neuen Gattung deckt sich mit der Gattungsbeschreibung. So weit bis jetzt beobachtet wurde, schwankt die Zahl der Kristallplatten der proximalen Randscheibe von 18 bis 28, der distalen Randscheibe von 11 bis 13.

Größe des Holotypus: Durchmesser der vollständig erhaltenen distalen Randscheibe 3,1 µm.

Anmerkung: Der Erstnachweis dieser Art gelang an Hand einer Bohrprobe der Österreichischen Mineralölverwaltung AG, und zwar in obereozänem Bohrklein aus der Schussbohrung L 107/75 bei Klein Schweinbarth, Niederösterreich (Taf. 3, Fig. 5, Platte Nr. 1 521/65, 9.800 fach). Da es sich bei einer Bohrung nur um einen vorübergehenden Aufschluss handelt und die gleiche Art im neuseeländischen Obereozän von Oamaru jederzeit in zugänglichen „outcrops“ gefunden werden kann, wur-



Text-Fig. 26a.

Original drawing of *Ilselithina iris*.

Distal view of the proximal plate with fragments of the core (12), distal view of the distal plate (13, holotype), distal view of the inner plate (14), reconstruction of a complete specimen (15).

All specimens from Oamaru, New Zealand.

de Oamaru als Typuslokalität gewählt (vgl. STRADNER & EDWARDS, 1967, Pl. 21).

English translation:

Holotype: TEM stereo-plates 2 595+2 596/65; paratype; 2 533+2 534/65.

Derivation of name: Iris = goddess of the rainbow (Greek mythology)

Type locality: Diatomite of Oamaru, New Zealand (STRADNER & EDWARDS, 1968).

Level: Upper Eocene.

Diagnosis and description: The features of this as yet only species of the new genus *Ilselithina* are described in the generic definition.

Remarks: *Ilselithina iris* was originally discovered in cuttings of a seismic drilling by OMV AG in Austria (L 107/75 near Klein Schweinbarth, Lower Austria). For type locality, however, the New Zealand Oamaru site was preferred, since it is always accessible.



Text-Fig. 26b.

Electron micrograph of a fragmentary specimen corresponding to Text-Fig. 26a/12.

Comments:

Taxonomic status: *Hayella elegans* ROTH, 1969, p. 464, Pl. 1, Figs. 1, 2 is a junior synonym of *Iselithina iris* STRADNER, 1966.

Stratigraphic distribution: Upper Eocene – Lower Oligocene (Priabonian–Rupelian); Zone NP19–20–NP22.

Genus: *Sphenolithus* DEFLANDRE 1952

Type species *Sphenolithus radians* DEFLANDRE in GRASSÉ 1952, p. 466, Text-Figs. 343J–K, 363A–G.

Synonym: *Nannoturbella* BRÖNNIMANN & STRADNER, 1960, p. 368.

Type species: *Nannoturbella moriformis* BRÖNNIMANN & STRADNER 1960, p. 368, Text-Figs. 11–16.

Comments:

Taxonomic status: *Nannoturbella moriformis* BRÖNNIMANN & STRADNER 1960 exhibits the morphological, optical and structural characteristics of sphenoliths for which the genus *Sphenolithus* was erected. Based on ICBN rules, the name *Sphenolithus* has priority over *Nannoturbella*.

Original description of *Nannoturbella moriformis* BRÖNNIMANN & STRADNER, 1960

Derivatio nominis: *nannos* (gr.) = Zwerg, *turbo* (Lat.) = Kreisel.

Locus typicus: Alkazar-Formation, BR-Stat. 538, Kuba.

Stratum typicum: Unter-Eozän.

Diagnose: Ein aus zahlreichen keil- bis kegelförmigen Elementen zusammengesetztes, meist halbkugelförmiges Kalkkörperchen. Die Einzelelemente sind nach außen hin konvex, wodurch das äußere Erscheinungsbild einer zusammengesetzten Beere entstehen kann. Wegen der radialen Anordnung der Einzelelemente zeigt das Kalkkörperchen im polarisierten Lichte bei gekreuzten Nikols in jeder beliebigen Lage ein charakteristisches Lösungskreuz.

Größe: ca. 5 µm.

Beziehungen: *Nannoturbella* schließt sich morphologisch eng an *Nannoconus* an, von welcher Gattung sie aber durch ihre geringen Dimensionen und durch den Mangel eines offenen Lumens (Hohlraumes) abweicht. Auch das Verhalten im polarisierten Lichte kann gut zur Unterscheidung beider Gattungen herangezogen werden.

English translation:

Derivation of name: *nannos* (gr.) = dwarf, *turbo* (Lat.) = top.

Type location: Alkazar Formation, BR-St. 538, Cuba.

Level: Lower Eocene.

Diagnosis and description: Hemispherical or elongated hemispherical calcareous bodies, composed of numerous cone or wedge-shaped separate elements. Due to their radial arrangement and the elongated form of these crystal elements *Nannoturbella* shows a distinct extinction cross in polarized light.

Size: 5 µm.

Relation: The genus *Nannoturbella* seems closely related to the genus *Nannoconus*, from which it differs by the lack of a central canal or cavity.

Original description of *Nannoturbella moriformis* BRÖNNIMANN & STRADNER, 1960

Lectotypus: GBA 2009/058/0018/3.

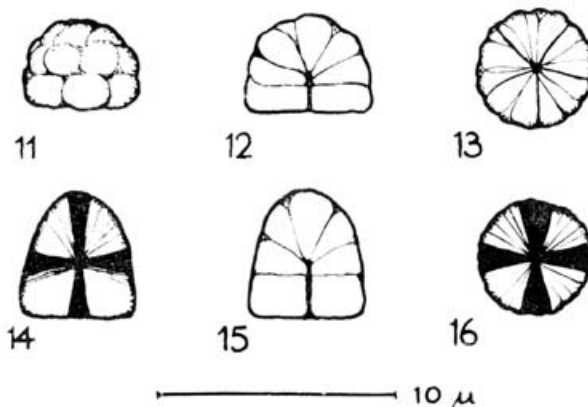
Derivatio nominis: *morum* (Lat.) = die Maulbeere.

Locus typicus: Alkazar-Formation, BR-Stat. 538, Kuba.

Stratum typicum: Unter-Eozän.

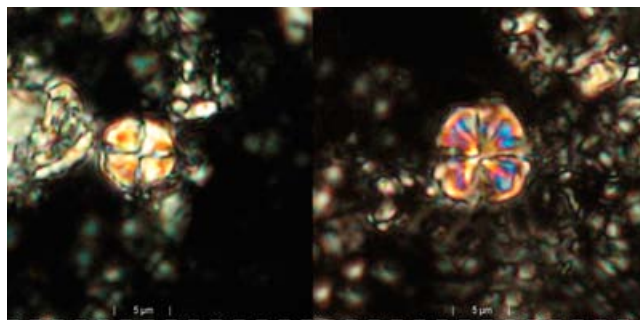
Diagnose: Bis jetzt die einzige Art der neuen Gattung. Ihre Diagnose stimmt mit der des Genotypus überein.

Größe: Durchmesser des Holotypus: 5 µm.



Text-Fig. 27a.

Original drawings of *Nannoturbella moriformis*: side views and axial views.



Text-Fig. 27b.

Lectotype in normal light and polarized light.

English translation:

Lectotype: GBA 2009/058/0018/3 (BR/538/1T).

Derivaton of name: *morum* (Lat.) = mulberry.

Type locality: Alkazar Formation, BR-St. 538, Cuba.

Type level: Lower Eocene.

Diagnose: See the generic description. The rounded ends of the wedge-like elements result in an appearance reminding of a mulberry.

Order: Pontosphaerales AUBRY (in press)

Family: Pontosphaeraceae LEMMERMANN, 1908

Genus: *Scyphosphaera* LOHMANN, 1902

Type species: *Scyphosphaera apsteinii* LOHMANN 1902, p. 132, Pl. 4, Figs. 26–30.

Comments:

Taxonomic status: The name *Argyrosphaera* AUBRY, LIU, DE VARGAS & PROBERTS in AUBRY & BORD (2009) [NOT 2008]

may have been introduced prematurely for Eocene lopadoliths with a flat basal plate and a thick margin. The recombinations *Argyrosphaera columella* (STRADNER) AUBRY, LIU, DE VARGAS & PROBERTS in AUBRY & BORD 2009 (= *Scyphosphaera columella* STRADNER, 1968, p. 416, Pl. 88, Figs. 1–4, Text-Fig. 2[7–9]) and *Argyrosphaera tubicena* (STRADNER) AUBRY, LIU, DE VARGAS & PROBERTS in AUBRY & BORD 2009 (= *Scyphosphaera tubicena* STRADNER, 1968, p. 416, Pl. 88, Figs. 9–12, Text-Fig. 2) are not followed here.

**Original description of *Scyphosphaera columella*
STRADNER, 1969**

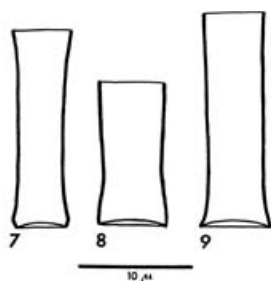
Synonym: 1961 “Lopadolith from Dodo 39”, BRAMLETTE & SULLIVAN, Pl. 5, Fig. 19.

Holotype: GBA 2009/058/0065/2.

Derivation of name: *columella* (Lat.) = small pillar.

Type locality: Hagenbach Valley, Northern Vienna Woods, Lower Austria, Stat. 400.

Level: Lower Eocene.



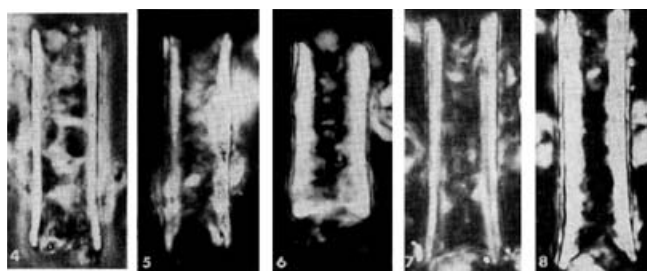
Text-Fig. 28a.
Original drawings of *Scyphosphaera columella*.

Diagnosis and description: Tube-shaped lopadoliths with almost parallel side lines, only slightly constricted above the somewhat widening bottom-end, which is closed by an inward vaulted plate. No striation of tube or perforation of bottom plate discernible.

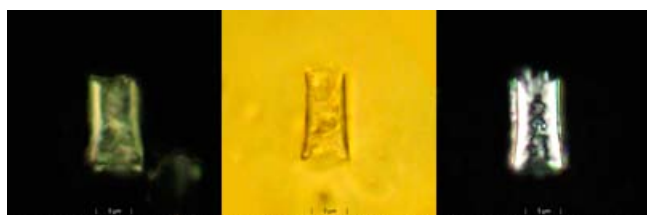
Size: 12 µm.

Comments:

Stratigraphic distribution: Lower and Middle Eocene (Ypresian–Lutetian); Zone NP12–NP16.



Text-Fig. 28b.
Original photographs of syntypes.



Text-Fig. 28c.
Syntype in normal light and polarized light at different focus levels.

**Original description of *Scyphosphaera tubicena*
STRADNER, 1969**

Synonym: Lopadolith from Dodo 52, BRAMLETTE & SULLIVAN, 1961, Pl. 5, Fig. 20.

Holotype: GBA 2009/058/0065/3.

Derivation of name: *tubicen* (Lat.) = “trumpet-blower”.

Type locality: Hagenbach Valley, Northern Vienna Woods, Lower Austria, Stat. 2060.

Level: Lower Eocene.

Diagnosis and description: Trumpet-shaped lopadoliths. In side view shaft with parallel contour, flaring towards the bottom, which is closed by a plane or only slightly vaulted bottom plate. No striation of shaft or perforation of bottom plate recognizable. Proximal end in many specimens damaged and bottom plate missing. Inside often filled with substance showing optical refraction similar to calcite.

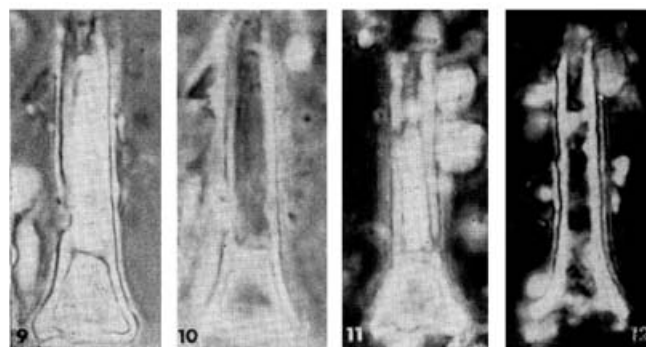
Size: 20 µm.

Comments:

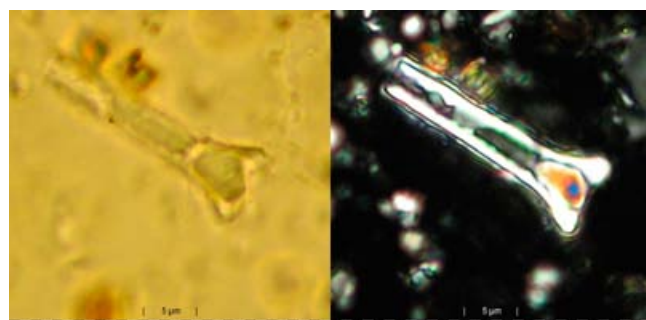
Stratigraphic distribution: Lower and Middle Eocene (Ypresian–Lutetian); Zone NP12–NP15.



Text-Fig. 29a.
Original drawings of *Scyphosphaera tubicena*.



Text-Fig. 29b.
Original photographs of the holotype.



Text-Fig. 29c.
Lectotype in normal light and polarized light.

**Order: Syracosphaerales HAY, 1977 emended
YOUNG et al., 2003**

Family: Blackitaceae AUBRY (in press)

**Genus: *Blackites* HAY & TOWE, 1962, emended
STRADNER & EDWARDS, 1968**

Blackites hayi STRADNER & EDWARDS, 1968, p., Pl. 31, Figs. 6, 7, Text-Figs. 5a, b

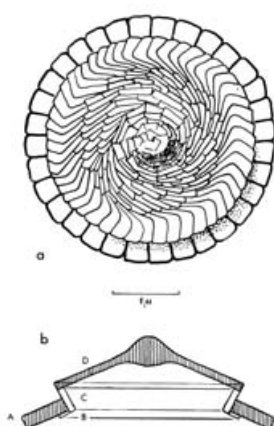
Original description of *Blackites hayi* STRADNER & EDWARDS, 1968

Holotype: TEM Micrographs 3376+3377/65.

Derivation of name: Named in honour of Prof. William W. HAY, Univ. of Illinois.

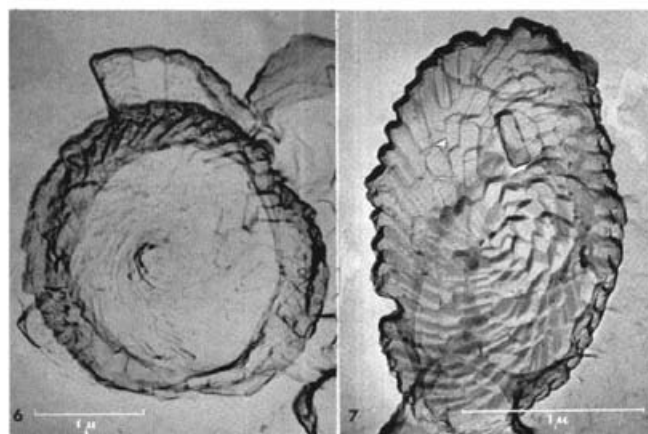
Type locality: Diatomite at William's Bluff, Oamaru, N. Z.

Level: Upper Eocene.



Text-Fig. 30a.
Original drawings of *Blackites hayi*.

Description: Rhabdoliths with a circular, cupula-shaped basalplate without central tube. The outer ring (A) of trapezoid-shaped crystal plates is similar to that of *Blackites rectus* (DEFLANDRE), as far as can be judged from the fragmentary specimen of Pl. 31, Fig. 6. The inner cupula-shaped structure (D) of spirally arranged crystal units is overlapping two cycles which can be correlated with the cycles (B) and (G) of *Blackites rectus* (DEFLANDRE). There is a narrow



Text-Fig. 30b.
Electron micrographs of holotype (6) and paratype (7).

cycle of radial crystals supporting the cycle (A) at its proximal side and another reversed-conical cycle (G) of crystal laths, which are thought to be analogous to cycle (G) in *Blackites rectus*. The cupula (D) is composed of a whirl of numerous elongated crystals adjoining and partly penetrating each other. At the centre they are turned upright so that the cupula is thicker there and appears tipped like the cupula of a mosque.

Size: Diameter 3–7 μm in holotype (TEM Micrographs 3376+3377/65), diameter of the cupula 2–9 μm in holotype, 2–2 μm in paratype (TEM Micrographs 1899+1900/65).

Discussion: *Blackites hayi* nov. spec., is an atypical representative of the genus because it lacks the characteristic tube or shaft. However, the ultrastructure of the basal plate leaves no doubt as to its generic position, since it shows all typical features of *Blackites* described first by Hay & Towe.

Blackites herculeus (STRADNER) AUBRY 1999 (= *Rhabdosphaera herculea* STRADNER 1969, p. 415, Pl. 89, Figs. 9–12

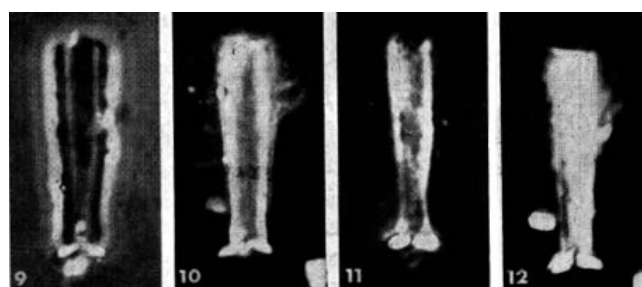
**Original description of *Rhabdosphaera herculea*
STRADNER, 1969**

Holotype: GBA 2009/058/0065/1.

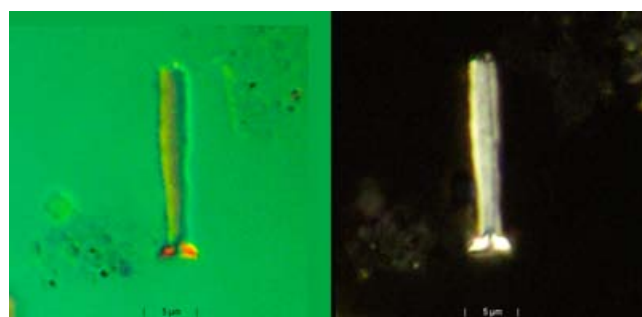
Derivation of name: Hercules = name of hero (Greek Mythology)

Type locality: Hagenbach Valley, Northern Vienna Woods, Lower Austria Stat. 4 and 14.

Level: Lower Eocene, "*Marthasterites tribrachiatus* Zone".



Text-Fig. 31a.
Original photographs of the holotype (10, 12) and paratype (9, 11) of *Rhabdosphaera herculea*.



Text-Fig. 31b.
Syntype in normal light and polarized light.

Diagnosis and description: Rhabdoliths with shaft in form of a large hollow tube, which is slightly constricted in its proximal quarter and slowly flaring towards its widely opened distal end. Striation of shaft enclosing an angle of

about 70° with the direction of the main axis. Some specimens with shaft slightly tapering in its distal half. Greatest diameter of shaft equal or greater than that of basal plate. Usually only the “club-shaped” shafts without basal plate are encountered. Therefore a zone of minor resistance can be expected within the collar-zone or between the collar and the basal plate.

Size: 18 µm.

Comments:

Taxonomic status: *Rhabdolithus solus* PERCH-NIELSEN, 1971, p. 52, Pl. 45, Figs. 10-13 and Pl. 61, Figs. 36-38, is a junior synonym of *B. herculeus* (STRADNER).

Stratigraphic range: Lower Eocene (Ypresian); Zone NP10–NP12.

Cretarhabdus lentus STRADNER in STRADNER & EDWARDS, 1968, p. 33, 34, Pl. 44, Fig. 7, Text-Fig. 6

Original description of *Cretarhabdus lentus* STRADNER in STRADNER & EDWARDS, 1968

Holotype: TEM Micrographs 3325+3326/65.

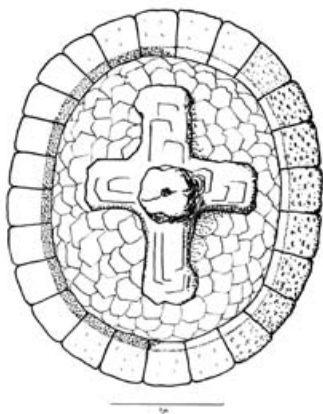
Derivation of name: *lentus* (Lat.) = late.

Type locality: Williams Bluff diatomite, Oamaru, New Zealand.

Level: Upper Eocene.

Diagnosis and description: Coccoliths consisting of a broadelliptical basal plate with a narrow outer ring of about 32 relatively large, rectangular to trapezoidal plates and a wide central area completely filled in with a mesh structure of tightly packed irregular crystal units, which partly overlap each other like tiles. A robust axial cross is spanning the central area and pointing with its central knob in distal direction.

Size: Length 3–8 µm, width 2–9 µm (holotype).



Text-Fig. 32a.
Original drawings of *Cretarhabdus lentus*.

Discussion: The stereoscopic couple of the only specimen encountered yet does not show a second proximal basal plate. Up to now the genus *Cretarhabdus* has only been reported from Cretaceous sediments. Reworking has not been observed in any of the Oamaru samples. It therefore seems likely that this specimen is either of upper Eocene age or has been introduced during the laboratory preparation of this sample.



Text-Fig. 32b.
Electron micrograph of the holotype.

Comments:

Taxonomic status: *Cretarhabdus lentus* is a junior synonym of *Blackites vitreus* (DEFLANDRE) SHAFIK 1981 (= *Rhabdolithus vitreus* DEFLANDRE in DEFLANDRE & FERT, 1954, 157, Pl. 12, Figs. 28, 29, Text-Figs. 83, 84). Recombination to *Blackites* should be provisional (AUBRY, 1999).

Genus: *Rhabdosphaera* HAECKEL 1894, p. 111 emend. NORRIS 1984

Type species: *Rhabdosphaera clavigera* MURRAY & BLACKMANN, 1898, p. 438, 439, Text-Figs. (designated by HAY & TOWE, 1962, p. 504).

Rhabdosphaera sicca (STRADNER) STRADNER & FUCHS 1977 (= *Rhabdolithus siccus* STRADNER in BACHMANN, PAPP & STRADNER, 1963, p. 158, Pl. 24, Fig. 8, Text-Figs. 3, 3a).

Original description of *Rhabdolithus siccus* STRADNER, 1963 in BACHMANN, PAPP & STRADNER, 1963

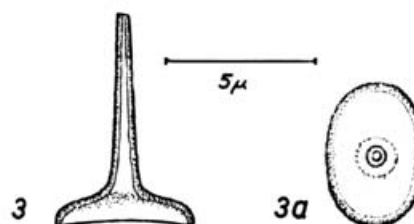
Holotypus: GBA 2009/058/0061.

Derivatio nominis: *siccus* (Lat.) = schlicht, einfach.

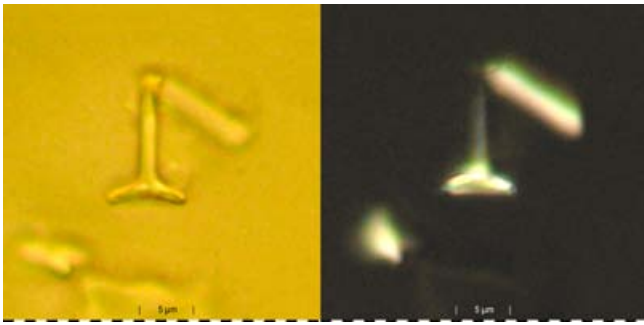
Locus typicus: Ziegelei Frättingsdorf, Niederösterreich.

Stratum typicum: Torton, untere Lagenidenzone.

Diagnose und Beschreibung: Im Umriss breitelliptische, distal leicht aufgewölbte und mit einem langen zentralen konischen Verlängerungsrohr versehene Coccolithen (Gehäuseelemente von Kalkflagellaten). Weder der Rand der Basalscheibe noch deren Fläche oder der für die Gattung *Rhabdolithus* (*Rhabdosphaera*) kennzeichnende röhrenförmige



Text-Fig. 33a.
Original drawings of *Rhabdolithus siccus*.



Text-Fig. 33b.
Holotype of *Rhabdolithus siccus* in normal light and polarized light.

Aufsatz zeigen irgendeine Ornamentation. Von dem im ungarischen Torton massenhaft vorkommenden *Rhabdolithus pannonicus* BALDI-BEKE unterscheidet sich *Rhabdolithus siccus* durch den elliptischen Umriss der Basalplatte und durch das Vorhandensein eines Zentralkanals.

Vorkommen: In fast allen nannofossilführenden Tortonmergeln Österreichs selten; leicht auffindbar im Torton des Lavantales, wo kieselige Bruchstücke fehlen.

Dimensionen: Basalplatte: 3 x 5 µm, Höhe 14 µm.

English translation:

Holotype: GBA 2009/058/0061.

Derivation of name: *siccus* (Lat.) = simple.

Type locality: Brickyard Frättingsdorf, Lower Austria.

Type level: Badenian, Lower Miocene, lower Lagenid zone.

Diagnosis and description: Rhabdoliths with slightly vaulted elliptical basalplate and a long central tapering tube extending in distal direction. No ornamentation recognizable on basal plate or tube by light microscopical means.

Related to *Rhabdolithus pannonicus* BALDI-BEKE, from which it differs by its oval plate and its hollow tube.

Size: Basal plate: 3 x 5 µm, height 14 µm.

Comments:

Stratigraphic distribution: Upper Miocene (Tortonian); Zone NN9–NN11.

**Family: Syracosphaeraceae LEMMERMANN, 1903
emended AUBRY, 2009**

Genus: Syracosphaera LOHMANN, 1902

Type species: *Syracosphaera pulchra* LOHMANN, 1902, p. 133, 134, Pl. 4, Figs. 34, 36, 36a, b, 37 (designation by LOEBLICH & TAPPAN, 1963).

?*Syracosphaera lunularia* STRADNER & FUCHS, 1978, p. 496, 497, Pl. 12, Figs. 15, 6, Pl. 13, Figs. 13–16.

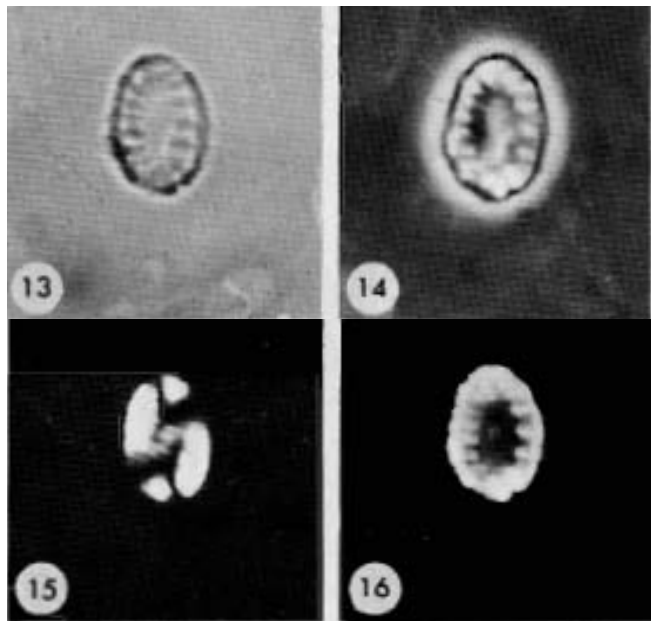
**Original description of *Syracosphaera lunaria*
STRADNER & FUCHS, 1978**

Holotypus: GBA 2009/058/0069.

Derivatio nominis: Entfernte Ähnlichkeit mit den Schotenwänden der Mondviole (*Lunaria rediviva*).

Locus typicus: Stützenhofen, NÖ.

Stratum typicum: Untere Lagenidenzone des Badenien. Mittelmiozän.



Text-Fig. 34.
Original photographs of the holotype of *Syracosphaera lunaria* in normal light (13), polarized light (15), positive (14) and negative (16) phase contrast.

Beschreibung: Elliptische Kalkplättchen, deren Randzone durch ca. 7–16 zentripetale oder schräg liegende Einschnitte gekennzeichnet ist. Zuordnung zu *Syracosphaera fraglich*, eventuell *Pontosphaera*?

Größe: 7–10 µm.

English translation:

Holotype: GBA 2009/058/0069.

Derivation of name: In plan view resembling the fruit membranes of *Lunaria rediviva*, in shape but not in size.

Type locality: Stützenhofen, Lower Austria.

Level: Badenian, Middle Miocene, lower Lagenid zone.

Diagnosis and description: Elliptical calcareous plates with a distinct rim, inside of which a row of elongated pores is running parallel to the rim. Number of pores 7–16.

Size: Length 10 µm, width 7 µm.

Relations: Assignment to the genus *Syracosphaera* is hypothetical.

Comments:

Taxonomical status: The coccolith clearly exhibits the characteristics of the Family Syracosphaeraceae. However assignment to the genus *Syracosphaera* s. st. is provisional because the coccosphere is unknown. Coccospheres of *Syracosphaera* are typically dimorphic.

Stratigraphic distribution: Middle Miocene (Badenian); Zone NN5.

**Order: Zygodiscales YOUNG & BOWN, 1997
emended AUBRY in press**

Family: Zygodiscaceae HAY & MOHLER, 1967

Genus: Nothodiscus AUBRY & STRADNER nov. nom.

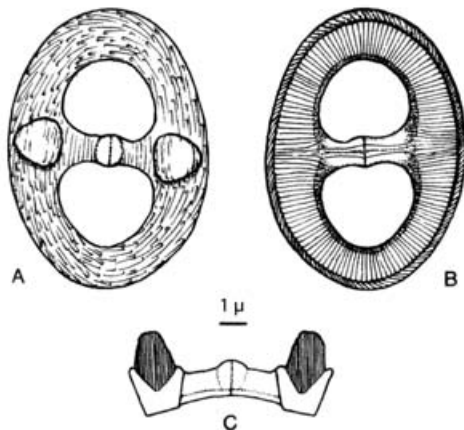
Type species: *Nothodiscus pax* AUBRY & STRADNER nov.com. (*Transversopontis pax* STRADNER & SEIFERT, 1980, p.281, Pl.1, Figs. 1–9).

Description: Coccoliths consisting of the four structural units characteristic of the family. The tranverse bar is mar-

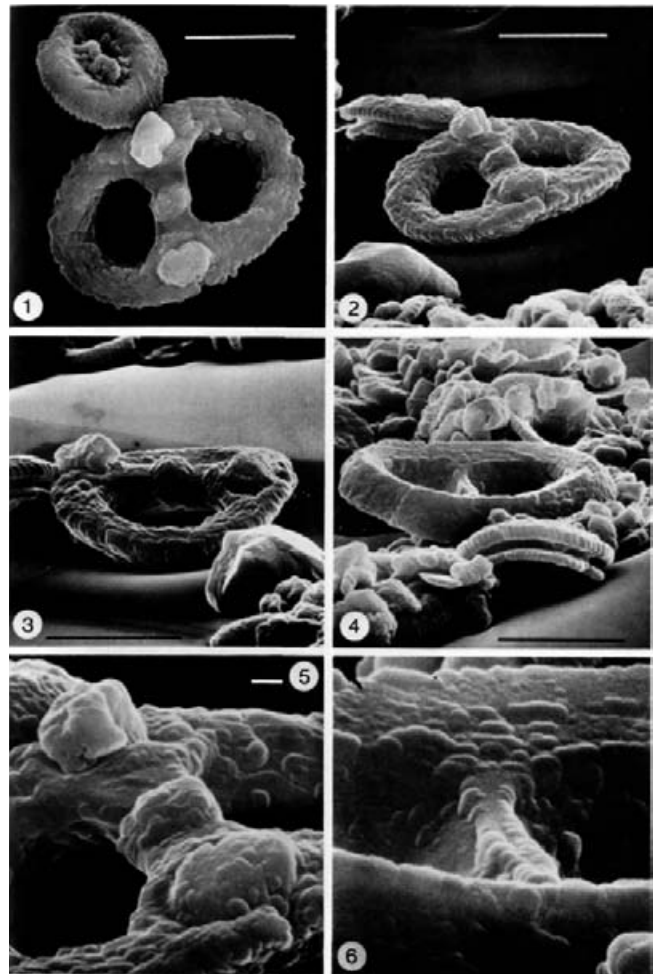
edly beveled in the basal plate, with corresponding prominent and irregular outgrowths on the distal side. Thickenings may also occur on the distal side of the bar.

Remarks: The relation of *N. pax* to *N. fibula* (GHETA, 1976, p. 144, Pl. 2, Figs. 1, 4–9) AUBRY and STRADNER n. c. requires clarification. *N. pax* may be a junior synonym of *N. fibula*, which would broaden the range of the taxon.

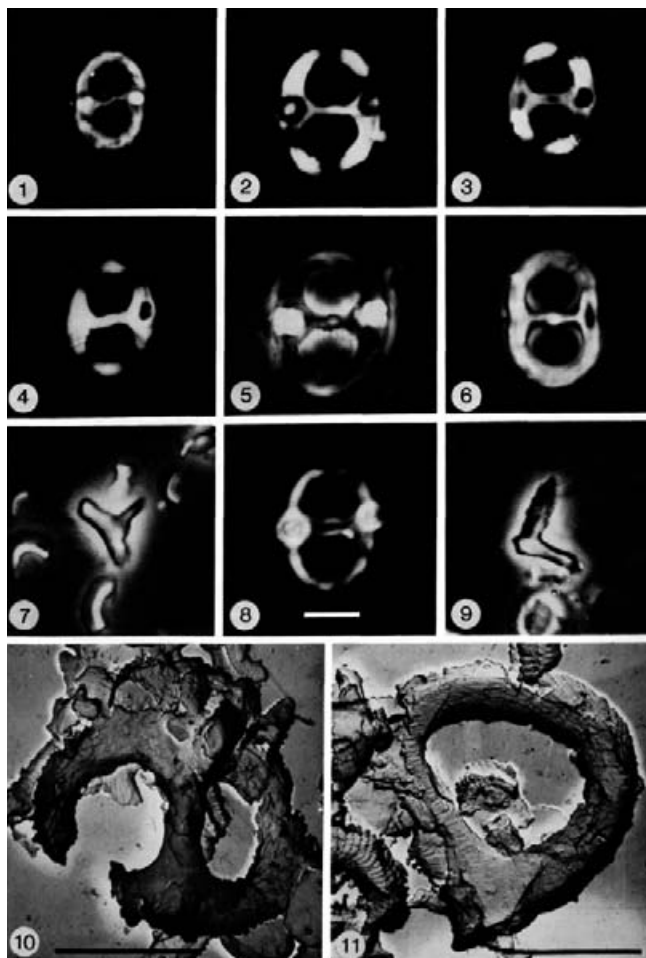
**Original description of *Transversopontis pax*
STRADNER & SEIFERT, 1980**



Text-Fig. 35a.
Original drawings of *Transversopontis pax*.
A: distal view, B: proximal view, C: lateral view.
Scale = 1 µm.



Text-Fig. 35c.
Stereoscan images of the holotype.
Distal view (1), oblique distal view (2), lateral view (3), close up of the transversal bridge showing two distal horns, strongly corroded and a medial hump.
Oblique proximal view of the paratype (4), close up of transversal bridge showing two parallel pads; oblique proximal view (6).
Scale in Text-Figs. 1–4: 5 µm.
Scale in Text-Figs. 5 and 6: 1 µm.



Holotypus: Pl. 2, Figs. 1–3 in STRADNER & SEIFERT, 1980 (GBA 2009/058/0070).

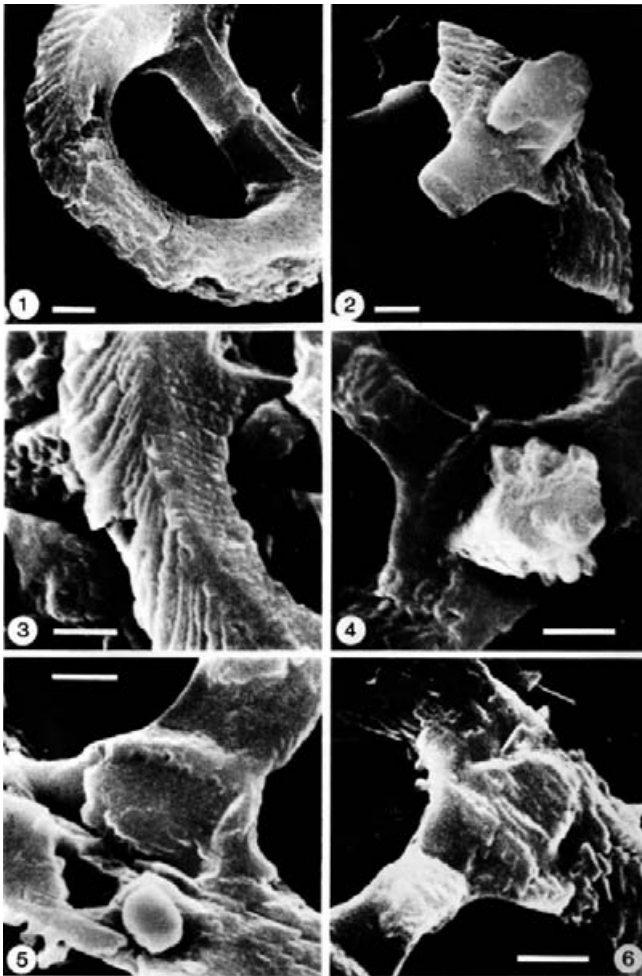
Derivatio nominis: *pax* (Lat.) = Frieden.

Locus typicus: Niederhollabrunn, Niederösterreich.

Stratum typicum: Diatomeenschichten des basal Oligozän (NP21).

Diagnose und Beschreibung: Discolithen der Heterococcolithen-Phase mit elliptischem Basalring und einer annähernd in Richtung der Querachse liegenden oder etwas schräg gestellten, mit zwei lateralen Distalhörnern und einer mit einem nur wenig aufragenden Mittelhöcker versehenen Querbrücke. Die Ultrastruktur der Distal- und der Proximalseite entspricht denjenigen bei anderen Arten von *Transversopontis*, *Discolithina* (vgl. STRADNER & EDWARDS, 1968: 36)

Text-Fig. 35b.
Photographs of the plane view.
Polarized light (2, 3, 4) and phase contrast (1, 5, 6, 8); basal ring and distal horn in phase contrast (7, 9). Electron micrograph of a damaged specimen (10, 11) – distal views showing two distal horns (10). Proximal view (11) of a corroded specimen without preserved ultrastructure of the proximal side.
Scale = 5 µm.



Text-Fig. 35d.
Stereoscan images of syntypes.
Oblique proximal view showing a distinct suture in the transversal bridge (1), oblique distal view of a fragment with single distal horn (2), proximal view of the ultrastructure of the proximal side and the basal ring (3), distal view of a large distal horn and of the medial hump (4), distal view of the basal ring and the transversal bridge after loss of a distal horn (5), oblique distal view of the transversal bridge and of a distal horn (6).
Scale = 1 µm.

und auch *Helicosphaera*: auf der Distalseite sind die Suturen flach spiralig bis randparallel, auf der Proximalseite hingegen radiär angeordnet. Die Schrägseite des Basalringes zeigt proximal betrachtet gegen den Uhrzeigersinn geneigte Riefen. Die Querbrücke lässt eine Quernaht und proximal zwei parallele Wülste erkennen. Die Distalhörner und der Mittelhöcker entsprechen in ihrer Ultrastruktur der Distalseite. Die Basalringe sind leicht in proximaler Richtung konkav gewölbt, entsprechend der mehr oder weniger sphärischen Gestalt der lebenden Kalkflagellatenzelle, der sie aufsäßen.

Dimensionen: Längsachse von 9–13 µm, Länge der Distalhörner von 1 bis über 5 µm schwankend.

Holotypus: Länge 12 µm, Breite 8 µm, Höhe 4 µm.

English translation:

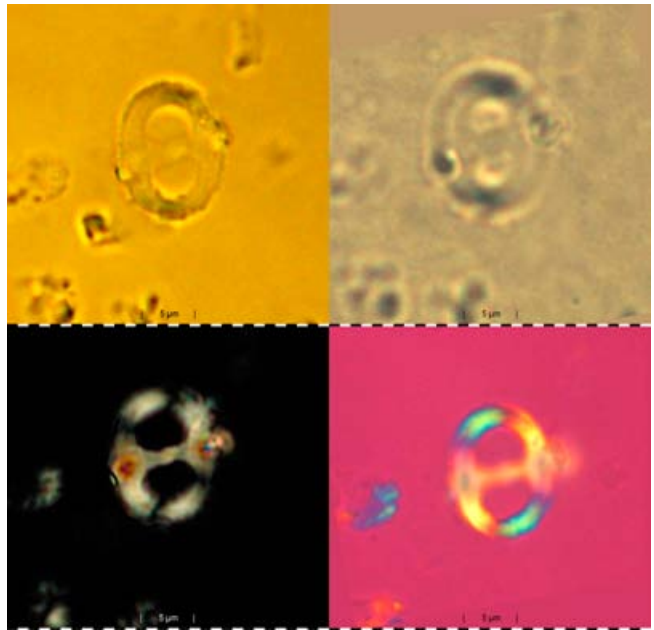
Holotype: Pl. 2, Fig. 1–3, paratype: Pl. 2, Figs. 4–6.

Derivation of name: *pax* (Lat.) = peace.

Type locality: Niederhollabrunn, Lower Austria.

Type level: Diatomaceous marl of basal Oligocene (NP21).

Discoliths built during the Heterococcolith phase of life cycle. The basal ring is elliptical with a transversal bridge,



Text-Fig. 35e.
Syntype in normal light and polarized light at different focus levels.

which is divided by a suture line. Two clumsy horns situated on the distal side of either side of the transversal bridge are the characteristic feature of this species. The ultrastructure of the distal as well as of the proximal side is similar to that of other species in the genera *Transversopontis*, *Helicosphaera* and *Discolithina* (compare STRADNER & EDWARDS, 1968); The central bridge, which can be slightly tilted against the transversal axis, shows thickenings on the distal as well as on the proximal side. The basal ring is concavely vaulted and thus fitting the spherical volume of the living cell.

Size: Length 12 µm, width 8 µm, height 3 µm.

Comments:

Stratigraphic distribution: Uppermost Eocene to Lowermost Oligocene; Zone NP21.

Incertae sedis

Family: Braarudosphaeraceae DEFLANDRE, 1947

Genus: Braarudosphaera DEFLANDRE, 1947

Braarudosphaera africana STRADNER, 1961, Text-Fig. 44

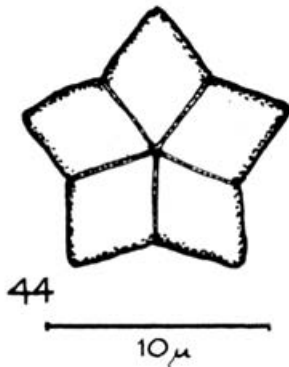
= NOËL 1958, Étude de Coccolithes, S. 189, T. IX, Fig. 4 [informally described as “Braarudosphaera à pentalithes très affilés (Albien des Ravix)”].

Original description of Braarudosphaera africana STRADNER, 1961

Paratypus: GBA 2009/058/0008/1.

Von NOËL wurde diese Art in Phosphaten des Albium von Ravix, Nordafrika, gefunden, aber nicht beschrieben. Pentolithen, deren Einzelteile mit ihren distalen Kanten spitze Winkel einschließen. Zwischen den Spitzen der Einzelteile liegen Einschnitte, in welche die Unterteilungslinien münden.

Größe: 10–15 µm.



Text-Fig. 36.
Original drawing of *Braarudosphaera africana* (hypotype).

Weiteres Vorkommen: Aragon, Mexiko (Mittelleozän), selten.

English translation:

This species was described by Noël from the Albian phosphates of Ravix, North Africa, but not named. Pentaliths, consisting of five rhombical parts of identical shape, with the distal tips of these enclosing acute angles. The suture lines between the parts meet the outline of the pentalith halfway between the tips.

Size: 10–15 µm.

Another occurrence: Aragon Formation, Mexico, rare.

Comments:

STRADNER thought, wrongly, that taxa signalled by Noël came from North Africa, but Ravix is in France.

Stratigraphic range: Upper Aptian to Lower Cenomanian. This taxa was probably reworked in Aragon Formation.

Braarudosphaera bigelowi subsp. *parvula* STRADNER, 1960, p. 3, Text-Fig. 2

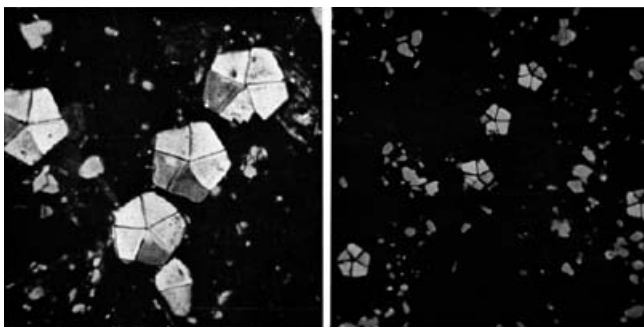
Original description of *Braarudosphaera bigelowi* subsp. *parvula* STRADNER, 1960

Syntypes: GBA 2009/058/0014.

Derivation of name: *parvula* (Lat.) = die kleine

Type level: OMV deepwell Himberg 1, 1189.5–1380 m. OMV deepwell Laxenburg 1.305 m, Upper Sarmatian of the Vienna Basin.

Die durch ihre geringen Dimensionen auffallende Kleinform von *Braarudosphaera bigelowi* (GRAN & BRAARUD) DEFLANDRE. Die Pentalithen dieser neuen Unterart entsprechen in ihrem Aufbau denen der typischen Art, sie sind aber an-



Text-Fig. 37a.
Original images of syntypes of *Braarudosphaera bigelowi* ssp. *parvula* (right), *Braarudosphaera bigelowi* (left).

nähernd um die Hälfte kleiner und wesentlich dünner. Im polarisierten Lichte erscheinen sie wegen ihrer geringen Dicke nur wenig leuchtend; ihr Durchmesser ist meist kleiner als 10 µm, ihre durchschnittliche Dicke beträgt 2 µm. Da diese neue Unterart auch selbständig ohne Beigesellung der typ. *Braarudosphaera bigelowi* vorkommt, erscheint eine Abtrennung der neuen Unterart *Braarudosphaera bigelowi parvula* gerechtfertigt und angezeigt. Man beachte, dass das Mikrofoto 2, welches die neue Unterart im polarisierten Lichte zeigt, mit der gleichen Vergrößerung (Objektiv 100x mit Ölimmersion, Planokular 10 X) wie das Mikrofoto 1 der typischen Art hergestellt wurde. Hauptvorkommen im Sarmat des südlichen Wiener Beckens: Tiefbohrung Himberg 1: 950 bis 1030 m, Tiefbohrung Laxenburg 1: 300 bis 305 m, Tiefbohrung Laxenburg 2: Spülprobe bei 205 m. Da die Hauptvorkommen der Kleinform, so weit bis jetzt beobachtet, im Hangenden des Vorkommens der typischen Form liegen, also in geologisch jüngeren Schichten des Sarmats, kann die Größenverminderung als eine Folge der zunehmenden Verbrackung des Sarmatmeeres angesehen werden. Hauptvorkommen im Sarmat des südlichen Wiener Beckens: Tiefbohrung Himberg 1: 1189,5 bis 1380 m; Tiefbohrung Laxenburg 1: 350 bis 355 m, Tiefbohrung Laxenburg 2: Spülprobe bei 210 m.

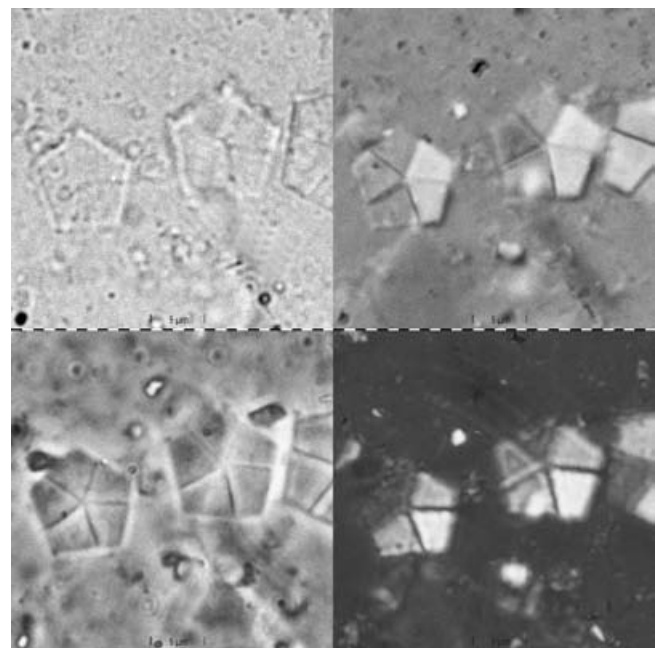
English translation:

Syntypes: GBA 2009/058/0014.

Derivation of name: *parvula* (Lat.) = the small one.

Type level: OMV deepwell Himberg 1, 1189.5 m – 1380 m. OMV deepwell Laxenburg 1.305 m, Upper Sarmatian of the Vienna Basin.

Pentaliths of *Braarudosphaera bigelowi* (GRAN & BRAARUD) DEFLANDRE that are only half the size of the common species. They measure less than 10 µm. Since they are thinner than the common species, they appear darker under crossed nicols. The blooms of this subspecies occurred in the younger Sarmatian, at a time when the water of the Paratethys was turning brackish, that is in core distance about 50 m above the occurrence of the normal-sized pentaliths.



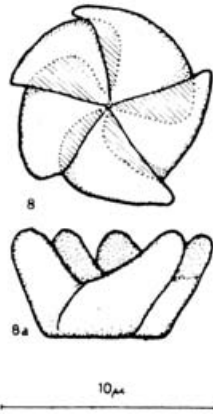
Text-Fig. 37b.
Syntypes in normal and polarized light and phase contrast.

Comments:

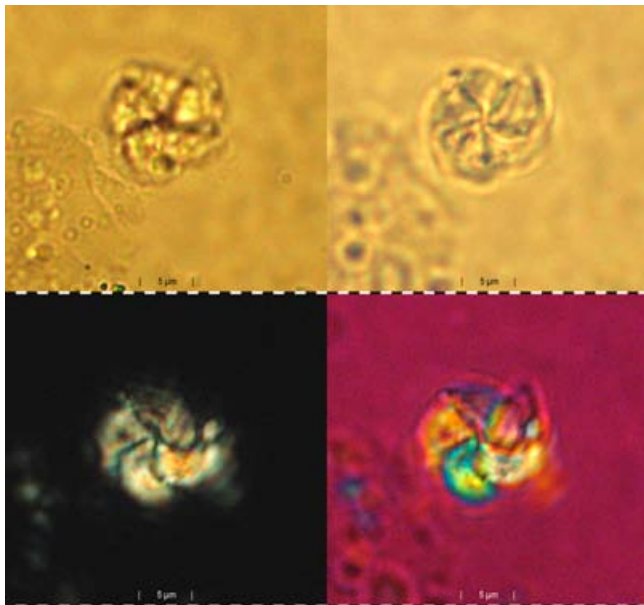
Stratigraphic distribution: Upper Miocene (Sarmatian); Zone NN11.

Braarudosphaera turbinea STRADNER, 1963, p. 10, Pl. 6, Figs. 8, 8a

Original description of *Braarudosphaera turbinea* STRADNER, 1963



Text-Fig. 38a. Original drawings of *Braarudosphaera turbinea*.



Text-Fig. 38b. Lectotype in normal and polarized light at different focus levels.

Holotype: GBA 2009/058/0049.

Derivation of name: *turbineus* (Lat.) = whirling.

Type locality: Haidhof W Ernstbrunn, Lower Austria.

Level: Danian.

Description: Pentaliths consisting of 5 roughly triangular sectors overlapping each other counterclockwise, the tips of which are tilted up to the distal side.

Comments:

Stratigraphic distribution: Upper Cretaceous to lower Paleocene (Maastrichtian–Danian); HO in Zone NP3.

Braarudosphaera undata STRADNER, 1959b, p. 487, Text-Fig. 65

Original description of *Braarudosphaera undata* STRADNER, 1959b

Lectotypus: GBA 2009/058/0008/2.

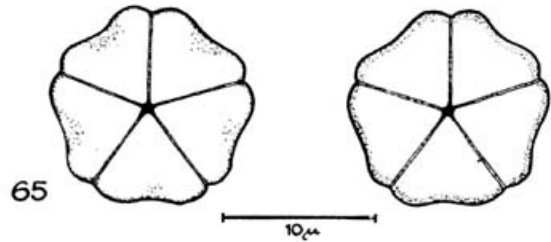
Derivatio nominis: *unda* (Lat.) = Welle.

Locus typicus: Aragon-Formation, Mexico.

Stratum typicum: Unter-Eozän.

Diagnose: Pentalithen mit gewelltem Umriss. Jeder Einzelteil hat zwischen zwei runden Höckern eine sanfte Einbuchtung. Paläozän (Thanetium) von Mattsee, Stat. 130, Salzburg; Unteres Eozän von Aragon, Mexiko.

Größe: 12–14 µm.



Text-Fig. 39a. Original drawings of *Braarudosphaera undata*.

English translation:

Lectotype: GBA 2009/058/0008/2.

Derivation of name: *unda* (Lat.) = wave.

Type locality: Aragon Formation, Mexico.

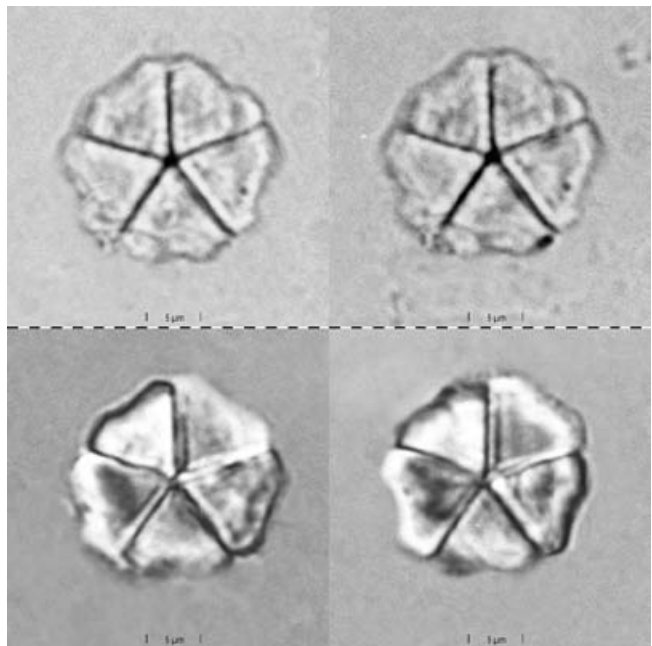
Level: Lower Eocene.

Pentaliths with wavy outline. Each of the five symmetrical segments is slightly indented on its peripheral side.

Size: 12–14 µm

Comments:

Stratigraphic distribution: Middle Eocene (Lutetian); Zone NP14b–NP15b.



Text-Fig. 39b. Lectotype in normal and polarized light.

Genus: *Micrantholithus* DEFLANDRE in DEFLANDRE & FERT, 1954

Micrantholithus angulosus STRADNER in STRADNER & PAPP, 1961, p. 482 (= *Micrantholithus flos* subcent. *angulosus* STRADNER 1959b, p. 482, Text-Figs. 61, 62).

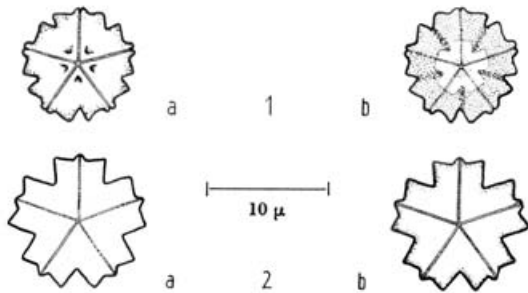
Original description of *Micrantholithus flos* subcent *angulosus* STRADNER, 1959b

Lectotypus: GBA 2009/058/0038.

Derivatio nominis: *angulosus* (Lat.) = winkelig.

Locus typicus: Gujabal, Mexiko.

Level: Mittel-Eozän.

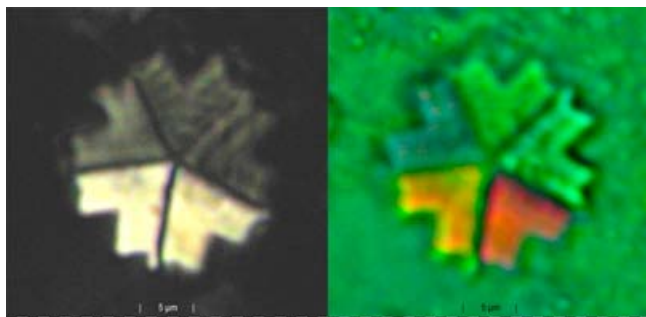


Text-Fig. 40a.
Original drawings of *Micrantholithus angulosus*.

Diagnose und Beschreibung: Pentalithen bestehend aus 5 Einzelteilen, deren Umrisslinien kantig sind und am Außenrand des Einzelsteines 3 Buchten bilden, eine tiefere in der Mitte und je eine seichtere nahe der rechten und linken Unterteilungslinie. Die zwischen den seichten Lateralbuchten liegenden Anteile von je 2 benachbarten Einzelsteinen ragen ein wenig in distaler Richtung vor. Verstärkungsleisten fehlen oder sind nur sehr dünn ausgebildet. Die Pentalithen sind flach, gelegentlich aber sehr dick.

Durchmesser: 9–13 µm.

Beziehungen: *Micrantholithus angulosus* hat die beiden Lateralbuchten mit *Micrantholithus bramlettei* DEFLANDRE gemeinsam, welcher allerdings an Stelle eines Mitteleinschnittes eine distale Erweiterung der Einzelsteine besitzt. Ansonsten steht *Micrantholithus angulosus* vermittelnd zwischen *Micrantholithus flos* DEFLANDRE und *Micrantholithus vesper* DEFLANDRE.



Text-Fig. 40b.
Holotype in polarized and normal light.

English translation:

Lectotype: GBA 2009/058/0038.

Derivation of name: *angulosus* (Lat.) = angular.

Type locality: Gujabal, Mexico.

Type level: Middle Eocene.

Diagnosis and description: Pentaliths consisting of five radially arranged triangular symmetrical parts with rough-edged distal rim. This rim shows a deeper notch in the middle and two smaller lateral notches. The straight suture lines are extended in distal direction. The pentaliths vary in thickness, some are flat, others sturdy.

Size: 9–13 µm.

Remarks: *Micrantholithus angulosus* can be considered a transitional form between *Micrantholithus flos* DEFLANDRE and *Micrantholithus vesper* DEFLANDRE.

Comments:

Stratigraphic distribution: Middle Eocene (Bartonian); Zone NP16–NP17.

Micrantholithus obtusus STRADNER, 1963, p. 11, Pl. 6, Figs. 11 and 11a

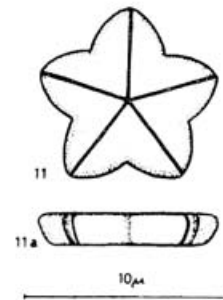
Original description of *Micrantholithus obtusus* STRADNER, 1963

Holotype: GBA 2009/058/0056.

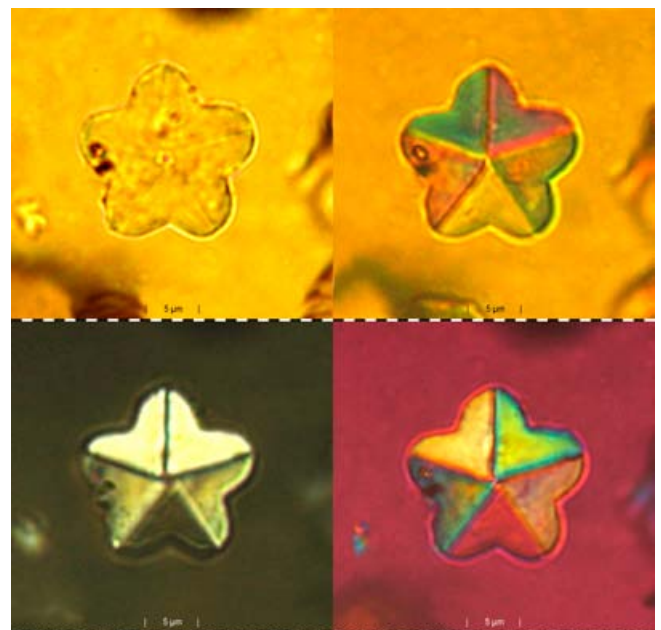
Derivation of name: *obtusus* (Lat.) = blunt.

Type locality: Nordhorn Nord 11, Germany.

Level: Upper Hauterivian.



Text-Fig. 41a.
Original drawings of *Micrantholithus obtusus*.

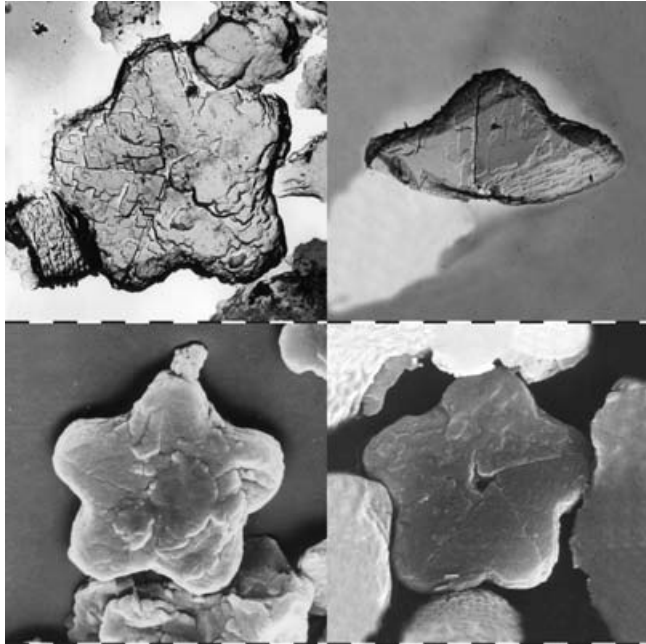


Text-Fig. 41b.
Lectotype in polarized and normal light at different focus levels.

Diagnosis and description: Star-like pentoliths consisting of 5 flat sectors with notched margins and blunt tips.

Comments:

Stratigraphic distribution: Berriasian to Aptian.



Text-Fig. 41c.
TEM and SEM micrographs of *Micrantholithus obtusus*.

Family: Lithostromationaceae DEFLANDRE, 1959

Genus: Trochoaster KLUMPP, 1953

Type species: *Trochoaster simplex* KLUMPP 1953, p. 385.

Synonym: *Polycladolithus* DEFLANDRE in DEFLANDRE & FERT, 1954, p. 170.

Type species: *Polycladolithus operosus* DEFLANDRE in DEFLANDRE & FERT, 1954, p. 170, Pl. 12, Figs. 3–6, Text-Fig. 125.

Comments:

Taxonomic status: MARTINI & STRADNER (1960) established synonymy of *Polycladolithus* and *Trochoaster*.

Trochoaster conglobatus STRADNER, 1962, p. 374, Pl. 2, Figs. 16, 18.

Original description of *Trochoaster conglobatus* STRADNER, 1962

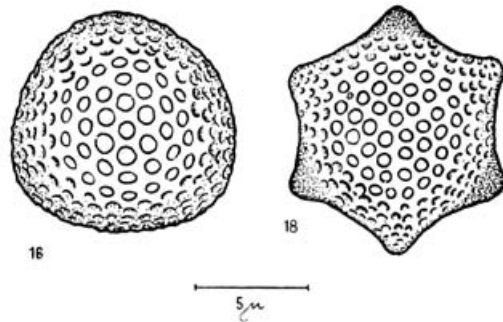
Holotypus: GBA 2009/058/0039/3.

Derivatio nominis: *conglobatus* (Lat.) = gerundet.

Locus typicus: Basale Glaukonitsande des Steinbruches Reingruberhöhe bei Bruderndorf, Niederösterreich.

Stratum typicum: Obereozän (jüngeres Led; GOHRBANDT, 1962).

Diagnose und Beschreibung: Durch unzählige runde Poren durchbrochene, stark aufgetriebene, im Umriss annähernd runde bis abgerundete-sechseckige hohle Kalkkörperchen. Ähnlich wie bei *Trochoaster deflandrei* (STRADNER) MARTINI & STRADNER sind je drei durch Winkel von 120° voneinander getrennte Sternspitzen einer Seite zugekehrt, während die zu diesen alternierend angeordneten anderen Spitzen der

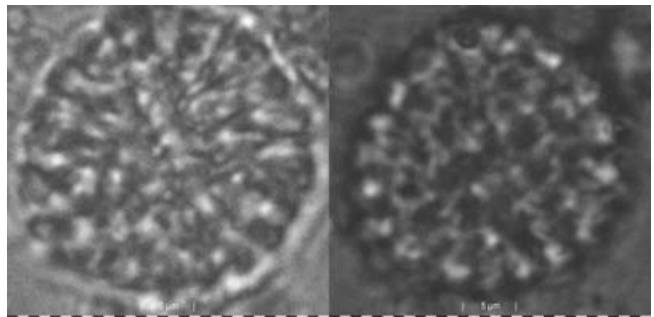


Text-Fig. 42a.
Original drawing of *Trochoaster conglobatus*.

gegenüberliegenden Seite zugekehrt sind. Die Lage der Poren ist keinem starren Muster unterworfen, gelegentlich liegen jedoch Poren im Quincunx-Muster. Selten.

Dimensionen: Durchmesser 8–10 µm, Höhe 7–9 µm.

Beziehungen: *Trochoaster* ist nahe mit *Trochoaster deflandrei* (STRADNER) MARTINI & STRADNER verwandt, von welchem er sich durch den plumpen Bau und die weitaus größere Anzahl von Poren unterscheidet. Der gleichzeitig im Typusmaterial vorkommende *Trochoaster simplex* KLUMPP (vgl. Taf. II, Fig. 17) hat wesentlich größere Poren bzw. Fenster, welche nach einem sehr regelmäßigen System angeordnet sind (vgl. STRADNER & PAPP, 1961, S. 130–134).



Text-Fig. 42b.
Holotype in normal light at different focus levels.

English translation:

Holotype: GBA 2009/058/0039/3.

Derivation of name: *conglobatus* (Lat.) = rounded.

Type locality: Basal glauconitic sands of the Reingruberhöhe quarry, Bruderndorf, Lower Austria.

Level: Upper Eocene (Led; GOHRBANDT, 1962). Stratotype of the NP19 Nannoplankton Zone of MARTINI.

Diagnosis and description: Rounded or broadly hexagonal inflated nannofossils showing innumerable pores on their surface. Similar to *Trochoaster deflandrei* (STRADNER) MARTINI & STRADNER in the hexagonal forms the blunt tips are alternatively pointing to either this or that side of the nannofossil, with angles of 120 degrees between them. The small round pores show a more or less random distribution, sometimes they lie in quincunx pattern.

Relations: *Trochoaster conglobatus* is closely related to *Trochoaster deflandrei*, from which it differs by its massive volume and the greater number of pores. The co-occurring *Trochoaster simplex* KLUMPP has larger pores or windows respectively, which are aligned in a very regular system (compare STRADNER & PAPP, 1961, p. 130–134).

Size: 10–12 µm.

Comments:

Stratigraphic distribution: Upper Eocene (Priabonian); Zone NP19–20.

Trochoaster deflandrei (STRADNER) MARTINI & STRADNER, 1960 (= *Polycladolithus deflandrei* STRADNER, 1959b, p. 487, Text-Fig. 76, 77i–l).

Original description of *Polycladolithus deflandrei* STRADNER, 1959b

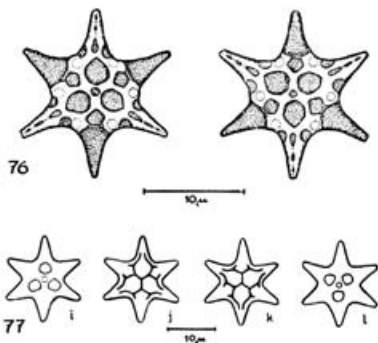
Lectotypus: GBA 2009/058/0011.

Derivatio nominis: Herrn Dir. Prof. Dr. G. DEFLANDRE, Paris, in Dankbarkeit gewidmet.

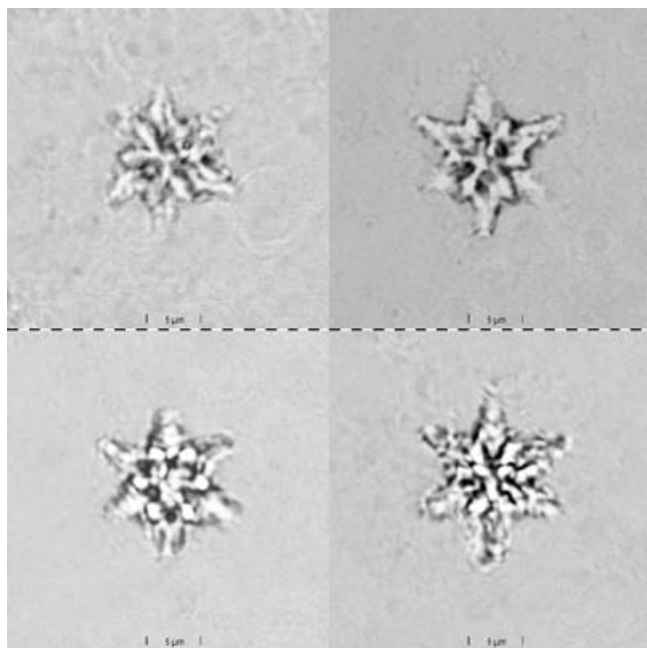
Locus typicus: Aragon, Mexiko.

Stratum typicum: Unter-Eozän.

Diagnose und Beschreibung: Sechssarmige Kalkkörperchen mit reichen Oberflächenverzierungen. Die Primärfenster sind im Gegensatz zu *Polycladolithus stellaris* groß ausgebildet, wodurch sich die gesamten Symmetrieverhältnisse des Kalkkörperchens von denen der vorigen Formart unterscheiden. Je drei zu einer Seite gehörenden Arme stehen räumlich ab. Die schematische Darstellung der Strukturen



Text-Fig. 43a. Original drawings of *Polycladolithus deflandrei*.



Text-Fig. 43b. Holotype in normal light at different focus levels.

zeigt deutlich den eigenartigen Bau dieses wundersamen Nannofossiles.

Größe: 15–17 µm.

English translation:

Lectotype: GBA 2009/058/0011.

Derivation of name: Thankfully dedicated to Prof. Dr. Georges DEFLANDRE, Paris.

Type locality: Aragon, Mexico.

Level: Lower Eocene.

Description and diagnosis: Star shaped calcareous nannofossils with six pointed rays and rich surface ornamentation. Contrary to *Polycladolithus stellaris* nov. spec., the primary windows surrounding the central hole are larger than there. Three alternating rays with angles of 120 degrees between them are pointing either towards the observer or away from it. The schematic drawings show the complicated inner structure of this astounding nannofossil at different optical levels.

Size: 15–17 µm.

Comments:

Stratigraphic distribution: Lower Eocene to Upper Pliocene (Ypresian–Gelasian).

Polycladolithus stellaris STRADNER, 1959b, p. 487, Text-Figs. 74, 75, 77e–h

Original description of *Polycladolithus stellaris*, STRADNER, 1959b

Lectotypus: GBA 2009/058/0012.

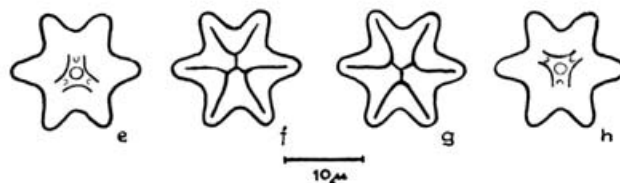
Derivatio nominis: *stellaris* (Lat.) = sternförmig.

Locus typicus: Tiefbohrung Puchkirchen 1, Oberösterreich.

Stratum typicum: Unteroligozän.

Beschreibung: Kalkkörperchen mit sternförmigem Umriss, meist sechsstrahlig. Ein zentrales Fenster und die kräftigen Sternarme unterscheiden diese Formart von der vorhergehenden. Der Aufbau der Hauptachsen ähnelt dem von Lithostromation. Die dem Zentralfenster nahen Primärfenster sind in ihrer Ausbildung unterdrückt.

Größe: 12–15 µm.



Text-Fig. 44a. Original drawings of *Polycladolithus stellaris*.

English translation:

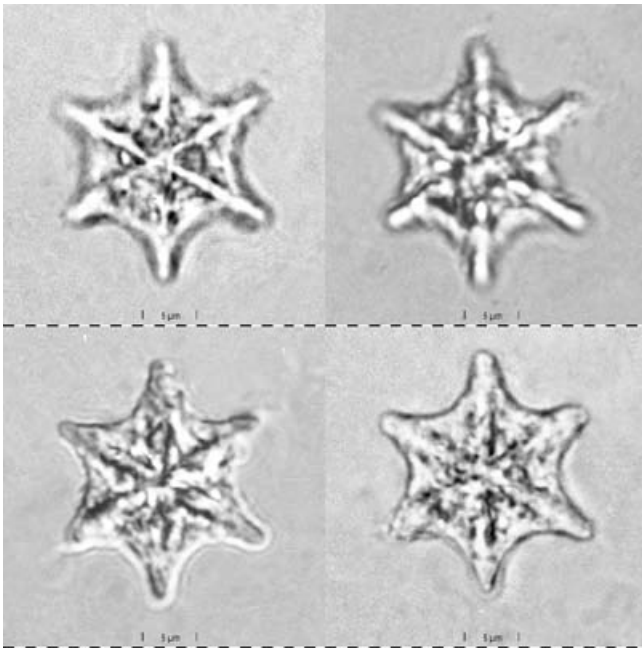
Lectotype: GBA 2009/058/0012.

Derivation of name: *stellaris* (Lat.) = star-shaped.

Type locality: RAG deepwell Puchkirchen 1, Upper Austria.

Level: Lower Oligocene.

Diagnosis and description: Calcareous bodies of star-shaped outline, in most cases hexangular. The reticulate surface pattern is identical on both sides, however shifted by 120 degrees, as can be recognized by the position of the Y-shaped part surrounding the central hole.



Text-Fig. 44b.
Holotype of *Polycladolithus stellaris* in normal light at different focus levels.

The primary windows surrounding it are reduced in size. By studying different optical levels of this delicate nanno-fossil, one can understand its complicated structure.

Size: 12–15 µm.

Comments:

Taxonomic status: *P. stellaris* is a junior synonym of *Trochoaster simplex* (see MARTINI & STRADNER, 1960, p. 266).

Family: Nannotetrinaceae AUBRY & STRADNER nov. fam.

Type genus: Nannotetrina ACHUTHAN & STRADNER, 1969, p. 7.

Diagnosis: Nannoliths in the form of a pyramid with a roughly quadrangular or hexagonal base. The sides are formed by four lateral plate-like elements that may be thickened outwardly along their main axis. The inside of the pyramid is divided into four alveolar cavities by four central elements forming an orthogonal cross. The central elements meet with the lateral elements along their main axis, and thus the four central plates alternate with sutures between the lateral elements.

Genus: Nannotetrina nom. nov. subst. pro Nannotetraster sensu restr. ACHUTHAN & STRADNER, 1969, p. 7

Type species: *Nannotetraster fulgens* (STRADNER) ACHUTAN & STRADNER, 1969 (= *Nannotetraster fulgens* STRADNER in MARTINI & STRADNER 1960, p. 268, Text-Figs. 10, 16a, b).

Original description of Nannotetraster fulgens STRADNER in MARTINI & STRADNER, 1960

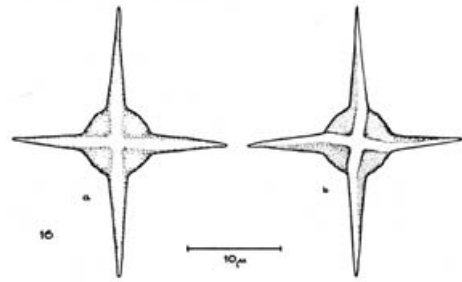
Lectotypus: GBA 2009/058/0020.

Derivatio nominis: *fulgere* (Lat.) = strahlen.

Locus typicus: Aragon, Mexiko.

Stratum typicum: Unter-Eozän.

Diagnose: Ein *Nannotetraster* mit vier langen dünnen spitzen Strahlen, die aufeinander senkrecht stehen.

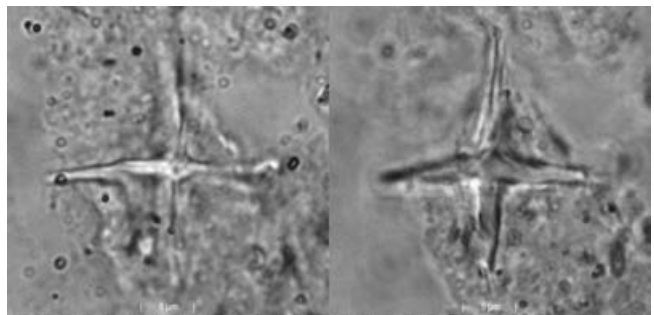


Text-Fig. 45a.
Original drawings of *Nannotetraster fulgens*.

Beschreibung: Das Relief der beiden Flachseiten ist verschieden. Auf der Facies superior, als welche nicht wie bisher die das stärker erhabene Kreuz tragende Seite angesehen werden kann, sondern die bei vielen Nannotetrasterarten mit Unterteilungslinien versehene Flachseite betrachtet werden muss, sind die Strahlen durchlaufend geradkantig. Auf der Facies inferior hingegen sind die erhabenen Kanten der Strahlen in distaler Richtung leicht nach links geknickt.

Größe: 20–30 µm.

Beziehungen: *Nannotetraster fulgens* gehört wegen seiner geknickten Strahlenkanten in die Verwandtschaft von *Nannotetraster swasticoides* (MARTINI) MARTINI & STRADNER, *N. coronatus* MARTINI, *N. insignatus* MARTINI und *N. alatus* MARTINI.



Text-Fig. 45b.
Holotype in normal light at different focus levels.

English translation:

Lectotype: GBA 2009/058/0020.

Derivation of name: *fulgens* (Lat.) = beaming, radiating.

Type locality: Aragon Formation, Mexico.

Level: Lower Eocene.

Diagnosis and description: Asteroliths with four pointed spines exceeding in their length the diameter of the central disc. The reliefs of their flat sides are different: One side is decorated with a straight cross extending out into the spines, while the stronger cross-shaped structure of the other side is twisted in clockwise direction. No suture lines are visible.

Relations: Due to its twisted cross *Nannotetraster fulgens* appears closely related to *N. swasticoides* (MARTINI) STRADNER & MARTINI, to *N. insignatus* MARTINI and *N. alatus* MARTINI.

Size: 20–30 µm.

Comments:

Stratigraphic distribution: Middle Eocene (Lutetian). The lowest occurrence of *N. fulgens* defines the base of Zone NP15. Highest occurrence in lower Zone NP16.

Nannotetrina spinosa (STRADNER) BUKRY 1973 (= *Nannotetraster spinosus* STRADNER, 1960 in MARTINI & STRADNER, 1960, p. 269, Text-Figs. 11, 17a–c

Original description of *Nannotetraster spinosus* STRADNER, 1960 in MARTINI & STRADNER, 1960

Lectotypus: GBA 2009/058/0021.

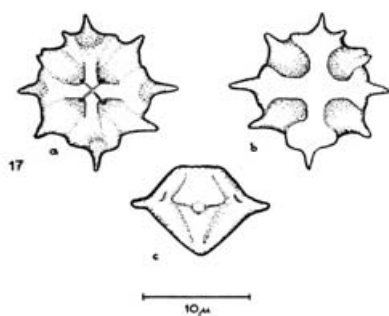
Derivation nominis: *spinosus* (Lat.) = dornig.

Locus typicus: Mattsee Station 37, Salzburg, Österreich.

Stratum typicum: Mittleres Eozän (Lutetium).

Weiteres Vorkommen: Kühlgraben, Salzburg (Ypres).

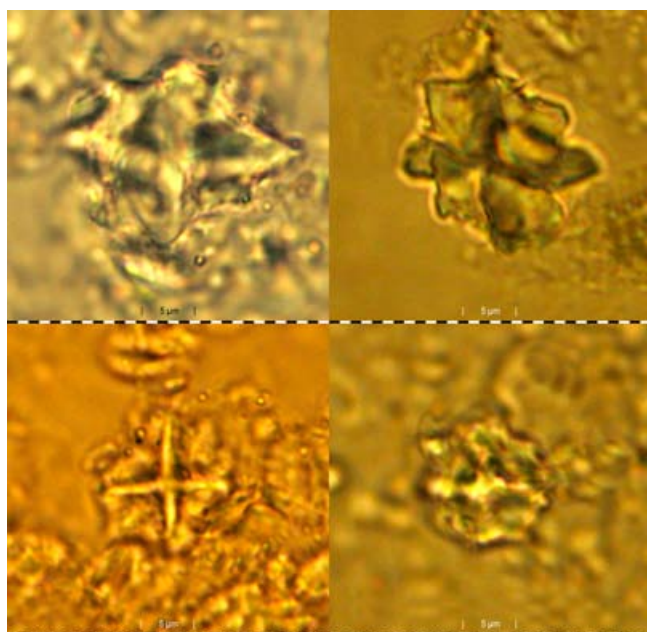
Diagnose: Ein *Nannotetraster*, dessen vier Strahlen distal stark verbreitert sind und von einem kurzen Dorn überragt werden.



Text-Fig. 46a.
Original drawings of *Nannotetraster spinosus*.

Beschreibung: Die Facies superior zeigt im Zentrum Unterteilungslinien. Die vier Strahlen sind auf beiden Seiten reliefartig erhoben, auf der Facies superior weniger als auf der Facies inferior. Die Reliefkanten der Facies superior sind nahe der Peripherie gegabelt, doch tragen auch die neben diesen Gabelungen gelegenen Anteile der Sektoren Dornfortsätze.

Größe: 13–15 µm.



Text-Fig. 46b.
Syntypes in normal light.

Beziehungen: *Nannotetraster spinosus* scheint mit *Nannotetraster cristatus* (MARTINI) MARTINI & STRADNER nahe verwandt zu sein, da letztere Art auf der Facies superior ebenso symmetrische Gabelungen aufweist.

English translation:

Lectotype: GBA 2009/058/0021.

Derivation of name: *spinosus* (Lat.) = with spines.

Type locality: Mattsee Station 37 (ABERER & BRAUMÜLLER, 1958), Salzburg, Austria.

Level: Middle Eocene (Lutetian).

Diagnosis and description: Asterolithus consisting of four sectors which on their outline are surmounted by two or more short spines. One side is decorated with a cross-shaped structure distally broadened near the rim. The other side also shows a cross-shaped central structure, which is bifurcated near the rim thus embracing one of the thorns, the main spine of each sector.

Remarks: Closely related to *Nannotetraster cristatus* (MARTINI) MARTINI & STRADNER, which also shows bifurcations.

Size: 13–15 µm.

Comments:

Stratigraphic distribution: Middle Eocene (Lutetian). Subzone NP14b–NP15.

Nannotetrina austriaca (STRADNER) AUBRY, 1988 (= *Trochoaster austriacus* STRADNER, 1959a, p. 8, Text-Fig. 11).

Original description of *Trochoaster austriacus* STRADNER, 1959a

Lectotype: GBA 2009/058/0007.

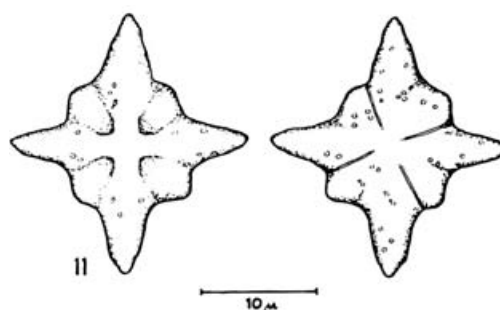
Derivatio nominis: *austriacus* (Lat.) = Austrian.

Type locality: Nußdorf at Haunsberg (Holzmannberg).

Level: Middle Eocene (Lutetian).

Diagnosis and description: Asteroliths consisting of 4 rays which are almost twice as long as the radius of the basal plate. In this new formspecies the basal plate seems to be derived from parts of the rays, as can be concluded from the course of the suture-lines. On one face the rays are united in the center to a slender, low relief cross, on the other side the suture-lines can be seen dividing the asterolith into four similar rays of irregular symmetry.

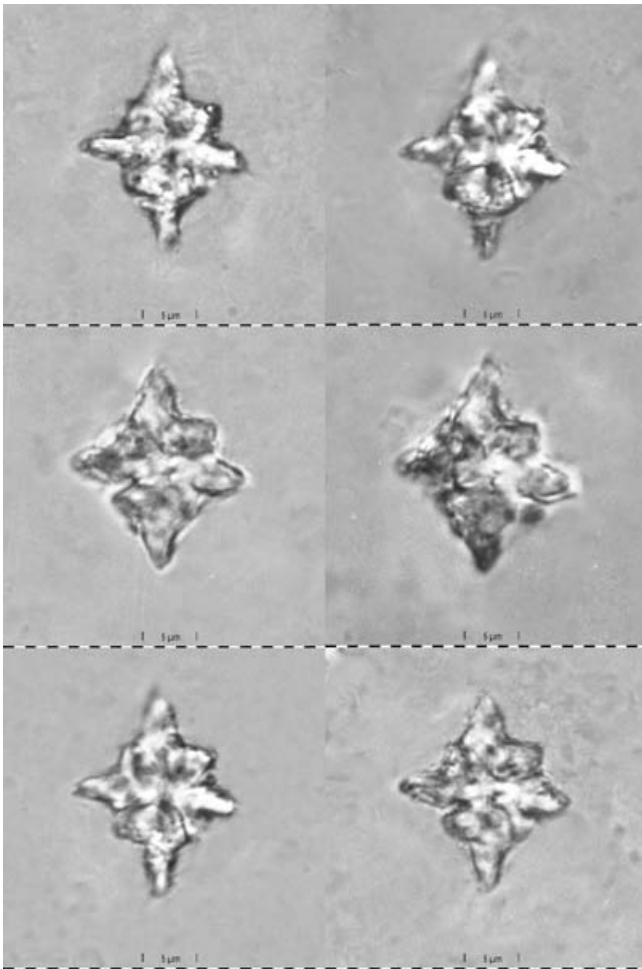
Size: 15–20 µm.



Text-Fig. 47a.
Original drawings of *Trochoaster austriacus*.

Comments:

Stratigraphic distribution: Middle Eocene (Lutetian); Zone NP15a to lower NP16.



Text-Fig. 47b.
Lectotype of *Trochoaster austriacus* in normal light at different focus levels.

Nannotetrina mexicana (STRADNER) BUKRY, 1973b (= *Trochoaster mexicanus* STRADNER, 1959b, p. 480, Text-Fig. 55)

**Original description of *Trochoaster mexicanus*
STRADNER, 1959b**

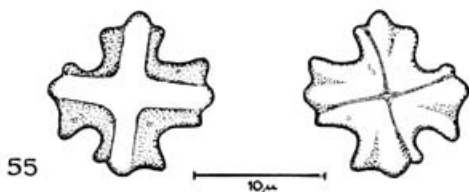
Lectotypus: GBA 2009/058/0013.

Derivatio nominis: *Mexicanus* = aus Mexiko stammend.

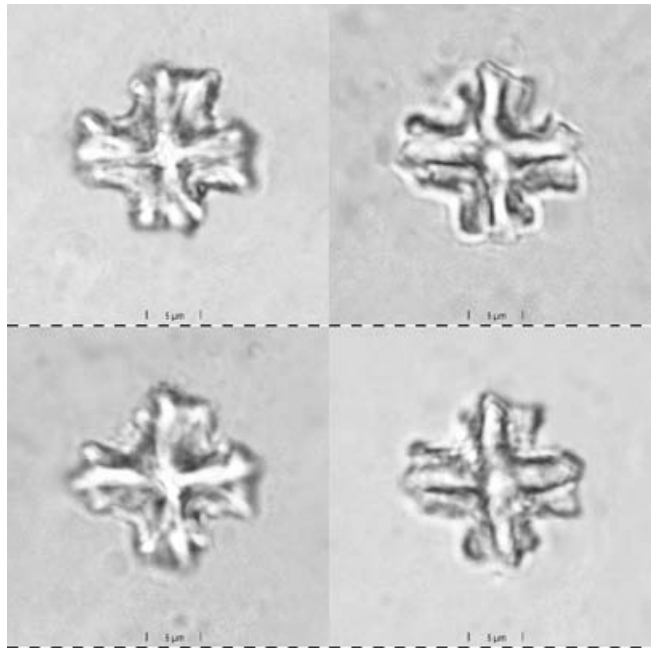
Locus typicus: Aragon, Mexiko; selten.

Stratum typicum: Unteres Eozän.

Beschreibung: Asterolithen bestehend aus vier Asteroradien, von denen jeder in drei verschieden große Höcker ausläuft. Wie von der Facies inferior her betrachtet zu erkennen ist, sind die beiden vom Mittelpunkt am weitesten entfernten Strahlenenden eng miteinander verwachsen und nur durch eine schwache Furche getrennt. Der drit-



Text-Fig. 48a.
Original drawings of *Trochoaster mexicanus*.



Text-Fig. 48b.
Holotype in normal light at different focus levels.

te und kleinste Strahlenanteil ist von den beiden größeren durch eine weite Bucht getrennt und als kleiner Höcker dem ihm anliegenden nächsten Asteroradius angeschlossen. Die Facies superior trägt ein reliefartig erhöhtes Balkenkreuz, die Facies inferior hat deutliche Unterteilungslinien.

Größe: 10–12 µm.

English translation:

Derivation of name: occurring in Mexico.

Lectotype: GBA 2009/058/0013.

Type locality: Aragon Formation.

Level: Lower Eocene. Rare.

Diagnosis and description: Asteroliths of four-rotate symmetry, consisting of four asymmetrical parts separated by slightly curved suture lines. These are visible only on one side, while the other side is decorated by a heavy cross-shaped structure. The four sectors show a wavy outline with three bigger knobs on the left separated by a bay from a small knob on the right (viewed from the side with the sutures).

Size: 10–12 µm.

Comments:

Stratigraphic distribution: Middle Eocene (Lutetian); Zone NP15a to lower NP16.

Nannotetrina pappi (STRADNER) PERCH-NIELSEN, 1971 (= *Trochoaster pappi* STRADNER, 1959b, p. 480, Text-Fig. 54)

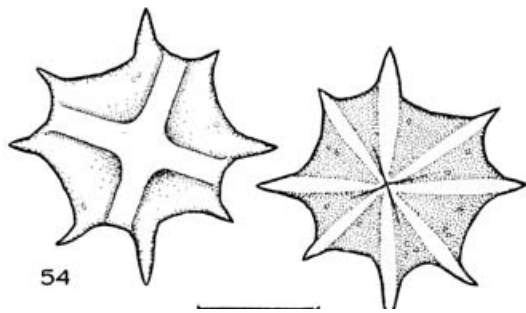
**Original description of *Trochoaster pappi*
STRADNER, 1959b**

Lectotypus: GBA 2009/058/0010/2.

Derivatio nominis: Herrn Univ. Prof. Dr. A. PAPP in Dankbarkeit gewidmet.

Locus typicus: Aragon, Mexiko.

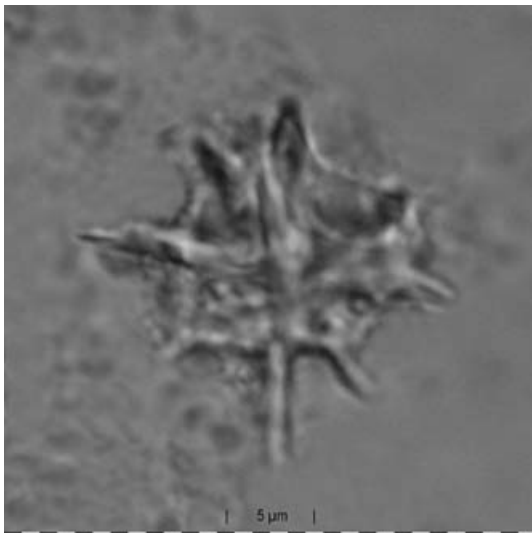
Stratum typicum: Unter-Eozän.



Text-Fig. 49a.
Original drawings of *Trochoaster pappii*.

Beschreibung: Asterolithen mit gebuchtetem Unterbau, der von acht spitzen Strahlenfortsätzen überragt wird. Die Balken des Reliefkreuzes der Facies superior enden in den Buchten des Unterbaues. Die Facies inferior ist durch acht strahlenförmig angeordnete Rippen verziert. Die Unterteilungslinien lassen erkennen, dass zu jedem Asteroradius ein kräftiger langer und ein etwas kürzerer Dornfortsatz gehören, die mit den entsprechenden Fortsätzen des anliegenden Asteroradius Winkel von 90° einschließen.

Größe: 20–22 μm .



Text-Fig. 49b.
Holotype in normal light.

English translation:

Lectotype: GBA 2009/058/0010/2.

Derivation of name: Thankfully dedicated to Univ. Prof. Dr. A. PAPP, Vienna.

Type locality: Aragon Formation, Mexico.

Level: Lower Eocene.

Diagnosis and description: Asteroliths of four-rayed symmetry, each of the four sectors being extended into two pointed spines that unite at the centre. One side is decorated by a broad cross-shaped structure, while on the other side short suture lines are visible near the centre.

Size: 20–22 μm .

Comments:

Stratigraphic distribution: Middle Eocene (Lutetian); Zone NP15.

Family: Rhomboasteraceae AUBRY (in press)

Genus: *Imperiaster* MARTINI, 1970

Type species: *Imperiaster obscurus* (MARTINI) MARTINI, 1970 (= *Discoaster obscurus* MARTINI, 1958, p. 358, Pl. 1, Figs. 4a-c).

Syn: *Marthasterites reginus* STRADNER, 1962, p. 372, Pl. 3, Figs. 8–10.

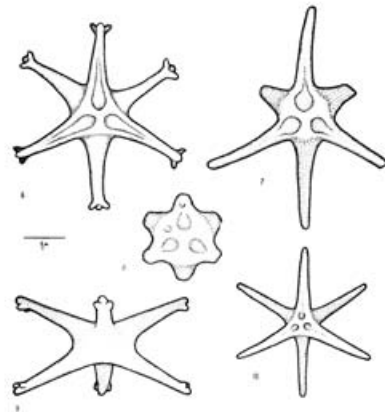
Original description of *Marthasterites reginus* STRADNER, 1962

Holotypus: GBA 2009/058/0044.

Derivatio nominis: *reginus* (Lat.) = königlich.

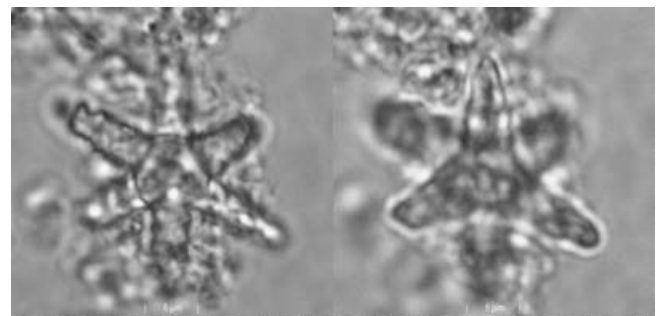
Locus typicus: Argiles d'Ypres, Steinbruch der Gebr. De Simpele in Kortemark, Belgien.

Stratum typicum: Unteres Ypresian.



Text-Fig. 50a.
Original drawings of *Marthasterites reginus*.

Diagnose und Beschreibung: Kalkkörperchen aus einem ortholithisch aufgebauten Stück bestehend aus sechs sich verjüngenden, distal mit je zwei lateral abstehenden Fortsätzen versehenen, leicht gekrümmten Armen, ohne Nahtlinien. Je drei Arme schließen bei Flachansicht Winkel von 120° ein und sind zu den alternierend angeordneten Armen, welche in einer anderen Ebene liegen, um 60° verschoben. Durch Heben und Senken des Objektivs ist an flachliegenden Exemplaren zu erkennen, dass je drei Arme zum bzw. vom Beschauer weggerichtet sind und dass die Mitte des Kalkkörperchens beiderseits konkav ist. Das Mittelfeld ist durch drei in der Mitte vereinte Rippen und dazwischenliegende Furchen, welche in Richtung der Arme liegen, verziert. Die von den Enden der Arme schräg lateral abstehenden Fortsätze sind gegen die alternierend



Text-Fig. 50b.
Holotype in normal light at different focus levels.

angeordneten Arme gerichtet. Die nicht an allen Exemplaren erkennbare sehr schwache Krümmung der Arme lässt die Zusammengehörigkeit von je zwei Armen, ähnlich wie bei *Marthasterites contortus* (STRADNER) DEFLANDRE, erkennen. Nicht selten.

Größe: Durchmesser 18–28 µm, Höhe 8–13 µm.

English translation:

Holotype: GBA 2009/058/0044.

Derivation of name: *reginus* (Lat.) = royal.

Type locality: Argiles d'Ypres, quarry of Gebr. De Simpele, Kortemark, Belgium.

Level: Lower Ypresian.

Diagnosis and description: Ortholithical calcareous bodies in their overall design resembling *Marthasterites bramlettei*, however showing long tapering and slightly curved rays, which in well preserved specimens show small bifurcations near the ends of the rays. The triangular flat sides are concave with three ribs uniting in the centre. The dimples between these ribs are elongated into grooves in distal direction. Related to *M. bramlettei* and *M. contortus* as well. Not rare.

Size: Diameter 18–28 µm, height 8–13 µm.

Comments:

Stratigraphic distribution: Lower Eocene (Ypresian). Short stratigraphic range in Zone NP11.

Genus: *Rhombaster* BRAMLETTE & SULLIVAN, 1961

Rhombaster spineus (SHAFIK & STRADNER) PERCH-NIELSEN, 1984 (= *Marthasterites spineus* SHAFIK & STRADNER, 1971, p. 93, Text-Figs. 6, 7a–d)

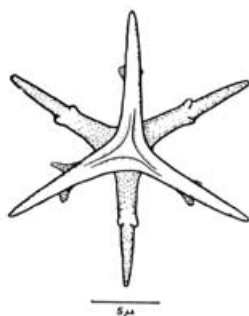
Original description of *Marthasterites spineus* SHAFIK & STRADNER, 1971

Holotype: GBA 2009/058/0067.

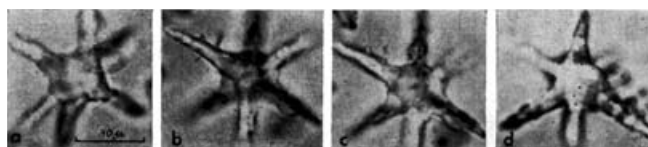
Derivatio nominis: *spineus* (Lat.) = with spines.

Type locality: Ash El-Mellaha range, Western Red Sea Coast, Egypt (Esna shale).

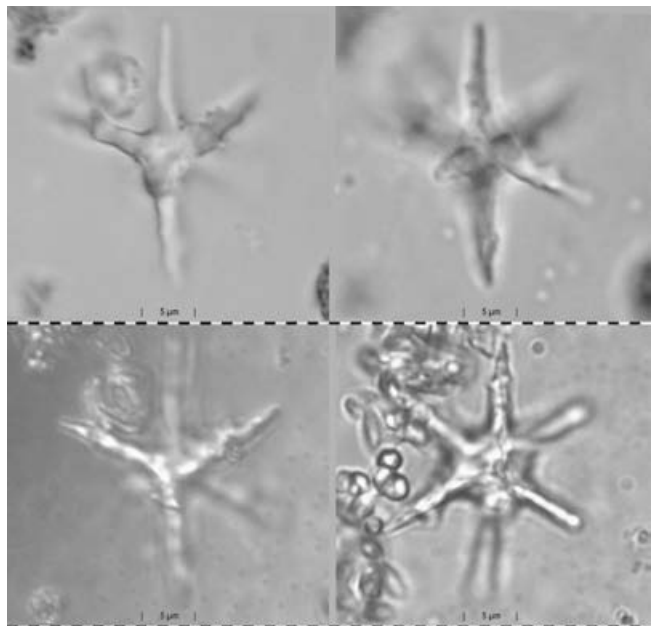
Level: Paleocene.



Text-Fig. 51a.
Original drawings of *Marthasterites spineus*.



Text-Fig. 51b.
Original photographs of the holotype.



Text-Fig. 51c.
Holotype in normal light at different focus levels.

Diagnosis: An ortholithical nannofossil consisting of a pair of triradiate stars, which are united at their centre and shifted by 60° to give the appearance of a regular sixradiate star with arms alternating at different focus. The arms wear spines directed towards each other at about the middle of their free length.

Comments: A species of *Marthasterites*, which in its general appearance is similar to *M. reginus*, from which it differs however by the following features:

- a) The spine-like bifurcation of the six free arms is not at their ends, but at about half of their free length and not very regular. There is mostly only one spine, sometimes there are two.
- b) the curving of the arms is very slight, the coiling is reversed as compared to *M. reginus*.
- c) the ornamentation of the central field consists of three ridges, which are uniting at the centre enclosing angles of 120°. These ridges are in the same direction as the arms and not shifted 60° as in *M. reginus*.

Size: 30–40 µm.

Comments:

Stratigraphic distribution: Upper Paleocene (Thanetian); Zone NP9b.

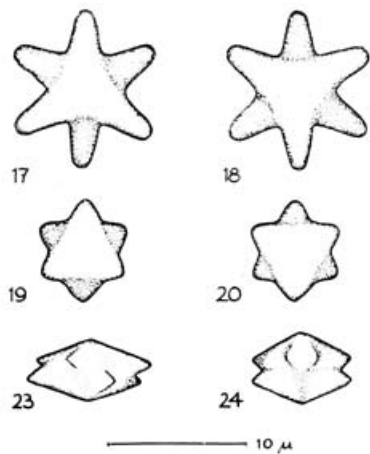
Genus: *Tibrachiatus* SHAMRAI, 1963

Tibrachiatus bramlettei (BRÖNNIMANN & STRADNER) PROTO DECIMA, ROTH & TODESCO, 1975 (= *Marthasterites bramlettei* BRÖNNIMANN & STRADNER, 1960, p. 366, Text-Figs. 17–20, 23, 24; = *Marthasterites riedeli* BRÖNNIMANN & STRADNER, 1960, p. 366, Pl. 1, Figs. 21, 22)

Original description of *Marthasterites bramlettei* BRÖNNIMANN & STRADNER, 1960

Lectotypus: GBA 2009/058/0018/1.

Derivatio nominis: Zu Ehren von Herrn Prof. M.N. BRAMLETTE, La Jolla, Kalifornien, der diese Art als erster fand (Briefliche Mitteilung vom 12. November 1958).



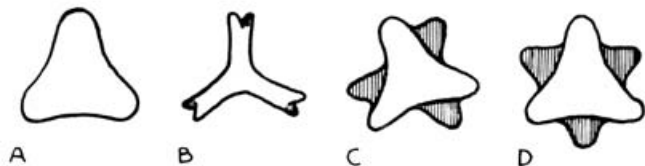
Text-Fig. 52a.
Original drawings of *Marthasterites bramlettei*.

Locus typicus: Alkazar-Formation, BR-Stat. 538, Kuba.

Stratum typicum: Unter-Eozän (*Tr. velascoensis*-Zone).

Diagnose und Beschreibung: Ein Kalkkörperchen von regelmäßigem sechsstrahligem Umriss ohne Unterteilungslinien, von dem je drei Armenden wie die Zacken eines Zionsternes miteinander verbunden sind. Von einer Flachseite her betrachtet erscheinen die drei dem Beschauer näher liegenden verbundenen Strahlen als gleichseitiges Dreieck, unter welchem beim Senken des Objektivs die anderen drei Strahlen als ein um 60° gedrehtes ebenso großes Dreieck erscheinen.

Größe: 8–13 µm.

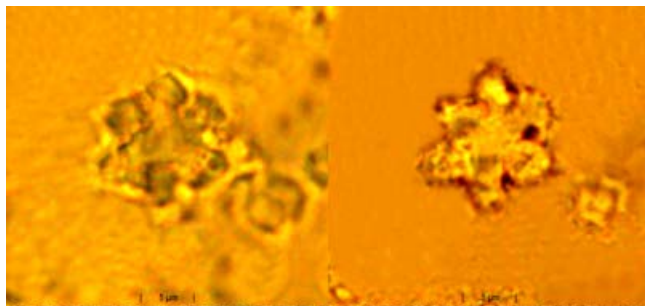


Text-Fig. 52b.
Schematic drawings showing the different orientation of the rays of *Marthasterites tribrachiatus robustus* (A), *Marthasterites tribrachitus tribrachiatus* (B), *Marthasterites contortus* (C) and *Marthasterites bramlettei* (D).

Beziehungen: *Marthasterites bramlettei* stellt offenbar das Endglied in den Phasen der Aufspaltung der Arme innerhalb der Gattung *Marthasterites* dar. *Marthasterites contortus* STRADNER ist als die unmittelbar davorstehende Phase anzusehen.

English translation:

Lectotypus: GBA 2009/058/0018/1.



Text-Fig. 52c.
Syntypes in normal light at different focus levels.

Derivation of name: In honour of Prof. M.N. BRAMLETTE, La Jolla, California, who has seen this species for the first time (his letter of Nov. 12th, 1958).

Type locality: Alkazar Fm, BR-Stat. 538, Cuba.

Level: Lower Eocene (*Tr. velascoensis* Zone).

Diagnosis and description: Calcareous body with star-shaped six-rayed outline, partition lines missing. In plan view this fossil appears composed of two equilateral triangular parts that are offset from each other in an angle of 60 degrees, thus resembling a Zionistic star emblem. By shifting the focus of the microscope objective the different levels of both triangles can be understood best.

Size: 8–13 µm.

Relations: Whether the different degrees of splitting represent an evolutionary line from *Marthasterites tribrachiatus robustus* via *M. tribrachiatus tribrachiatus* to *M. contortus* and finally to *M. bramlettei* or vice versa has to be clarified.

Comments:

Taxonomic status: The concept of *Tribrachiatus bramlettei* is based on overgrown material. This has led to widespread confusion with the closely related species of *Rhombaster*. We agree with Romein's interpretation (1979) of the morphological and structural differences between the nannoliths in the two genera.

Stratigraphic distribution: The lowest occurrence of *T. bramlettei* defines the base of Zone NP10. Highest occurrence in lowermost Subzone NP10d (Aubry, 1996).

Synonym: *Marthasterites riedelii* BRÖNNIMANN & STRADNER, 1960, p. 366, Pl. 1, Figs. 21, 22, is most likely a synonym of *T. bramlettei*.

Original description of *Marthasterites riedelii* BRÖNNIMANN & STRADNER, 1960

Lectotypus: GBA 2009/058/0018/2.

Derivatio nominis: Zu Ehren von Herrn Geologen W.R. RIEDEL, La Jolla, Kalifornien.

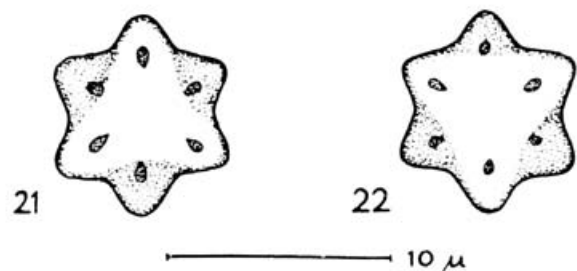
Locus typicus: Alkazar-Formation, BR-Stat. 538. Kuba.

Stratum typicum: Unter-Eozän (*Tr. velascoensis* Zone).

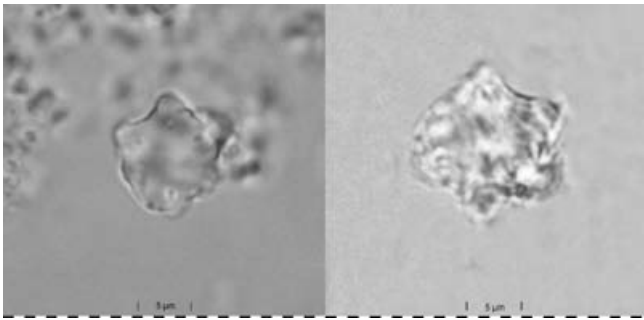
Diagnose und Beschreibung: Ein Kalkkörperchen mit demselben räumlichen Aufbau wie die vorhergegangene Art *Marthasterites bramlettei*, von der es sich durch den Besitz von je sechs länglichen Poren unterscheidet.

Größe: 10 µm.

Beziehungen: Eine zunächst mit *Marthasterites bramlettei* und im weiteren Sinne mit *Marthasterites contortus* (STRADNER) DEFLANDRE und *Marthasterites tribrachiatus* (BRAMLETTE & RIEDEL) DEFLANDRE verwandte Art.



Text-Fig. 53a.
Original drawings of *Marthasterites riedelii*.



Text-Fig. 53b.
Holotype in normal light at different focus levels.

English Translation:

Lectotype: GBA 2009/058/0018/2 (BR/535/1J).
Derivation of name: In honour of W.R. RIEDEL, geologist, La Jolla, California.
Type locality: Alkazar Formation, BR-Sta. 538, Cuba.
Level: Lower Eocene (*Tr. velascoensis* Zone).
Diagnosis and description: Calcareous bodies of identical geometrical structure as *Marthasterites bramlettei* n. sp., from which it differs by the presence of 6 elongate pores on each of its flat sides. Related to *M. bramlettei*, *M. contortus* and *M. tribrachiatus*.

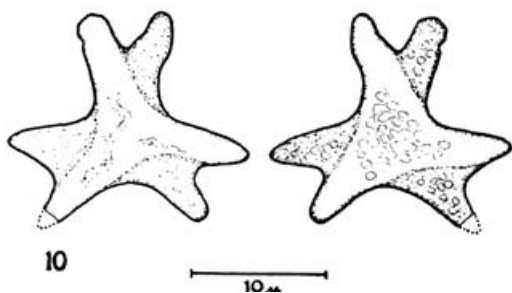
Comments:

Taxonomic status: *M. riedelii* is likely based on a strongly overgrown specimen of *T. bramlettei*.

Tribrachiatus contortus (STRADNER) BUKRY, 1972 (= *Discoaster contortus* STRADNER 1959a, p. 187, Text-Figs. 35, 36)

Original description of *Discoaster contortus* STRADNER, 1959a

Lectotype: GBA 2009/058/0002.
Derivation of name: *contortus* (Lat.) = twisted.
Type locality: Göllersdorf.
Level: Miocene.



Text-Fig. 54a.
Original drawings of *Discoaster contortus*.

Description: Asteroliths consisting of six arms of which three on each side are connected in a similar way as those of *Discoaster tribrachiatus*. The angle of contortion between the pair of ray-groups is about 40°, so that the rays are on either face of the asterolith alternatively high and low, the angles between them alternatively 40° and 80°. No sutures, generally no central knob (Helvetium). Possibly reworked from the Cretaceous where similar forms were found.



Text-Fig. 54b.
Holotype in normal light.

Comments:

Taxonomic status: the lectotype of *T. contortus* was first illustrated by AUBRY (1996, Pl. 2, Figs. 1–6) to emphasize the differences between this taxon and *Tribrachiatus digitalis* AUBRY 1996, p. 245, 246, 249, Pl. 1, Figs. 1–12, Pl. 2, Figs. 11, 12.
Biostratigraphic range: Lowest occurrence defines the base of Subzone NP10d (Aubry, 1996). Highest occurrence defines the top of Zone NP10 (MARTINI, 1971).

Tribrachiatus robustus (STRADNER) AUBRY & STRADNER n. c. (= *Discoaster tribrachiatus* subcent. *robustus* STRADNER, 1959, p. 477, Text-Figs. 4, 9; = *Marthasterites robustus* STRADNER in STRADNER & PAPP, 1961, p. 109, Pl. 34, Figs. 7a, b, 8; Text-Figs. 11[4], 20[1]).

Original description of *Discoaster tribrachiatus* subcent. *robustus* STRADNER, 1959b

Holotypus: nicht festgelegt.
Locus typicus: Kühlgraben am Untersberg (Salzburg, Österreich).
Stratum typicum: Paläozän.
Beschreibung: Die dreiarmigen schlanken Asterolithen dieser Formart sind in Bezug zur Hauptebene gewölbt. Die Enden der Arme können einfach oder gegabelt sein. Bei den stark gegabelten Formen ist die zu *Discoaster contortus* analoge Orientierung der Enden auffallend. *Discoaster lodonensis* MARTINI und *Discoaster bramlettei* MARTINI, welche *Discoaster tribrachiatus* recht ähnlich sind, konnten bis jetzt in Österreich noch nicht nachgewiesen werden. Die ältesten Formen aus dem Dan II sind sehr robust und haben im Gegensatz zu den später vorkommenden Asterolithen im Querschnitt ovale Arme. Man könnte diese Formen auch *Discoaster tribrachiatus robustus* nov. subcent. bezeichnen.

English translation:

Holotype: not designated.
Type locality: Kühlgraben am Untersberg (Salzburg, Österreich).
Level: Paläozän.

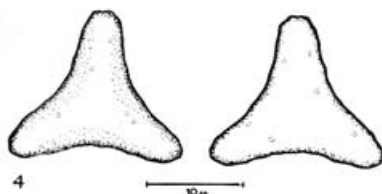
Description: This is the oldest form of *Discoaster tribrachiatus*, which is very robust and has arms that are ovoid in cross section.

Original description of *Marthasterites robustus* (STRADNER) STRADNER in STRADNER & PAPP, 1961

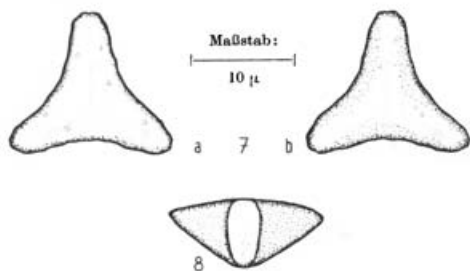
Lectotype: GBA 2009/058/0005/2.
Derivatio nominis: *robustus* (Lat.) = robust.

Locus typicus: Kühlgraben am Untersberg (Salzburg, Österreich).

Stratum typicum: Paläozän.



Text-Fig. 55a.
Original drawings of *Marthasterites robustus*.



Text-Fig. 55b.
Original drawings of *Marthasterites robustus*.

Diagnose und Beschreibung: Dreieckige oder Y-förmige Kalkkörperchen, deren Arme im Querschnitt sehr hoch und elliptisch sind und Winkel von je 120° einschließen. Die Enden der Arme sind entweder abgerundet oder leicht gekerbt. In der Seitenansicht erscheint das Kalkkörperchen im Gegensatz zu *Marthasterites tribrachiatus* (BRAMLETTE & RIEDEL) DEFLANDRE immer dreieckig und nie konkav-konvex gewölbt.

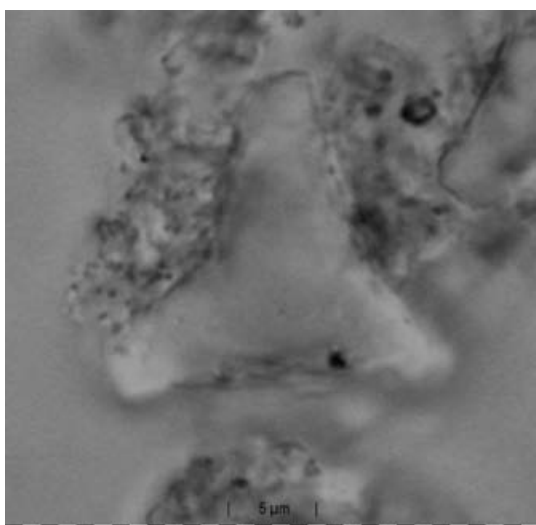
Durchmesser: 6–16 µm.

Beziehungen: *Marthasterites robustus* scheint der direkte Vorläufer des nach HAY & SCHAUB erst im oberen Ilerdien einsetzenden *Marthasterites tribrachiatus* zu sein.

English translation:

Lectotype: GBA 2009/058/0005/2.

Derivation of name: *robustus* (Lat.) = robust.



Text-Fig. 55c.
Lectotype in normal light.

Type locality: Kühlgraben, Untersberg, Salzburg.

Level: Paleocene.

Calcareous bodies of triangular or Y-shaped outline, without suture lines. In side view the arms appear elliptical in cross section. Contrary to *Marthasterites tribrachiatus* (BRAMLETTE & RIEDEL) DEFLANDRE the arms are neither curved nor split.

Size: 6–16 µm.

Comments:

Taxonomic status: the taxon *robustus* is recombined to *Tribrachiatus* to correct unsatisfactory generic assignments to *Discoaster* and *Marthasterites*. It is not clear however whether *T. robustus* is a discrete species or part of the morphologic variability of *T. orthostylus*.

Stratigraphic range: Originally reported as a Paleocene taxon.

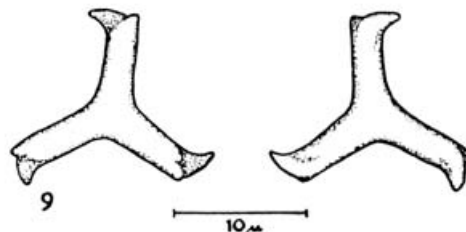
Tribrachiatus rotans (STRADNER) AUBRY & STRADNER n. c. (= *Discoaster rotans* STRADNER, 1959a, p. 4, Text-Fig. 9)

Original description of *Discoaster rotans* STRADNER, 1959a

Lectotype: GBA 2009/058/0004/2.

Derivation of name: *rotans* (Lat.) = turning.

Type locality: Mattsee Station 133.



Text-Fig. 56a.
Original drawings of *Discoaster rotans*.

Level: Middle Paleocene (Thanetian).

Description: Asteroliths of similar shape as those of *Discoaster tribrachiatus* from which they differ in the bifurcation of their arms. One of the two endings of an arm is a short stub, whereas the other is a sturdy curved spine, the terminal notch being shallow and oblique. Seen from the convex side of the asterolith all three spines point counter-clockwise, thus giving the asterolith somewhat a resemblance to a germanic sun-rune.

Comments:

Taxonomic status: the taxon *rotans* is recombined to *Tribrachiatus* to correct unsatisfactory generic assignments to



Text-Fig. 56b and c.
Holotype in normal light at different focus levels..

Discoaster and to *Marthasterites* (by DEFLANDRE, 1959, p. 139). It is not clear however whether *T. rotans* is a discrete species or part of the morphologic variability of *T. orthostylus*.
Stratigraphic range: Originally reported as a Paleocene taxon.

Family: Triquetrorhabdulaceae LIPPS, 1969

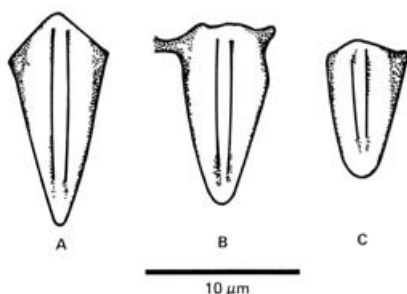
Genus: *Triquetrorhabdulus* LIPPS, 1969

Triquetrorhabdulus auritus STRADNER & ALLRAM, 1981, p. 595, Pl. 7, Figs. 1–8

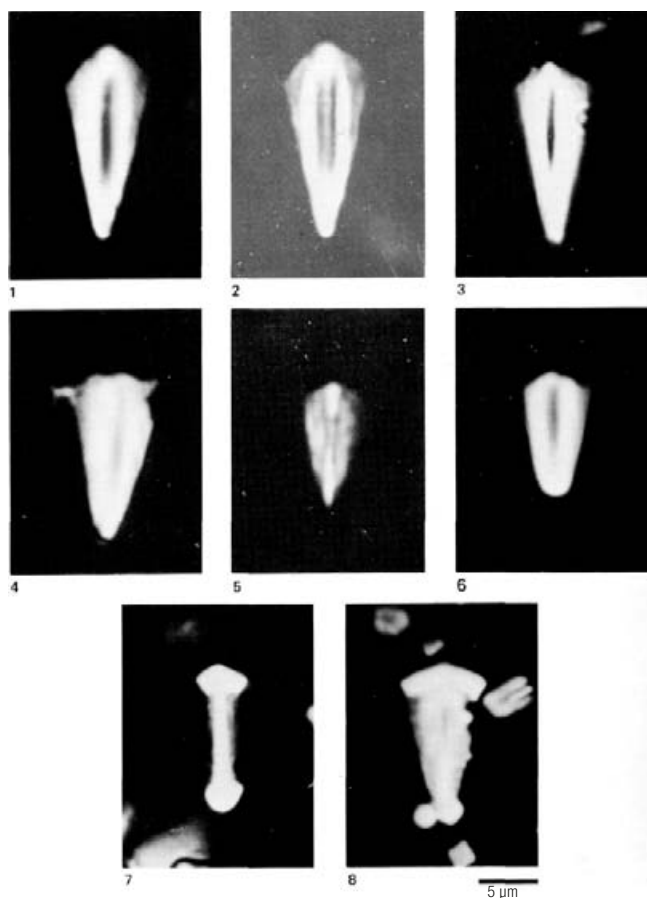
Original description of *Triquetrorhabdulus auritus* STRADNER & ALLRAM, 1981

Holotype: GBA 2009/058/0071.

Derivation of name: *auritus* (Lat.) = with ears.



Text-Fig. 57a.
Original drawings of *Triquetrorhabdulus auritus*.



Text-Fig. 57b.
Original photographs of syntypes.

Type locality: DSDP Sample 489A-12.CC, Middle America Trench off Southern Mexico.

Level: Lower Miocene, *Discoaster druggii* nannoplankton Zone NN2.

Diagnosis: Calcareous bodies consisting of three elongate triangular flat blades that are united with their hypotenuse at angles of 120°, thus forming wedge-shaped bodies of deltoid outline in side view. At their greatest width these bodies are extended, in some specimens, into “ears”.

Remarks: *Triquetrorhabdulus auritus* is distinguished from *T. carinatus* by its shorter, more deltoid outline; from *T. milowii* by its projecting ridges or spineous extensions at the wide area of the blades. For *T. milowii* no such angular ridges or extensions have been described. While the lateral view of *T. milowii* shows a more or less rounded outline, *T. auritus* has a more wedge-shaped outline with straight edges.

Size (Holotype): Length 14 µm, width 6 µm.

Comments:

Stratigraphic distribution: Lower Miocene (Aquitanian–Burdigalian); Zone NN1–NN2.

Family: Lapideacassaceae BOWN & YOUNG, 1997

Genus: *Scampanella* FORCHHEIMER & STRADNER, 1973, p. 286 emended PERCH-NIELSEN & FRANZ, 1977, p. 852

Type species: *Scampanella cornuta* FORCHHEIMER & STRADNER, 1973, p. 285, Pl.1, Figs.1-5, 7 and 8

Original description of *Scampanella* FORCHHEIMER & STRADNER, 1973

Derivatio nominis: S = Abkürzung für Schweden, *campanella* (Lat.) = Glöckchen.

Diagnose: Zylindrische, hohe Coccolithen, die aus zirka acht länglichen, parallelen Platten aufgebaut sind, von denen zwei gegenüberliegende Platten distal in zwei divergierende Stacheln verlängert erscheinen. Nahe dem distalen Ende dieser Platten befindet sich ein Kranz von Poren oder Kerben, je eine pro Platte.

Anmerkung: Diese neue Gattung kann als ein Vorläufer des obereozänen Coccolithen *Naninfula deflandrei* PERCH-NIELSEN, welcher ein Holococcolith ist, angesehen werden. Die Ultrastruktur von *Scampanella cornuta* gibt Hinweise darauf, dass es sich auch hier eher um Holococcolithen als um Heterococcolithen handeln dürfte.

English translation:

Derivation of name: S = abbr. for Sweden, *campanella* (Lat.) = bell.

Diagnosis: Cylindrical hollow coccoliths, consisting of about eight elongate parallel plates, two of which extending into diverging spines. Near the extensions of the rounded distal end there is a cycle of pores or notches, one to each plate.

Remarks: This new genus might be considered a forerunner of the Upper Eocene nanofossil *Naninfula deflandrei* Perch-Nielsen, which is a holococcolith. The ultrastructure of *Scampanella cornuta* indicates that it could be a holococcolith rather than a heterococcolith.

**Original description of *Scampanella cornuta*
FORCHHEIMER & STRADNER, 1973**

Derivatio nominis: *cornu* (Lat.) = Horn.

Holotypus: Das in den Figuren 1 bis 5, 7 und 8 dargestellte Exemplar (Katalognummer S Kp 359/59 a).

Locus typicus: Tiefbohrung Köpingsberg 1, bei 986,35 m, Schweden.

Stratum typicum: Hauterive (nach Pollenanalysen eingestuft).

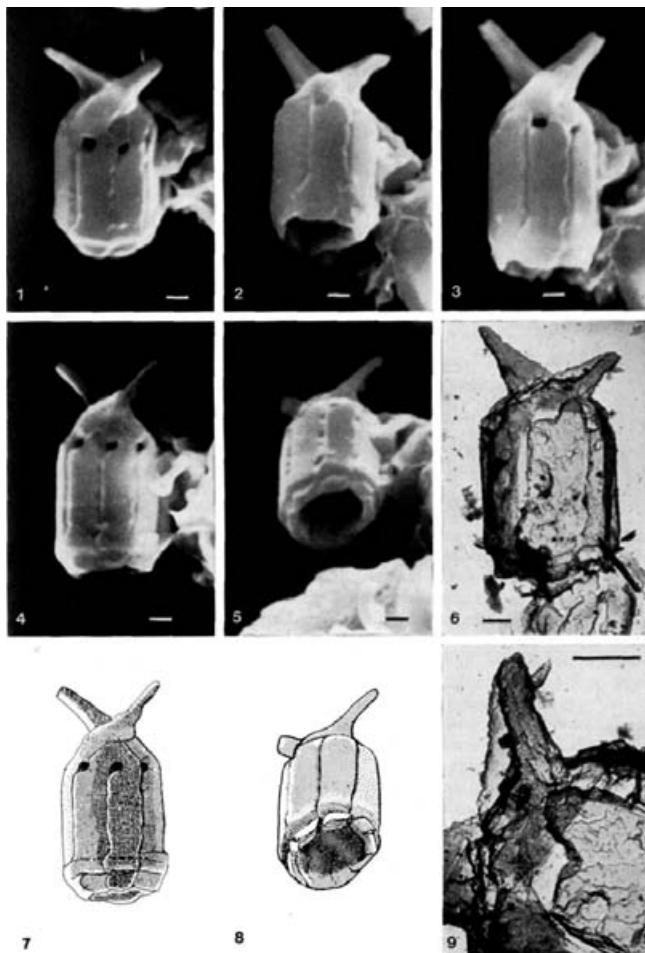
Paratypus: Das in den Figuren 6 und 9 dargestellte Exemplar (Katalognummer GBA Elmilab 2968).

Fundort des Paratypus: Klafferbrunn, Niederösterreich

Alter: Coniacium.

Diagnose: Siehe Gattungsdiagnose.

Beschreibung: Das proximale, offene Ende zeigt kreisförmige Rillen, welche möglicherweise andeuten, dass der zylindrische Körper in eine Basalplatte eingesetzt gewesen ist. Die distale Seite mit den zwei Hörnern ist gerundet, die beiden Hörner scheinen Verlängerungen von je einem oder mehreren separaten Apikalelementen zu sein. Aus der Lage der Suturen ist ersichtlich, dass es sich nicht um direkte Verlängerungen der Längsplatten handelt. Die Hörner sind in distaler Richtung von einer Längsfurche



Text-Fig. 58. Original photographs of the holotype and paratype of *Scampanella cornuta*. Holotype, oblique distal view (1), oblique proximal view (2), lateral view (3), lateral view after slight axial rotation (4), oblique view of proximal opening (5), schematic drawings of 4 and 5 (7, 8). Paratype, lateral view (6), close up of the distal part of the paratype showing ultrastructure of the horn (9). Scale bars: 1µm.

durchzogen. Im Elektronenmikrogramm (Fig. 9) sind zwei bevorzugte Richtungen in der Orientierung der Mikrokristalle zu erkennen, ähnlich wie bei Holococcolithen z. B. *Zygrhablithus bijugatus* DEFLANDRE (siehe STRADNER & EDWARDS, 1968, Pl. 42).

Größe:

	Holotypus	Paratypus
Gesamthöhe	10,0 µm	9,0 µm
Höhe ohne Hörner	7,6 µm	7,3 µm
Durchmesser	4,5 µm	5,0 µm
Länge der Hörner	3,0 µm	2,7 µm

English translation:

Holotype: The specimen shown in the Figs. 1–5, 7 and 8 (catalogue no. GBA Elmilab S Kp 359/59 a).

Paratype: The specimen shown in the Figs. 6 and 9 (catalogue no. GBA Elmilab 2968).

Derivation of name: *cornu* (Lat.) = horn.

Type locality: Köpingsberg Borehole No. 1, at 986.35 m, Sweden.

Level: Hauterivian (according to pollen analyses).

Paratype locality: Klafferbrunn, Lower Austria, station 947 of R. GRILL.

Level: Coniacian (according to foraminifera determined by W. FUCHS).

Diagnosis: The same as the generic diagnosis.

Description: The proximal open end shows circular grooves, which might indicate that the cylindrical body was inserted in a basal plate. The distal side with the two horns is rounded, the horns appear to be extensions of one or more separate apical elements each. As shown by the position of the sutures they are not extensions of the longitudinal plates. Each horn has a longitudinal groove, which is open in distal direction. In the transmission electronmicrograph two preferred directions are evident in the orientation of the microcrystals, similar to holococcoliths such as *Zygrhablithus bijugatus* DEFLANDRE (see STRADNER & EDWARDS, 1968, Pl. 42).

Size:

	Holotype	Paratype
Total height	10,0 µm	9,0 µm
Height without horns	7,6 µm	7,3 µm
Diameter	4,5 µm	5,0 µm
Length of horns	3,0 µm	2,7 µm

Genus: *Favolithora* STRADNER, 1961

Type species: *Favolithora cyclopa* STRADNER, 1961, p. 87, Text-Figs. 72, 73.

Original description of *Favolithora* STRADNER, 1961

Derivatio nominis: *favus* (Lat.) = Honigwabe, *lithos* (gr.) = Stein, *thora* = die ersten beiden Silben des Gattungsnamen *Thoracosphaera*.

Hohle Kalkgehäuse, deren Wände aus prismatischen Bausteinen aufgebaut sind. Die Größe der in Reihen angeordneten, im Umriss meist sechseckigen Einzelsteine beträgt

4–6 µm. Im polarisierten Lichte verhalten sie sich ähnlich wie die Porolithen von *Thoracosphaera heimi* Kamptner.

English translation:

Derivation of name: combination of *favus* (Lat.) = honeycomb, *lithos* (Gr.) = stone.

Calcareous shells the walls of which are composed of prismatic blocks. The size of these usually hexagonal blocks is 4–6 µm. Under crossed nicols they show similarity to the poroliths of *Thoracosphaera heimi*.

Comments:

Favolithora is an isolated fragmentary calcareous fossil of indeterminate origin, possibly a fragment of a dinocyst.

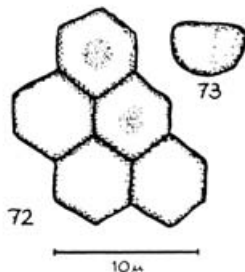
Original description of *Favolithora cyclopia* STRADNER, 1961

Holotypus: GBA 2009/058/0031.

Derivatio nominis: *cyclopius* (Lat.) = zyklisch.

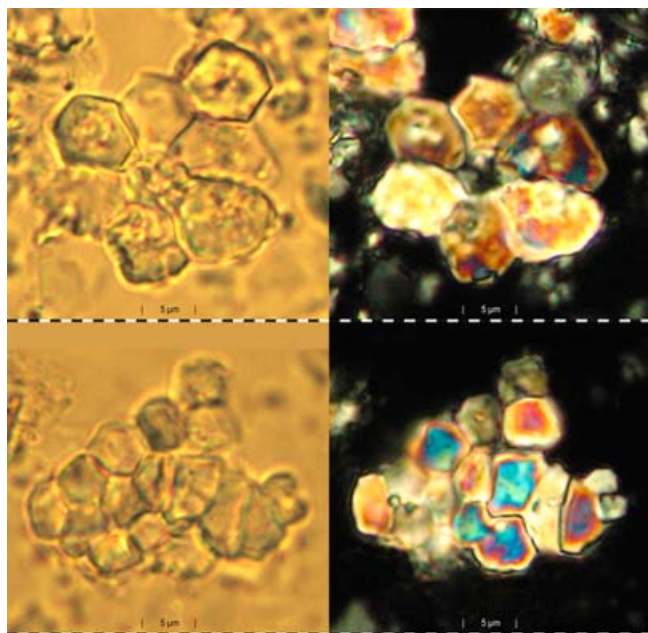
Locus typicus: Eitelgraben S Salzburg. Nicht selten.

Stratum typicum: Paläozän.



Text-Fig. 59a.
Original drawings of *Favolithora cyclopia*.

Die Beschreibung dieser Art ist durch die des Genotypus gegeben. In den verschiedenen aufgesammelten Wandbruchstücken überwiegen die sechseckigen Bausteine gegenüber den fünfeckigen. Sie erinnern in der Art, wie sie aneinandergefügt sind, an die sogenannten Zyklopenmauern des prähistorischen Griechenland (Mykene).



Text-Fig. 59b.
Syntypes in polarized and normal light.

Größe der Einzelteile: Durchmesser meist 5 µm, Höhe 3–5 µm.

English translation:

The description of this species corresponds to that of the genus. Some fragments show blocks with pentagonal outline also. In cross-polarized light the blocks show different orientations.

Size: Diameter of the blocks about 5 µm, height 3–5 µm.

Holococcolith genera

Genus: *Corannulus* STRADNER, 1962, P. 365

Type species: *Corannulus germanicus* STRADNER, 1962, p. 366, Pl. 1, Figs. 21–30.

Synonyms: *Guttolithion* STRADNER, 1962, p. 374.

Type species: *Guttolithion cassum* STRADNER, 1962, p. 375, Pl. 3, Figs. 1–5.

Comments:

Two species were originally included in the genus *Corannulus*: *Corannulus arenarius* STRADNER, 1962, p. 368, Pl. 1, Figs. 14–20.

Corannulus germanicus STRADNER, 1962, p. 366, Pl. 1, Figs. 21–30.

Original description of *Corannulus* STRADNER, 1962

Derivatio nominis: Wortzusammensetzung aus den lateinischen Hauptwörtern *corona* = Krone und *annulus* = Ring.

Von fossilen Kalkflagellaten herrührende großporige Gehäuseelemente von unregelmäßig ovalem oder zahnkranzartigem Umriss. Von einem schwach ovalen bis annähernd kreisrunden zentralen, erhöhten Ring nehmen 7–12 in zentrifugaler Richtung steil abfallende radiale Stege ihren Ausgang. Ihre Ansatzstellen sind als erhöhte Rippen auch bei stark reduzierten Arten erhalten. Die peripheren Enden der Stege können frei sein (*Corannulus germanicus* n. sp.) oder durch Bögen miteinander verbunden sein (*Corannulus arenarius* n. sp.). Die große zentrale Öffnung, welche an den Ansatzstellen der Stege leicht ausgebuchtet ist, ist in letzterem Falle von einem Kranz von abgerundet dreieckigen oder trapezförmigen Fenstern umgeben. Diese Gattung von Coccolithen scheint durch starke Reduktion großporiger Vorläuferformen ex gr. *Discolithus macroporus* DEFLANDRE entstanden zu sein. Da die beiden neuen Arten *Corannulus arenarius* und *Corannulus germanicus* schwer in der Gattungsdiagnose von *Discolithus* KAMPTNER 1955 unterzubringen waren, wurde für sie der neue Gattungsname *Corannulus* gewählt.

English translation:

Derivation of name: combined from two latin nouns: *corona* = crown; *annulus* = ring.

Holococcolithic elements with widely open pores and irregular oval outline, in *Corannulus germanicus* resembling a cogwheel. The oval ring surrounding a large central pore shows 7–12 centrifugal extensions that in *Corannulus germanicus* are free, in *Corannulus arenarius* however are joined by arcs thus forming a bumpy outline that is embracing a ring of trapezoid or triangular windows. In side view it can be seen, that these frail looking structures are composed of relatively high ledges or strips of calcite. No extinction un-

der crossed nicols. This genus seems to be related to *Discolithus macroporus* DEFLANDRE.

Comments:

Taxonomic status: *Diademopetra* HAY, MOHLER & WADE, 1966, p. 397 is also a junior synonym of *Corannulus* STRADNER 1962.

Original description of *Corannulus arenarius* STRADNER, 1962

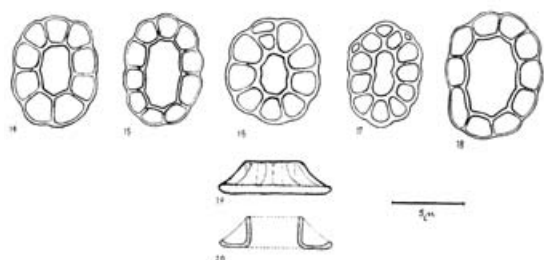
Holotypus: GBA 2009/058/0039/1.

Derivatio nominis: *arena* (Lat.) = Sand.

Locus typicus: Basale Glaukonitsande des Steinbruches Reingruberhöhe bei Bruderndorf, Niederösterreich.

Stratum typicum: Obereozän (jüngeres Led; Gohrbandt, 1962).

Diagnose und Beschreibung: Gehäuseelemente im Umriss unregelmäßig oval, sehr großporig, mit stark erhöhter zentraler Porenumrandung. Um einen großen, durch die Verschmelzung von zwei Poren entstandenen freien Raum (Zentralpore oder „Arena“) schart sich ein Kranz von sehr weiten peripheren Poren, deren Durchmesser jedoch stets kleiner ist als der der länglichen Zentralpore. Mitunter können auch noch zusätzliche Poren (vgl. Taf. I, Fig. 17) ein-

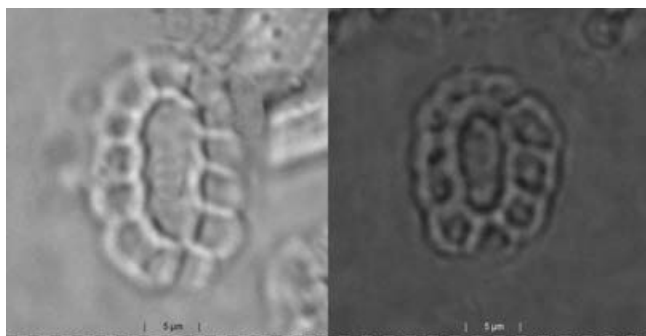


Text-Fig. 60a. Original drawings of *Corannulus arenarius*.

geschoben sein. Der Rand ist außen, den Konturen der peripheren Poren entsprechend, leicht gebuchtet. Die Seitenansicht zeigt, dass die Stege zwischen den Poren am Rande niedrig sind, gegen die Zentralpore steil (ca. 45°) ansteigen und als Umrandung der Zentralpore stark erhöht sind. Der Außenrand des Coccolithen erscheint leicht aufgebördelt.

Dimensionen: Längsachse 7–9 µm, Querachse 5–7 µm, Höhe 2,5 µm.

Beziehungen: Diese neue Nannofossilart scheint ein Vorläufer von *Corannulus germanicus* n. sp. zu sein. Differential-



Text-Fig. 60b. Syntypes in normal light.

diagnostisch sind die unterschiedlichen Porendurchmesser gegenüber anderen ähnlichen Arten, wie z. B. *Discolithus macroporus* DEFLANDRE, von Wichtigkeit.

English translation:

Holotype: GBA 2009/058/0039/1.

Derivation of name: *arena* (Lat.) = sand.

Type locality: Basal glauconitic sands of the Reingruberhöhe quarry at Bruderndorf, Lower Austria, which is the stratotype locality of nannoplankton Zone NP19.

Diagnosis and description: Calcareous shell elements of irregular oval outline, with large pores, and elevated ring. The central pore seems to be equivalent to two combined pores without septum between them. The central ring is surrounded by 9 to 13 trapezoid or triangular pores; their outer limitations being wavy. The side view shows that the central ring is higher than the ledges surrounding it (see Fig. 19 and 20).

Size: Length 4–7 µm, width 3.5–6 µm, height 2 µm.

Occurrence: As yet only known from the Reingruberhöhe, Bruderndorf in Lower Austria, stratotype locality of nannoplankton Zone NP19.

Relations: This new species is closely related to *Discolithus macroporus*, from which it differs by its double size, and with *Corannulus germanicus*, which has no outer rim however.

Comments:

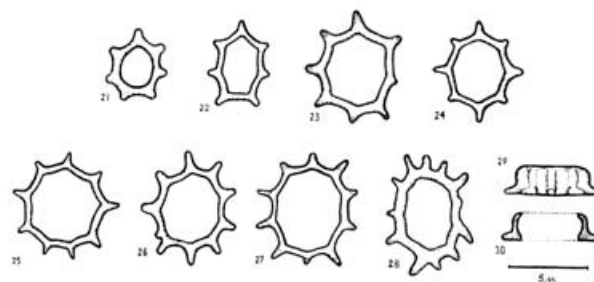
Stratigraphic distribution: Middle to Upper Eocene (Bartonian to Priabonian); Zone NP16–NP19.

Original description of *Corannulus germanicus* STRADNER, 1962

Holotypus: GBA 2009/058/0039/2.

Derivatio nominis: *germanicus* (Lat.) = aus Deutschland.

Die erste Mitteilung über diese Art von Nannofossilien stammt „aus Deutschland“, und zwar von Dr. Erlend MARTINI, welcher 1958 ein Mikrophoto (Taf. 6, Fig. 31) beschriftet als „unbestimmtes Skelettelement SM. B 7996 (A 31.1/101.3). – Hohne 1001: 155,7–121,7 m K. 2; oberes Obereozän“ wiedergab.

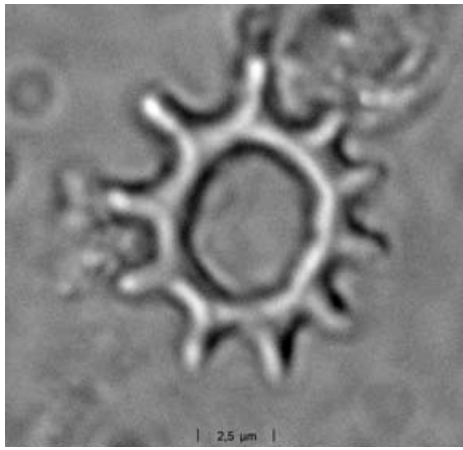


Text-Fig. 61a. Original drawings of *Corannulus germanicus*.

Locus typicus: Basale Glaukonitsande des Steinbruches Reingruberhöhe bei Bruderndorf, Niederösterreich.

Stratum typicum: Obereozän (jüngeres Led; K. GOHRBANDT, 1962).

Diagnose und Beschreibung: Gehäuseelemente von zahnkranzartiger Gestalt, jedoch nur selten annähernd kreisrund, sondern meist etwas längsoval. Die Zahl der mehr oder weniger spitzen Stege („Zähne“) variiert von 7–12.



Text-Fig. 62b.
Holotype in normal light.

Das eine große zentrale Fenster ist an den Ansatzstellen der Stege leicht peripher ausgebuchtet. Die Seitenansicht zeigt, dass die Umrandung des Zentralfensters stark erhöht ist und durch die rippenartig hinauslaufenden Stege verstärkt wird. Die Abstände zwischen den Stegen, welche als stark reduzierte Umrandungsteile von nicht ausgebildeten peripheren Fenstern anzusehen sind (vgl. *Corannulus arenarius* n. sp.), sind meist untereinander gleich, doch können auch sehr unregelmäßige Formen, wie z. B. Taf. I, Fig. 28, gefunden werden.

Dimensionen: Längsachse 4–7 μm, Querachse 3,5–6 μm, Höhe 2 μm.

Vorkommen und Fundorte: In Österreich bis jetzt nur aus dem Obereozän der Reingrubberhöhe (loc. typ.) bekannt, dort mäßig häufig; in Deutschland aus dem oberen Obereozän der Tiefbohrung Hohne 1001, 115,7–121,7 m K. 2.

Beziehungen: *Corannulus germanicus* n. sp. lässt sich von *Corannulus arenarius* n. sp., welcher vermittelnd zwischen dieser Art und großporigen Vorläuferformen ex gr. *Discolithus macroporus* steht, ableiten. Bemerkungen: Dieses Nannofossil erscheint bei Betrachtung in negativem Phasenkontrast wegen seiner starken Lichtbrechung sehr hell, in normalem Durchlicht jedoch sehr dunkel, was auch aus dem Mikrophoto in MARTINI (1958, Taf. 6, Fig. 31) deutlich hervorgeht.

English translation:

Holotype: GBA 2009/058/0039/2.

Derivation of name: *germanicus* (Lat.) = from Germany.

The first hint at this new species was given by MARTINI (1958 on plate no. 6, Fig. 31), described as “undetermined skeletal element” from the upper Eocene of deepwell Hohne 1001 (115.7–121.7 m, K. 2) in Germany.

Type locality: Basal glauconitic sands of the Reingrubberhöhe quarry at Bruderndorf, Lower Austria, which is the stratotype locality of nannoplankton Zone NP19.

Diagnosis and description: calcareous shell elements of a hitherto unknown coccolithophorid in his motile phase. These elements in their outline resemble little cogwheels, however most of the time they are oval and rarely circular. The number of their more or less pointed “teeth” varies from 7 to 12. The large circular aperture is slightly sinuated at the points where the “teeth” are situated on the outside. In side view one can see that these are not round,

but rather strips or ledges on the outside of the more or less cylindrical central annulus. Irregular forms are not uncommon.

Size: Length 4–7 μm, width 3.5–6 μm, height 2 μm.

Comments:

Taxonomic status: *Diademopetra luma* HAY, MOHLER & WADE 1966, p. 397, Pl. 13, Figs. 4, 5 and *Guttolithion cassum* STRADNER 1962 are junior synonyms of *Corannulus germanicus* STRADNER 1962.

Biostratigraphic range: Ranges from upper middle Eocene through Upper Eocene (Bartonian–Priabonian; NP17–NP19).

Original description *Guttolithion* STRADNER, 1962

Derivatio nominis: *gutta* (Lat.) = Tropfen, *lithos* (Gr.) = Stein.

Flache, plankonvexe Kalkplättchen von unregelmäßig ovalem, gebuchtetem Umriss, mit einer konischen zentralen Durchbohrung, welche auf der konvexen Flachseite von einem unregelmäßig gelappten Wall umgeben ist. Der Umriss wird durch 10–16 nicht immer gleich weit voneinander entfernten, mehr oder weniger spitzen Zacken und dazwischenliegenden runden Buchten bestimmt. Die Oberfläche des Kalkkörperchens ist etwas gerauht und lässt keine Unterteilungslinien erkennen. Herrn Doz. Dr. E.J. Zirkl, welcher das Genero-Typus-Exemplar polarisationsoptisch untersuchte, ist der Verfasser für die folgende Diagnose zu Dank verpflichtet:

„Das Nannofossil *Guttolithion cassum* erscheint bei gekreuzten Polarisatoren vollständig isotrop. Da die Lichtbrechung größer ist als 1,5 (Lichtbrechung des Einbettungsmittels), scheiden Opal, Chalzedon und andere SiO₂-Modifikationen aus. Im konoskopischen Licht erhält man ein deutliches negatives Interferenzbild. Damit muss das Nannofossil aus einem Kalziteinzelkristall bestehen.“

English translation:

Derivation of name: *gutta* (Latin) = drop, *lithos* (Gr.) = stone.

Type locality: Basal glauconitic sands of the Reingrubberhöhe quarry at Bruderndorf, Lower Austria.

Level: stratotype locality of nannoplankton Zone NP19 (Upper Eocene).

Flat, broad, elliptical platelet with irregular dented outline, flat on the proximal side, slightly conical on the distal side, and with a central oval conical perforation. The characteristic outline shows 10–16 tips with bays between them. No sutures or separation lines. A holococcolith, which in polarized light is completely isotropic, in conoscopic light showing a negative interference picture like a single calcite crystal (diagnose by J. ZIRKL).

Comments:

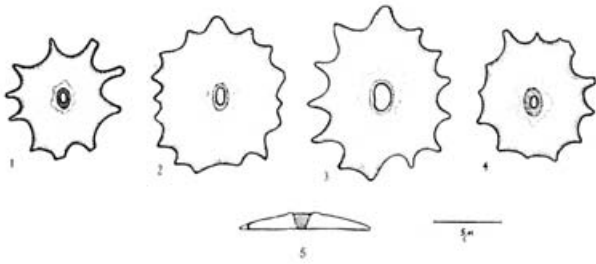
Taxonomic status: Junior synonym of *Corannulus* STRADNER 1962 (see AUBRY, 1988).

Original description *Guttolithion cassum* STRADNER, 1962

Holotypus: GBA 2009/058/0040.

Derivatio nominis: *cassus* (Lat.) = leer.

Locus typicus: Basale Glaukonitsande des Steinbruches Reingrubberhöhe bei Bruderndorf, Niederösterreich.



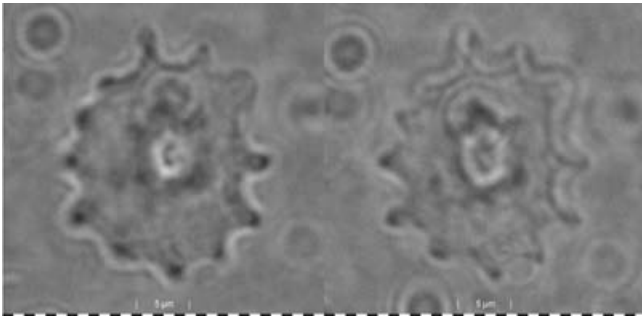
Text-Fig. 62a.
Original drawings of *Guttolithion cassum*.

Stratum typicum: Obereozän (jüngeres Led; K. GOHRBANDT, 1962).

Diagnose und Beschreibung: Die Beschreibung dieser bis jetzt einzigen Art der Gattung *Guttolithion* deckt sich mit der des Genero-Typus (s.o.). Selten.

Dimensionen: Längsachse 9–13 µm, Querachse 8–12 µm, Höhe 1 µm.

Beziehungen: *Guttolithion cassum* kann wegen seiner polarisationsoptischen Eigenschaften unter die Ortholithae DEFLANDRE s. l. eingereiht werden, doch fehlen zur Zeit noch Hinweise, in welche engere systematische Gruppe dieses außergewöhnlich einfach geformte Nannofossil einzureihen ist.



Text-Fig. 62b.
Holotype in normal light at different focus levels.

English translation:

Holotype: GBA 2009/058/0040.

Derivation of name: *cassus* (Lat.) = empty.

Type locality: Basal glauconitic sands of the Reingruberhöhe quarry at Bruderndorf, Lower Austria.

Level: stratotype locality of nannoplankton Zone NP19 (Upper Eocene).

Diagnosis and description: Identical with the description of the as yet monospecific genus.

Size: Length 9–13 µm, width 8–12 µm, height 1 µm.

Comments:

Taxonomic status: Regarded as a junior synonym of *Corrannulus germanicus* STRADNER 1962 by AUBRY (1988, p. 81). However, a quantitative study ought to clarify this relationship.

Genus: *Lanternithus* STRADNER, 1962, p. 375

Type species: *Lanternithus minutus* STRADNER, 1962, p. 375, Pl. 2, Figs. 12–15.

Original description of *Lanternithus* STRADNER, 1962

Derivatio nominis: *lanterna* (Lat.) = Laterne; *lithos* (Gr.) = Stein. Aus mehreren Platten zusammengesetzte, in der Draufsicht länglich-sechseckige, in den Seitenansichten trapezförmige Umrisslinien zeigende Kalkkörperchen mit zentralem Hohlraum. Je dicker die polarisationsoptisch als Einzelkristalle sich verhaltenden Platten sind, umso kleiner ist der zentrale Hohlraum. Die einzelnen Platten sind durch schräge, die Winkel halbierende Verbindungsflächen miteinander vereinigt.

English translation:

Derivation of name: *lanterna* (Lat.) = lantern; *lithos* (Gr.) = stone.

Calcareous composite shell of a holococcolith, in top view elongate hexangular, in side view trapezoidal, with a central cavity. The plates composing the shell are joining in acute angles as can be seen under crossed nicols.

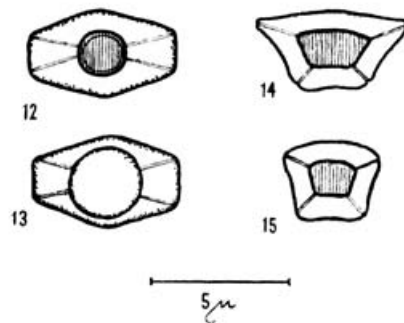
Original description of *Lanternithus minutus* STRADNER, 1962

Holotypus: GBA 2009/058/0041.

Derivatio nominis: *minutus* (Lat.) = winzig.

Locus typicus: Basale Glaukonitsande des Steinbruches Reingruberhöhe bei Bruderndorf, Niederösterreich. Stellenweise sehr häufig.

Stratum typicum: Obereozän (jüngeres Led; K. GOHRBANDT, 1962).



Text-Fig. 63a.
Original drawings of *Lanternithus minutus*.

Diagnose und Beschreibung: Die Beschreibung dieser bis jetzt einzigen Art der Gattung *Lanternithus* ist durch die des Genero-Typus gegeben.

Dimensionen: Längsachse 3,5–5,5 µm, Querachse 2–3 µm, Höhe 2–3 µm.

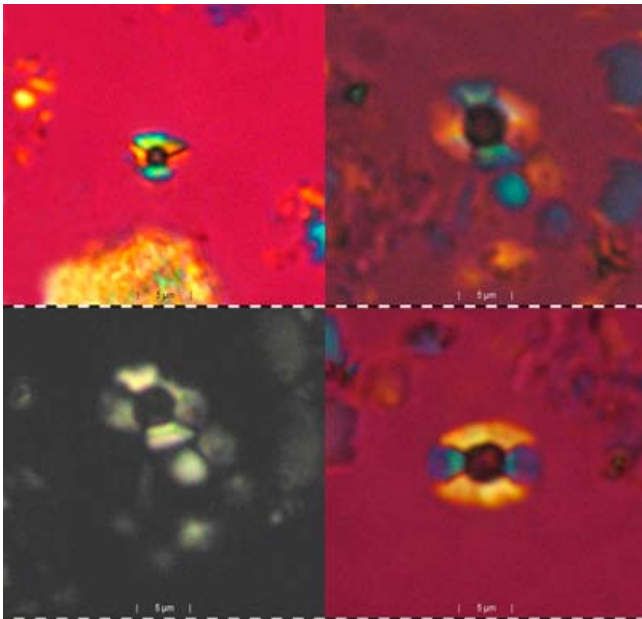
Beziehungen: *Lanternithus minutus* kann mit keinem bis jetzt beschriebenen Nannofossil des Alttertiärs oder des Mesozoikums in Verbindung gebracht werden. *Pyxilithus problematicus* DEFLANDRE hat einen relativ größeren Hohlraum und anders gestaltete Umrisslinien.

Bemerkungen: Der Hohlraum von *Lanternithus minutus* ist häufig durch einen Pyritkristall oder infolge schlechten Eindringens des Einschlussmediums von einer winzigen Luftblase erfüllt.

English translation:

Holotype: GBA 2009/058/0041.

Derivation of name: *minutus* (Lat.) = tiny.



Text-Fig. 63b.
Syntypes of *Lanternithus minutus* in polarized light.

Type locality: Basal glauconitic sands of the Reingrubberhöhe quarry at Bruderndorf, Lower Austria.

Level: stratotype locality of nannoplankton Zone NP19.

Diagnosis and description: Identical with the description of the as yet monospecific genus.

Relations: It differs from *Pyxillithus problematicus* DEFLANDRE, which has a larger central cavity and different outlines.

Remarks: Often we can find the central cavity of *Lanternithus minutus* filled with pyrite crystals or with a tiny air bubble.

Comments:

Stratigraphic range: middle Eocene through lower Oligocene (Lutetian–Rupelian; Zone NP15–NP23).

Genus: *Orthozygus* BRAMLETTE & WILCOXON, 1967, p. 116

Type species: *Zygodolithus aureus* STRADNER, 1962, p. 368, Pl. 1, Figs. 31–36.

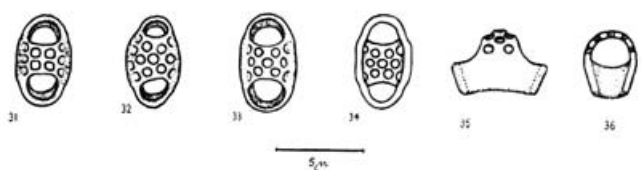
Original description of *Zygodolithus aureus* STRADNER, 1962

Holotypus: GBA 2009/058/0045.

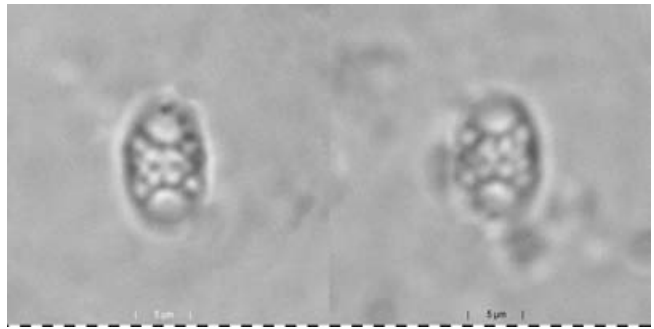
Derivatio nominis: *aureus* (Lat.) = golden.

Locus typicus: Basale Glaukonitsande des Steinbruches Reingrubberhöhe bei Bruderndorf, Niederösterreich.

Stratum typicum: Obereozän (jüngeres Led; K. GOHR-BANDT, 1962).



Text-Fig. 64a.
Original drawings of *Zygodolithus aureus*.



Text-Fig. 64b.
Holotype in normal light at different focus levels.

Diagnose und Beschreibung: Gehäuseelemente bestehend aus einem in Draufsicht ovalen, sich proximal konisch verjüngenden hohen Ring, welcher distal in Richtung der Querachsen von einem durch zahlreiche Poren durchbrochenen, stark gewölbten Joch überspannt wird. Die Anordnung der Poren entspricht im Mittelteil des Joches meist dem Quincunx (eine zentrale Pore, welche von sechs gleichgroßen Poren umgeben ist), doch können auch Exemplare mit nur vier oder fünf Poren auf dem Apex des Joches gefunden werden. Die mehr lateral schauenden Poren sind wegen der starken Wölbung des Joches nur als Querschnitte zu erkennen.

Dimensionen: Längsachse 5–6 µm, Querachse 3–5 µm, Höhe 3–4 µm.

English translation:

Holotype: GBA 2009/058/0045.

Derivation of name: *aureus* (Lat.) = golden.

Type locality: Basal glauconitic sands of the Reingrubberhöhe quarry in Bruderndorf, Lower Austria. Stratotype locality of nannoplankton Zone NP19.

Calcareous shell elements of a holococcolith, with an oval outline, and a central transversal bridge perforated by several pores. Side view conical towards the proximal side, the bridge vaulting the larger distal opening of the basal ring. The pores of the bridge can be arranged either in the corners of a square, or in the so called “quincunx pattern” with one pore in the centre and 6 of equal size surrounding it.

Size: Length 5–6 µm, width 3–5 µm, height 3–4 µm.

Occurrences: In all Upper Eocene outcrops reported by the author (STRADNER, Verh. Geol. B.-A., 1962, III, p. 107) in the Waschbergzone, Lower Austria. At some places rather rare.

Relations: *Zygodolithus aureus* nov. spec. shows similarities to some recent Coccolith species (compare KAMPTNER, 1941, Pls. X–XII, e.g. *Corisphaera arethusae* KAMPTNER and *Corisphaera ponticulifera* KAMPTNER).

Comments:

Stratigraphic range: Upper Eocene to lower Oligocene (Priabonian–Rupelian; Zone NP19–NP23).

Genus: *Zygrhablithus* DEFLANDRE 1959

Type species: *Zygodolithus bijugatus* DEFLANDRE in DEFLANDRE & FERT, 1954, p. 148, Pl. 11, Figs. 20, 21, Text-Fig. 59

Comments:

Taxonomic status: Several species names have been erected to designate various views of the holococcolith

Zygrhablithus bijugatus (DEFLANDRE). *Isthmolithus claviformis* BRÖNNIMANN & STRADNER 1960, p. 368, Pl. 1, Figs. 25–43 and *Lucianorhabdus dispar* STRADNER 1961, p. 87, Text-Figs. 49, 51, 52) are such superfluous names.

**Original description of *Isthmolithus claviformis*
BRÖNNIMANN & STRADNER, 1960**

Lectotypus: GBA 2009/058/0017/2.

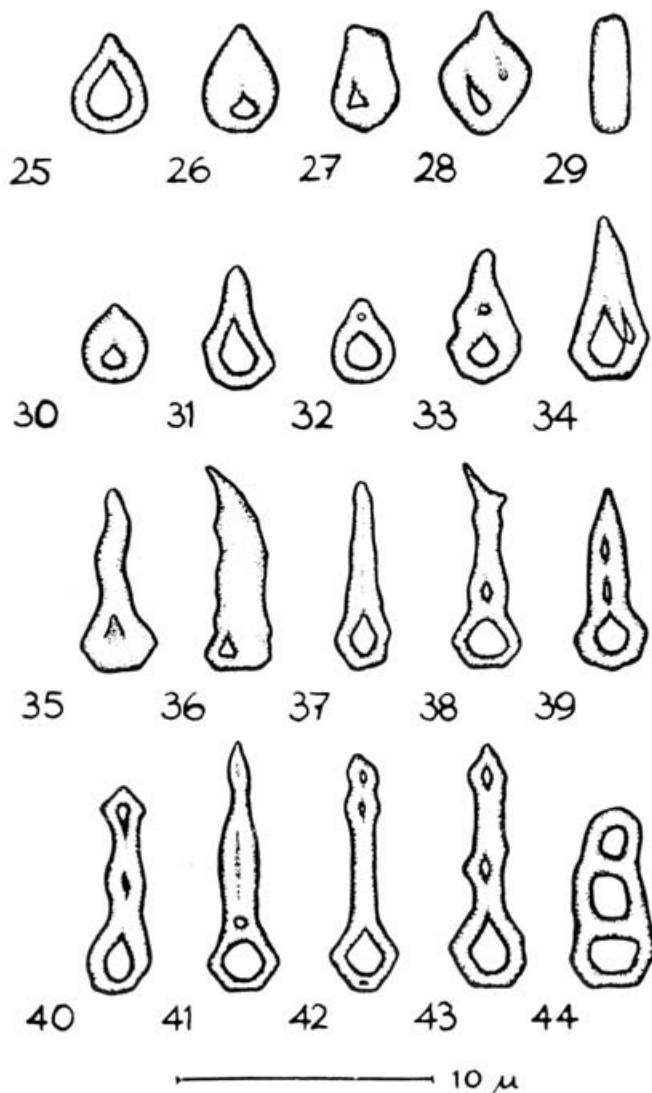
Derivatio nominis: *clavis* (Lat.) = Schlüssel.

Locus typicus: Universidad-Formation, BR-Stat. 489, Kuba.

Diagnose und Beschreibung: Flache, längliche Kalkplättchen, deren eines Ende verbreitert und von einem Fenster mit tropfenförmigem Umriss durchbrochen ist. Diese neue Art, welche meist nur durch ihre einfachsten Formen (1. Reihe) vertreten ist, bildet auch die verschiedensten Übergangsformen zu *Isthmolithus recurvus* DEFLANDRE.

Größe: 4–11 µm.

Beziehungen: *Isthmolithus claviformis* ist eng mit *Isthmolithus recurvus* DEFLANDRE verwandt, doch kann zur Zeit schwer



Text-Fig. 65.
Original drawings of *Isthmolithus claviformis*.

festgestellt werden, welche Art sich aus welcher entwickelt hat. *Isthmolithus claviformis* liegt in seinem Vorkommen vor *Isthmolithus recurvus* DEFLANDRE, welcher von MARTINI als typisch für das Ober-Eozän angesehen wird. Nur allzu leicht wäre man nämlich geneigt, *Isthmolithus claviformis* als degenerierte Form von *Isthmolithus recurvus* DEFLANDRE anzusehen, wogegen aber das zeitlich verschiedene Vorkommen spricht.

English translation:

Lectotype: GBA 2009/058/000.

Derivation of name: *clavis* = (Lat.) key; in the shape of a key. Diagnosis and description: Flat longitudinal calcareous plates, which on their wider end leave a tear-shaped window open. The other end is pointed. In overall view these very small specimens resemble small keys.

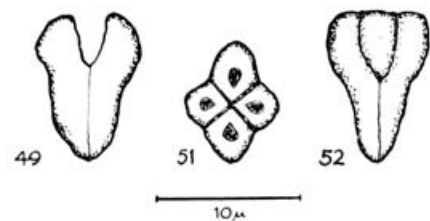
Comments:

Taxonomic status: *Isthmolithus claviformis* represents fragments of poorly preserved holococcoliths of *Z. bijugatus*.

**Original description of *Lucianorhabdus dispar*
STRADNER, 1961**

Holotypus: GBA 2009/058/0033.

Derivatio nominis: *dispar* (Lat.) = ungleich.



Text-Fig. 66.
Original drawings of *Lucianorhabdus dispar*.

Locus typicus: Mattsee, Salzburg. Häufig.

Stratum typicum: Mitteleozän.

Kalkkörperchen, deren vier längliche Einzelteile verschieden lang sind und auf der distalen Fläche vier grubige Vertiefungen besitzen. Je zwei gegenüberliegende Einzelteile sind gleichlang. Das in der Richtung der Querachse der Facies distalis liegende Paar von Einzelteilen kann leicht aus der Klammer der sie haltenden längeren Einzelteile herausfallen. Beim Drehen im linear polarisierten Lichte erscheinen je zwei gegenüberliegende Einzelteile abwechselnd hell und dunkel analog zu *Tetralithus pyramidus* GARDET.

Größe: 5–11 µm.

English translation:

Holotypus: GBA 2009/058/0033.

Derivatio nominis: *dispar* (Lat.) = different in size.

Wedgeshaped calcareous bodies consisting of four longitudinal elements of different length, two long ones and two short ones arranged alternating round the main axis. Viewed from the axial side these four elements appear under crossed nicols like a small *Tetralithus*. The broader flat basal end shows four tear-shaped dimples.

Size: 5–11 µm.

Comments:

Taxonomic status: *Lucianorhabdus dispar* designates poorly preserved holococcoliths of *Z. bijugatus*.

MESOZOIC

HETEROCOCCOLITHS

Order: Arkhangelskiales BOWN & HAMPTON in BOWN & YOUNG, 1997

Family: Kamptneriaceae BOWN & HAMPTON in BOWN & YOUNG, 1997

Genus: *Gartnerago* BUKRY, 1969

Gartnerago obliquum (STRADNER) REINHARDT 1970 (= *Arkhangelskiella obliqua* STRADNER, 1963, p. 176, Pl. 1, Figs. 2, 2a)

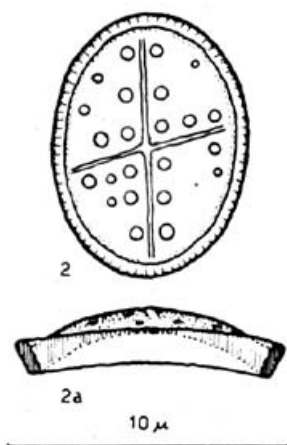
Original description of *Arkhangelskiella obliqua* STRADNER, 1963

Holotype: GBA 2009/058/0047.

Derivation of name: *obliquus* (Lat.) = oblique.

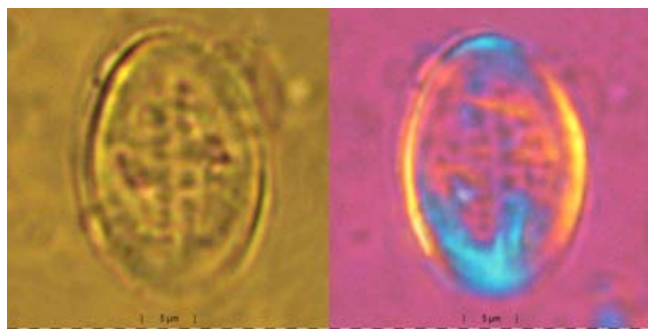
Type locality: Ameis 1 (ÖMV) Lower Austria.

Level: Upper Turonian.



Text-Fig. 67a.
Original drawing of *Arkhangelskiella obliqua*.

Description: Elliptical coccoliths with simple margin and wide central area, which is decorated with an oblique cross; the longer crossbars lie in direction of the main axis. A varying number of pores perforate the sectors of the central area.



Text-Fig. 67b.
Holotype in normal light at different focus levels.

Comments:

Stratigraphic distribution: Cenomanian to Campanian.

Genus: *Kamptnerius* DEFLANDRE, 1959

Kamptnerius punctatus STRADNER, 1963, p. 177, Pl. 2, Figs. 3-3a

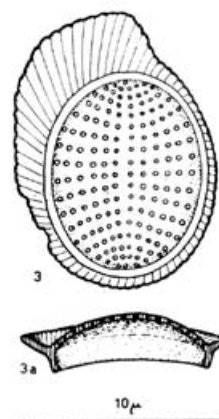
Original description of *Kamptnerius punctatus* STRADNER, 1963

Holotype: GBA 2009/058/0043/2.

Derivation of name: *punctatus* (Lat.) = dotted.

Type locality: Klafferbrunn, Lower Austria (GRILL 4557/3/947).

Level: Upper Turonian – Emscherian.



Text-Fig. 68a.
Original drawing of *Kamptnerius punctatus*.

Description: Coccoliths with large vaulted elliptical central area, which is perforated by numerous pores arranged to a symmetrical pattern of lines. The peripheral fringe is radiatingly striated and in most cases of irregular outline.



Text-Fig. 68b.
Holotype in normal light and partly polarized light.

Comments:

Stratigraphic distribution: Turonian to Maastrichtian.

Family: Arkhangelskiellaceae BUKRY, 1969 emend. BOWN & HAMPTON in BOWN & YOUNG, 1997

Genus: *Aspidolithus* NOEL, 1969

Aspidolithus parvus parvus (STRADNER) NOEL 1969 (= *Arkhangelskiella parca* STRADNER, 1963, p. 176, Pl. 1, Figs. 3, 3a)

**Original description of *Arkhangelskiella parca*
STRADNER, 1963**

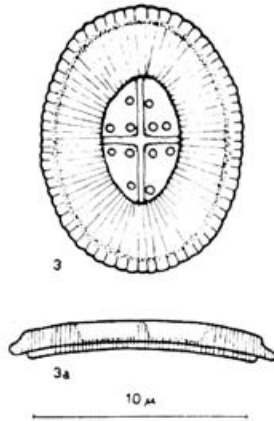
Holotype: GBA 2009/058/0048.

Derivation of name: *parcus* (Lat.) = modest.

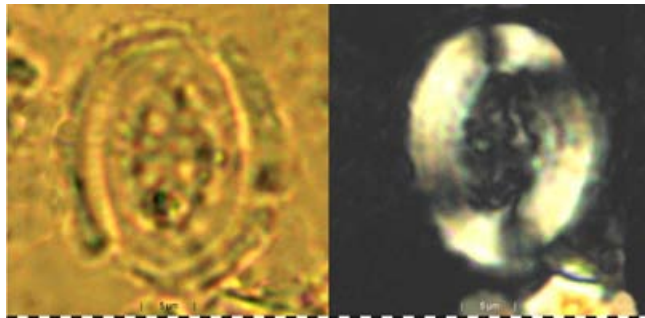
Type locality: Perwang 1 (RAG).

Level: Upper Campanian.

Description: Elliptical coccoliths with narrow central area and wide double marginal plates. A straight central cross divides the central area into sectors, which are perforated each by a few pores.



Text-Fig. 69a.
Original drawing of *Arkhangelskiella parca*.



Text-Fig. 69b.
Holotype in normal light and polarized light.

Comments:

Taxonomic status: *Aspidolithus* NOËL, 1969 is considered as a junior synonym of *Broinsonia* BUKRY, 1969 by some authors. *Broinsonia* is often used for taxa with a distinct central cross and *Aspidolithus* for taxa with perforated segments separated by axial sutures.

The evolution of the *Aspidolithus parcus* group has been discussed by many authors (see PERCH-NIELSEN, 1984). The subspecies *A. parcus parcus* (STRADNER) NOËL, 1969 most closely resembles STRADNER's holotype.

Stratigraphic distribution: Campanian.

**Order: Podorhabdales ROOD, HAY & BARNARD,
1971 emend. BOWN, 1987**

Family: Cretarhabdaceae THIERSTEIN, 1973

Genus: *Cretarhabdus* BRAMLETTE & MARTINI, 1964

Cretarhabdus striatus (STRADNER) BLACK 1973 (= *Arkhangelskiella striata* STRADNER, 1963, p. 176, Pl. 1, Figs. 1, 1a)

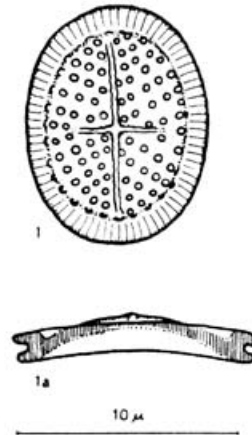
**Original description of *Arkhangelskiella striata*
STRADNER, 1963**

Holotype: GBA 2009/058/0046.

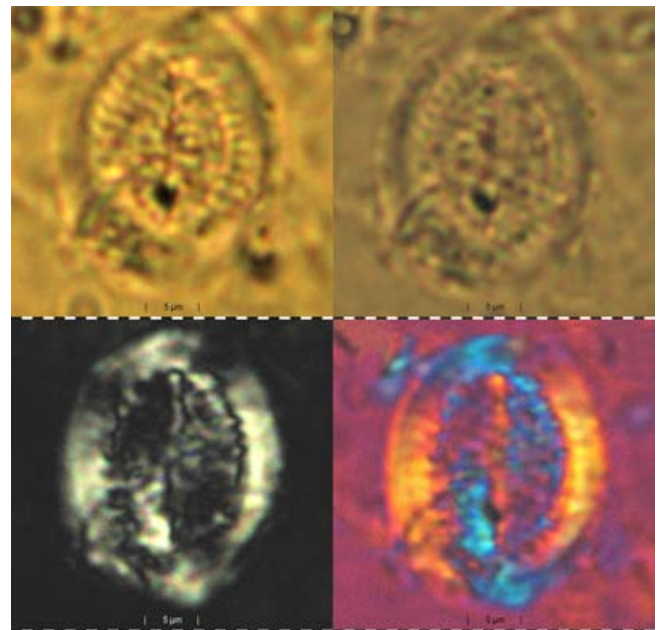
Derivation of name: *striatus* (Lat.) = striped.

Type locality: Leidschendam 1 (NV. Ned. Aardolie Maatsch.), Netherlands.

Level: Lower Albian.



Text-Fig. 70a.
Original drawing of *Arkhangelskiella striata*.



Text-Fig. 70b.
Holotype in normal light and polarized light at different focus levels.

Description: Elliptical coccoliths with wide central area and double marginal plates. Numerous pores are arranged in lines which meet at oblique angles at the straight central cross.

Comments:

Stratigraphic distribution: Aptian to Cenomanian.

Genus: *Polypodorhabdus* NOËL, 1965

Polypodorhabdus pienaari SHAFIK & STRADNER, 1971, p. 86, Pl. 14, Figs. 1–4, Text-Fig. 4

Synonyms: 1969 PIENAAR, p. 92, Pl. 8, Fig. 8. *Cretarhabdus decorus*.

non 1954 DEFLANDRE, in DEFLANDRE & FERT, p. 45, Pl. 13, Figs. 4–6, Text-Fig. 87; non 1964 BRAMLETTE & MARTINI, p. 300, Pl. 3, Figs. 9–12.

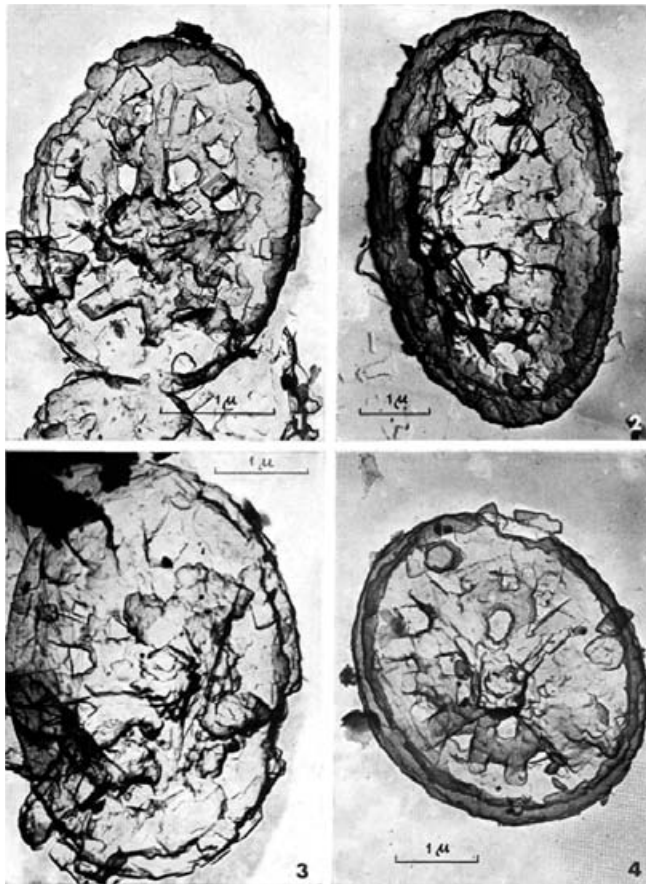
**Original description of *Polypodorhabdus pienaari*
SHAFIK & STRADNER, 1971**

Holotype: Electron micrograph 1395, Pl. 14, Fig. 4.

Paratypes: Electron micrograph 1119 u. 1467, Pl. 14, Figs. 1 & 3.



Text-Fig. 71a.
Original drawing of *Polypodorhabdus pienaari*.



Text-Fig. 71b.
TEM micrographs of syntypes (1–3) and distal view of the holotype (4).

Derivation of name: This new species is dedicated to Richard N. PIENAAR, University of Natal, Durban, S. A., who published the first picture of this species in 1968.

Type locality: Gebel Tarbouli, Egypt, Stat. Nr. 6.

Level: Upper Maastrichtian.

Description: Elliptical coccoliths with bilamellar rim and a wide central area spanned by a complicated symmetric structure, which according to PIENAAR, is described as follows: “Two parallel bars originate halfway down the longitudinal and transverse arms of the cross and are attached to the distal shield. From each of these bars two further bars develop opposite each other. These small bars fuse resulting in 4 pores in each quadrant.” The central stalk was not found to be hollow, but compact and quadrangular in cross-section.

Differential diagnosis: *Polypodorhabdus pienaari* does not have a hollow stem as indicated by microphotographs showing *C. decorus* in side view (see DEFLANDRE & FERT (1954), BRAMLETTE & MARTINI (1964), and PIENAAR (1969), Pl. 11, Fig. 8). All available electron micrographs give evidence of a compact stalk. Therefore a distinction from *Cretarhabdus decorus* seems justified.

Comments:

Stratigraphic distribution: Maastrichtian.

**Family: Axopodorhabdaceae BOWN & YOUNG,
1997**

Genus: *Cribracorona* PERCH-NIELSEN, 1973

Cribracorona gallica (STRADNER) PERCH-NIELSEN, 1973 (= *Coccolithus gallicus* STRADNER, 1963, p. 176, Pl. 1, Text-Figs. 8–8a)

**Original description of *Coccolithus gallicus*
STRADNER, 1963**

Holotype: GBA 2009/058/0051.

Derivation of name: *gallicus* (Lat.) = from France.

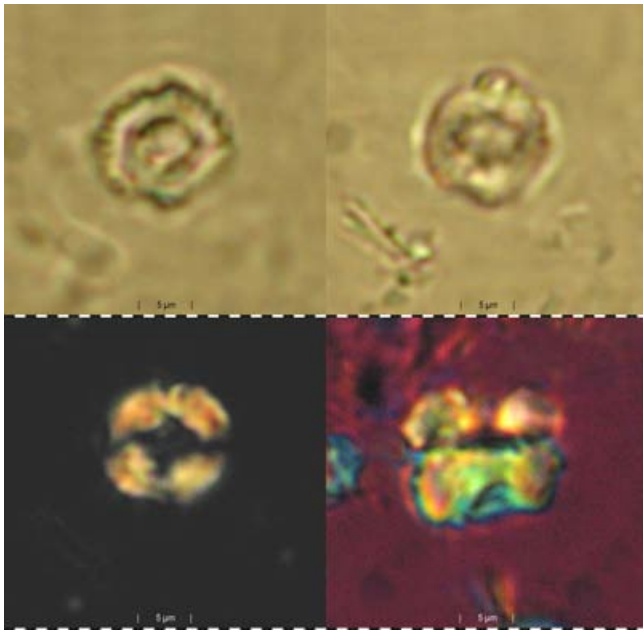
Type locality: Atlantic coast between Biarritz and Bidart, SW France.

Level: Maastrichtian.

Description: Coccoliths consisting of two subcircular or circular plates; the distal one consists of slightly counter-clockwise radiating petaloid plates, the proximal one is of more cylindrical form with a smaller diameter.



Text-Fig. 72a.
Original drawing of *Coccolithus gallicus*.



Text-Fig. 72b.
Axial view of holotype at different focus levels (1, 2), in polarized light (3), side view (4).

Comments:

Stratigraphic distribution: Upper Campanian to Maastrichtian.

Family: Biscutaceae BLACK, 1971

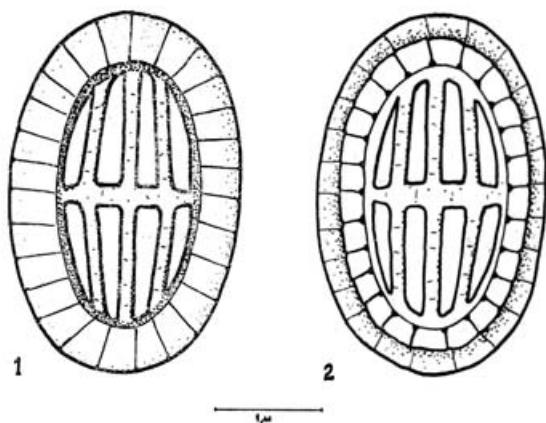
Genus: *Sollasites* BLACK, 1967

Sollasites horticus (STRADNER, ADAMIKER & MARESCH) CEPEK & HAY, 1969 (= *Coccolithus horticus* STRADNER, ADAMIKER & MARESCH in STRADNER & ADAMIKER 1966, p. 337, Text-Figs. 1, 2, Pl. 2, Fig. 4)

Original description of *Coccolithus horticus* STRADNER, ADAMIKER & MARESCH, 1966

Holotypus: Platte Nr. 17 769, 20.000 fach, Facies proximalis.

- 1. Paratypus: Platte Nr. 18 150, 8.000 fach, Facies distalis.
- 2. Paratypus: Stereo-Platten Nr. 821/822/65, 4.800 fach.



Text-Fig. 73a.
Original drawing of *Coccolithus horticus*.



Text-Fig. 73b.
TEM micrograph of the holotype and syntype in phase contrast.

Derivatio nominis: *horticus* = (Lat.) Gärtner.

Typuslokalität: Tiefbohrung Delft 2 (NAM), Niederlande.

Stratum typicum: Albium.

Coccolithen mit elliptischem Umriss, einer größeren distalen und einer etwas kleineren proximalen Randscheibe; der relativ große Binnenraum ist von acht Längsfenstern durchbrochen, welche je vier von einem Quersteg getrennt werden. Von den Längsstegen liegt der mittlere in der Hauptachse. Die rechts und links davon liegenden Seitenstege verlaufen nicht genau parallel dazu, so dass die Fenster des Binnenraumes nicht parallelrandig, sondern unregelmäßig trapezförmig sind, wobei die breitere Basis der Trapeze auf dem Quersteg zu liegen kommt. Die Randscheiben sind aus Kristallplatten zusammengesetzt, welche sich nur wenig überlappen und nur schwach geneigt sind. Die Coccusphaere der unbegeißelten Phase, von der die hier beschriebenen Coccolithen stammen, scheint derjenigen von *Coccolithus pelagicus* oder *Coccolithus helis* ähnlich gewesen zu sein, also von kugelförmiger Gestalt.

Größe des Holotypus: 3,3 µm lang, 2 µm breit.

Anmerkungen: Eine nahe verwandte Art scheint *Coccolithus helis* STRADNER nach den von BRAMLETTE & MARTINI 1964, Taf. 7, Fig. 5 und 6 gezeigten Elektronenmikrogrammen zu sein. Bei dieser Art sind die seitlichen Längsstege noch mehr geneigt, so dass es zur Ausbildung von dreieckigen Fenstern kommt. *Coccolithus helis* tritt im Danium – Paleozän auf.

English translation:

Holotype: TEM 17769.

Paratypes: TEM 18150 and TEM 621/622/65.

Derivation of name: *horticus* (Lat.) = gardener.

Type locality: NAM deep well Delft 2, Netherlands.

Level: Albian.

Size: Length 3.3 µm, width 2 µm.

Elliptical coccoliths with narrow marginal plates, a larger distal plate and a smaller proximal plate, surrounding a wide central opening, which is decorated with a grid of one transversal bar and six longitudinal bars. The broader transversal bar and the somewhat narrower longitudinal bars are the framework which embraces four central trapezoidal and four lateral triangular windows. The sutures between the plates of the marginal rim are straight and are orientated in centrifugal direction. These coccoliths are hetero-coccoliths, that means products of the non-motile phase of a living organism.

Comments:

Stratigraphic distribution: Upper Jurassic to Upper Cretaceous.

Order: Watznaueriales BOWN, 1987

Family: Watznaueriaceae ROOD, HAY & BARNARD, 1971

Genus: *Watznaueria* REINHARDT, 1964

Watznaueria britannica (STRADNER) REINHARDT, 1964 (= *Coccolithus britannicus* STRADNER, 1963, p. 176, Pl. 1, Figs. 7–7a)

Original description of *Coccolithus britannicus* STRADNER, 1963

Holotype: GBA 2009/058/0050.

Derivation of name: *britannicus* (Lat.) = from England.

Type locality: Redcliff Point between Weymouth and White Nothe, Dorset (BARNARD 1952).

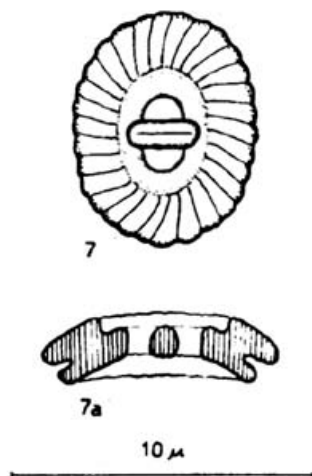
Level: Lower Oxfordian.

Description: Elliptical coccoliths consisting of two closely appressed plates; the oval central opening is transversely spanned by a short sturdy bridge.

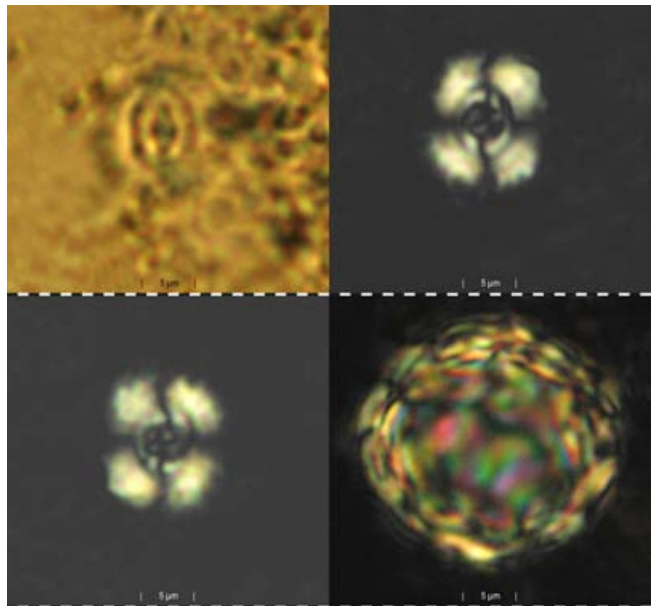
Comments:

Taxonomic status: Assignment to the genus *Watznaueria* should be regarded as provisional.

Stratigraphic distribution: Toarcian to Campanian.



Text-Fig. 74a.
Original drawing of *Coccolithus britannicus*.



Text-Fig. 74b.
Syntypes of *Coccolithus britannicus* in normal light and polarized light (1, 2, 3) and coccospaere (4).

Watznaueria opaca (STRADNER) REINHARDT, 1966 (= *Coccolithus opacus* STRADNER, 1961, p. 79, Text-Fig. 11–13)

Original description of *Coccolithus opacus* STRADNER, 1961

Holotypus: GBA 2009/058/0022.

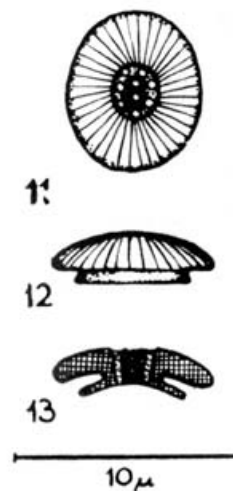
Derivatio nominis: *opacus* (Lat.) = dunkel.

Locus typicus: Schleifenbächle hinter Achdorf, Wutachgebiet, Württemberg. Häufig.

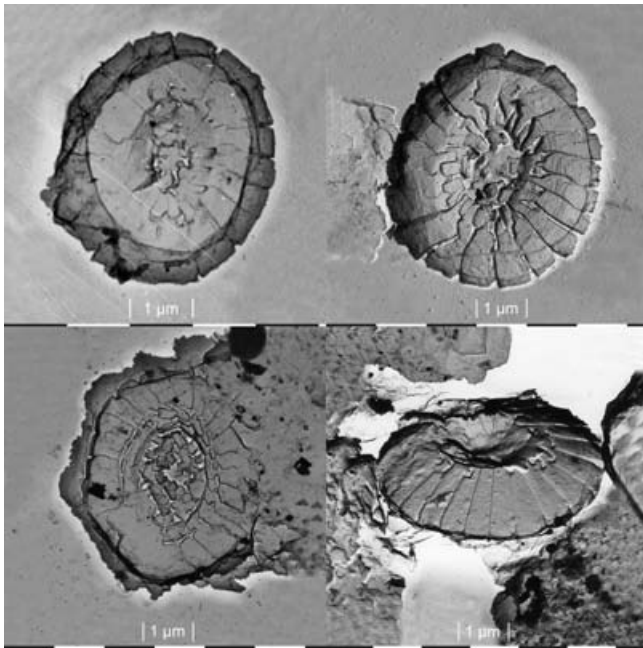
Stratum typicum: *Variabilis*-Zone (Unterer Lias Zeta).

Ein breitelliptischer Placolith, der aus einer gewölbten distalen Randscheibe, einer etwas kleineren proximalen Randscheibe und einem durch mehrere Poren durchbrochenen Mittelstück besteht. Die Randscheiben sind leicht gerieft. Der Coccolith zeigt im polarisierten Lichte ein typisches Löschungskreuz, er erscheint aber im Vergleich zu *Coccolithus pelagicus* (WALLICH) SCHILLER wesentlich dunkler.

Größe: 5–8 µm.



Text-Fig. 75a.
Original drawing of *Coccolithus opacus*.



Text-Fig. 75b.
TEM micrographs of *Coccolithus opacus* syntypes of (distal views [1–2], proximal view [3], oblique side view [4]).

English translation:

Holotype: GBA 2009/058/0022.

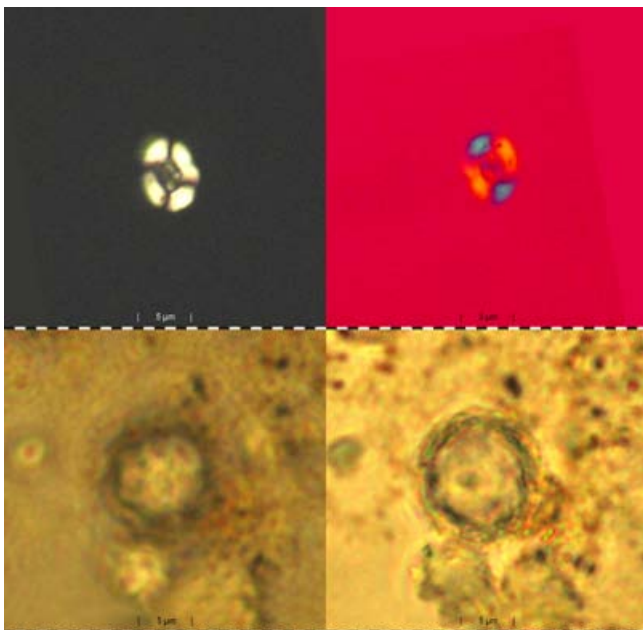
Derivation of name: *opacus* (Lat.) = dark.

Type locality: Schleifenbächle at Achdorf, Wutach district, Württemberg, Germany.

Level: *Variabilis* Zone, lower Jurassic (“Lias – Zeta”).

Size: 5–8 µm.

Description: Broad-elliptical placoliths with a vaulted, radially striated distal plate and a somewhat smaller proximal plate. The central area is perforated by several small pores. In cross-polarized light the coccoliths show the typical extinction cross as in *Watznaueria barnesae*, they are however smaller and darker.



Text-Fig. 75c
Syntypes in polarized light (1–2), coccosphaere at different focus levels (3–4).

Comments:

Taxonomic status: Assignment to the genus *Watznaueria* should be regarded as provisional.

Stratigraphic distribution: Liassic.

Genus: Lotharingius NOËL, 1973

Lotharingius sigillatus (STRADNER) PRINS in GRÜN, PRINS & ZWEILI, 1974 (= *Discolithus sigillatus* STRADNER, 1961, p. 79, Text-Figs. 14, 15)

Original description of *Discolithus sigillatus* STRADNER, 1961

Holotypus: GBA 2009/058/0030.

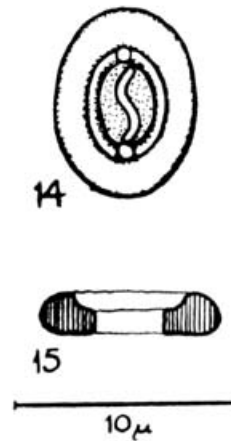
Derivatio nominis: *sigillatus* (Lat.) = mit kleinen Figuren verziert.

Locus typicus: Schleifenbächle hinter Achdorf, Wutachgebiet, Württemberg. Mäßig häufig.

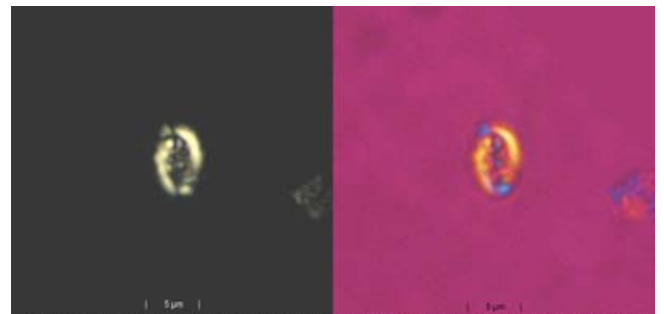
Stratum typicum: *Variabilis*-Zone (Unterer Lias Zeta).

Ein elliptischer Discolith, dessen Binnenraum durch eine sigma-förmige Figur verziert ist und dessen innerer vertiefter Rand durch zwei in der Längsachse der Ellipse liegende Punkte verziert ist.

Größe: 6–8 µm.



Text-Fig. 76a.
Original drawing of *Discolithus sigillatus*.



Text-Fig. 76b.
Syntype in polarized light.

English translation:

Holotype: GBA 2009/058/0030.

Derivation of name: *sigillatus* (Lat.) = decorated with small figures.

Type locality: Schleifenbächle at Achdorf, Wutach district, Württemberg, Germany.

Level: *Variabilis* Zone, lower Liassic.

Diagnosis and description: Elliptical discolith, the central area of which is decorated with a sigma-shaped design, with two dots on each side along the longer axis of the ellipse.

Size: 6–8 µm.

Comments:

Stratigraphic distribution: Upper Pliensbachian to Oxfordian.

Order: Eiffelithales ROOD, HAY & BARNARD, 1971

Family: Chiastozygaceae ROOD, HAY & BARNARD, 1973, emend. VAROL & GIRGIS, 1994

Genus: *Loxolithus* NOËL, 1965

Type species: *Loxolithus armilla* (BLACK & BARNES) NOËL, 1965 (= *Cyclolithus armilla* BLACK & BARNES, 1959, p. 327, Pl. 12, Fig. 2).

Original description of *Discolithus lucidus* STRADNER, 1963

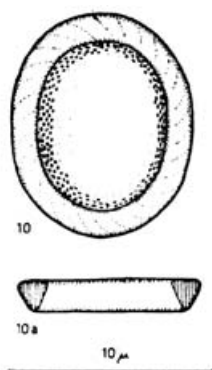
Holotype: GBA 2009/058/0054.

Derivation of name: *lucidus* (Lat.) = bright.

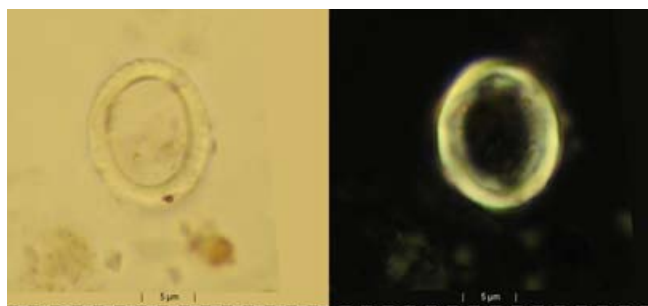
Type locality: Waidach, Salzburg, Field sample 28/14 (ABERER & BRAUMÜLLER, RAG).

Level: Upper Maastrichtian.

Description: Elliptical coccoliths with simple marginal ring of triangular cross section; the large central opening is spanned by a very delicate membrane.



Text-Fig. 77a.
Original drawing of *Discolithus lucidus*.



Text-Fig. 77b.
Holotype in normal and polarized light.

Comments:

Taxonomic status: *Discolithus lucidus* STRADNER, 1963, p. 11, Pl. 4, Text-Figs. 10-10a, is regarded here as a junior synonym of *Loxolithus armilla* (BLACK & BARNES, 1959) NOËL, 1965, p. 67, Fig. 3.

Stratigraphic distribution: Oxfordian to Maastrichtian.

Genus: *Barringtonella* BLACK, 1973

Barringtonella flabellosa (STRADNER, ADAMIKER & MARESCH) BLACK, 1973 (= *Zycolithus flabellus* STRADNER in STRADNER, ADAMIKER & MARESCH, 1968, p. 36, Pl. 31)

Original description of *Zycolithus flabellus* STRADNER in STRADNER, ADAMIKER & MARESCH, 1968

Holotype: TEM Plate 17589.

Paratype: TEM Plate 888/65.

Derivation of name: *flabellum* (Lat.) = fan.

Type locality: NAM deep well Delft 2, Netherlands.

Level: Albian.



Text-Fig. 78.
TEM micrographs of holotype (1) and paratype (2).

Diagnosis and description: *Zycoliths* with elliptical rim composed of imbricated crystal plates and a transversal or a cross-shaped central structure subdividing the central area into two halves or into four quadrants. A fan-shaped curtain of crystals, which are converging towards the focuses of the ellipse, fills the openings. It connects the rim with the middle part of the transversal bar, in specimens with also longitudinal bars it also inserts in these. On the distal side a central knob or tube can be observed, on the proximal side the double row of crystal plates and sutures in the medial line of the cross bars are the same as with *Zycolithus crux*.

Size: Holotype: length 5.7 µm, width 4 µm; paratype: length 3 µm, width 2.4 µm.

Discussion: In optical microscopes this species is not with certainty discernable from *Zygodiscus erectus* or from *Zygodiscus crux* depending on whether longitudinal bars are developed or not. As also intermediate forms between those shown in Pl. 31, Fig. 1 and Fig. 2 could be found, both the forms with single bridge and with central cross were included in this species, if the fan-like crystal-lace typical for *Zygodiscus flabellus* was present. *Discolithus surirella* DEFLANDRE & FERT 1954, p. 144, Text-Figs. 30 and 31 differs from *Zygodiscus flabellus* in not having a central structure. The system of lamellae, however, is rather similar.

Comments:

Stratigraphic distribution: Albian to Cenomanian.

Genus: *Tranolithus* STOVER, 1966

Tranolithus tarboulensis (SHAFIK & STRADNER) BONNEMAISON & STRADNER (n. c.) (= *Zygodiscus tarboulensis* SHAFIK & STRADNER, 1971, p. 91, Pl. 37, Figs. 1–4, Text-Fig. 5)

Original description of *Zygodiscus tarboulensis* SHAFIK & STRADNER, 1971

Holotype: EM no. 1135 (Fig. 2).

Paratypes: EM no. 443, EM no. 1147 (Figs. 1, 3).

Derivation of name: Discovered in a sample from the Gebel Tarbouli, Egypt Type locality: Gebel Tarbouli, Egypt, Stat. no. 7–1.

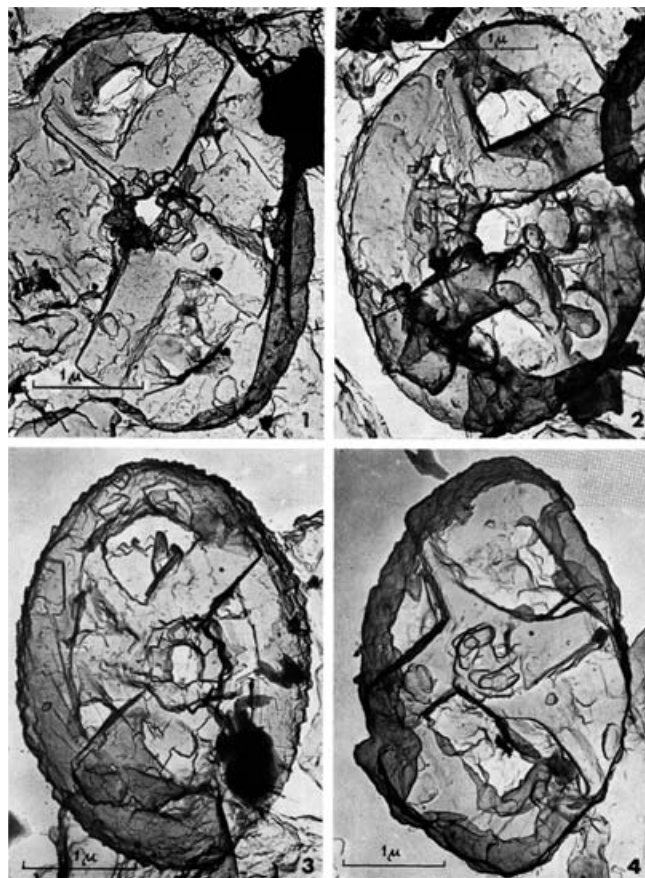
Level: Upper Maastrichtian.



Text-Fig. 79a.
Original drawing of *Zygodiscus tarboulensis*.

Diagnosis and description: Elliptical “zygodisc” with smooth or slightly serrate rim consisting of 30–50 dextrally imbricated elements. The central area is bridged by three elements: one transversal low bridge, from which rises a hollow stem, and two angular structures with arms of different width. These angles support the central stem with their corners and embrace less than 90 degrees. They are not symmetrical, but identical after rotation of 180°. Lines bisecting the angles bypass the central stem and run about parallel to the main axis of the elliptical rim. There are six windows with notches towards the centre, two large ones and four small ones.

Remarks: *Zygodiscus tarboulensis* is closely related to *Zygodiscus macleodae* BUKRY, from which it differs by the asymmetrical arrangement of the central structure and by the sharp notches of the framed perforations.



Text-Fig. 79b.
TEM micrographs of holotype (2) and syntypes (1, 3, 4).

Comments:

Taxonomic status: *T. tarboulensis* is closely related to *Z. biclavatus* BUKRY, 1969. The short arms of the two “L”-shaped elements bordering the central stem, are approximately parallel to the coccolith short axis in the holotype of *Z. biclavatus* and form an angle with it in *T. tarboulensis*.

Stratigraphic distribution: Upper Maastrichtian.

Family: Rhagodiscaceae HAY, 1977

Genus: *Rhagodiscus* REINHARDT, 1967

Rhagodiscus angustus (STRADNER) REINHARDT, 1971 (= *Rhabdolithus angustus* STRADNER, 1963, p. 178, Pl. 5, Text-Figs. 6–6a)

Original description of *Rhabdolithus angustus* STRADNER, 1963

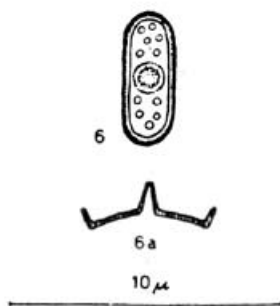
Holotype: GBA 2009/058/0059/2.

Derivation of name: *angustus* (Lat.) = narrow.

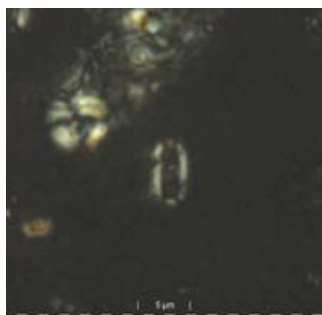
Type locality: Wanneperveen 1 (N. V. Ned. Aardolie Maatsch.), Netherlands.

Level: Upper Albian.

Diagnosis and description: Slightly vaulted coccoliths with parallel longitudinal flanks, rounded at the ends and margin tilted up to the distal side. The central stem is conical and comparatively short.



Text-Fig. 80a.
Original drawing of *Rhabdolithus angustus*.



Text-Fig. 80b.
Syntype in polarized light.

Comments:

Stratigraphic distribution: Aptian to Maastrichtian.

Rhagodiscus asper (STRADNER) REINHARDT, 1967 (= *Discolithus asper* STRADNER, 1963, p. 177, Pl. 2, Text-Figs. 4, 4a, 5, 5a)

Original description of *Discolithus asper* STRADNER, 1963

Holotype: GBA 2009/058/0053.

Derivation of name: *asper* (Lat.) = rough.

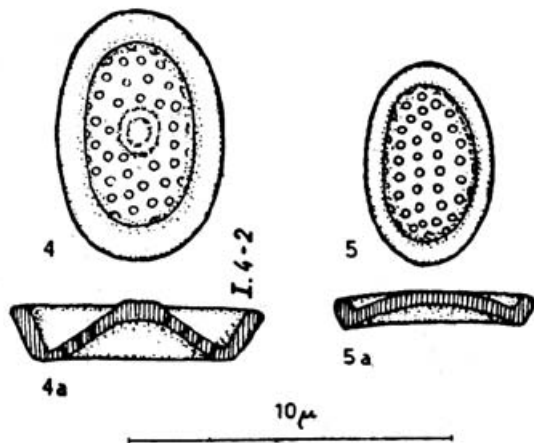
Type locality: Nordhorn Nord 11, Germany.

Level: Upper Hauterivian.

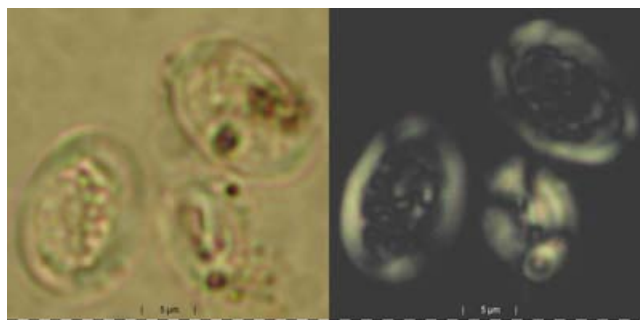
Description: Elliptical coccoliths with vaulted central area perforated by many pores; simple margin tilted up in distal direction.

Comments:

Stratigraphic distribution: Tithonian to Cenomanian.



Text-Fig. 81a.
Original drawing of *Rhabdolithus asper*.



Text-Fig. 81b.
Two syntypes in normal and polarized light.

Order: Stephanolithiales BOWN & YOUNG, 1997

Family: Stephanolithiaceae BLACK, 1968

Genus: *Corollithion* STRADNER, 1961, p. 83

Type species: *Corollithion exiguum* STRADNER, 1961, p. 83, Text-Figs. 58–61.

Original description of *Corollithion* STRADNER, 1961

Derivatio nominis: *corolla* (Lat.) = kleine Krone, *lithos* (Gr.) = Stein.

Flache, radiäre Kalkkörperchen von sechseckigem Umriss mit sechs in Richtung der Diagonalen gelegenen Durchbrechungen. Der nabenartige Mittelteil, von dem die Speichen ausgehen, trägt einen in Richtung der Hauptachse distal abstehenden kurzen Stiel. Der Rand des Kalkkörperchens ist geneigt, so dass der proximale Durchmesser kleiner ist als der distale. Die Gattung *Corollithion* gehört wahrscheinlich in die engere Verwandtschaft von *Stephanolithion* DEFLANDRE und *Zygoolithus* KAMPTNER.

English translation:

Derivation of name: *corolla* (Lat.) = little crown, *lithos* (Gr.) = stone.

Flat calcareous bodies with hexagonal circumference and six triangular windows arranged along the diagonals of the hexagon. The centre, which is elongated into a knob showing in distal direction is connected with the rim by six spikes. In side view one can see the rim converging in proximal direction.

Relation: Closely related to the genera *Stephanolithion* DEFLANDRE and *Zygoolithus* KAMPTNER.

Original description of *Corollithion exiguum* STRADNER, 1961

Holotypus: GBA 2009/058/0024.

Derivatio nominis: *exiguus* (Lat.) = winzig.

Locus typicus: Waidach, Nußdorf (Haunsberg), Salzburg. Mäßig häufig.

Stratum typicum: Obere Kreide (Senon).

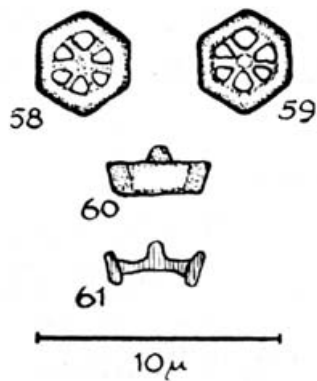
Die Beschreibung der bis jetzt einzigen Art der Gattung *Corollithion* fällt mit der des Genotypus zusammen. Größe: 4–7 µm.

English translation:

Holotype: GBA 2009/058/0024.

Derivation of name: *exiguus* (Lat.) = tiny.

Type locality: Waidach, Nußdorf (Haunsberg), Salzburg, Stat. 28 GOHRBANDT.

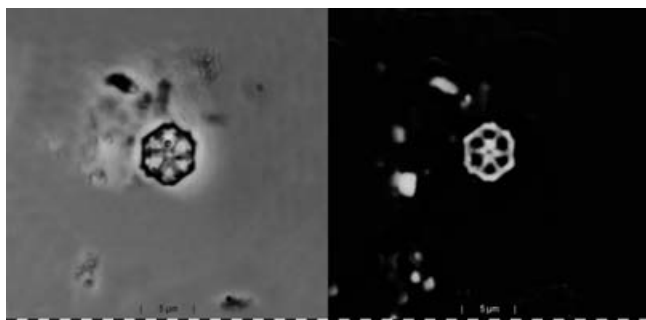


Text-Fig. 82a.
Original drawing of *Corollithion exiguum*.

Level: Upper Maastrichtian, *Micula prinsii* Zone.

Diagnosis: See the generic diagnosis.

Size: 4–7 µm.



Text-Fig. 82b.
Holotype in positive and negative phase contrast.

Comments:

Stratigraphic distribution: Upper Cenomanian to Maastrichtian.

Corollithion signum STRADNER, 1963, p. 177, Pl. 1, Text-Figs. 13–13a.

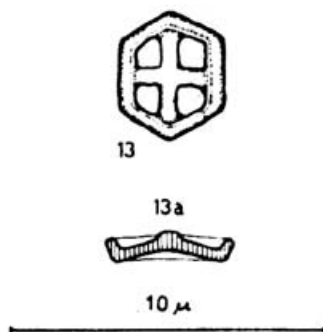
**Original description of *Corollithion signum*
STRADNER, 1963**

Holotype: GBA 2009/058/0052.

Derivation of name: *signum* (Lat.) = sign.

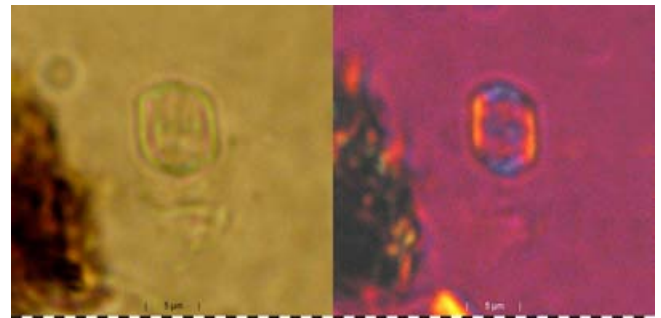
Type locality: Klafferbrunn, Lower Austria (GRILL 4557/3/947).

Level: Upper Turonian – Emscherian.



Text-Fig. 83a.
Original drawing of *Corollithion signum*.

Description: Coccoliths with hexagonal outline; the large central opening is filled out with a straight cross (Lat.: cum signo crucis).



Text-Fig. 83b.
Lectotype in normal and polarized light.

Comments:

Stratigraphic distribution: Albian to Maastrichtian.

Genus: *Stoverius* PERCH-NIELSEN, 1986

Stoverius baldiae (STRADNER) PERCH-NIELSEN, 1986 (= *Zygoolithus baldiae* STRADNER & ADAMIKER, 1966, p. 338, Pl. 2, Fig. 2, Text-Figs. 3, 4)

**Original description of *Zygoolithus baldiae*
STRADNER & ADAMIKER, 1966**

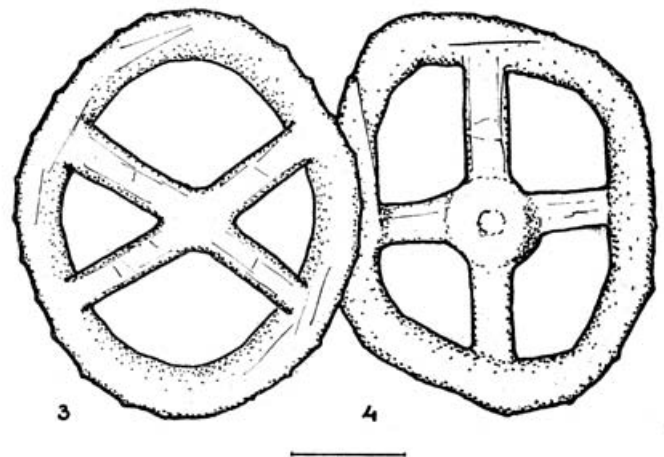
Holotypus: Platte Nr. 17 707, 8.000 fach.

Paratypus: Stereo-Platten Nr. 519/520/65, 4.000 fach.

Derivatio nominis: Frau Dr. Maria BALDI, Budapest, zugeeignet, die diese Art erstmalig aus ungarischem Barrémium dokumentiert hat. Literatur: BALDI-BEKE, M., 1964, Taf. 1, Fig. 7; MANIVIT, H., 1965, Taf. 1, Fig. 6 a, b, S. 194.

Locus typicus: Tiefbohrung Delft 2 (NAM), Niederlande.

Stratum typicum: Albium.



Text-Fig. 84a.
Original drawing of *Zygoolithus baldiae*.

Diagnose: Zygoolithen mit breitelliptischem bis annähernd kreisförmigem Umriss und diagonal liegendem schlankem Zentralkreuz, dessen Balken sich meist nicht rechtwinkelig schneiden. Der Rand des Zygoolithen ist schmal, aus sich weit überdeckenden, annähernd in peripherer Richtung

angeordneten Kristallplatten zusammengesetzt. Seine Form ist oft von der Idealellipse abweichend, und zwar, wenn sogenannte „Quetschformen“ vorliegen. Bei solchen können die Ränder an ein oder mehreren Stellen begründet sein, so dass rhombische, trapezförmige und sogar sechseckige, abgerundete Umrisse entstehen. Quetschformen scheinen auf eine sehr dichte Lagerung der Entstehungszentren der Zygoolithen innerhalb des Plasmakörpers des Flagellaten zurückzuführen sein. Auch *Zygoolithus delftensis* und die Kalkkörperchen der Gattungen *Scapholithus*, *Corolithion* und *Calciosolenia* scheinen auf diese Weise ihre geradkantigen Umrisse erhalten zu haben.

Größe: 3,5 µm lang, 3 µm breit.



Text-Fig. 84b.
TEM micrograph of holotype and syntype in polarized light.

English translation:

Derivation of name: Dedicated to Dr. Maria BALDI, who for the first time showed a picture of this species.

Holotype: TEM no. 17707; paratype: 519/520/65.

Diagnosis and description: Zygooliths with broad-oval or circular outline. The narrow basal ring is spanned by four bars which are united in the centre. These bars forming the letter X enclose angles more or less than 90 degrees. Squeezed forms like in Fig. 4 and some with a central knob can also be found. The marginal rim is composed of overlapping crystal plates.

Remark: The cause for square-cut edges in Zygooliths can be understood as lack of space on the surface of the coccosphere during its construction. Straight outlines can be seen also in *Zygoolithus delftensis* and *Corolithion exiguum*.

Size: Length 3.5 µm, width 3 µm.

Comments:

Stratigraphic distribution: Albanian.

Genus: *Truncatoscaphus* ROOD, HAY & BARNARD, 1971

Truncatoscaphus delftensis (STRADNER & ADAMIKER) ROOD, et al., 1971 (= *Zygoolithus delftensis* STRADNER & ADAMIKER, 1966, p. 338, Pl. 2, Fig. 3, Text-Figs. 8–11)

Original description of *Zygoolithus delftensis* STRADNER & ADAMIKER, 1966

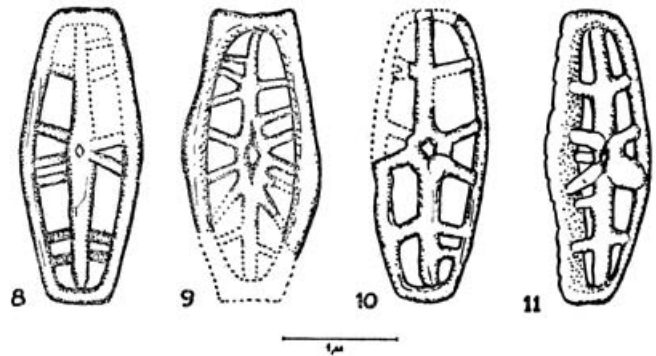
Derivatio nominis: aus Delft, Niederlande.

Holotypus: Platte Nr. 348/65, 20.000 fach und Stereoplatten 346/347/65, 9.800 fach.

Paratypus: Platte Nr. 17 479, 20.000 fach.

Locus typicus: Tiefbohrung Delft 2 (NAM), Niederlande.

Stratum typicum: Albium.



Text-Fig. 85a.
Original drawing of *Zygoolithus delftensis*.

Diagnose: Zygoolithen mit durchlaufendem Längssteg, von welchem zu beiden Seiten eine variable Anzahl von Seitenstegen fiederförmig abzweigt. Umriss des Außenringes länglich sechseckig; Die beiden sich gegenüber liegenden Endkanten sind verkürzt, der Längssteg steht rechtwinkelig zur kurzen Querdiagonale des Sechseckes. Die Seitenstege sind, wie Stereogramme zeigen, nicht alle in einer Ebene angeordnet, sondern treffen den äußeren Ring,



Text-Fig. 85b.
TEM micrograph of holotype and syntype in polarized light.

welcher aus flachliegenden Kristallplatten aufgebaut ist, in verschiedener Höhe. Längliche Zentralpore meistens vorhanden.

Anmerkung: Diese neue Art scheint mit *Zygoolithus rhombicus* verwandt zu sein, von der sie sich durch den hier sechseckigen, dort rautenförmigen Umriss und durch den durchlaufenden Längssteg unterscheidet. Auch *Zygoolithus geometricus* GORKA gehört in die nähere Verwandtschaft dieser Arten. Man kann annehmen, dass an der lebenden Zelle die einzelnen Zygoolithen von *Zygoolithus delftensis* nach einem Quincunx-Muster, welches in Richtung des Längssteges gestreckt war, angeordnet waren. Die komplette Zelle hatte vermutlich spindelförmige Gestalt.

Größe des Holotypus: 2,4 µm lang, 1,2 µm breit.

English translation:

Holotype: TEM Plate 348/65 and stereo plates 346+347/65.

Derivation of name: *delftensis* = originating from Delft.

Type locality: NAM deep well Delft 2, Netherlands.

Level: Albian.

Diagnosis and description: Elongate hexagonal zygooliths with a central bar in den direction of the main axis, from which several oblique lateral bars are extending to the rim. The elongate bar is perforated in its centre. The short lateral bars are lying in different levels as can be seen in stereo micrographs.

Remarks: Related to *Zygoolithus rhombicus* and to *Zygoolithus geometricus* GORKA. It can be assumed that the complete coccosphere was spindle-shaped and that the zygooliths on it were arranged in an elongate quincunx pattern.

Size of holotype: Length 2.4 µm, width 1.2 µm.

Comments:

Stratigraphic distribution: Tithonian? to Albian.

Genus: *Rhombolithion* BLACK, 1973

Rhombolithion rhombicum (STRADNER) BLACK, 1973 (= *Zygoolithus rhombicus* STRADNER & ADAMIKER, 1966, p. 339, Pl. 2, Fig. 1, Text-Figs. 5–7)

**Original description of *Zygoolithus rhombicus*
STRADNER & ADAMIKER, 1966**

Holotypus: Stereo-Platten Nr. 895/896/65, 9.800 fach.

Paratypus: Stereo-Platten Nr. 823/824/65, 9.300 fach.

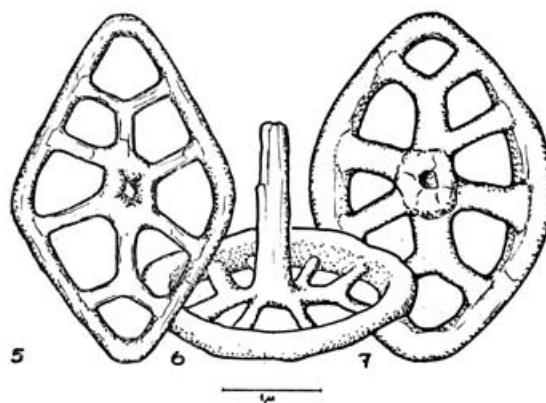
Derivatio nominis: *rhombos* (griech.) = Raute.

Locus typicus: Tiefbohrung Delft 2 (NAM), Niederlande.

Stratum typicum: Albium.

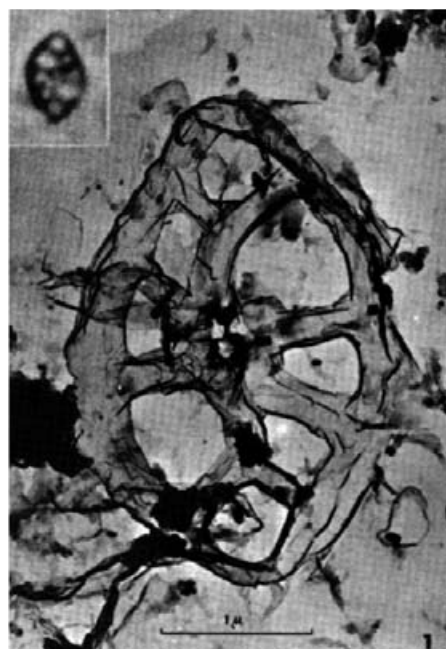
Diagnose: Zygoolithen mit rautenförmigem Umriss und einem den Binnenraum unterteilenden Stegsystem, welches acht annähernd gleichgroße Fenster freilässt. Der in der Längsachse liegende Steg ist an seinen Enden gegabelt. Von ihm zweigen zu beiden Seiten je vier Seitenstege ab. Der Rand besteht aus flach übereinanderliegenden länglichen Kristallplatten. Von der Mitte des Zygoolithen kann, ähnlich wie bei *Zygoolithus erectus* DEFLANDRE & FERT, ein in distaler Richtung sich etwas verjüngendes, röhrenförmiges Gebilde absteigen. Falls dieses nicht ausgebildet oder zerstört ist, kann eine zentrale Pore erkennbar sein.

Größe des Holotypus: 3,2 µm lang, 2,2 µm breit.



Text-Fig. 86a.
Original drawing of *Zygoolithus rhombicus*.

Anmerkung: Die Stege können wie bei vielen anderen Zygoolithen-Arten als Verschmelzungsprodukte von Bogenelementen angesehen werden. Diese Art unterscheidet sich von der Gattung *Dictyolithus* GORKA durch ihren streng zygomorphen Bau und eine geringere Porezahl.



Text-Fig. 86b.
TEM micrograph of holotype and syntype in phase contrast.

English translation:

Holotyp: TEM Plate no. 895/896/65.

Paratype: TEM Plate no.823/824/65.

Derivation of name: *rhombus* (Gr.) = rhombus.

Type locality: NAM deep well Delft 2, Netherlands.

Level: Albian.

Diagnosis and description: Zygooliths with rhombical or rounded rhombical outline and a central knob or rod pointing in distal direction, similar to *Zygoolithus erectus* DEFLANDRE & FERT. This central structure is connected with the delicate rim by a system of bars, which radiate from the centre. Two stronger bars or ribs are aligned along the main axis and bifurcated, four other non-bifurcated shorter bars are spreading laterally towards the rim, two on each side. They are bypassing the shorter axis of the zygoolith.

A central pore can be seen in some specimens. The rim is composed of calcite laminae.

Remark: This zygolith differs from those of the Genus *Dicthyolithus* GORKA by its strictly zymorphic outline and its lesser number of windows.

Comments:

Stratigraphic distribution: Oxfordian to Tithonian, and from Albian to Campanian.

Incertae sedis

Genus: *Liliasterites* STRADNER & STEINMETZ, 1984, P. 594

Type species: *Liliasterites angularis* SVABENICKA & STRADNER in STRADNER & STEINMETZ p. 594, Pl. 24, Figs. 1–4, Text-Fig. 6A

Original description of *Liliasterites*

Derivation of name: The six rays of this nannofossil alternate in two levels, reminiscent of the three petals and three sepals in the flower of a lily (latin *Lilium*).

Remarks: This Genus comprises six-rayed, star-shaped, flat, calcareous nannofossils, composed of angular elements. In better-preserved specimens, sutures can be observed. Two levels of rays – that is rays 1, 3, and 5 in the upper level and rays 2, 4, and 6 in the lower level, with the intervals between the rays alternately wide and narrow – give these forms a close similarity to *Marthasterites contortus*. They differ from *Marthasterites* by the presence of sutures. Also, disintegrated angular elements throw light on the composition of *Liliasterites*, which possibly is an ancestor of the Genus *Marthasterites*.

Original description of *Liliasterites angularis* SVABENICKA & STRADNER, 1984

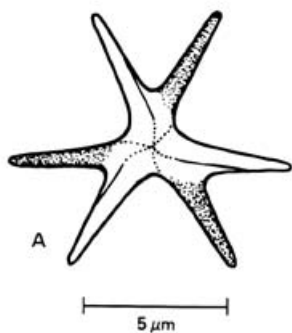
Holotype: Plate 24 in STRADNER & STEINMETZ, 1984, Fig. 1; Paratypes: Plate 24, Figs. 2–4

Derivation of name: *angularis* (Lat.) = angular.

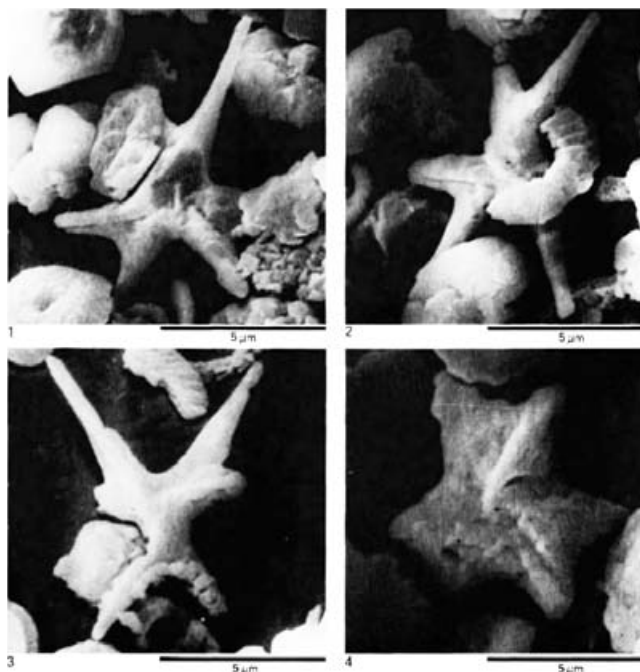
Type locality: Right bank of the Ohre river, S. of Kystra vilage, CSSR.

Level: Upper Turonian

Remarks: A species of *Liliasterites* with six tapering, pointed rays. In the central area three-rayed symmetry dominates. Two neighboring rays, each in a different level, are separated by a suture line, which indicates that the nannofossil is composed of angular elements (hence the species epithet “angularis”).



Text-Fig. 87a.
Original drawing of *Liliasterites angularis*.



Text-Fig. 87b.
SEM images of holotype (1) and syntypes (2–4).

Size: Diameter of holotype 12 µm, length of free ray 4 µm.

Another occurrence in the Angola Basin, South Atlantic: DSDP Sample 530A-95-1, 107–108 cm. Late Turonian.

Discussion: *Liliasterites angularis* together with *L. atlanticus* are considered evolutionary steps in a line which leads to the Genus *Marthasterites*. *L. angularis* marks with its first occurrence the lower boundary of the new late Turonian nanoplankton zone bearing its name. In Bohemia, *L. angularis* is a rare species in a late Turonian nannoflora without *Marthasterites furcatus* and without *Micula staurophora*. The layer in which it is found is between 3 and 4 m below the so-called coprolite horizon, which marks the upper boundary of the Jizera Formation to the overlying Teplice Formation. A detailed description of these two formations is to be found in CECH et al. (1980, pp. 286–291). A diagrammatic section of the lower Teplice Formation and the upper Jizera Formation at Kystra is shown in Fig. 9 of that paper. The Kystra samples with *L. angularis* are a deep-grey, calcareous clay stone with silty admixture and biodeutral streaks. The vilage of Kystra lies near Louny in the western part of the Bohemian Cretaceous Basin. The exposure is 150 m long and 20 m high, on the right bank of the Ohre river south of Kystra. In KRHOVSKY (1981, p. 2.1) SVABENICKA has reported on the occurrence of *Marthasterites furcatus* in the coprolite layer of Kystra (lowest occurrence) and at 0.55 and 2.5 m above the coprolite layer. This indicates that the coprolite layer at Kystra corresponds to the base of the *M. furcatus* nanoplankton zone, which is considered the base of the Coniacian (sensu CEPEK & HAY, 1969, emend. PERCH-NIELSEN, 1977). In Bohemia, the correlation between *Inocerami* and *M. furcatus* at the Turonian/Coniacian boundary by KRHOVSKY (1981) has shown the importance of more detailed biostratigraphic work being done at the new standard Turonian and Coniacian stratotypes. KRHOVSKY concludes that in the Cretaceous of Bohemia the Turonian/Coniacian boundary is to run along the IX–X Formations contact in the upper Jizera Formation, provided that *M. furcatus* is proven at the Coniacian stratotype. The *Inoceramus*

schloenbachi – *L. inconstans* group would thus be of Coniacian age. Possibly the distinction between the genera *Liliasterites* and *Marthasterites* in the critical boundary layers will provide means for a more detailed zonation.

Comments:

Stratigraphic distribution: Middle to Upper Turonian.

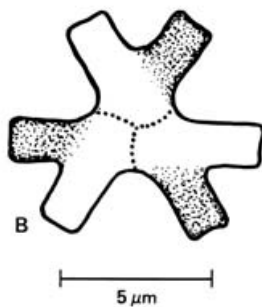
**Original description of *Liliasterites atlanticus*
STRADNER & STEINMETZ, 1984**

Holotypes: Plate 23, Fig. 5 (holotype); Plate 22, Fig. 7, Plate 23, Figs. 2 and 4 (paratypes).

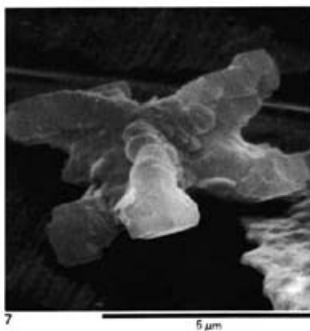
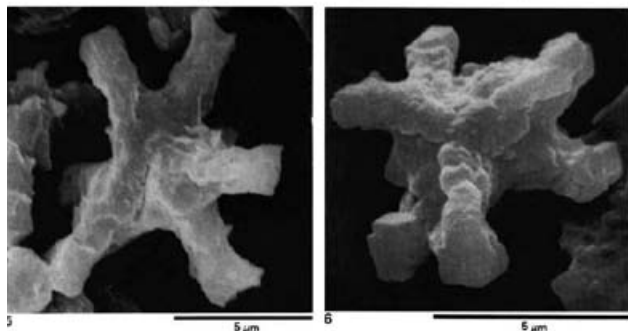
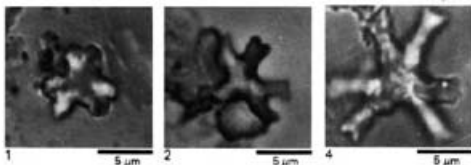
Derivation of name: *atlanticus* = from the Atlantic Ocean.

Type locality: South Atlantic (Angola Basin), DSDP Sample 530A-95-1, 107–108 cm.

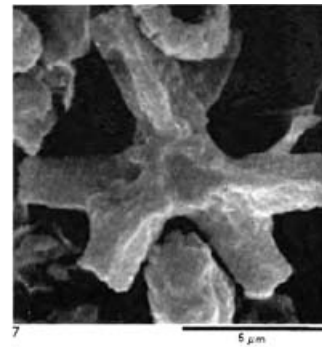
Level: Upper Turonian.



Text-Fig. 88a.
Original drawing of *Liliasterites atlanticus*.



Text-Fig. 88b.
Syntypes in normal light (1, 2, 4). SEM images of holotype (5) and syntypes (6, 7).



Text-Fig. 88c.
SEM image of paratype.

Description: A species of *Liliasterites* with broad, truncated rays, the ends of which are either notched or block-shaped. Three alternating rays with angles of 120 degrees between them in one level are offset against the other three rays by about 60 degrees, so that three bundles of two alternating arms result.

Comments:

Stratigraphic distribution: Upper Turonian.

Genus: *Ceratolithoides* BRAMLETTE & MARTINI, 1964

Ceratolithoides aculeus (STRADNER) PRINS & SISSINGH in SISSINGH, 1977 (= *Zygrhablithus aculeus* STRADNER, 1961, p. 82, Text-Figs. 53–57)

**Original description of *Zygrhablithus aculeus*
STRADNER, 1961**

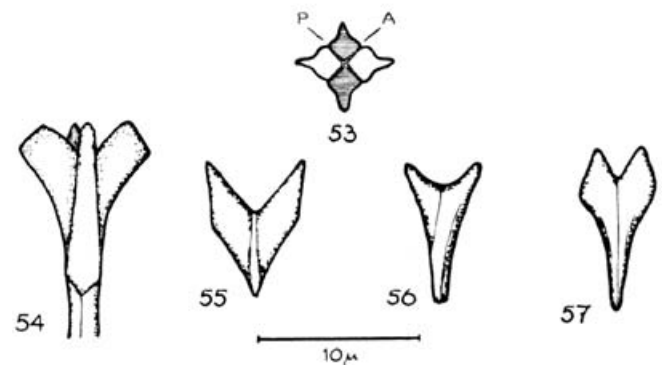
Holotypus: GBA 2009/058/0036.

Derivatio nominis: *aculeus* (Lat.) = Spitze.

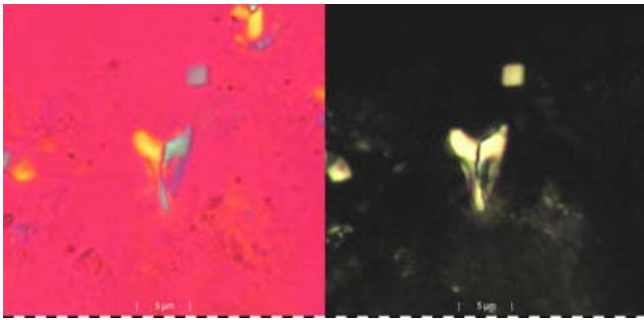
Locus typicus: Steinbruch östlich der Straße NW Hochbruckenbergr, Wienerwaldflysch, Niederösterreich. Mäßig häufig.

Stratum typicum: Senon im weiteren Sinne.

Beschreibung: Ein *Zygrhablithus*, dessen distaler, tetralithischer Fortsatz spitzig ist und flügelartige Enden hat. Letztere schließen im Gegensatz zu *Zygrhablithus interciscus* DEFLENDRE einen spitzen Winkel ein. Die Facies distalis des Fortsatzes entspricht in ihrem polarisationsoptischen Verhalten weitgehend der von *Tetralithus pyramidus* GARDET. Vollständige Exemplare (Placolithischer + tetralithischer Teil) konnten noch nicht gefunden werden.



Text-Fig. 89a.
Original drawings of *Zygrhablithus aculeus*.



Text-Fig. 89b.
Lectotype in polarized light.

Größe: 8–10 µm.

English translation:

Holotype: GBA 2009/058/0036.

Derivation of name: *aculeus* (Lat.) = tip.

Type locality: Vienna Woods, BRIX Stat. 86, quarry NW Hochbruckenberg.

Level: Upper Cretaceous.

Description: Presumably distal tips of zygraliths occurring separately and behaving in polarized light like tiny tetraliths of *Tetralithus pyramidus* GARDET, in lateral view they resemble arrow tips. No complete specimens (Placolith + tetralithic tip) could be found yet.

Size: Length 8–10 µm.

Comments:

Stratigraphic distribution: Campanian to Maastrichtian.

Family: Polycyclolithaceae FORCHHEIMER, 1972 emend. VAROL, 1992

Genus: *Lithastrinus* STRADNER, 1962, p. 369

Type species: *Lithastrinus grillii* STRADNER 1962, p. 369, Pl. 2, Figs. 1–5.

Original description of *Lithastrinus* Stradner 1962

Derivatio nominis: Wortzusammensetzung aus den griechischen Hauptwörtern *lithos* = Stein und *astron* = Stern.

Von fossilen Kalkflagellaten herrührende Gehäuseelemente von 6- bis 9-strahligem radiärem Aufbau, in der Hauptebene stark eingeschnürt. Die 6–9 Sektoren, welche sich polarisationsoptisch ähnlich wie die Einzelteile der Pentolithen von Braarudosphaeriden verhalten, sind durch links-gängig-schraubige Verbindungsflächen miteinander vereinigt, wodurch sie in Bezug zur Richtung der Hauptachse schräg zu liegen kommen. Die sternförmig zusammenlaufenden Verbindungsflächen (Unterteilungslinien) weichen auf halbem Wege zwischen Außenbegrenzung des Kalkkörperchens und Hauptachse (Mittellinie) etwas auseinander (Aussparungen). Die peripher abstehenden Enden der Sektoren können spitz und gebogen (*Lithastrinus grillii*) oder gerundet (*Lithastrinus floralis*) sein und liegen in zwei zur Hauptebene parallelen Ebenen (Flachseiten). Durch die starke Verwindung der Einzelsektoren kommen die beiden in verschiedenen Ebenen liegenden abstehenden Enden eines Sektors jeweils über oder unter das Ende eines Nachbarsektors zu liegen. Dies bewirkt beim Heben und

Senken des Immersionsobjektives ein Rotieren des Zentrums und ein Umspringen des Bildes der Randpartien des Nannofossils, da ja die in verschiedenen Schärfeebenen liegenden Flachseiten aus den peripher abstehenden Enden schraubig gedrehter Sektoren gebildet werden.

English translation:

Derivation of name: word combination of *lithos* (Gr.) = stone and *astron* (Gr.) = star.

Star-shaped bodies derived from cretaceous calcareous flagellates. Number of sectors 6–9, which behave similar to the sectors of the Braarudosphaerids on behalf of their optical orientation. The sectors are united by oblique planes in a left-coiling way, thus giving the fossil a twisting appearance when the optical focus is changed. The two tips of each sector point in centrifugal direction and cause the two levels of the star-shaped fossil. In the generotype *Lithastrinus grillii* the sectors of the star are slightly curved and pointed, in *Lithastrinus floralis* they are short and rounded. In *Lithastrinus grillii* the upper rays of the star overlap the rays underneath, which are shifted 60 degrees. Near the centre the sutures widen to little pores.

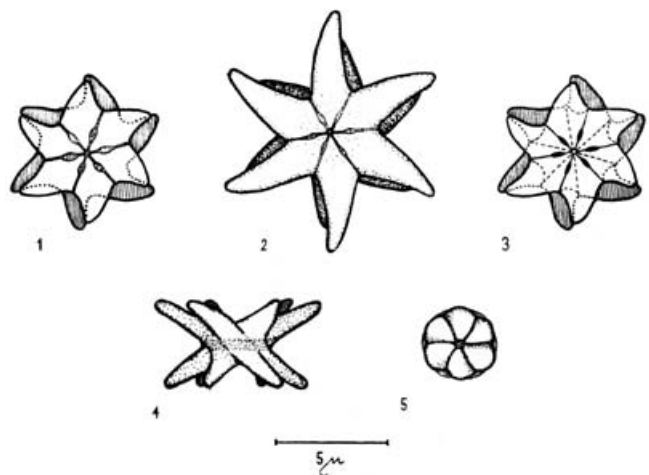
Original description of *Lithastrinus grillii* STRADNER, 1962

Holotypus: GBA 2009/058/0043/1.

Derivatio nominis: Herrn Chefgeologen Dr. Rudolf GRILL, Geologische Bundesanstalt Wien, Erdölabteilung, in Dankbarkeit zugeeignet.

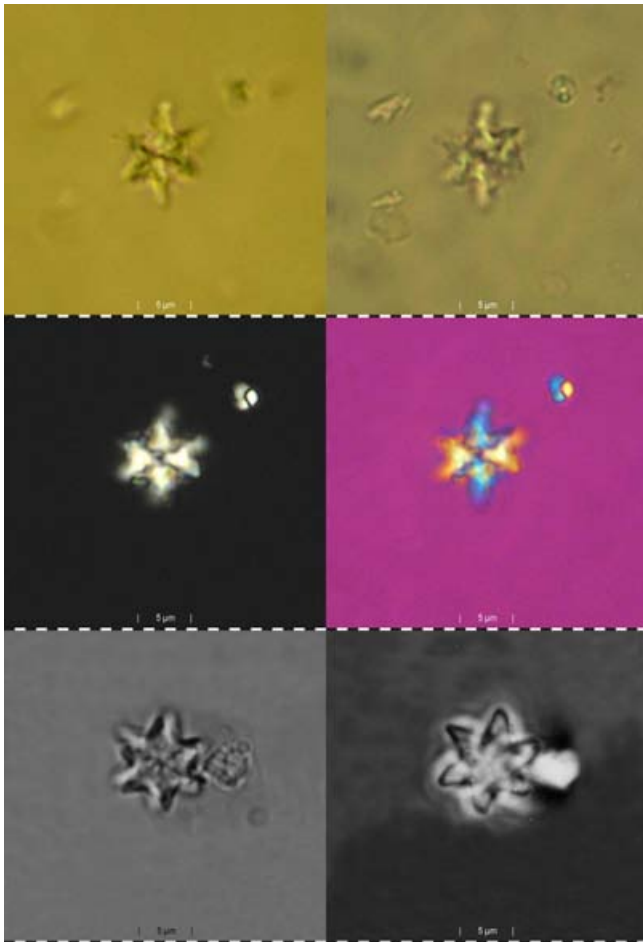
Locus typicus: Graben nordwestlich Klafterbrunn, 1 km westlich Bildstock 407, Niederösterreich (GRILL, 1953, S. 77).

Stratum typicum: Klementer Schichten (Höheres Turon – Emscher).



Text-Fig. 90a.
Original drawings of *Lithastrinus grillii*.

Diagnose und Beschreibung: Sternförmige Kalkkörperchen aus 6 stark gedrehten, gegabelten, sich überdachenden Sektoren bestehend. Bei Änderung der Schärfeebene können zwei verschieden orientierte sternförmige Umrissbilder eingestellt werden, von denen das jeweils höher liegende in zentrifugaler Richtung nach rechts gebogene Spitzen zeigt. In der Seitenansicht (Taf. II, Fig. 4) ist die starke Einschnürung des Kalkkörperchens in der Hauptebene zu sehen. Die Durchmesser der beiden sternförmigen



Text-Fig. 90b.
Syntypes in normal light, polarized light and phase contrast at different focus levels of *Lithastrinus grillii*.

migen Flachseiten sind besonders bei großen Exemplaren verschieden. Es ist anzunehmen, dass die größere Flachseite in Bezug zur Lage des Zellkernes des Kalkflagellaten in distaler Richtung orientiert war. Die Sektoren lassen an den Unterteilungsflächen auf halber Strecke zwischen dem sehr feinen Zentralkanal und dem Außenrand schwache Aussparungen erkennen, welche wegen der starken Schräglage der Sektoren jedoch nicht als Fenster erscheinen. Selten.

Dimensionen: Durchmesser 7–11 µm, Höhe 3–5 µm.

Beziehungen: *Lithastrinus grillii* ist wegen der polarisationsoptischen Eigenschaften seiner Sektoren, die sich wie Einzelkristalle verhalten, in die engere Verwandtschaft der Familie der Braarudosphaeriden zu stellen. Ob auch Beziehungen zu den aus dem Paleozän beschriebenen Gattungen *Heliolithus* BRAMLETTE und *Fasciculithus* BRAMLETTE und SULLIVAN bestehen, ist noch ungeklärt.

Bemerkungen: Für die Untersuchung dieses Nannofossiles eignet sich positive und negative Phasenkontrastbeleuchtung (Anoptral-Kontrast) in besonderem Maße.

English translation:

Holotype: GBA 2009/058/0043/1

Derivation of name: Thankfully dedicated to Dr. Rudolf GRILL, chief geologist at the Geological Survey of Austria

Type locality: NW Klafferbrunn, Lower Austria.

Level: Klement Beds, Upper Turonian – Emscherian.

Diagnosis and description: Star-shaped calcareous bodies consisting of six curved overlapping sectors, which are joined in such a way that their rays are offset by 60 degrees. In plan view they seem to consist of two different stars, the upper one twisted counterclockwise, the one below it twisted clockwise, depending on the focus level of the microscope. In side view the waist of the calcareous body looks laced. In larger specimens one of the stars, the distal one (?) can be wider than the other one. The suture lines embrace a tiny central pore and also between themselves oval pores at a certain distance from the centre.

Relations: Closely related to *Lithastrinus floralis*, but evidently not to the tertiary Genus *Discoaster*. Relation to the genera *Braarudosphaera* and *Hexalithus* are uncertain.

Size: 7–11 µm in diameter, 3–5 µm in height.

Comments:

Taxonomic status: Corrected name: *L. grillii*.

Stratigraphic distribution: Coniacian to Campanian.

Genus: *Eprolithus* STOVER, 1966

Eprolithus floralis (STRADNER) STOVER, 1966 (= *Lithastrinus floralis* STRADNER, 1962, p. 370, Pl. 2, Figs. 6–11)

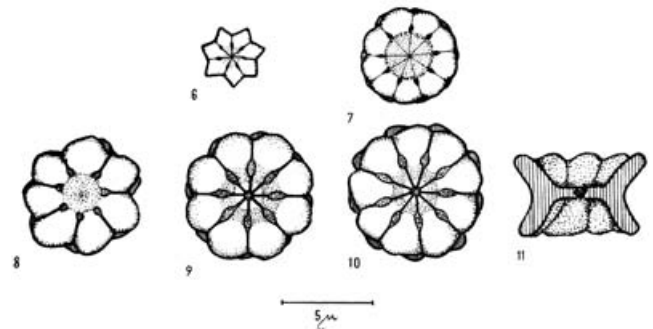
Original description of *Lithastrinus floralis* STRADNER, 1962

Holotypus: GBA 2009/058/0042.

Derivatio nominis: *flos* (Lat.) = Blüte, Blume.

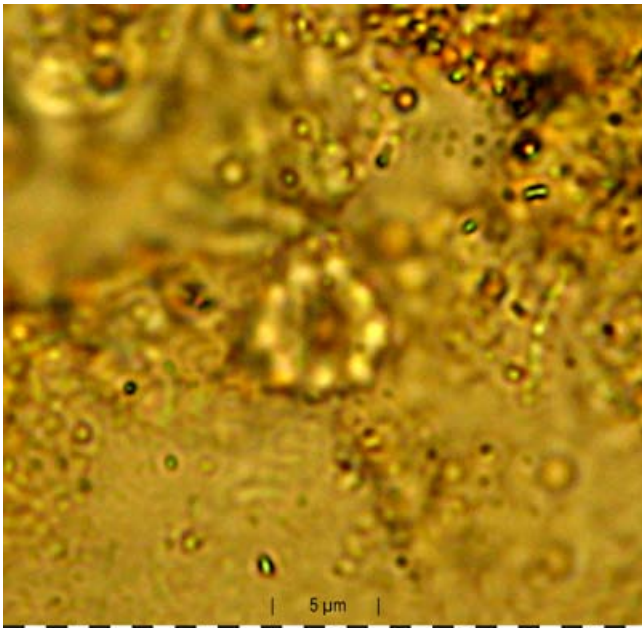
Locus typicus: Haidberg, Hohlweg von P. 387 NE gegen Falkenstein, großer Hangrutsch knapp NE des angeführten Punktes (R. Grill 4557/1/510), Niederösterreich.

Stratum typicum: Höheres Senon.



Text-Fig. 91a.
Original drawings of *Lithastrinus floralis*.

Diagnose und Beschreibung: Kalkkörperchen bestehend aus 7–9 gegabelten Sektoren, welche so zusammengesetzt sind, dass sie in der Flachansicht zwei sich überdeckende und zueinander linksgängig-schraubig verstellte rosettenförmige „Blütenbilder“ ergeben. Die Flachansichten (Taf. II, Fig. 7–10) zeigen, dass die Sektoren etwa auf der halben Strecke zwischen der Zentralachse und der Peripherie des Kalkkörperchens beiderseits Aussparungen haben, wodurch eine den Sektoren entsprechende Anzahl von Fenstern freibleibt. Die meist gerundeten oder stumpfen distalen Enden eines Sektors stehen, wie dem Schnittbild Taf. II, Fig. 11 zu entnehmen ist, weit voneinander ab



Text-Fig. 91b.
Holotype in normal light.

und geben so zur Bildung von zwei konkaven Flachseiten Anlass. Ein kurzer Zentralkanal durchdringt die Mittelwand des Kalkkörperchens und verbindet so die beiden hohlen Flachseiten.

Dimensionen: Durchmesser 3,5–8 µm, Höhe 2,5–5 µm.

Weitere Vorkommen: Im Gegensatz zum seltenen *Lithastrinus grilli* konnte *Lithastrinus floralis* auch in zahlreichen Turonium-Vorkommen anderer Länder (Böhmen, Deutschland, Holland, Polen) nachgewiesen werden. Stellenweise häufig.

Beziehungen: Für *Lithastrinus floralis* als nächsten Verwandten von *Lithastrinus grilli* sind die gleichen systematischen Beziehungen, wie dort besprochen, anzunehmen.

English translation:

Holotype: GBA 2009/058/0042.

Derivation of name: *flos* (Lat.) = flower.

Type locality: Haidberg S Falkenstein, Lower Austria.

Level: Upper Senonian.

Diagnosis and description: Calcareous bodies composed of 7 to 9 forked and twisted elements in such a way that they form a flower-shaped face on the basal as well as on the upper side. The twist of the sectorial elements is sinistrotrogyr. The sutures between the sectors leave a tiny central pore open. At a certain distance towards the periphery of the "flower" a circle of oval pores is imitating a ring of stamina. Upper and lower face are concave and connected by the central pore.

Relations: *Lithastrinus floralis* n. sp. is closely related to *Lithastrinus grillii* and possibly also to other genera mentioned there.

Size: 10–15 µm.

Comments:

Stratigraphic distribution: Aptian to Santonian.

Genus: Tegulalithus CRUX, 1986

Tegulalithus septentrionalis (STRADNER) CRUX, 1986 (= *Lithastrinus septentrionalis* STRADNER, 1963, p. 11, Pl. 2, Text-Figs. 7-7a)

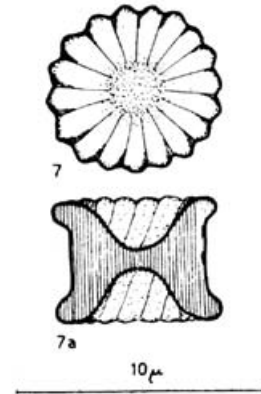
Original description of *Lithastrinus septentrionalis* STRADNER, 1963

Holotype: GBA 2009/058/0055.

Derivation of name: *septentrionalis* (Lat.) = northerly.

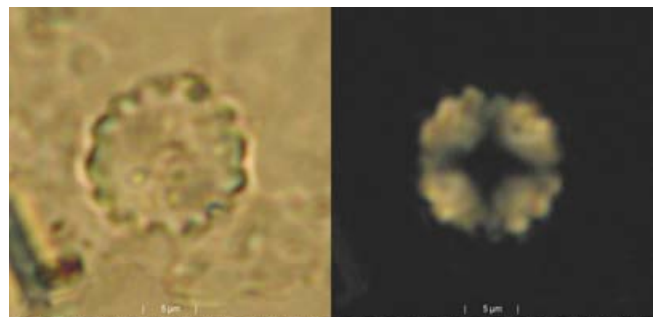
Type locality: Nordhorn Nord 11, Germany.

Level: Upper Hauterivian.



Text-Fig. 92a.
Original drawing of *Lithastrinus septentrionalis*.

Coccoliths in plan-view rosette-shaped, circular, in side-view (cross-section) resembling a time-glass. Number of the twisted sectors 15–20 as compared to *Lithastrinus floralis* STRADNER with usually 9 sectors.



Text-Fig. 92b.
Holotype in normal and polarized light.

Comments:

Stratigraphic distribution: Hauterivian.

Tegulalithus tessellatus (STRADNER, ADAMIKER & MARESCH) CRUX, 1986 (= *Lithastrinus tessellatus* STRADNER in STRADNER et al., 1968, p. 43, Pls. 43, 44, Text-Figs. 7/1, 7/2)

Original description of *Lithastrinus tessellatus* STRADNER in STRADNER et al., 1968

Holotype: Electron micrograph 17 223.

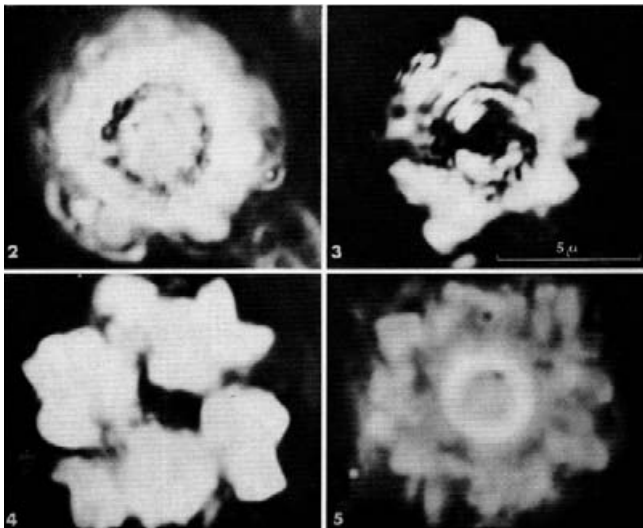
Paratype: Electron micrograph 17 376.

Derivation of name: *tessellatus* (Lat.) = tessellated.

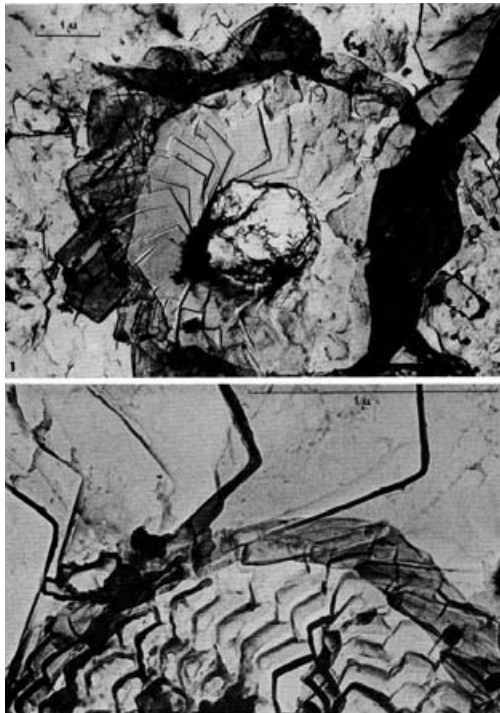
Type locality: Netherlands, deep well Delft 2.

Level: Albian.

Diagnosis and description: Circular coccoliths in shape of a flat spool, composed of very numerous superimposed crystal slabs of rhombohedral design. The crystal plates



Text-Fig. 93a.
Syntypes of *Lithastrinus tessellatus* in phase contrast and polarized light.



Text-Fig. 93b.
TEM micrographs of holotype and paratype.

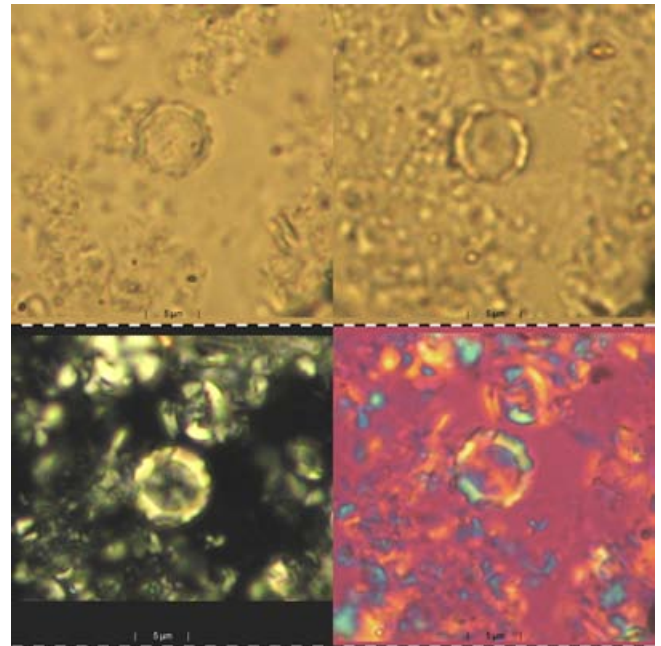
which form the upper and lower rim of the spool are larger than those of the constricted middle part of it. A regular tessellated or mosaic-like pattern is formed inside the concave cavities on either side of the coccolith. The inner parts of crystal slabs are arranged there in slanting rows and after shadowing with heavy metal they show serrate margin lines.

Size: Diameter of holotype 8 μm, of paratype 7 μm.

Dicussion: *Lithastrinus tessellatus* seems closely related to *Lithastrinus septentrionalis* STRADNER, as far as can be judged from comparisons with the optical microscope. The latter species however has a more regular outline and the crystal elements of the rims can be more clearly recognized there.

Comments:

Stratigraphic distribution: Albian.



Text-Fig. 93c.
Syntypes in normal and polarized light.

Genus: *Micula* VEKSHINA, 1959

Micula swastica (sensu PRINS, 1977) STRADNER & STEINMETZ, 1984, p. 595, Pl. 31, Figs. 3, 5, 6

**Original description of *Micula swastica*
STRADNER & STEINMETZ, 1984**

Holotype: Plate 31, Fig. 6.

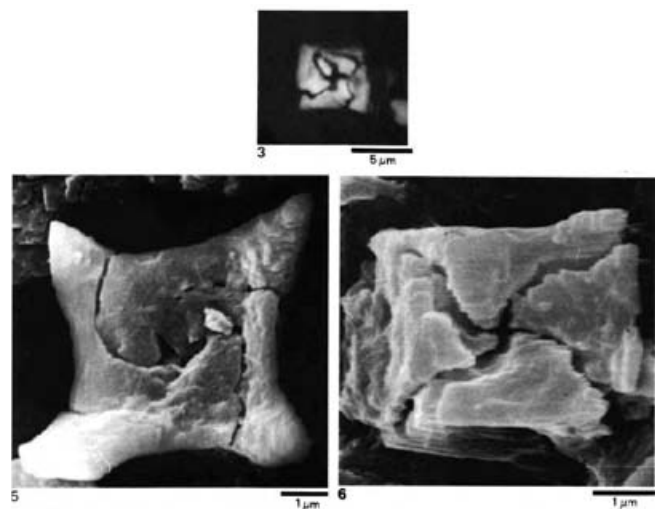
Paratype: Plate 31, Fig. 3 in STRADNER & STEINMETZ, 1984.

Derivation of name: In ancient India a “swastica” was a kind of cross emblematic for the sun.

Type location: DSDP Sample 530A-50-2, 13–14 cm (South Atlantic, Angola Basin).

Level: Upper Maastrichtian, at the Cretaceous/Tertiary boundary.

Diagnosis and Description: Cube-shaped calcareous bodies composed of two layers, each consisting of four hook-



Text-Fig. 94.
SEM images of holotype (6) and syntype (5) of *Micula swastica*; paratype in polarized light(3).

shaped elements combined in such a way that the suture lines on two opposing faces of the cube form a “swastica”.
 Remarks: In November 1977, B. PRINS demonstrated the evolutionary trends from *Eprolithus* STOVER to *Micula* VEKSHINA at a meeting on mid-Cretaceous nannofossils in The Hague, Netherlands. In his lectures he applied the new name “*Micula swastica*” to those types of *Micula* which show crooked suture lines and which finally evolved into *M. murus* and *M. prinsii*. As far as we know, this new name has not yet appeared in print. At Hole 530A such types, which fit into the pictorial definitions of *M. swastica* and *M. cf. swastica* sensu PRINS (1977) are described as follows:

Reference: PRINS (1977): Meeting on mid-Cretaceous Nannofossil. Working papers, chapter on *Micula*, Pl. 9, Figs. 4, 6; Pl. 10, figs, laic. CRUX 1982, p. 99.

Comments:

Stratigraphic distribution: ?Coniacian to Maastrichtian.

Micula concava (STRADNER) VERBEEK, 1976 (= *Nannotetraster concavus* STRADNER in MARTINI & STRADNER, 1960, p. 269, Figs. 18a-d

Original description of *Nannotetraster concavus* STRADNER, 1960

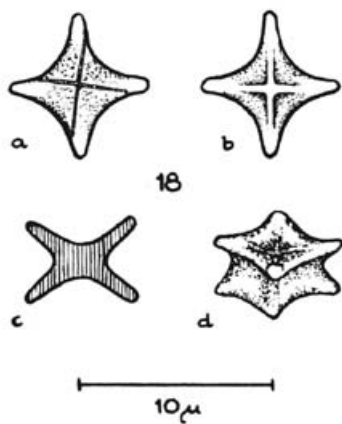
Holotypus: GBA 2009/058/0019.

Paratypus: WA 01/F.

Derivation of name: *concavus* (Lat.) = ausgehöhlt.

Locus typicus: Waidach, Haunsberg, Salzburg, Österreich.

Stratum typicum: Obere Kreide (Senon).



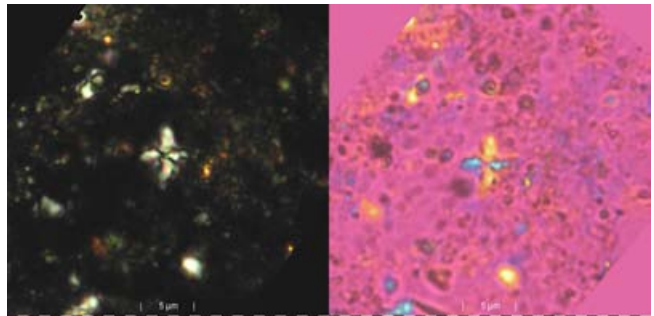
Text-Fig. 95a.
 Original drawings of *Nannotetraster concavus*.

Diagnose: Ein kleinwüchsiger Nannotetraster mit konkav gewölbten Reliefseiten und kurzen Strahlen, die nicht in der Hauptebene, sondern in der Richtung der Sagittalachsen gegabelt sind.

Beschreibung: Dieser kleine Nannotetraster, der in Bezug auf seine geringen Dimensionen nur von *Nannotetraster staurophorus* (GARDET) MARTINI & STRADNER unterboten wird, ändert beim Wenden in flüssigem Einschlußmedium scheinbar nie seine Umrissform. Dies kommt davon, dass alle sechs Seiten dieses winzigen Kalkkörperchens eingedellt sind. Das Reliefkreuz der Facies inferior liegt also im Gegensatz zu allen bisher gefundenen Nannotetrastern in einer Mulde ebenso wie die Unterteilungslinien der Facies superior.

Größe: 5–7 µm.

Beziehungen: *Nannotetraster concavus* hat mit *Nannotetraster staurophorus* (GARDET) MARTINI & STRADNER nicht nur das oberkretazische Alter gemeinsam, sondern ist auch mit letzterer Art größenordnungsmäßig vergleichbar.



Text-Fig. 95b.
 Syntype in polarized and normal light.

English translation:

Nannotetraster concavus STRADNER 1960 in MARTINI & STRADNER, 1960

Holotype: GBA 2009/058/0019.

Derivation of name: *concavus* (Lat.) = concave.

Type locality: Waidach, Haunsberg, Salzburg, Austria.

Level: Upper Cretaceous.

Description: Minute calcareous nannofossils showing a slender rhombical outline, which is repeatedly showing up when the object is revolving in liquid embalming medium. This phenomenon results from the fact, that *Nannotetraster concavus* resembles a dice with all six sides pressed in towards the centre. The four sectors are forked in the direction of the main axis thus producing two spines each.

Size: 5–7 µm.

Relations: Closely related to *Nannotetraster staurophorus* (GARDET) STRADNER & MARTINI.

Comments:

Stratigraphic distribution: Santonian to Maastrichtian.

Micula quadrata (STRADNER, 1961) PERCH-NIELSEN, 1984 (= *Tetralithus quadratus* Stradner, 1961, p. 86, Fig. 92)

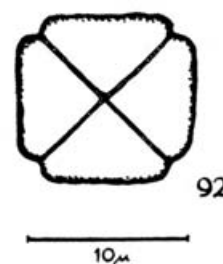
Original description of *Tetralithus quadratus* STRADNER, 1961

Holotypus: GBA 2009/058/0035.

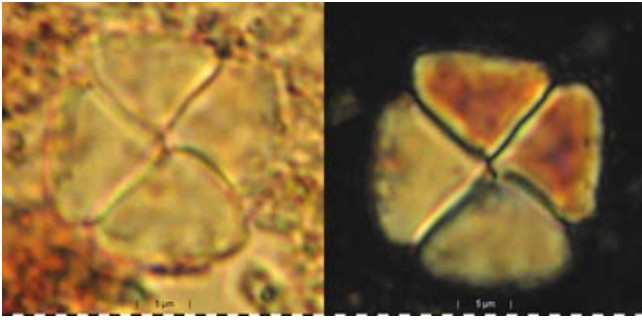
Derivatio nominis: *quadratus* (Lat.) = viereckig, quadratisch.

Locus typicus: Eitelgraben, Salzburg. Selten.

Stratum typicum: Paläozän.



Text-Fig. 96a.
 Original drawing of *Tetralithus quadratus*.



Text-Fig. 96b.
Holotype of *Tetralithus quadratus* in normal and polarized light.

Ein Tetralith, dessen Umfang annähernd quadratisch ist und dessen Unterteilungslinien in der Richtung der Diagonalen des Quadrates liegen. Die Ecken des Quadrates sind ausgespart. Polarisationsoptisches Verhalten so wie von *Tetralithus pyramidus* GARDET.

Größe: 8–12 µm.

English translation:

Holotype: GBA 2009/058/0035.

Derivation of name: *quadratus* (Lat.) = square; quadratic.

Type locality: Eitelgraben, Untersberg, Salzburg.

Level: Paleocene.

Tetraliths with roughly quadratic circumference, with the corners of the square left out, with sutures in the direction of the diagonals pointing to the missing corners. In other words: Tetraliths consisting of four triangular prismatic parts, which are joined together with their right-angled sides, the hypotenuses forming the circumference. Related to *Tetralithus pyramidus* GARDET.

Size: 8–12µm.

Comments:

Stratigraphic distribution: Santonian to Maastrichtian, probably reworked in Paleocene.

Family: Microrhabdulaceae DEFLANDRE, 1963

Genus: Microrhabdulus DEFLANDRE, 1959

Microrhabdulus constrictus STRADNER, 1963, p. 11, Pl. 4, Fig. 16

Original description of *Microrhabdulus constrictus* STRADNER, 1963

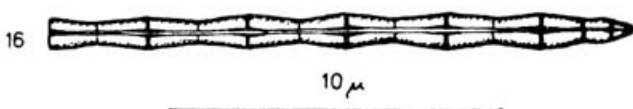
Holotype: GBA 2009/058/0057.

Derivation of name: *constrictus* (Lat.) = tied.

Type locality: Hallembaye, (S. A. Les Ciments Liégeois), Smectique (gray marl), Netherlands.

Level: Campanian.

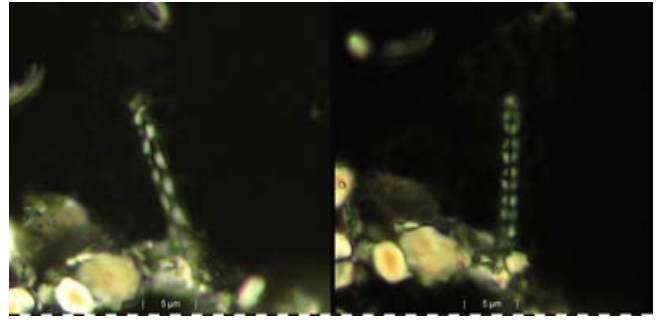
Diagnosis and description: Rod-shaped nannofossils with slight constrictions at intervals about twice their diameters. Central canal very narrow.



Text-Fig. 97a.
Original drawing of *Microrhabdulus constrictus*.

Comments:

Taxonomic status: The irregular outline of this *Microrhabdulus* species may be the result from diagenesis. Probably a superfluous taxon.



Text-Fig. 97b.
Syntypes in polarized light at different orientation.

Microrhabdulus nodosus STRADNER, 1963, p. 11, Pl. 4, Fig. 13

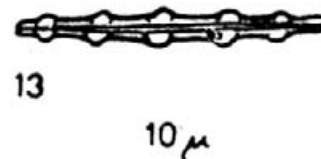
Original description of *Microrhabdulus nodosus* STRADNER, 1963

Holotype: GBA 2009/058/0058.

Derivation of name: *nodosus* (Lat.) = knotty.

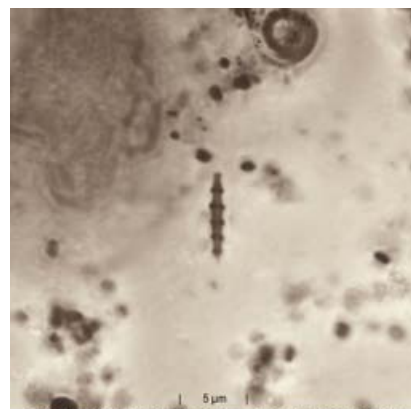
Type location: Deep well Ameis 1 (ÖMV) Lower Austria.

Level: Turonian.



Text-Fig. 98a.
Original drawing of *Microrhabdulus nodosus*.

Diagnosis and description: Rod-shaped nannofossils with knotty thickenings at certain intervals of their lengths. Central canal very narrow.



Text-Fig. 98b.
Holotype in phase contrast.

Comments:

Taxonomic status: *Microrhabdulus nodosus* STRADNER is a junior synonym of *Microrhabdulus belgicus* HAY & TOWE, 1963.

Stratigraphic distribution: Cenomanian to Maastrichtian.

Family: *Nannoconaceae* DEFLANDRE, 1959

Genus: *Nannoconus* KAMPTNER 1931, p. 289

**Original description of *Nannoconus abundans*
STRADNER & GRÜN, 1973**

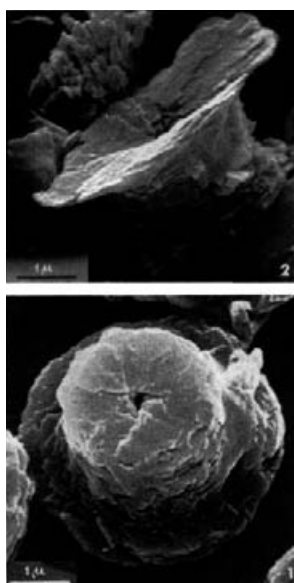
Holotype: Electron micrograph 71.234/9 – Pl. 3, Fig. 2.
Paratypes: Electron micrograph Nr. 71.95/2 – Pl. 1, Fig. 1 (paratype A). Nr. 71.95/3 – Pl. 1, Fig. 2 (paratype A). Pl. 6, Figs. 1–3 (paratype B).

Derivation of name: *abundans* (Lat.) = abundant (number of laminae).

Type locality: Schacht Konrad I, near Salzgitter, Germany, at 673 m.

Level: Lower Cretaceous, Lower Barremian.

Diagnosis: A unicellular flagellate forming a sphere con-

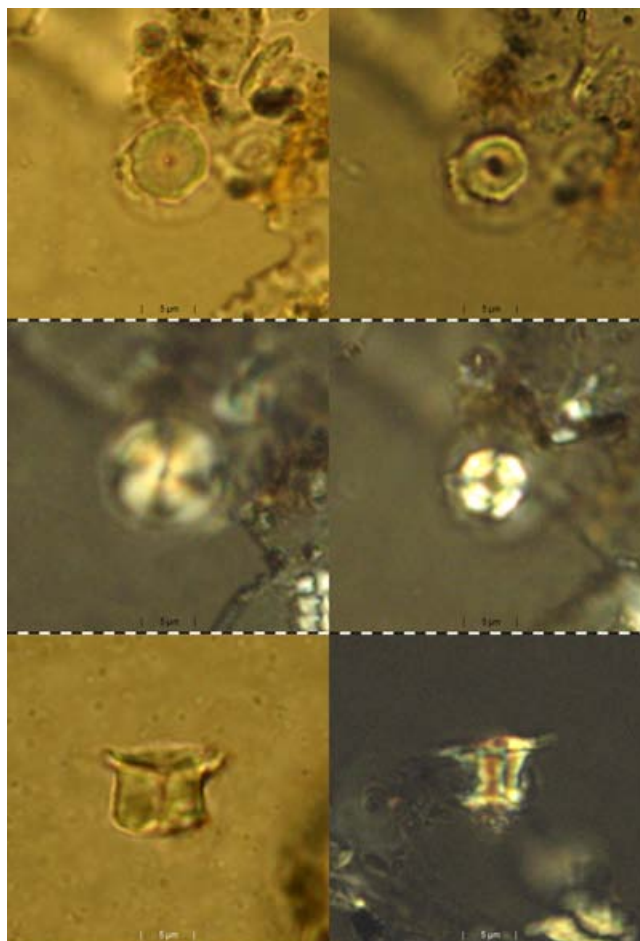


Text-Fig. 99a.
SEM image of holotype (2) and paratype (1) of *Nannoconus abundans*.

sisting of calcareous, cylindrical to hyperboloidal bodies (= nannoconus) built up by flat, wedge-shaped calcite plates of various length arranged around a straight axial canal forming a pillar of about the same height as its diameter, with a flaring flange presumably at the distal end and a small flange at the proximal end. The distal flange may have twice the diameter of the pillar, the proximal flange is inconspicuous and not always present. The central pillar, which is slightly constricted in its middle part, shows obliquely situated grooves arranged clockwise. The distal flange is composed of only a few layers of calcite plates and is flat-concave on its distal side. The central canal is usually narrow with a serrate inner contour.

Size: Maximum diameter 12 μm , maximum height 8 μm .

Discussion: The newly described *Nannoconus abundans* is related to those *Nannoconus* species, which show a constriction in their outline, e. g. *Nannoconus boletus* DEFLANDRE (1962, p. 2639, Fig. 6 and 1967, p. 776) and *Nannoconus dauvillieri* DEFLANDRE (1959, p. 2374, Figs. 1, 2). It differs from these two species by having a thin flaring distal end composed of only few crystal layers. The axial view of *Nannoconus abundans* can be similar to *Coccolithites circumradius*



Text-Fig. 99b.
Syntypes in normal light (1, 2), polarized light (3, 4) and side view (5, 6).

STOVER (1966, p. 138, pi. 5, Figs. 2–4) especially under the light microscope. However, the SEM and TEM pictures reveal a completely different shape.

Distribution: To the authors *Nannoconus abundans* is known only from the Barremian of Schacht Konrad I, near Salzgitter. Considering the worldwide distribution of calcareous nannoplankton one would assume a wider occurrence. However only few Barremian nannofloras have been described (BALDI-BEKE, 1965; BOUCHE, 1963; NOEL, 1959; BRÖNNIMANN, 1955; THIERSTEIN, 1971).

This fact, a possibly limited stratigraphic range as well as ecological factors might be the reason for *Nannoconus abundans* not having become known before.

Comments:

Stratigraphic distribution: Barremian to Aptian.

**Original description of *Nannoconus planus*
STRADNER, 1963, p. 177, Pl. 3, Figs. 7, 7a, 7b**

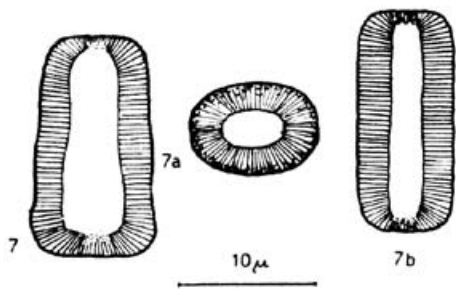
Holotype: GBA 2009/058/0059/1.

Derivation of name: *planus* (Lat.) = flat.

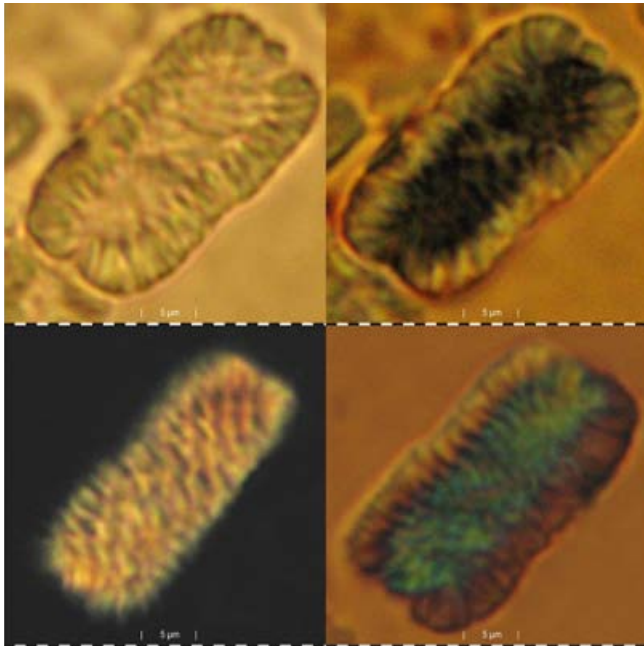
Type locality: Leidschendam 1 (N. V. Ned. Aardolie Maatsch.) Netherlands.

Level: Lower Albian.

Diagnosis and description: Tests in cross section elliptical, in axial section either cylindrical or rather inflated depend-



Text-Fig. 100a.
Original drawing of *Nannoconus planus*.



Text-Fig. 100b.
Syntypes in normal and polarized light at different focus levels.

ing whether viewed from the smaller side or from the flat-tened side.

Comments:

Stratigraphic distribution: Albian.

Family: Schizosphaerellaceae DEFLANDRE 1959

Genus: Schizosphaerella DEFLANDRE 1938, p. 1116

Type species: *Schizosphaerella punctulata* DEFLANDRE & DANGE-ARD 1938, p. 1116, Figs. 1–6

Synonym: *Nannopatina* STRADNER 1961, p. 78.

Type species: *Nannopatina grandaeva* STRADNER 1961, p. 78, Text-Figs. 1–10.

Original description of Nannopatina STRADNER, 1961

Derivatio nominis: *nannos* (Gr.) = Zwerg, *patina* (Lat.) = Schüssel.

Diagnose: Aus zwei dünnwandigen, halbkugeligen oder tonnenförmigen Schalen zusammengesetzte Kalkgehäuse von einzelligen Meeresorganismen. Die Primärschale umfasst mit ihrem Äquatorialrand den etwas nach außen gebogenen Rand der Sekundärschale. Die Außenfläche ist von Poren und Höckern, die im Quincunx angeordnet sind,

übersät. Der submikroskopische Aufbau der Wand zeigt Ähnlichkeit mit dem von *Thoracosphaera*.

English translation:

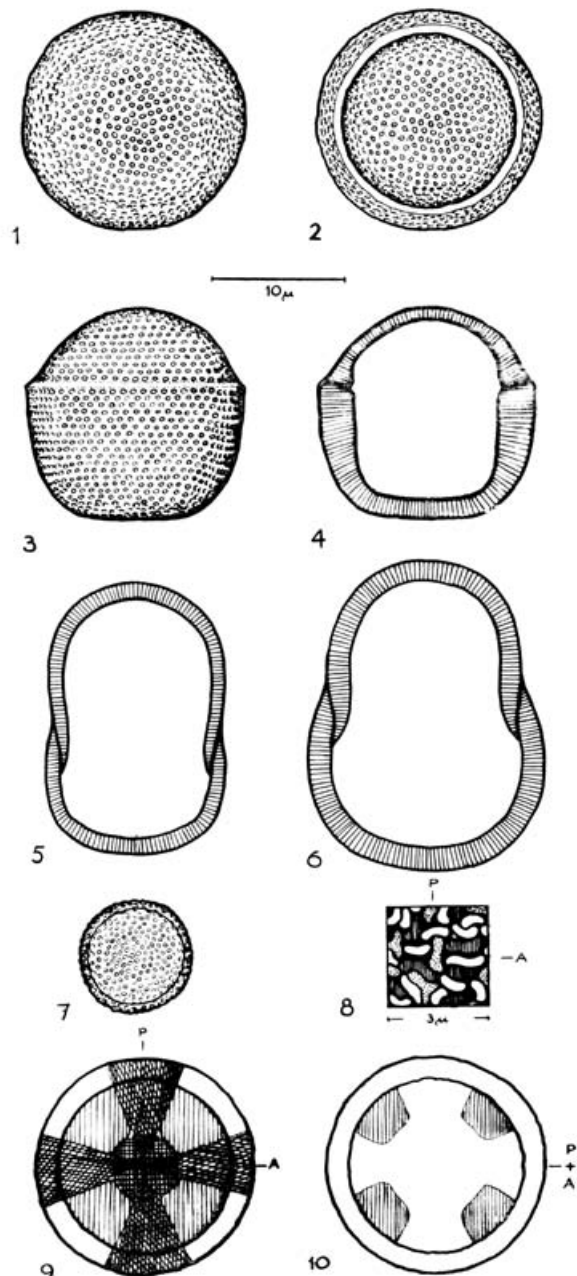
Derivation of name: *nannos* = dwarf; *patina* = bowl.

Diagnosis: Calcareous shells composed of two semi-globular or barrel-shaped halves, originating from unicellular marine organisms. The primarily constructed of these half-shells is overlapping with its equatorial rim the somewhat smaller other half. The surface shows numerous small perforations and humps. The submicroscopical structure of the wall is similar to that of *Thoracosphaera*.

Original description of Nannopatina grandaeva STRADNER, 1961

Holotypus: GBA 2009/058/0034

Derivatio nominis: *grandaevus* (Lat.) = sehr alt.



Text-Fig. 101.
Original drawings of *Nannopatina grandaeva*.

Locus typicus: Schleifenbächle hinter Achdorf, Wutachgebiet, Württemberg, sehr häufig.

Stratum typicum: Lias Zeta, Jurensis-Mergel. Weitere Vorkommen: *Variabilis*-Zone desselben Fundortes; Steilwand des Aubächle oberhalb Aselfingen, Wutachgebiet, Württemberg; *Numismalis*-Mergel (Unterer Lias Gamma); Schleifenbächle hinter Achdorf, Wutachgebiet, Württemberg; *Opalinus*-Ton (Oberer Dogger Alpha). England: Wear Cliff or Green Belemnite Marls (Lower Lias) near Seatown, Dorset, England.

Diagnose: Die Beschreibung dieser einstweilen einzigen Art der neuen Gattung fällt mit der des Genotypus zusammen. Die im englischen Lias gefundenen Schalen und Gehäuse sind vereinzelt äquatorial etwas eingeschnürt und zeigen die feinen Poren nicht so deutlich und auch nicht so regelmäßig angeordnet wie diejenigen aus dem deutschen Lias.

Größe: 8–20 µm.

English translation:

Holotypus: GBA 2009/058/0034

Type locality: Schleifenbächle near Achdorf, Wutach area, Württemberg, abundant.

Level: Lower Jurassic, *Jurensis* Marlstone.

Other occurrences: *Variabilis* Zone of the same locality; Württemberg; *Opalinus* Clay (Middle Jurassic).

England: Wear Cliff or Green Belemnite Marls (Lower Lias) near Seatown, Dorset, England.

Description: The species definition coincides with the generic description. The calcareous shells of this species found in England have a slightly reduced diameter at the equatorial level.

Size: 8–20 µm.

Comments:

Taxonomic status: *Stomiosphaera minutissima* is also a synonym of *Schizosphaerella punctulata* (AUBRY, DÉPÊCHE & DUFOUR, 1988, p. 715).

HOLOCOCOLITHS

Family: Calyptosphaeraceae BOUDREAUX & HAY, 1969

Genus: *Calculites* PRINS & SISSINGH IN SISSINGH, 1977

Calculites ovalis (STRADNER) PRINS & SISSINGH in SISSINGH, 1977 (= *Tetralithus ovalis* STRADNER, 1963, p. 178, Pl. 6, Text-Figs. 7, 7a)

**Original description of *Tetralithus ovalis*
STRADNER, 1963**

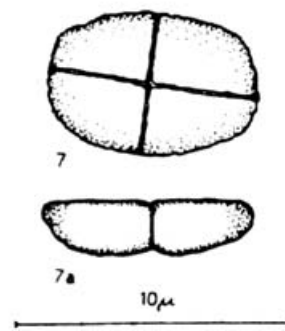
Holotype: GBA 2009/058/0060.

Derivation of name: *ovalis* (Lat.) = oval.

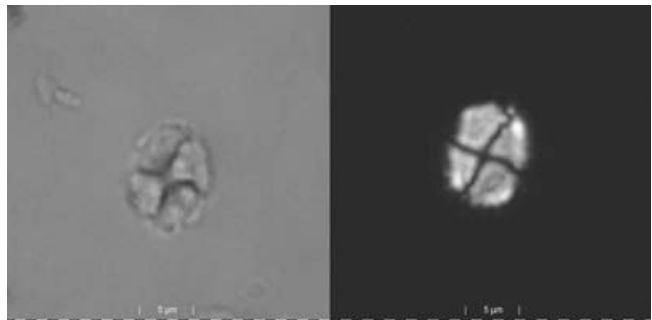
Type locality: Klafferbrunn, Lower Austria.

Level: Upper Turonian – Emscherian.

Diagnosis and description: Flat tetraliths consisting of four sectors fitting closely together to form a plate with oval circumference. The suture lines may lie in the main axes or diagonally or in between.



Text-Fig. 102a.
Original drawing of *Tetralithus ovalis*.



Text-Fig. 102b.
Holotype in normal and polarized light.

Comments:

Stratigraphic distribution: Upper Coniacian to Campanian.

Calcareous dinoflagellate

Class: Dinophyceae FRITSCH, 1929

Order: Peridinales HAECKEL, 1894

**Suborder: Peridiniineae FOTT, 1959
emend. BUJAK & DAVIES, 1983**

Family: Peridiniaceae EHRENBERG, 1831

**Subfamily: Calciodinelloideae FENSOME
et al., 1993**

Genus: *Cervisiella* HILDEBRAND-HABEL, WILLEMS & VERSTEEGH, 1999

Type species: *Cervisiella saxea* (STRADNER) HILDEBRAND-HABEL, WILLEMS & VERSTEEGH, 1999 (= *Thoracosphaera saxea* STRADNER, 1961, p. 84, fig. 71)

**Original description of *Thoracosphaera saxea*
STRADNER, 1961**

Holotypus: GBA 2009/058/0032/2.

Derivatio nominis: *saxeus* (Lat.) = steinern.

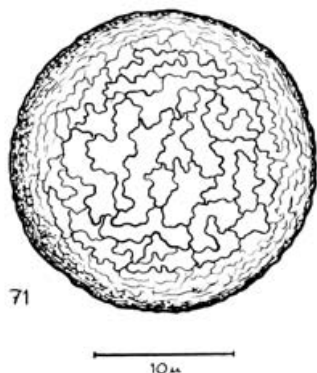
Locus typicus: Haidhof bei Ernstbrunn, Niederösterreich.

Stratum typicum: Danien. Mäßig häufig.

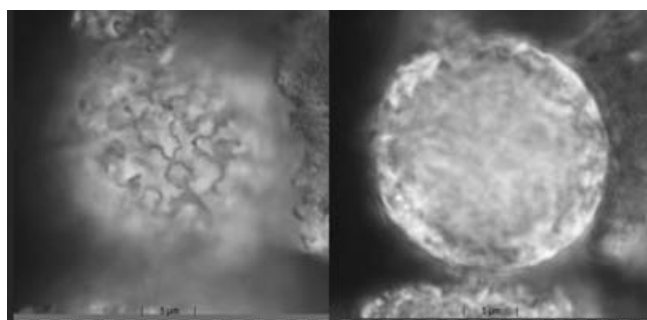
Ein aus zahlreichen, sehr unregelmäßig geformten Einzelsteinen zusammengesetztes, hohlkugeliges Gehäuse mit geschlängelten Nahtlinien. Die bei gekreuzten Nikols verschiedenartig löschenden Einzelsteine stellen nicht einzelne Porolithen wie bei *Thoracosphaera heimi* KAMPTNER dar,

sondern können nur als Verschmelzungseinheiten aus einer größeren Anzahl von außergewöhnlich kleinen ortholithischen Bausteinen von gleicher polarisationsoptischer Orientierung aufgefasst werden.

Größe: Gehäusedurchmesser 30 µm, Länge der Einzelsteine 4–6 µm.



Text-Fig. 103a.
Original drawing of *Thoracosphaera saxea*.



Text-Fig. 103b.
Syntype in polarized light at different focus levels.

English translation:

Holotype: GBA 2009/058/0032/2.

Derivation of name: *saxeus* (Lat.) = stony.

Type locality: Haidhof near Ernstbrunn, Lower Austria.

Type level: Danian (Zone NP 2).

Diagnosis and description: Spherical calcareous hollow shells with erratic suture lines, like those of a skull. In polarized light separate groups of small poroliths seem to be molten together showing identical crystal orientation, contrary to *Thoracosphaera heimi* KAMPTNER, in which the separate poroliths show different orientations each.

Size: 30 µm. Size of the stone elements 4–6 µm.

Comments:

Stratigraphic distribution: Abundant in the Danian.

UNCLASSIFIED TAXON

Original description of *Coccolithus nuntius*
STRADNER, 1968 IN STRADNER, ADAMIKER &
MARESCH, 1968, p. 26, Pl. 5, Figs. 2, 3, Text-Fig. 9

Holotype: TEM plate 17355.

Paratype: TEM plate 18072.

Derivation of name: *nuntius* (Lat.) = messenger.

Type locality: NAM deep well Delft 2.

Level: Albian.

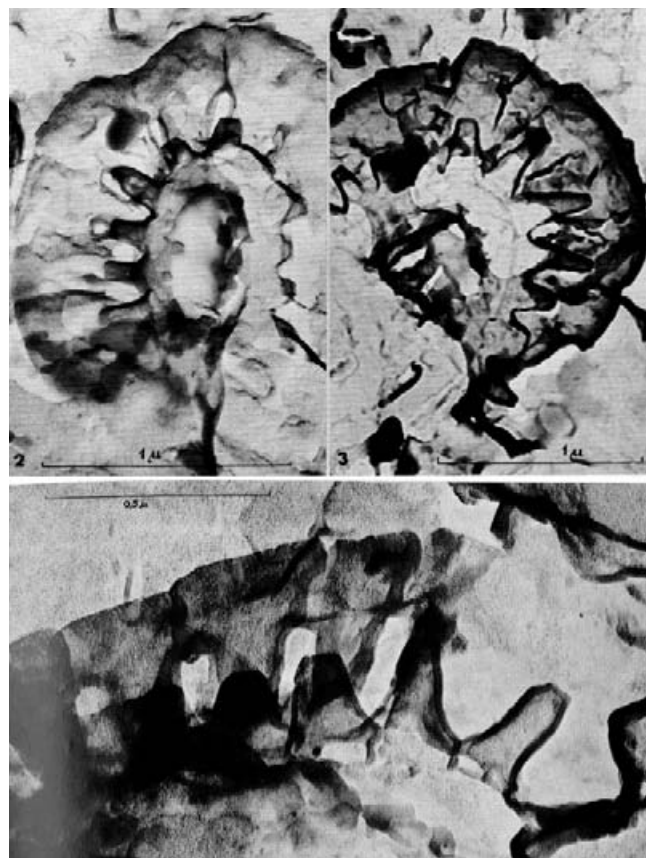
Diagnosis and description: Elliptical coccoliths with one shield formed in a similar way as in *Coccolithus* HUXLEY, with crystal plates sparing out slot-shaped windows orientated in radial direction. Number of segments ranging from 14 to 20. The other shield, which is only fragmentarily known, consists of an equal number of spine-shaped rays. These are protruding from an elliptical ring surrounding the central area and are in most places damaged, with broken-off ends. No outer rim of that other shield was encountered in any of the specimens found.

Size: Holotype: length 1.7 µm, width 1.4 µm; paratype: length 2.8 µm, width 1.7 µm.

Discussion: This new species agrees in many respects with *Coccolithus* HUXLEY shown by BRAARUD, GAARDER, MARKALI & NORDLI 1952 and COHEN 1965, from which it differs by the smaller number of segments. Whether there is a central structure in this new Albian species is not certain, but can be assumed.

Comments:

Taxonomic status: With only pictures of fragmentary specimens, we are not able to assign this taxon to a genus.



Text-Fig. 104a.
TEM micrographs of holotype (2) and syntypes of *Coccolithus nuntius*.

Acknowledgements

We are most grateful to Hans EGGER for his tireless assistance during the completion of this project; we take pleasure in acknowledging the invaluable evaluations of the formal status of species of coccolithophores in taxonomic compilations by A. LOEBLICH and H. TAPPAN (1966 to 1973), S.E. VAN HECK (1979 to 1982), J. STEINMETZ (1983 to 1989) and W. SIESSER (1990–2003). These have consid-

erably facilitated our taxonomic work over the years. For their assistance in preparing the figures we are indebted to Markus KOGLER and Stephan PRIBITZER.

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