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Calcareous Nannofossils from Nal'chik (Northwest Caucasus)

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With 13 plates (I–XIII)

I. INTRODUCTION

The samples studied here are from a well located northeast of the town of Nal'chik in the northwest Caucasus. The stratigraphic section exposed in this well has become part of the standard of reference for correlation of the Upper Eocene in the southwestern USSR. The material for this study was generously provided by Dr. HANSPETER LUTERBACHER of the Naturhistorisches Museum in Basel, Switzerland, to whom we are greatly indebted. Dr. LUTERBACHER had obtained it from V. I. SAMODUROV of the Geological Institute of the Soviet Academy of Science while on a scientific sojourn in Moscow.

The authors wish to express their thanks to Professor G. DEFLANDRE, Paris, France, for providing information on the types of some coccolith species, and for his generous contribution to topotype material of the Oligocene diatomite of Oamuru, New Zealand.

The techniques used in this investigation consist of electron microscopic examination of carbon replicas, ordinary light microscopy, phase microscopy and study of the interference figures observed with crossed nicols. The work was carried out at the Department of Geology and Central Electron Microscope Laboratory of the University of Illinois. Details of the sample preparations and examination procedures will be reported in another article by HAY, GARTNER & MOHLER (in press).

II. TERMINOLOGY OF CALCAREOUS NANNOFOSSILS

So many different terms have been introduced to describe coccoliths and the structural elements of which they are formed, that some confusion over the meaning of terms has arisen. It is therefore appropriate to include here a glossary of the terms proposed up to the present time along with their definitions. The cytological and ultrastructural terminology is as in other flagellates with the addition of these special terms:

Coccolithophore – (LOHMANN, 1902) any chromatophore bearing protist which at some phase of its life cycle produces coccoliths.

Coccolith – (HUXLEY, 1858) 1) a general term applied to any calcified skeletal element having heliolithid structure or complexly constructed of minute calcite rhombs; 2) two shields connected by a central tube.

Plate-scales – (PARKE & ADAMS, 1960) oval to elliptical organic scales imbedded in the surface layer of the periplast.

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Haptonema – (PARKE, MANTON & CLARKE, 1955; PARKE & ADAMS, 1960) a thread to club-like organic structure located between the two flagellae; it can be contracted into a spiral or extended and used as an organ of attachment to substrate material; it is more rigid than the flagellae.

Motile phase – (PARKE & ADAMS, 1960) the flagellated phase of the life-cycle, producing holococcoliths, caneoliths, cyrtoliths, cricoliths and cribriliths.

Non-motile phase – (PARKE & ADAMS, 1960) the non-flagellated phase of the life-cycle, producing scapholiths, rhabdoliths, placoliths, osteoliths, and pentaliths.

Coccosphere – (WALLICH, 1860) the entire spherical test of a coccolithophore, composed of interlocking coccoliths.

Naked flagellar field – (LOHMANN, 1902) in flagellate coccolithophores lacking a complete cover of coccoliths, the area around the flagellae in which no coccoliths are present.

Covered flagellar field – (LOHMANN, 1902) in flagellate coccolithophores coccolith cover complete in flagellar region.

Naked pole – (= *pole buccale* DEFLANDRE, 1952) in non-flagellate coccolithophores, that end which is free of coccoliths.

Terms based on light microscopical studies of coccoliths themselves are generally descriptive, but have little or nothing to do with true coccolith ultrastructure:

Discolith – (HUXLEY, 1868; = Monodiske HAECKEL, 1870) a single apparently imperforate elliptical or circular shield with thickened margin.

Cyatholith – (HUXLEY, 1868; = Amphidiske HAECKEL, 1870) two shields connected by a central tube (never used in the literature).

Placolith – (LOHMANN, 1902) two shields connected by a central tube, supposedly perforate (frequently used up to 1941, unambiguous, should be used in modern descriptions).

Rhabdolith – (SCHMIDT, 1870) a shield surmounted by a long stem, supposedly perforate.

Tremalith – (LOHMANN, 1913) 1) centrally perforate coccoliths, i.e. placoliths and rhabdoliths; 2) (redefined KAMPTNER, 1941) two shields connected by a central tube (= placoliths only).

Lopodolith – (LOHMANN, 1902) a basket-shaped coccolith opening distally (*Scyphosphaera*).

Calyptrolith – (LOHMANN, 1902) a basket-shaped coccolith opening proximally (*Calyptrosphaera*).

Zygolith – (KAMPTNER, 1937) an elliptical ring with a crossbar arching slightly or strongly upward (i.e. distally), and bearing a knob or short spine.

Cricolith – (KAMPTNER, 1958) any elliptical ring coccolith.

Cyclolith – (KAMPTNER, 1948) any elliptical or circular ring coccolith (should be restricted to circular forms).

Sphenolith – (DEFLANDRE, 1952) a nannofossil having a prismatic base formed by radial elements surmounted by a cone.

Pentalith – (GRAN & BRAARUD, 1935) coccolith formed of five crystal units.

Porolith – (DEFLANDRE, 1952) a polygonal prism with an axial perforation (a term created for the elements of *Thoracosphaera* which EM studies have shown to be both perforate and imperforate).

Stomatal coccolith – (HALLDAL & MARKALI, 1955; = Mündungscoccolith (*coccolithi oris*): KAMPTNER, 1937) in flagellate coccolithophores exhibiting dimorphism, one of the modified coccoliths surrounding the flagellar field.

Tail coccolith – (HALLDAL & MARKALI, 1955) in flagellate coccolithophores exhibiting dimorphism, a modified coccolith located at the end opposite the flagellar field (*Calciopappus*).

Pole coccolith – (HALLDAL & MARKALI, 1955; = Polcoccolith: KAMPTNER, 1937) in flagellate coccolithophores exhibiting dimorphism, one of the modified coccoliths found at the flagellar and tail ends (*Acanthoica*).

Polar spine – (= *aiguillons polaires*, DEFLANDRE, 1952) in non-motile fusiform coccolithophores, exhibiting dimorphism modified coccoliths located at the ends (*Calciosolenia*).

Whorl coccolith – (HALLDAL & MARKALI, 1955) in non-motile coccolithophores exhibiting dimorphism, one of the modified coccoliths forming a whorl about the naked pole (*Ophiaster*).

Float coccolith – (HALLDAL & MARKALI, 1955) in non-motile coccolithophores exhibiting dimorphism, one of the coccoliths modified to serve as a suspension organ (*Thorosphaera*).

Ordinary coccolith – (HALLDAL & MARKALI, 1955) in coccolithophores exhibiting dimorphism, one of the unmodified coccoliths.

Micro-coccolith – (MARKALI & PAASCHE, 1955) in coccolithophores exhibiting dimorphism but with the dimorphic coccoliths irregularly placed, the smaller coccoliths.

Macro-coccolith – (MARKALI & PAASCHE, 1955) in coccolithophores exhibiting dimorphism but the dimorphic coccoliths irregularly placed, the larger coccoliths.

Asterolith – (DEFLANDRE, 1952, after SUJKOWSKI, 1930) star-shaped or rosette ortholithid elements.

Electron microscopy permits a description of coccoliths based on their ultrastructure, correspondingly a second group of terms is used for forms observed in the electron microscope:

Holococcolith – (BRAARUD, DEFLANDRE, HALLDAL & KAMPTNER, 1954) a coccolith consisting entirely of microcrystals of usual c ystallographic shape, identical or not.

Calyptroform holococcolith – (HALLDAL & MARKALI, 1955) basket-shaped (calotte-shaped) holococcolith. All calyptroliths thus far examined have been found to belong here.

Disciform holococcolith – (HALLDAL & MARKALI, 1955; = crystallolith PARKE & ADAMS, 1960) discolith-shaped holococcoliths, i.e. with a raised margin two or more cycles of microscrystals high.

Zygoform holococcolith – (HALLDAL & MARKALI, 1955) zygolith-shaped holococcoliths. All recent zygoliths thus far examined have been found to belong

here. The type species of the genus *Zygolithus* is, however, not a holococcolith, but is complexly constructed.

Heterococcolith – (BRAARUD, DEFLANNDRE, HALLDAL & KAMPTNER, 1954) a coccolith built of different elements.

Caneolith – (BRAARUD, DEFLANDRE, HALLDAL & KAMPTNER, 1954) «discoliths»: heterococcoliths having a central area with laths, a simple or complex wall, and petaloid upper and lower rims.

Complete caneolith – (HALLDAL & MARKALI, 1955) a caneolith having upper and lower rim elements and a wall.

Incomplete caneolith – (HALLDAL & MARKALI, 1955) a caneolith having upper and lower rim elements, but lacking a wall.

Scapholith – (DEFLANDRE, 1954; = rhombolith HALLDAL, 1954) elongate diamond-shaped heterococcoliths with a central area of parallel laths.

Cyrtolith – (BRAARUD, DEFLANDRE, HALLDAL & KAMPTNER, 1954) basket-shaped (calotte-shaped) heterococcoliths with laths and a projecting central structure.

Styliform cyrtolith – (HALLDAL & MARKALI, 1954) cyrtolith with a long spinose central appendix (pole coccoliths of *Acanthoica*).

Helatoform cyrtolith – (HALLDAL & MARKALI, 1954) cyrtolith with a nail-shaped central appendix (this term was created to refer to rhabdoliths, esp. *R. stylifer*. We have not obtained any good plan views of *R. stylifer*, but doubt that the base is a cyrtolith. HALLDAL & MARKALI's illustrations are inconclusive).

Labiatiform cyrtolith – (HALLDAL & MARKALI, 1955) cyrtolith with a double-lip shaped central appendix (*Anthosphaera robusta*).

Salpingiform cyrtolith – (BRAARUD, DEFLANDRE, HALLDAL & KAMPTNER, 1954) cyrtolith with a trumpet-shaped appendix (*Discosphaera tubifer*).

Placolith s. s. – (BRAARUD, DEFLANDRE, HALLDAL & KAMPTNER, 1954) heterococcoliths having two shields connected by a central tube.

Cricolith – (BRAARUD, DEFLANDRE, HALLDAL & KAMPTNER, 1954) heterococcoliths having units arranged in a simple ring.

Osteolith – (HALLDAL & MARKALI, 1955) heterococcoliths having a femur-shape, built up of lamellae (*Ophiaster hydroideus*).

Lepidolith – (HALLDAL & MARKALI, 1955) thin apparently homogeneous elliptical plates (for surface coccoliths of *Thorosphaera flagellata*, may represent the surficial organic plate-scales described by PARKE & ADAMS, 1960).

Cribrilith – (HALLDAL & MARKALI, 1955) discoliths with numerous central perforations and a lamellar rim.

Pentalith – (BRAARUD, DEFLANDRE, HALLDAL & KAMPTNER, 1954) a nannofossil with pentagonal outline.

Simple pentalith – (DEFLANDRE, 1957) a pentalith with heliolithid structure.

Composite pentalith – (DEFLANDRE, 1957) a pentalith composed of five crystal units.

The terminology of coccolith ultraarchitecture is relatively young. The following terms have been adapted from HALLDAL & MARKALI (1954, 1955), BLACK & BARNES (1959, 1961), and HAY & TOWE (1962):

Holococcoliths:

rhombohedric microcrystals – rhombohedral calcite crystals having an edge length from 430-2500 Å

hexagonal microcrystals-found in calyptroform holococcoliths

Heterococcoliths:

General terms:

segment – any of the parts into which a coccolith naturally separates or is divided

rhomb – six-sided, roughly equidimensional

tabula – six-sided, two dimensions equal, the tird smaller

lamina – two dimensions large, the third very small

lamella – two dimensions large, the third → 0

lath – one dimension large, one intermediate, one very small

rod – one dimension large, two much smaller

wedge – five-sided, two dimensions subequal, the third small at one edge, → 0 at the other

central area – the center of the coccolith

margin – the edge of the coccolith

cycle – a ring of segments

jugum – a transverse structure crossing the center, connecting one side of the cycle with the other

dextral imbrication – each segment overlaps the one to the right when viewed from the center of the cycle

sinistral imbrication – each segment overlaps the one to the left when viewed from the center of the cycle

suture – the boundary between segments

clockwise inclination – suture inclined to the right as it proceeds to the periphery

counterclockwise inclination – suture inclined to the left as it proceeds to the periphery

radial – suture corresponds to a radius in a circular form or to a straight line drawn through the nearest focus or the line connecting the foci of an elliptical form

flange – a part that spreads out like a rim

Special terms:

1) for caneoliths:

bottom – (HALLDAL & MARKALI, 1954) the central area

wall – (HALLDAL & MARKALI, 1954; = girdle, HALLDAL & MARKALI, 1955) the raised margin

lower rim – (HALLDAL & MARKALI, 1954) proximal flange peripheral to the wall

upper rim – (HALLDAL & MARKALI, 1954) distal flange peripheral to the wall

2) for placoliths:

shield – (BLACK & BARNES, 1959) one of the discs of the placoliths

proximal shield – the shield on the concave side of the placolith

tube – (BLACK & BARNES, 1959) the central cylinder connecting the two shields distal shield – the shield on the convex side of the placolith.

III. STRATIGRAPHY

As noted above, the samples studied here are from a well near Nal'chik in the northwest Caucasus. The well section was sampled at 60 cm intervals. The complete suite was not examined for nannofossils, but eight of the best samples have been studied in detail. Numbering of the samples was from the top of the well down. The lowest samples stratigraphically, Nal 19, Nal 16, Nal 12, and Nal 11 are in the *Globigerinoides conglobatus* zone of the Alminskian Stage. The planktonic foraminifera characteristic for this zone are *Globigerina corpulenta*, *Globigerina inflata*, *Globigerina eocenica eocenica*, *Globigerina eocenica compacta* and *Globigerinoides conglobatus*. Samples Nal 9, Nal 7, Nal 6 and Nal 4 are higher, from the *Bolivina antegressa* zone of the Alminskian Stage. The characteristic microfossils of the zone are *Cibicides dutemplei*, *Cibicides ungerianus*, *Anomalina alazanensis*, *Cibicides perlucidus*, *Nonion curviseptum* and *Globigerina officinalis*. The nannofossil content of the samples is the same throughout the section with the single exception of *Chiasmolithus oamaruensis* (DEFLANDRE) which appears to be restricted to Nal 19. The most characteristic nannofossil species in the sequence is *Isthmolithus recurvus* DEFLANDRE already known from widely separated areas. The term *Isthmolithus recurvus* zone is suggested to include those strata characterized by the nannofossil assemblage described here.

IV. SYSTEMATICS

Familia Coccolithaceae KPT. 1928

Coccolithophores constructed of many component parts either all alike or different, generally having a heliolithid appearance in polarised light.

Subfamilia Coccolithoideae KPT. 1928

Coccolithophores characterised by a complete cover of sturdily constructed coccoliths; as far as is known, all genera lack flagellae.

Tribus Coccolitheae KPT. 1958

Coccolithophores bearing tremaliths (sensu LOHMANN, 1913), i.e. coccoliths possessing an apparent central tube which may or may not represent a central perforation; regions peripheral to the tube imperforate.

Subtribus Coccolithinae KPT. 1958

Elliptical placoliths.

Genus *Coccolithus* SCHWARZ, 1894

Synonyms: *Cyatholithus* HUXLEY, 1868; *Coccosphaera* WALLICH, 1877 (not *Coccosphaera* PERTY, 1852); *Cyathosphaera* HAECKEL, 1894; *Coccolithophora* LOHMANN, 1902; *Tremalithus* KAMPTNER, 1948.

Type species: *Coccosphaera pelagica* WALLICH, 1877. (Designated by LOEBLICH & TAPPAN, 1963.)

Coccolithophores bearing elliptical placoliths, proximal shield smaller than distal shield.

The distal shield is peculiar in having all of the calcite segments oriented so that the c-axes are perpendicular, or very nearly so, to the plane of the shield.

The interference figure observed in polarised light, like that of *Cyclococcolithus*, is produced by the proximal shield.

Coccolithus eopelagicus (BRAMLETTE & RIEDEL)

Pl. I, fig. 1

1954. *Tremalithus eopelagicus* BRAMLETTE & RIEDEL, Journ. Paleont., v. *28*, no. 4, p. 392, pl. 38, figs. 2a, b.

Hypotype: UI-H-2060.

Remarks: This species is distinguished by its very large size (16–21 μ) and large number of elements ($\sim$ 60) in the distal shield. It is rare at Nal'chik and has not been seen in the electron microscope.

Distribution: Found throughout the Nal'chik section. This species is reported to occur in numerous Upper Eocene-Oligocene strata.

Coccolithus sarsiae BLACK

Pl. I, figs. 2–5

1962. *Coccolithus sarsiae* BLACK, Geol. Mag., v. *94*, no. 2, p. 125–126, pl. 8, fig. 2, pl. 9, fig. 2–6.

Hypotypes: UI-H-2061, 2062.

Remarks: According to BLACK, this species has 39 rays in the larger shield. Specimens from Nal'chik have 40 rays but closely resemble BLACK's in all respects.

Distribution: Found throughout the Nal'chik section. BLACK's specimens were from a submarine outcrop of Tertiary strata on the continental slope off Brittany.

Coccolithus litos n. sp.

Pl. I, figs. 6–9

Holotype: UI-H-2063.

Dimensions of Holotype: Length 9.5 μ, width 7.5 μ.

Paratype: UI-H-2064.

Dimensions of Paratypes: Length 10 μ, width 8.7 μ.

Locus typicus: Nal'chik.

Stratum typicum: Nal 11.

Diagnosis: A species of the *C. pelagicus* group with only 25–26 segments in the distal shield.

Description: Distal shield composed of 25–26 wedge-shaped segments, only very slightly imbricate dextrally; sutures on the distal shield straight, inclined slightly clockwise centrally, curving counter-clockwise peripherally; center of distal shield a narrow elliptical crater-shaped depression lined with a cycle of thin tabular elements.

Relations: *Coccolithus pelagicus* (WALLICH) has about 48 segments; *C. eopelagicus* (BRAMLETTE & RIEDEL) is much larger and has about 60 segments; *C. sarsiae* (BLACK) has 39–40 segments; *C. celticus* (BLACK) is about the same size as the new species but has 50–60 segments.

Distribution: Rare in the Nal'chik samples.

Coccolithus pseudocarteri n. sp.

Pl. II, figs. 1–4

Holotype: UI-H-2065.

Dimensions of Holotype: Length 8.5 μ, width 7.4 μ.

Paratype: UI-H-2066.

Dimensions of Paratype: Length 10 μ, width 9.2 μ.

Locus typicus: Nal'chik.

Stratum typicum: Nal 11

Diagnosis: A species of the *C. pelagicus* group with about 35 segments in the distal shield and two central perforations.

Description: Distal shield elliptical composed of about 35 wedge-shaped segments; sutures on the distal shield straight, inclined clockwise peripherally in distal view; central depression lined with about 35 lath-like elements; central area divided into two perforations near foci of the ellipse by a proximal granule.

Remarks: The details of the proximal shield remain unclear. The biperforate nature of the coccolith is readily visible in light and phase microscopy. The central area shows a characteristic pair of «Z»'s when viewed in polarised light between crossed nicols.

Relations: This species closely resembles *Coccolithus carteri* (WALLICH) (= *Coccosphaera carteri* WALLICH, *not Helicosphaera carteri* (WALLICH) of KAMPTNER) but has fewer segments in the distal shield.

Distribution: Common in the Nal'chik section.

Genus *Reticulofenestra* n. gen.

Placoliths with a large central opening spanned by a reticulate or lacy net, a tube cycle of tall imbricate wedges exposed distally but not proximally, a narrow proximal rim of many thin rays and a wide distal rim of many tabular elements.

Type species: *Reticulofenestra caucasica* n. sp.

Remarks: This genus has features in common with both *Coccolithus* and *Syracosphaera*. It is immediately distinguished from *Coccolithus* by the large central opening, which is commonly $^1/_3$ or more the diameter of the entire fossil. Further, the tube cycle is exposed distally, and is not covered by a distal shelf as in *Coccolithus*. The shape is that of a caneolith. The central area generally resembles that of several species of *Syracosphaera*.

Species: DEFLANDRE & FERT (1954) described the species *Discolithus dictyodus* and illustrated specimens from the Eocene at Donzacq, France and the «Oligocene» at Oamaru, New Zealand. The two specimens figured represent two distinct species. As no holotype was designated for the species, that figured in text-fig. 15 from Donzacq is hereby selected as the lectotype. The Oligocene specimen belongs to a new, as yet undescribed, species. The Donzacq species has been illustrated in carbon replica by HAY & TOWE (1963) and can be referred to the genus *Reticulofenestra* as can also the Oligocene species.

Reticulofenestra caucasica n. sp.

Pl. II, figs. 5–8, pl. III, figs. 1–2, pl. IV, figs. 1–2

Holotype: UI-H-2072.

Dimensions for Holotype: Length 12.5 μ, width 10.5 μ.

Paratypes: UI-H-2067, 2068, 2069, 2070, 2071.

Dimensions of Paratypes: Length 9.15–16 μ, width 9–12.5 μ.

Locus typicus: Nal'chik.

Stratum typicum: Nal 11.

Diagnosis: A species of *Reticulofenestra* with a large central opening spanned by a large number of anastomosing rods producing narrow elongate fenestration marginally and reticulation centrally.

Description: Distal shield composed of about 100 dextrally imbricate wedge-shaped segments separated by sutures having slight counter-clockwise inclination when seen in distal view; tube covered distally by about 100 flattened wedge-shaped plates imbricate sinistrally. Proximal shield composed of about 100 thin lath-like segments bending centrally to form lining of tube; central area lacy, with 100 narrow rods at rim, anastomosing centrally to produce reticule with elongate perforations.

Relations: This species has much finer, more slit-like central fenestration than *R. dictyodus* (DEFLANDRE & FERT) and many more central laths than *R. scissura* n. sp.

Reticulofenestra scissura n. sp.

Pl. V, figs. 1–6

Holotype: UI-H-2073.

Dimensions of Holotype: Length 8.0 μ, width 7.4 μ.

Paratypes: UI-H-2074, 2075, 2076.

Dimensions of Paratypes: Length 6.4–10 μ, width 5.4–9 μ.

Locus typicus: Nal'chik.

Stratum typicum: Nal 11.

Diagnosis: A species of *Reticulofenestra* having a central opening about $^1/_4$ the diameter of the coccolith, spanned by 8–11 pairs of anastomosing laths producing elongate fenestration.

Description: Distal shield elliptical, outline serrate composed of 40–66 wedge-shaped segments which can be seen to be strongly imbricate sinistrally in proximal view, sutures inclined slightly clockwise in distal view; sutures on proximal side of distal shield radically directed; proximal shield about half as wide as distal shield, composed of an equal number of segments, sutures inclined slightly counter-clockwise in proximal view; central area with 8–11 pairs of anastomosing laths, each about twice as wide as the central termination of the segments of the proximal shield, producing elongate slits or openings, each pair touching along a line of commisive coinciding with the major axis of the ellipse.

Relationships: The central area of this coccolith resembles that of *Reticulofenestra dupouyi* (DEFLANDRE & FERT) but has much more elongate fenestration. The shields are more tightly constructed than in the case of *R. dupouyi*. *R. caucasica* is much larger and is much more complex.

Distribution: Common throughout the section at Nal'chik.

Genus *Apertapetra* n. gen.

Placoliths possessing a wide oval central opening with no trace of a central structure; a tube of tall imbricate elements, exposed both proximally and distally; a narrow proximal rim of numerous thin rays; and a wide distal rim of tabular elements.

Type species: *Apertapetra samodurovi* n. sp.

Remarks: This genus differs from *Coccolithus* in having a large open central area. It is distinguished from *Cricolithus* KAMPTNER, 1958 (= *Cyclolithus* KAMPTNER

(1948, invalid) ex DEFLANDRE, 1952 (non *Cyclolithus* FORTIS, 1802); = *Cyclolithella* LOEBLICH & TAPPAN, 1963) in possessing proximal and distal rim cycles. The general appearance of this genus is similar to that of *Reticulofenestra* n. gen. but the tube cycle is visible proximally in *Apertapetra*.

Species: *Coccolithus umbilicus* LEVIN may belong in this genus.

Apertapetra samodurovi n. sp.

Pl. VI, figs. 1–7

Name: For V. I. Samodurov of the Geological Institute of the Soviet Academy of Sciences, who provided the samples.

Holotype: UI-H-2080.

Dimensions of Holotype: Length 5.9 μ, width 5.2 μ.

Paratypes: UI-H-2077, 2078, 2079, 2081.

Dimensions of Paratypes: Length 5–12 μ, width 4–11 μ.

Locus typicus: Nal'chik.

Stratum typicum: Nal 11.

Diagnosis: A broadly elliptical species of *Apertapetra* with a central opening $^1/_3$–$^1/_2$ the diameter of the coccolith.

Description: Distal shield composed of usually 54–55 segments separated by sutures having a slight clockwise inclination in distal view; peripheral termination of the segments bluntly pointed, producing a serrate margin, proximal shield similar to distal shield in all respects except not so wide; tube composed of a cycle of 54–55 tall lath-like elements having sinistral imbrication in distal view.

Relations: Coccoliths of this sort, although common in many sediments, have not been given specific names in the past, but have been referred to as *Coccolithus pelagicus*. The non-imbricate nature of the segments of the shields distinguishes this species from species of the *C. pelagicus* group.

Distribution: This species is found in all of the samples from Nal'chik, but is especially abundant in samples 9 and 11.

Genus *Chiasmolithus* n. gen.

Placoliths having a very large central opening spanned by an «X»-shaped structure. Distal rim wider than the proximal rim.

Type species: *Tremalithus oamaruensis* DEFLANDRE 1954.

Remarks: This genus, like *Reticulofenestra* n. gen. has features in common with both *Coccolithus* and *Syracosphaera*. The diagnostic feature is the large «X»-shaped central structure.

Species: The following species can be tentatively assigned to this genus: *Coccolithus bidens* BRAMLETTE & SULLIVAN, *Coccolithus consuetus* BRAMLETTE & SULLIVAN, *Coccolithus danicus* BROTZEN, *Coccolithus expansus* BRAMLETTE & SULLIVAN, *Coccolithus gigas* BRAMLETTE & SULLIVAN, *Coccolithus grandis* BRAMLETTE & RIEDEL and *Coccolithus solitus* BRAMLETTE & SULLIVAN.

Chiasmolithus oamaruensis (DEFLANDRE)

Pl. VII, fig. 1

1954. *Tremalithus oamaruensis* DEFLANDRE, in DEFLANDRE & FERT, Ann. Paléont., v. *40*, p. 154, pl. 11, fig. 22, text-figs. 72–74.

1965. *Coccolithus oamaruensis* (DEFLANDRE) LEVIN, Jour. Paléont., v. *39*, no. 2, p. 265–266, pl. 41, fig. 3.

Hypotype: UI-H-2082.

Dimensions of Hypotype: Length 17 μ, width 13.5 μ.

Remarks: Specimens found at Nal'chik closely resemble those figured by DEFLANDRE.

Distribution: Found only in Nal 19. This species was originally described from the «Oligocene» (Upper Eocene?) of New Zealand. It has also been reported by LEVIN from the YAZOO Formation of Mississippi.

Subtribus Cyclococcolithinae KPT. 1958

Circular placoliths

Genus *Cyclococcolithus* KAMPTNER (1954, invalid)

ex KAMPTNER, 1958

Synonyms: *Cycloplacolithus* KAMPTNER, 1963 (the type species, *C. foliosus* KAMPTNER, 1963, is based on an electronmicrograph showing a proximal view of *Cyclococcolithus leptoporus* (MURRAY & BLACKMAN)); *Calcidiscus* KAMPTNER, 1952 (the type species, *Calcidisus quadriforatus* KAMPTNER, 1952, represents the isolated proximal shield of *Cyclococcolithus leptoporus* (MURRAY & BLACKMAN)); *Tiarolithus* KAMPTNER, 1958 (the type species, *Calcidiscus medusoides* KAMPTNER, 1954, represents the isolated distal shield and tube of *Cyclococcolithus leptoporus* (MURRAY & BLACKMAN)).

Type species: *Coccosphaera leptopora* MURRAY & BLACKMAN, 1898 (this genus can be considered monotypic, since the other species assigned to it by KAMPTNER in 1954, *Umbilicosphaera mirabilis* LOHMANN, was already type of *Umbilicosphaera* LOHMANN by monotypy. In 1958 KAMPTNER recognised *Cyclococcolithus* to be distinct from *Umbilicosphaera*). Coccolithophores bearing circular placoliths having a distal shield larger than the proximal shield, imperforate, but with a central depression on the distal shield, producing the illusion of a perforation in the light microscope.

Cyclococcolithus inversus DEFLANDRE

Pl. VII, fig. 2

1954. *Cyclococcolithus leptoporus* var. *inversus* DEFLANDRE, Ann. Paléont., v. *40*, p. 36–37, pl. 9, figs. 4–5 (*not* figs. 6–9).

non 1964. *Markalius inversus* (DEFLANDRE) of BRAMLETTE & MARTINI, Micropaleontology, v. *10*, no. 3, p. 302, pl. 2, figs. 4–9, pl. 7, fig. 2a–b.

Hypotype: UI-H-2083.

Dimensions of hypotype: Diameter 6.5 μ.

Remarks: Specimens in the Nal'chik section closely resemble that figured by DEFLANDRE from the diatomite at Oamaru (pl. 9, figs. 4–5) here designated as lectotype for the species. Nal'chik specimens, like that figured by DEFLANDRE, almost invariably have 28 rays and are mirror images of the modern species *C. leptoporus*. *C. leptoporus* shows a higher degree of variation in the number of rays than Upper Eocene-Oligocene forms. The consistent difference between the modern forms and the Paleogene specimens warrants elevation of the variety to the level of species. The Jurassic specimens referred by DEFLANDRE to this taxon belong elsewhere. One of the most characteristic features of *C. leptoporus* and *C. inversus* is that the c-axes of the elements of the distal shield are at right angles to the plane

of the disc, while the c-axes of the segments of the proximal shield are inclined to the plane of the shield. The effect in polarised light is that only the proximal shield produces an interference figure, the distal shield is dark. The Oxfordian specimens illustrated by DEFLANDRE show an interference figure the size of the distal shield, indicating a basically different sort of construction.

Distribution: Common throughout the Nal'chik section. First reported from the «Oligocene» diatomite of Oamaru, New Zealand.

Cyclococcolithus lusitanicus (BLACK)

Pl. VII, figs. 3–6

1964. *Coccolithus lusitanicus* BLACK, Paleontology, v. 7, pt. 2, p. 308–309, pl. 50, figs. 1–2.

Hypotypes: UI-H-2084, 2085.

Dimensions of hypotype: Diameter 8.5 μ to 10 μ.

Remarks: Specimens from Nal'chik closely resemble those figured by BLACK, but have 44–56 rays in the distal shield. Most of them thus fall within the range of variation (39–51 rays) mentioned by BLACK.

Distribution: Found throughout the Nal'chik section, common.

Subtribus Rhabdolithinae HAY n. subtr.

Coccolithophores bearing rhabdoliths (helatoform cyrtoliths).

Genus *Rhabdolithes* SCHMIDT, 1870

Type species: *Rhabdosphaera claviger* MURRAY & BLACKMAN, 1898 (designated by LOEBLICH & TAPPAN, 1963).

Coccolithophores bearing rhabdoliths with a circular base (Note: *Rhabdolithus* KAMPTNER, 1949, a term for isolated rhabdoliths, has never been validly published).

Rhabdolithes creber (DEFLANDRE)

1954. *Rhabdolithus creber* DEFLANDRE, Ann. Pal., v. *40*, p. 157, pl. 12, figs. 31–33, text figs. 81–82.

1961. *Rhabdosphaera crebra* (DEFLANDRE), BRAMLETTE & SULLIVAN, Micropaleontology, v. 7, no. 2, p. 146, pl. 5, figs. 1–3.

1963. *Rhabdosphaera crebra* (DEFLANDRE), HAY & TOWE, Eclogae geol. Helv.

Remarks: Specimens referred to this species agree closely with the holotype of DEFLANDRE.

Distribution: Rare to common in the Nal'chik samples. This species appears to have a relatively long range, occurring through the Middle and Upper Eocene.

Tribus Pontosphaereae HAY n. tr.

Coccolithophores bearing shallow lopodoliths.

Genus *Pontosphaera* LOHMANN, 1902

Synonym: *Ellipsolithus* SULLIVAN, 1964; «*Discolithus*» of various authors.

Type species: *Pontosphaera syracusana* LOHMANN, 1902 (designated by LOEBLICH & TAPPAN, 1963).

Remarks: Coccolithophores bearing simple shallow lopodoliths with a continuous elliptical wall.

Ultra-structural studies of modern species show that the wall of the lopodolith is formed by long thin strongly imbricate laths. The floor of these basket-shaped

forms is solid or minutely perforate, and convex distally. The lopodolith opens distally. In the light microscope the floor of the lopodolith is usually obscure in side view, so that the forms appear to be concave distally. Many of the forms described as «*Discolithus*» belong here.

Pontosphaera vadosa n. sp.

Pl. VIII figs. 1–4

Holotype: UI-H-2087.

Dimensions of Holotype: Length 6.5 μ, width 4.8 μ.

Paratype: UI-H-2086.

Dimensions of Paratype: Length 7 μ, width 6 μ.

Locus typicus: Nal'chik.

Stratum typicum: Nal 11.

Diagnosis: A species of *Pontosphaera* with a low wall, a floor concave proximally, with about 18 perforations.

Descriptions: Elliptical lopodoliths with floor moderately concave in proximal view; composed of numerous laths extending peripherally from a line of commisive in the major axis of the ellipse, which terminates near the foci of the ellipse; laths dividing peripherally, about 100 present along margin; base with perforations arranged in two ellipses, the inner with 6 holes, the outer with 12; wall low, composed of about 100 thin laths strongly imbricate dextrally in proximal view.

Remarks: The perforations of this species are too small to be resolved in the light microscope. Nevertheless it has been possible to identify this form in the light microscope. In phase microscopy it appears to have two vague slits in the major axis, an effect produced by the light passing near the line of commisive.

Relationships: This species is distinguished from *Pontosphaera syracusana* LOHMANN by its lower wall. *Pontosphaera macella* (BRAMLETTE & SULLIVAN) (type species of the genus *Ellipsolithus*) appears to be a form similar to the species described here, but has a wider, flatter wall. *Pontosphaera plana* (BRAMLETTE & SULLIVAN) has a less distinct, lower wall. *Pontosphaera versa* (BRAMLETTE & SULLIVAN) is more narrowly elliptical in outline.

Distribution: moderately common in most Nal'chik samples.

Genus *Transversopontis* n. gen.

Type species: *Discolithus obliquipons* DEFLANDRE.

Diagnosis: Shallow elliptical lopodoliths with two large openings in the ends of the ellipse, separated by a central bridge.

Species: The only species in addition to the type is *Transversopontis pulchra* (DEFLANDRE) (= *Discolithus pulcher* DEFLANDRE).

Transversopontis obliquipons (DEFLANDRE)

Pl. VIII, fig. 5

1954. *Discolithus obliquipons* DEFLANDRE, Ann. Paleont. v. *40*, p. 139, pl. 11, figs. 1–2 (? text-fig. 53).

1965. *Discolithina pulchra* (DEFLANDRE) of LEVIN, Journ. Paleont., v. *39*, no. 2, p. 266, pl. 41, figs. 6a–c.

Hypotype: UI-H-2088 (Nal 11).

Dimensions of Hypotype: Length 9.5 μ, width 6.5 μ.

Remarks: Specimens at Nal'chik closely resemble those figured in light micrograph by DEFLANDRE. The bridge of the specimen illustrated in his text-fig. 53 is much more oblique than those illustrated by light micrographs, and is probably a different species. Study of the electron micrographs of a Nal'chik specimen shows the rim to be composed of 150–200 thin laths strongly imbricate dextrally in proximal view. The floor of the lopodolith is made of an approximately equal number of elements. The specimen figured by LEVIN apparently belongs here. The holotype of *Transversopontis pulchra* (DEFLANDRE) has the bridge oriented along the minor axis of the ellipse.

Genus *Discolithina* LOEBLICH & TAPPAN, 1963

Type species: *Discolithus viginiforatus* KAMPTNER, 1948. Shallow cribrate lopodoliths.

Remarks: LOEBLICH & TAPPAN, 1963, proposed the new name *Discolithina* for *Discolithus* HUXLEY, 1868 (non *Discolithus* FORTIS, 1802), designating *Discolithus viginiforatus* KAMPTNER, 1948 as type. It appears to be a pontosphaerid.

The earlier type designations for *Discolithus* (of *Discolithus glabrus* VEKSHINA 1959 by VEKSHINA 1959; of *Coccolithites glabrus* KAMPTNER, 1955, by KAMPTNER, 1963) are invalid as the species designated were not among the first included species.

Discolithina confossa n. sp.

Pl. IX, figs. 1–6

Holotype: UI-H-2092.

Dimensions of Holotype: Length 7 μ, width 5.5 μ.

Paratypes: UI-H-2089, 29090, 2091.

Dimensions of Paratypes: Length 5.5–8 μ, width 4–5.7 μ.

Locus typicus: Nal'chik.

Stratum typicum: Nal 11.

Diagnosis: Shallow lopodoliths with 29–44 large perforations in the floor.

Description: Floor of the lopodolith convex distally, with large perforations arrange in three elliptical cycles or two cycles and along the line of commisive in the major axis of the ellipse; outer cycle with 16–22 holes, intermediate with 10–16 holes, inner cycle or line of commisive with 3–6 holes; rim composed of 100–150 thin laths strongly imbricate dextrally in distal view.

Remarks: The perforations in the species are at the limit of resolution of the light microscope but can be observed between crossed nicols.

Relations: *Discolithina multipora* (KAMPTNER) is similar but has larger pores, more readily observed in the light microscope. It also has a more broadly elliptical outline.

Distribution: Rare to moderately common throughout the Nal'chik section.

Subfamilia Syracosphaeroideae LOHMANN, 1902

Motile phases, generally characterized by a loose or complete cover of delicately constructed coccoliths.

Tribus Syracosphaereae KPT., 1958

Delicate heterococcoliths, commonly employing laths centrally and petaloid elements in the rims; caneoliths, cribriliths, cyrtoliths, deep lopodoliths.

Subtribus Syracosphaerinae KPT., 1958

Caneoliths, cribriliths.

Genus *Syracosphaera* LOHMANN, 1902

Synonym: *Eusyracosphaera* KAMPTNER, 1941.

Type species: *Syracosphaera pulchra* LOHMANN, 1902. (Designated by LOEBLICH & TAPPAN, 1963).

Remarks: Coccolithophores with naked flagellar pole, bearing dimorphic caneoliths, those of the circumflagellar cycle bearing a central spine, the others being simple.

Syracosphaera bisecta n. sp.

Pl. X, figs. 1–6

Holotype: UI-H-2094.

Dimensions of Holotype: Length 8.2 μ, width 7.1 μ.

Paratypes: UI-H-2093, 2095, 2096.

Dimensions of Paratypes: Length 8–11 μ, width 7–9.5 μ.

Locus typicus: Nal'chik.

Stratum typicum: Nal 11.

Diagnosis: Caneoliths with broad rim and central area with broad tabulae.

Description: Rim with about 66 wedge-shaped segments strongly imbricate dextrally in distal view, sutures inclined slightly clockwise, central area within multiple cycles of imbricate tabular elements.

Remarks: The rim of this species has the same structure as that of *Syracosphaera pulchra*, but has many more elements. In the light microscope, this species would be classed as a discolith.

Distribution: Common in the *Bolivina antegressa* zone samples, rare in the lower samples.

Genus *Zygrhablithus* DEFLANDRE, 1959

Type species: *Zygolithus bijugatus* DEFLANDRE, 1954 (by original designation).

Remarks: Isolated coccoliths with an elliptical rim and an x-shaped central structure surmounted by a spine.

Electronmicroscopic investigation reveals a rim like *Syracosphaera*.

Zygrhablithus bijugatus (DEFLANDRE)

1954. *Zyolithus bijugatus* DEFLANDRE (part) Ann. Paleont., v. *40*, p. 148, pl. 11, fig. 21 (not text-fig. 59).

1954. *Rhabdolithus costatus* DEFLANDRE, Ann. Paleont., v. *40*, p. 157, pl. 11, figs. 8–11, text-figs. 41–42, 77–79.

1959. *Zygrhablithus bijugatus* (DEFLANDRE), DEFLANDRE, Rev. Micropaleon., v. *2*, p. 135–136.

1961. *Zygrhablithus bijugatus* (DEFLANDRE) BRAMLETTE & SULLIVAN, Micropaleontology, v. *7*, no. 2, p. 151, pl. 6, figs. 16a–b, 17a–c, 18.

non 1962. *Zygrhablithus bijugatus* (DEFLANDRE) of HAY & TOWE, Eclogae geol. Helv., v. *55*, no. 2, p. 502, pl. 2, fig. 2.

Remarks: This species has been extensively illustrated elsewhere. The electron micrograph referred to this species by HAY & TOWE was incorrectly identified.

Distribution: Common in most of the Nal'chik samples.

Coccolith incertae sedis

Genus *Coronocyclus* n. gen.

Circular Cycloliths with a wide central opening, constructed of a ring of imbricate wedge-shaped segments, bearing nodes or short spines directed proximally, peripherally and distally.

Type species: *Coronocyclus serratus* n. sp.

Remarks: There is currently no valid generic name for circular cycloliths. Moreover, it is becoming apparent that the circular cycloliths are upon close examination a highly diverse group, related only by their general appearance in the light microscope.

Coronocyclus serratus n. sp.

Pl. XI, figs. 1–5

Holotype: UI-H-2098.

Dimensions of Holotype: Diameter 5.5 μ.

Paratypes: UI-H-2097, .2099.

Dimensions of Paratypes: Diameter 5.2–6 μ.

Locus typicus: Nal'chik.

Stratum typicum: Nal 19.

Diagnosis: A species of *Coronocyclus* having three sets of 32–36 stubby spines directed proximally, distally, and peripherally.

Description: Cyclolith composed of a single cycle of 32–36 strongly imbricate wedge-shaped segments; distal and proximal sides and periphery studded with an equal number of large serrations or stubby spines; central opening of diameter, margin of central opening smooth.

Relations: «*Cyclolithus*» *prionion* DEFLANDRE & FERT resembles the new species, but has a serrate margin lining the central opening.

Distribution: Rare in most Nal'chik samples, moderately common in Nal 11.

Familia Braarudosphaeraceae DEFL. 1947

Composite ortholithid pentaliths.

Genus *Braarudosphaera* DEFLANDRE, 1947

Synonym: *Eodiscoaster* MARTINI, 1961.

Type species: *Pontosphaera bigelowi* GRAN & BRAARUD, 1935 (by monotypy).

Remarks: Coccolithophores with pentaliths, each pentalith composed of five crystal units.

Braarudosphaera bigelowi (GRAN & BRAARUD)

1935. *Pontosphaera bigelowi* GRAN & BRAARUD, Journ. Biol. Board Canada, v. *1*, p. 388, text-fig. 67.

1947. *Braarudosphaera bigelow* (GRAN & BRAARUD) DEFLANDRE, C. R. Acad. Sci. Paris, v. *225*, p. 439, text-figs. 1–5.

1960. *Braarudosphaera bigelowi* (GRAN & BRAARUD), MARTINI, Umschau, in Wiss. u. Techn., n. *13*, p. 396, text-fig. 9.

Remarks: This long ranging cosmopolitan species occurs in Nal 7, but is extremely rare in the other samples.

Genus *Micrantholithus* Deflandre, 1950

Type species: *Micrantholithus flos* Deflandre, 1950 (by original designation).
Remarks: Star-shaped pentaliths, composed of five crystal units.

Micrantholithus attenuatus Bramlette & Sullivan

Pl. XI, fig. 7

1961. *Micrantholithus attenuatus* Bramlette & Sullivan, Micropaleontology, v. *7*, no. 2, p. 154, pl. 8, figs. 8a–b, 9–11.

Hypotype: UI-H-2101.
Dimensions of Hypotype: Diameter 16 μ.
Remarks: Specimens from Nal'chik closely resemble those figured by Bramlette & Sullivan.
Distribution: Rare in Nal 16.

Micrantholithus vesper Deflandre

Pl. XII, fig. 4

1950. *Micrantholithus vesper* Deflandre, 1950, C. R. Acad. Sci., v. *231*, p. 1157, text-figs. 5–7.
1954. *Micrantholithus vesper* Deflandre, Deflandre Ann. Paleont., v. *40*, p. 166, pl. 13, fig. 17, text-fig. 5.
1958. *Micrantholithus vesper* Deflandre, Martini, Senck, leth, v. *39*, no. 5/6, p. 356, pl. 1, fig. 3.
1961. *Micrantholithus vesper* Deflandre, Bramlette & Sullivan, Micropaleontology, v. *7*, no. 2, p. 156, pl. 9, fig. 10.

Hypotype: UI-H-2107.
Dimensions of Hypotype: Diameter 11 μ.
Distribution: Found only in Nal 11, this species is rare at Nal'chik. It has been reported from the Lower and Middle Eocene of California, the Cuisian of Donzacq, France and from the Middle and Upper Eocene of Northern Germany.

Familia Discoasteraceae Tan, 1927

Genus *Discoaster* Tan Sin Hok, 1927

Synonym: *Eudiscoaster* Tan Sin Hok, 1927, *Asterolithes* Sujkowski, 1931.
Type species: *Discoaster pentaradiatus* Tan Sin Hok, 1927 (designated by Loeblich & Tappan, 1963) Ortholithid asteroliths.

Discoaster binodosus hirundinus Martini

Pl. XIII, fig. 2

1959. *Discoaster binodosus hirundinus* Martini, Senck, leth., v. *39*, no. 5/6, p. 362, pl. 4, fig. 19a–b.

Hypotype: UI-H-2109.
Dimensions of Hypotype: Diameter 10.5 μ.
Remarks: An electronmicrograph showing the terminal indentation of the rays is reproduced here.
Distribution: This sub-species occurs in most of the Nal'chik samples. Found in Eocene deposits throughout much of the world.

Discoaster deflandrei Bramlette & Riedel

1954. *Discoaster deflandrei* Bramlette & Riedel, Journ. Paleont., v. *28*, no. 4, p. 399, pl. 39, fig. 6, text-fig. 1a–c.

Remarks: Specimens from Nal'chik closely resemble those figured by Bramlette & Riedel.

Distribution: This species is rare in Nal 7, probably reworked from older beds.

Discoaster germanicus Martini

1958. *Discoaster germanicus* Martini, Senck, leth., v. *39*, no. 5/6, p. 360–361, pl. 3, fig. 15a–b.

Remarks: Specimens at Nal'chik resemble that figured by Martini.

Distribution: This species occurs rarely in sample Nal 16, and is probably reworked from older beds.

Discoaster saipanensis Bramlette & Riedel

Pl. XI, figs. 8–9, pl. XIII, fig. 1

1954. *Discoaster saipanensis* Bramlette & Riedel, Journ. Paleont., v. *29*, p. 398, pl. 39, fig. 4.
1965. *Discoaster saipanensis* Bramlette & Riedel, Levin, Journ. Paleont., v. *39*, p. 270, pl. 43, fig. 2a–b.

Hypotypes: UI-H-2102, 2103, 2108.

Dimension of Hypotypes: Diameter 8–10 μ.

Remarks: Specimens closely resemble those figured by Bramlette & Riedel and Levin. The degree of extension of the rays is variable.

Distribution: Found abundantly in all Nal'chik samples. Known from Upper Eocene deposits in many widely separated areas.

Discoaster tani Bramlette & Riedel

Pl. XI, fig. 6

1954. *Discoaster tani* Bramlette & Riedel, Journ. Paleont., v. *28*, p. 397, pl. 39, fig. 1.

Hypotype: UI-H-2100.

Dimensions of Hypotype: Diameter 6 μ.

Remarks: Specimens are encountered with smooth and with nodose arms.

Distribution: Found in all of the Nal'chik samples. This species ranges through much of the Lower, Middle and Upper Eocene.

Genera incertae sedis

Genus *Isthmolithus* Deflandre, 1954

Type species: *Isthmolithus recurvus* Deflandre, 1954 (by original designation).

Remarks: Elongate parallelogram with two transverse bars.

Isthmolithus recurvus Deflandre

Pl. XII, figs. 1–3, pl. 13, fig. 3

1954. *Isthmolithus recurvus* Deflandre, in Deflandre & Fert, Ann. Paleont., v. *40*, p. 169, pl. 12, figs. 9–13, text-figs. 119–122.
1958. *Isthmolithus recurvus* Deflandre, Martini, Senck, leth., v. *39*, no. 5/6, p. 37, pl. 2, figs. 5a–b.
1965. *Isthmolithus recurvus* Deflandre, Levin, Journ. Paleont., v. *39*, no. 2, p. 269–270, pl. 42, fig. 10.

Hypotypes: UI-H-2104, 2105, 2106, 2110.

Dimensions of Hypotypes: Length 5.8–6.7 μ, width 2.5 μ, height 2.2 μ.

Remarks: Electron micrographs reveal that the wall of this nannofossil is composed of thin blades of calcite. Where the cross-bars meet the outer wall, the blades have a pillar-like thickening. The medial suture of the cross-bars is clearly visible.

Distribution: Found in all of the Nal'chik samples. This species is widely distributed in Upper Eocene and Oligocene deposits.

Genus *Diademopetra* n. gen.

Type species: *Diademopetra luma* n. sp.

Description: Short hollow cylindrical calcareous nannofossils with a few lateral thorns or spines.

Remarks: This type of nannofossil has been observed by MARTINI, who referred to it as an «unbestimmtes Skelettelement». They are common in Upper Eocene rocks, but are not closely related to any other known genus.

Diademopetra luma n. sp.

Pl. XIII, figs. 4–5

1958. «Unbestimmtes Skelettelement» MARTINI, Senck. leth., v. *39*, no. 5/6, p. 384, pl. 6, fig. 31.

Holotype: UI-H-2111.

Dimensions of Holotype: Diameter 7 μ.

Paratype: UI-H-2112.

Dimensions of Paratype: Diameter 8 μ.

Locus typicus: Nal'chik.

Stratum typicum: Nal 19.

Diagnosis: A short hollow cylinder with 6–8 lateral thorn or spine-like projections.

Description: Cylinder thick, thickness of wall about half the diameter of the central opening; laterally 6–8 peripherally directed thorn or spine-like projections, separated by concave depressions.

Remarks: This nannofossil species was first figured by MARTINI as an «unbestimmtes Skelettelement» occurring in the Upper Eocene of Northern Germany.

Distribution: Common in all of the Nal'chik samples. Occurs in Germany, Switzerland and the Caucasus.

Genus *Sujkowskiella* n. gen.

Type species: *Sujkowskiella enigmatica* n. sp.

Description: Elongate tapering nannofossils with an asymmetrical swelling at the thicker end. The swelling is hollow or pierced by a small hole.

Remarks: This nannofossil was first figured by SUJKOWSKI, but no name was proposed for it.

Sujkowskiella enigmatica n. sp.

Pl. XIII, figs. 6–7

1931. Unnamed skeletal element, SUJKOWSKI, Sprawoz. Polsk. Inst. Geolog., v. *6*, p. 50, text-fig. 1/27.

Holotype: UI-H-2114.

Dimensions of Holotype: Length 10 μ.

Paratype: UI-H-2113.

Dimensions of Paratype: Length 8 μ.

Locus typicus: Nal'chik.

Stratum typicum: Nal 19.

Diagnosis: Elongate tapering nannofossil with a perforate or hollow asymmetrical swelling at the larger end.

Description: Elongate smooth irregular nannofossil, tapering to bluntly rounded termination; larger end asymmetrical, swollen, about twice as thick as the central part of the shaft; swollen end perforate or hollow.

Remarks: Electron microscopic investigation fails to reveal any ultrastructural detail.

Distribution: Found rarely to commonly in the Nal'chik samples. The specimen figured by SUJKOWSKI was supposedly from the Upper Cretaceous, of Grodno, Poland (now in the USSR), but was associated with discoasters of Upper Eocene habitus.

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Plate I

Fig. 1 *Coccolithus eopelagicus* (BRAMLETTE & RIEDEL). Distal view in ordinary light. Hypotype: UI-H-2060 (Nal 16) 2500×.

Fig. 2 *Coccolithus sarsiae* BLACK. Distal view, electronmicrograph of carbon replica. Hypotype: UI-H-2061 (Nal 11) 10,000×.

Fig. 3 *Coccolithus sarsiae* BLACK. Distal view of specimen between crossed nicols. Hypotype: UI-H-2062 (Nal 11) 2500×.

Fig. 4 *Coccolithus sarsiae* BLACK. Distal view of specimen in ordinary light. Hypotype: UI-H-2062 (Nal 11) 2500×.

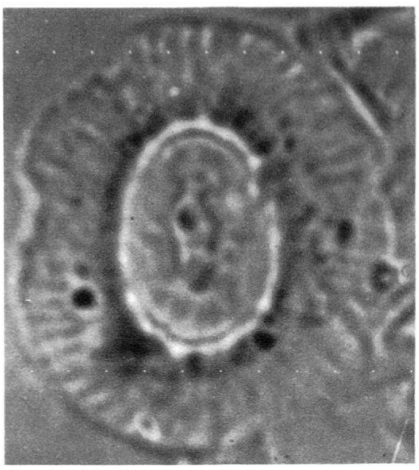
Fig. 5 *Coccolithus sarsiae* BLACK. Distal view of specimen in phase contrast. Hypotype: UI-H-2062 (Nal 11) 2500×.

Fig. 6 *Coccolithus litos* n. sp. Distal view of specimen in phase contrast. Paratype: UI-H-2064 (Nal 11) 2500×.

Fig. 7 *Coccolithus litos* n. sp. Distal view of specimen in ordinary light. Paratype: UI-H-2064 (Nal 11) 2500×.

Fig. 8 *Coccolithus litos* n. sp. Distal view of specimen between crossed nicols. Paratype: UI-H-2064 (Nal 11) 2500×.

Fig. 9 *Coccolithus litos* n. sp. Distal view, electronmicrograph of carbon replica. Holotype: UI-H-2063 (Nal 11) 10,000×.



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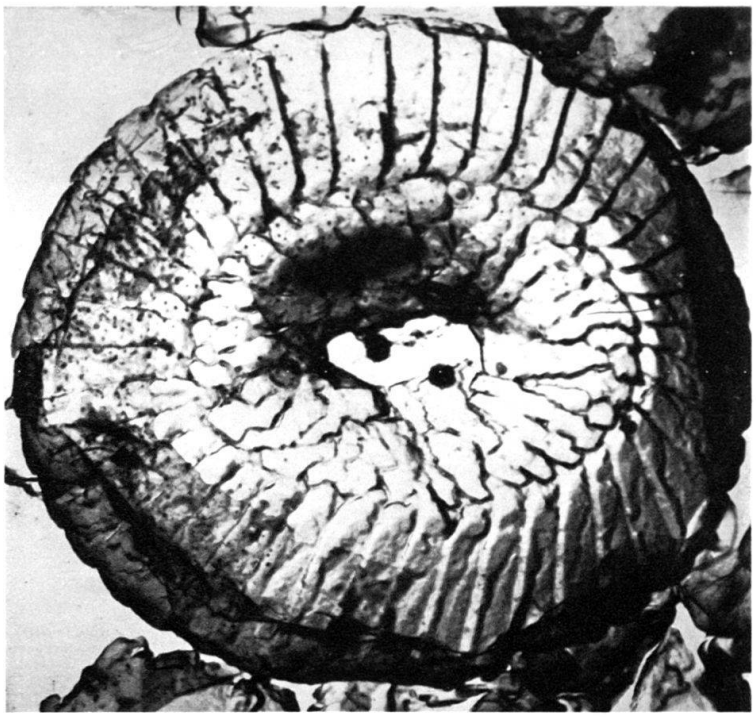

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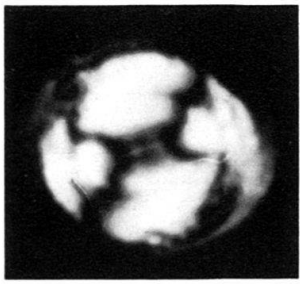

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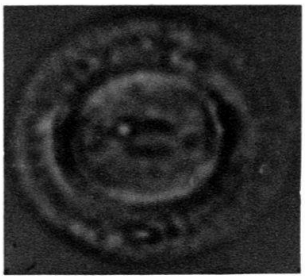

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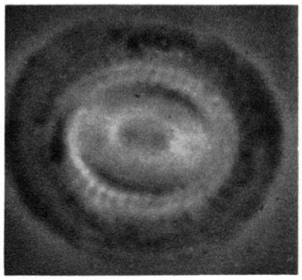

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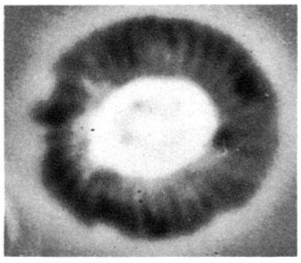

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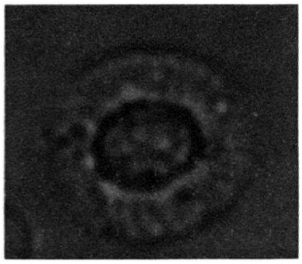

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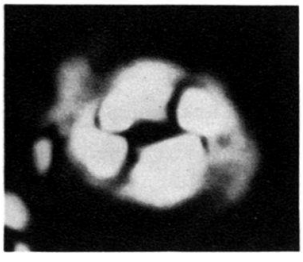

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Plate II

Fig. 1 *Coccolithus pseudocarteri* n. sp. Distal view, electronmicrograph of carbon replica. Holotype: UI-H-2065 (Nal 11) 10,000×.

Fig. 2 *Coccolithus pseudocarteri* n. sp. Distal view of specimen in phase contrast. Paratype: UI-H-2066 (Nal 11) 2500×.

Fig. 3 *Coccolithus pseudocarteri* n. sp. Distal view of specimen in ordinary light. Paratype: UI-H-2066 (Nal 11) 2500×.

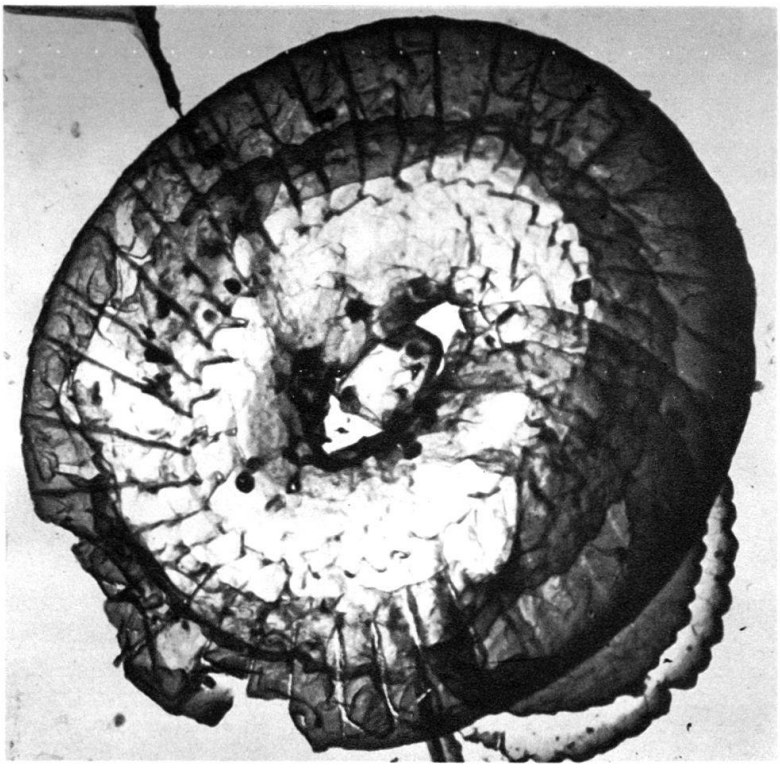
Fig. 4 *Coccolithus pseudocarteri* n. sp. Distal view of specimen between crossed nicols. Paratype: UI-H-2066 (Nal 11) 2500×.

Fig. 5 *Reticulofenestra caucasica* n. sp. Oblique proximal view, electronmicrograph of carbon replica. Paratype: UI-H-2067 (Nal 11) 5000×.

Fig. 6 *Reticulofenestra caucasica* n. sp. Distal view of specimen in phase contrast. Paratype: UI-H-2068 (Nal 11) 2500×.

Fig. 7 *Reticulofenestra caucasica* n. sp. Distal view of specimen in ordinary light. Paratype: UI-H-2068 (Nal 11) 2500×.

Fig. 8 *Reticulofenestra caucasica* n. sp. Distal view of specimen between crossed nicols. Paratype: UI-H-2068 (Nal 11) 2500×.



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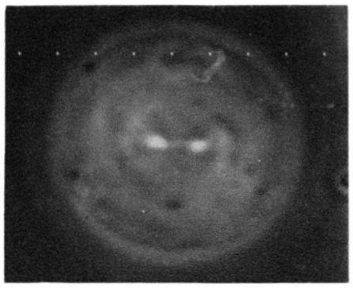

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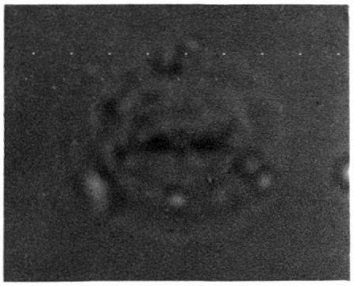

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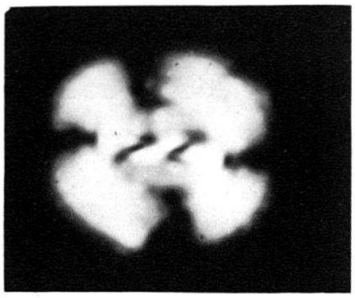

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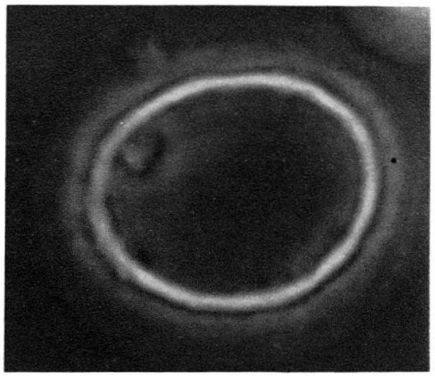

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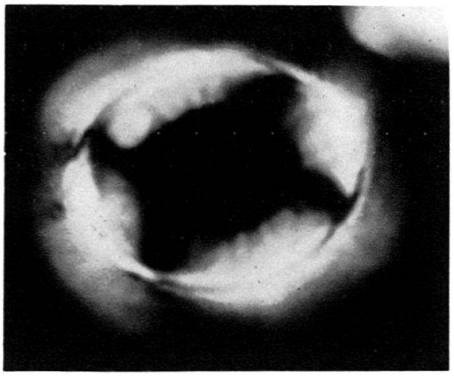

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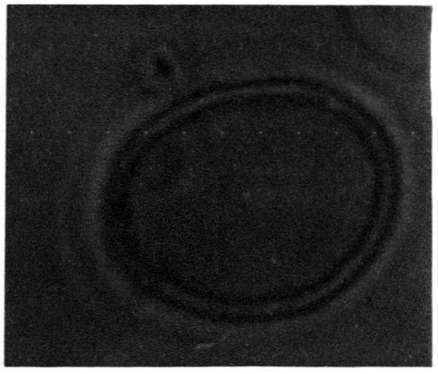

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Plate III

Fig. 1 *Reticulofenestra caucasica* n. sp. Distal view, electronmicrograph of carbon replica. Paratype: UI-H-2069 (Nal 11) 10,000×.

Fig. 2 *Reticulofenestra caucasica* n. sp. Distal view, electronmicrograph of carbon replica. Paratype: UI-H-2070 (Nal 11) 10,000×.

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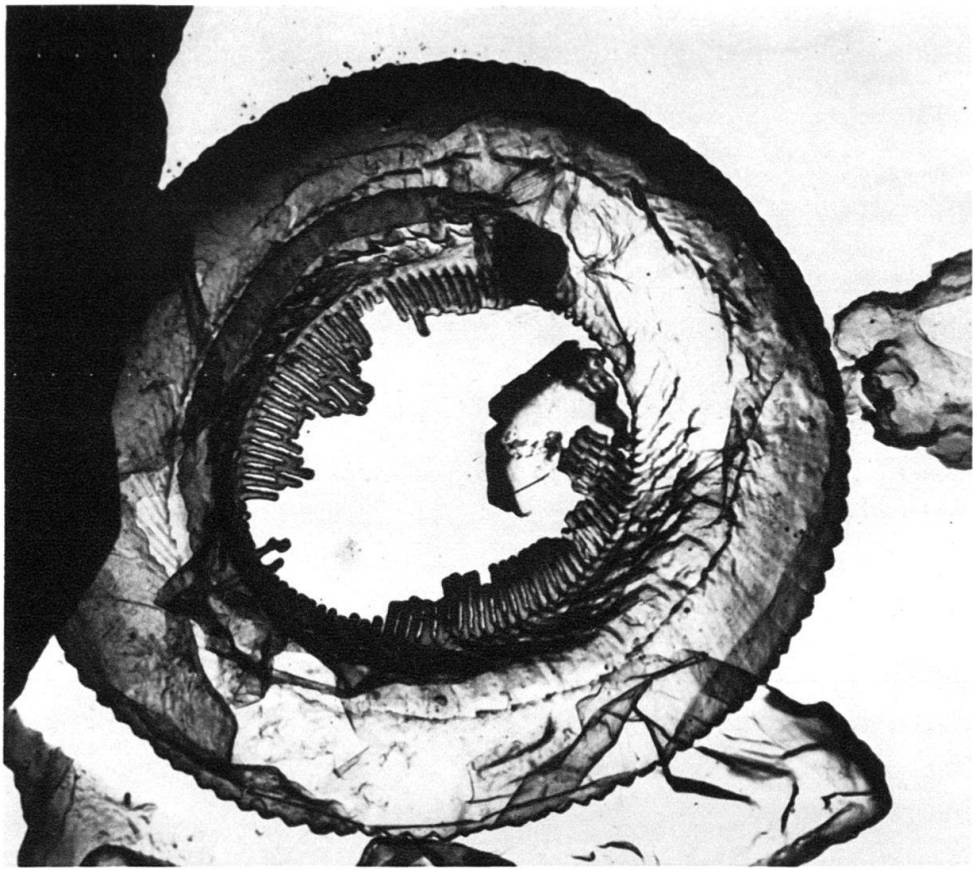

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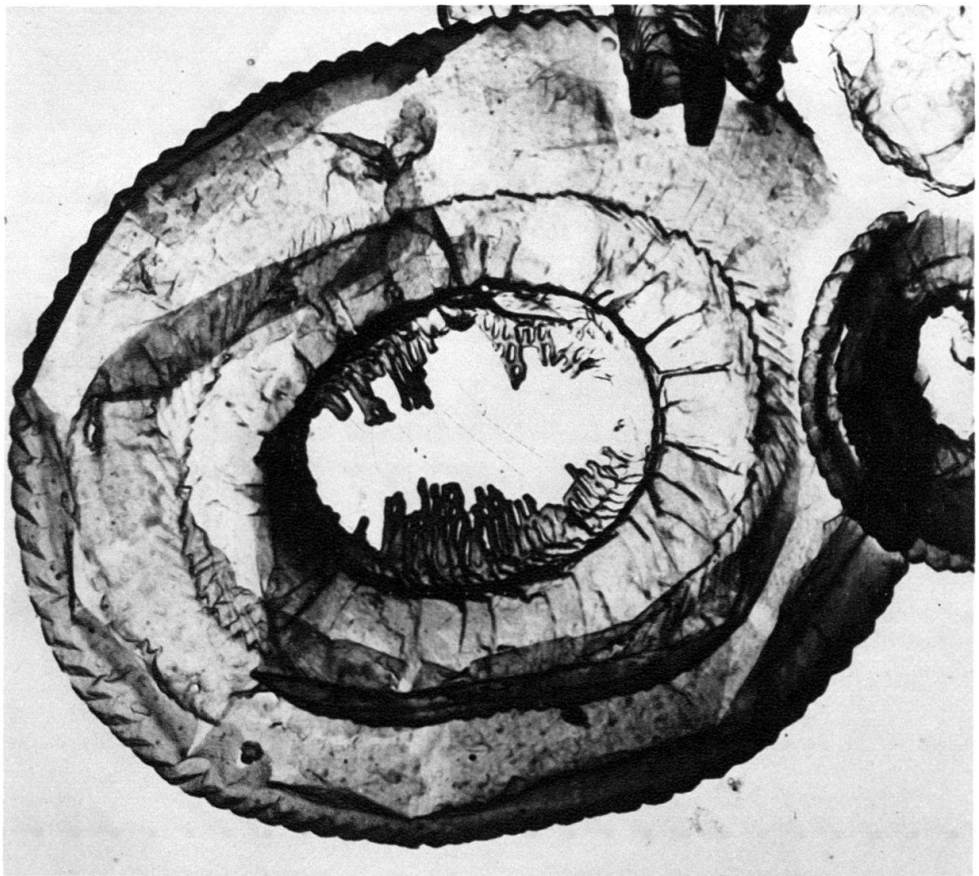

Plate IV

Fig. 1 *Reticulofenestra caucasica* n. sp. Distal view, electronmicrograph of carbon replica. Paratype: UI-H-2071 (Nal 11) 10,000×.

Fig. 2 *Reticulofenestra caucasica* n. sp. Proximal view, electronmicrograph of carbon replica. Holotype: UI-H-2072 (Nal 11) 10,000×.


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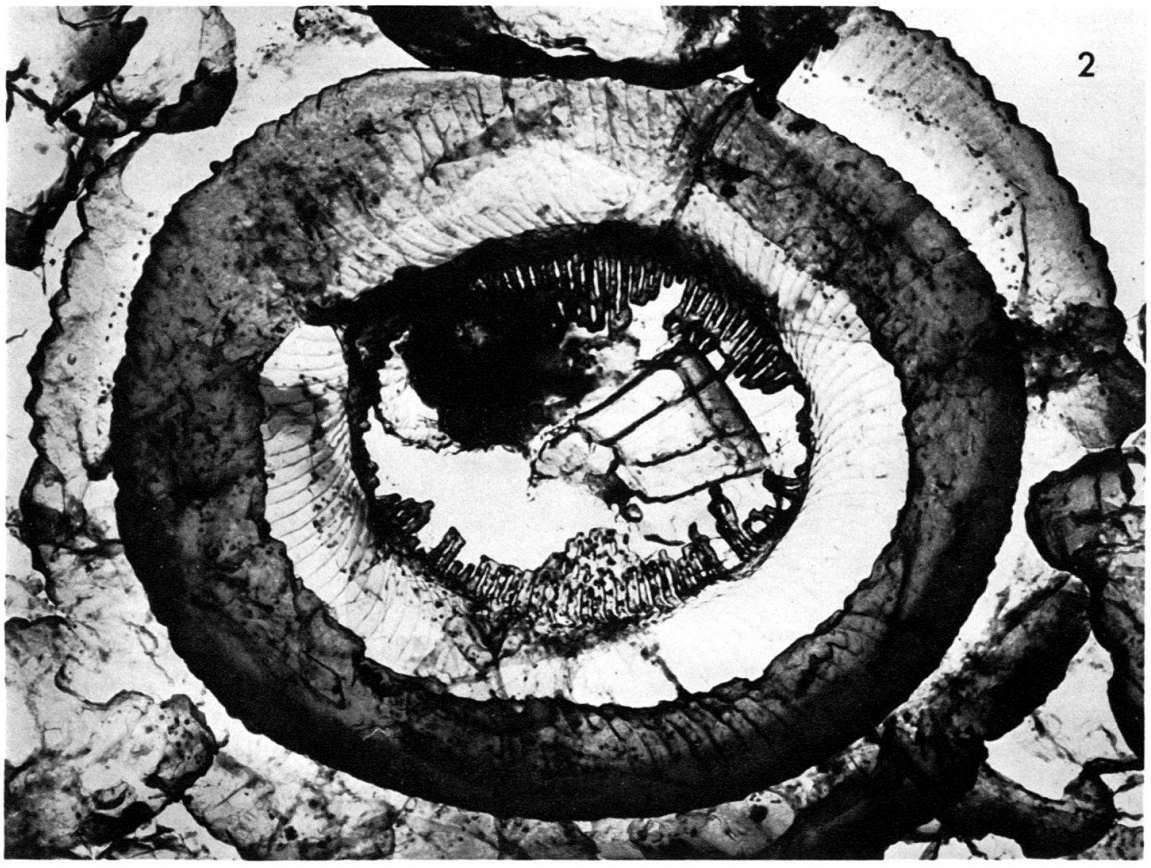
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Plate V

Fig. 1 *Reticulofenestra scissura* n. sp. Proximal view, electronmicrograph of carbon replica. Holotype: UI-H-2073 (Nal 11) 10,000×.

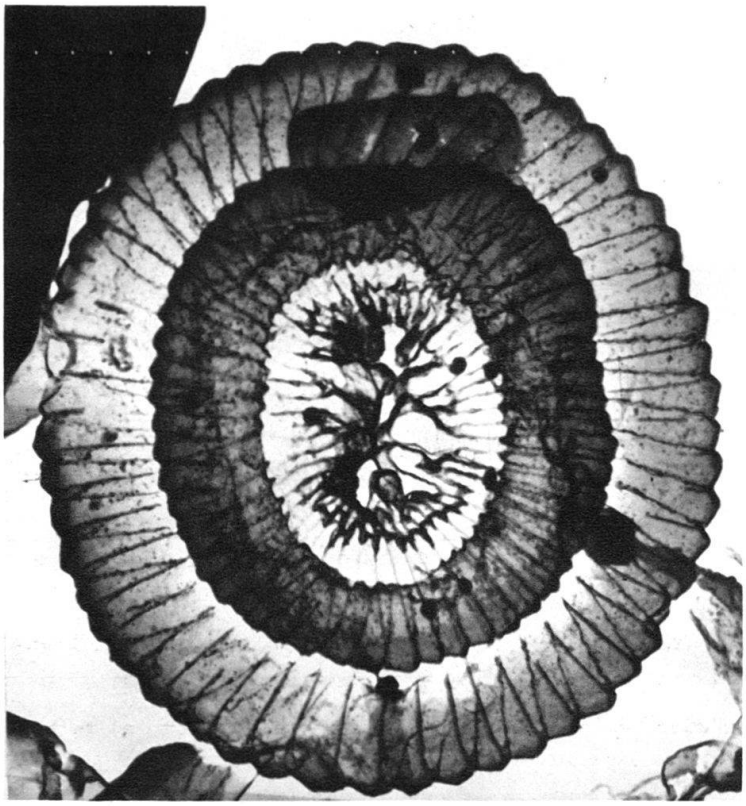
Fig. 2 *Reticulofenestra scissura* n. sp. Proximal view of specimen in phase contrast. Paratype: UI-H-2074 (Nal 11) 2500×.

Fig. 3 *Reticulofenestra scissura* n. sp. Proximal view of specimen in ordinary light. Paratype: UI-H-2074 (Nal 11) 2500×.

Fig. 4 *Reticulofenestra scissura* n. sp. Proximal view of specimen between crossed nicols. Paratype: UI-H-2074 (Nal 11) 2500×.

Fig. 5 *Reticulofenestra scissura* n. sp. Proximal view, electronmicrograph of carbon replica. Paratype: UI-H-2075 (Nal 9) 10,000×.

Fig. 6 *Reticulofenestra scissura* n. sp. Proximal view, electronmicrograph of carbon replica of damaged specimen. Paratype: UI-H-2076 (Nal 9) 10,000×.



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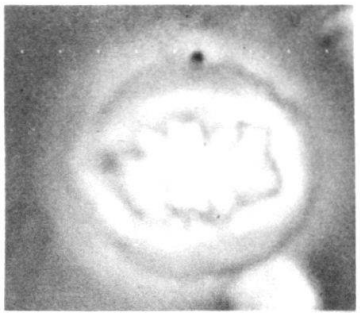

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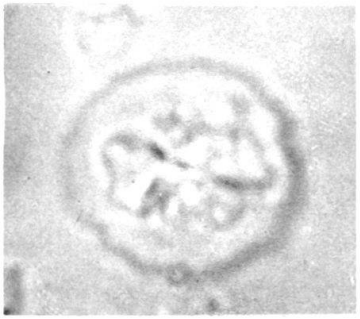

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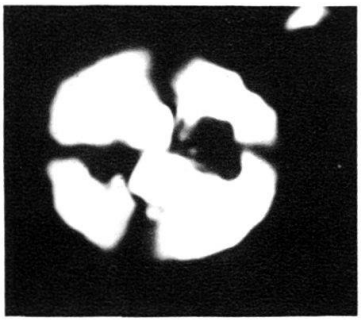

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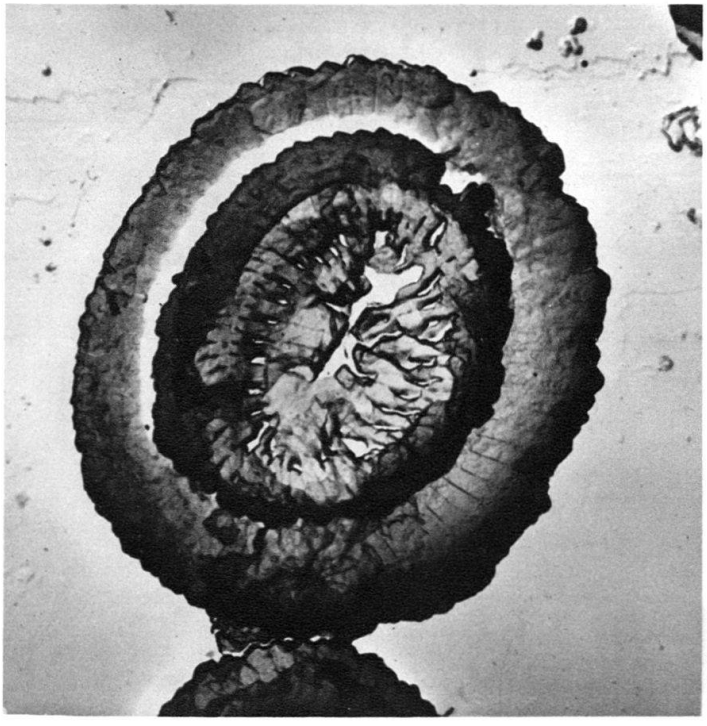

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Plate VI

Fig. 1 *Apertapetra samodurovi* n. sp. Distal view of specimen in phase contrast. Paratype: UI-H-2077 (Nal 11) 2500×.

Fig. 2 *Apertapetra samodurovi* n. sp. Distal view of specimen in ordinary light. Paratype: UI-H-2077 (Nal 11) 2500×.

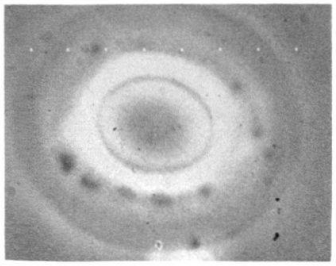
Fig. 3 *Apertapetra samodurovi* n. sp. Distal view of specimen between crossed nicols. Paratype: UI-H-2077 (Nal 11) 2500×.

Fig. 4 *Apertapetra samodurovi* n. sp. Distal view, electronmicrograph of carbon replica. UI-H-2078 (Nal 9) 10,000×.

Fig. 5 *Apertapetra samodurovi* n. sp. Side view, electronmicrograph of carbon replica. UI-H-2079 (Nal 11) 10,000×.

Fig. 6 *Apertapetra samodurovi* n. sp. Distal view, electronmicrograph of carbon replica. Holotype: UI-H-2080 (Nal 11) 10,000×.

Fig. 7 *Apertapetra samodurovi* n. sp. Proximal view, electronmicrograph of carbon replica. Paratype: UI-H-2081 (Nal 11) 10,000×.



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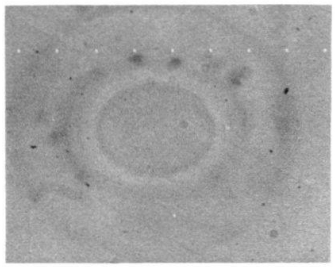

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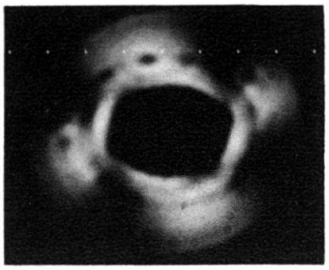

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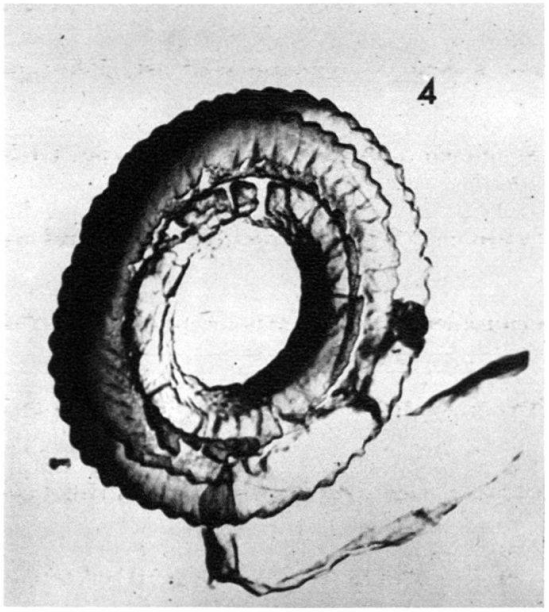

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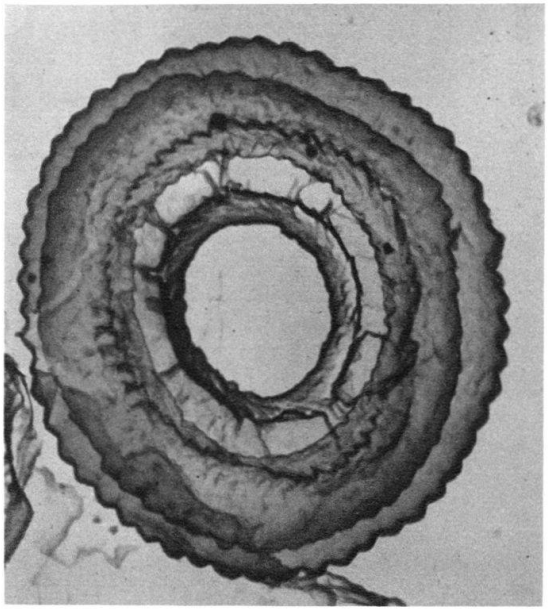


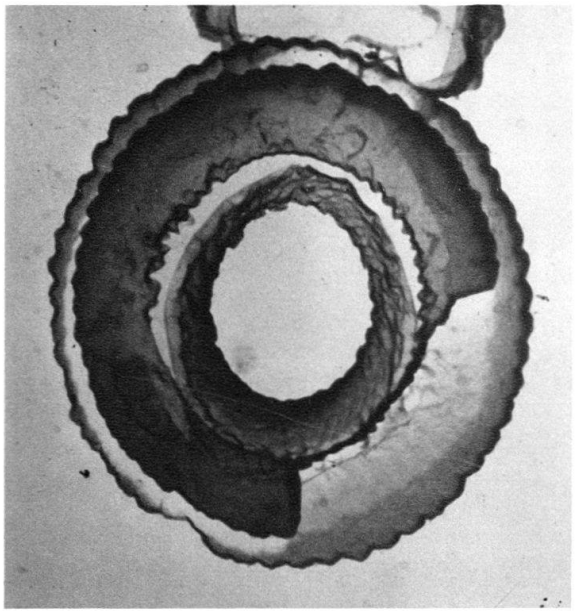


Plate VII

Fig. 1 *Chiasmolithus oamaruensis* (DEFLANDRE). Distal view of specimen in ordinary light. Hypotype: UI-H-2082 (Nal 19) 2500×.

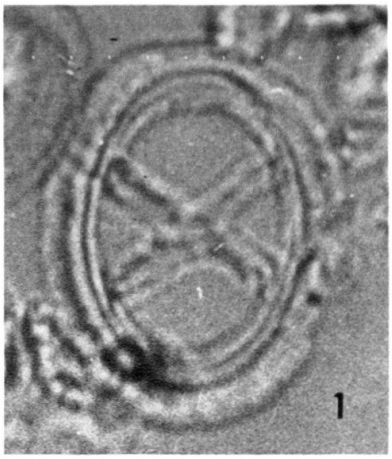
Fig. 2 *Cyclococcolithus inversus* DEFLANDRE. Proximal view, electronmicrograph of carbon replica. Hypotype: UI-H-2083 (Nal 11) 10,000×.

Fig. 3 *Cyclococcolithus lusitanicus* (BLACK). Distal view of specimen in phase contrast. Hypotype: UI-H-2084 (Nal 11) 2500×.

Fig. 4 *Cyclococcolithus lusitanicus* (BLACK). Distal view of specimen in ordinary light. Hypotype: UI-H-2084 (Nal 11) 2500×.

Fig. 5 *Cyclococcolithus lusitanicus* (BLACK). Distal view of specimen between crossed nicols. Hypotype: UI-H-2084 (Nal 11) 2500×.

Fig. 6 *Cyclococcolithus lusitanicus* (BLACK). Distal view, electronmicrograph of carbon replica. Hypotype: UI-H-2085 (Nal 9) 10,000×.



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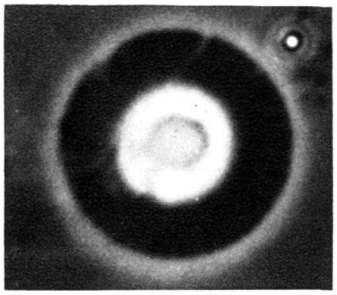

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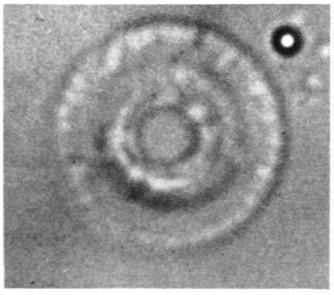

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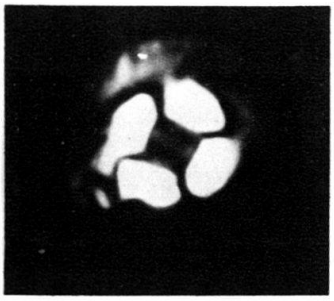

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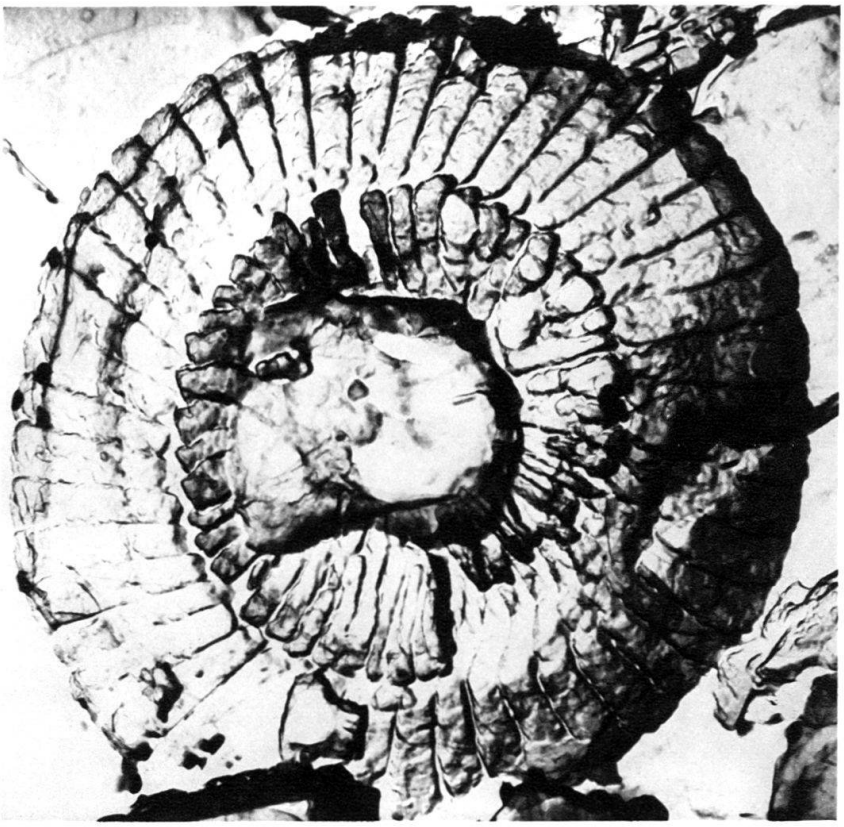


Plate VIII

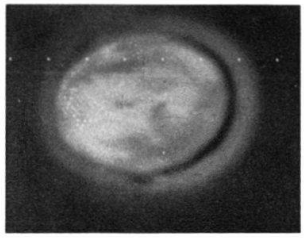
Fig. 1 *Pontosphaera vadosa* n. sp. Proximal view of specimen in phase contrast. Paratype: UI-H-2086 (Nal 11) 2500×.

Fig. 2 *Pontosphaera vadosa* n. sp. Proximal view of specimen in ordinary light. Paratype: UI-H-2086 (Nal 11) 2500×.

Fig. 3 *Pontosphaera vadosa* n. sp. Proximal view of specimen between crossed nicols. Paratype: UI-H-2086 (Nal 11) 2500×.

Fig. 4 *Pontosphaera vadosa* n. sp. Proximal view, electronmicrograph of carbon replica. Holotype: UI-H-2087 (Nal 11) 10,000×.

Fig. 5 *Transversopontis obliquipons* (DEFLANDRE). Distal view, electronmicrograph of carbon replica. Hypotype: UI-H-2088 (Nal 11) 10,000×.



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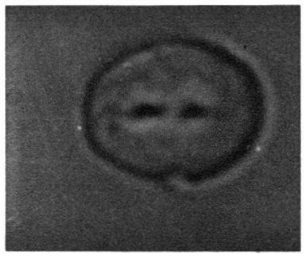

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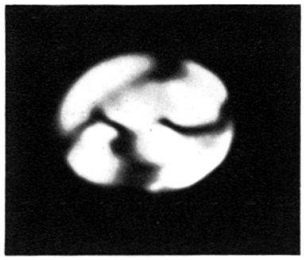

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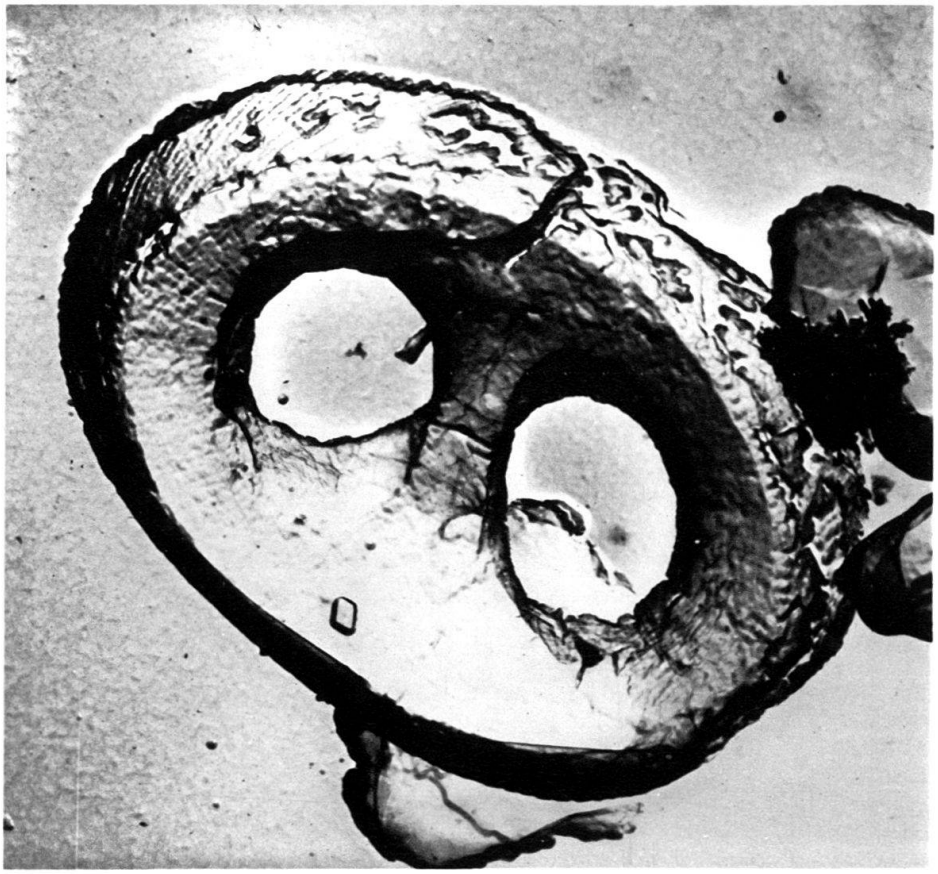

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Plate IX

Fig. 1 *Discolithina confossa* n. sp. Distal view, electronmicrograph of carbon replica. Paratype: UI-H-2089 (Nal 9) 10,000×.

Fig. 2 *Discolithina confossa* n. sp. Distal view, electronmicrograph of carbon replica. Paratype: UI-H-2090 (Nal 9) 10,000×.

Fig. 3 *Discolithina confossa* n. sp. Distal view of specimen in phase contrast. Paratype: UI-H-2091 (Nal 11) 2500×.

Fig. 4 *Discolithina confossa* n. sp. Distal view of specimen in ordinary light. Paratype: UI-H-2091 (Nal 11) 2500×.

Fig. 5 *Discolithina confossa* n. sp. Distal view of specimen between crossed nicols. Paratype: UI-H-2091 (Nal 11) 2500×.

Fig. 6 *Discolithina confossa* n. sp. Distal view, electronmicrograph of carbon replica. Holotype: UI-H-2092 (Nal 11) 10,000×.


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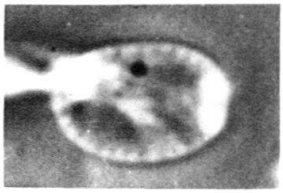
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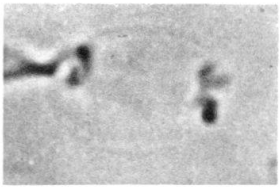
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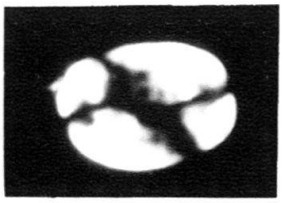
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Plate X

Fig. 1 *Syracosphaera bisecta* n. sp. Distal view of specimen in phase contrast. Paratype: UI-H-2093 (Nal 11) 2500×.

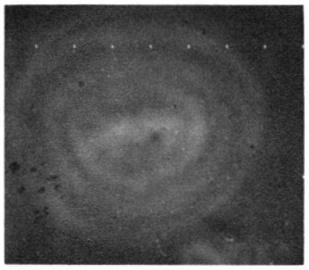
Fig. 2 *Syracosphaera bisecta* n. sp. Distal view of specimen in ordinary light. Paratype: UI-H-2093 (Nal 11) 2500×.

Fig. 3 *Syracosphaera bisecta* n. sp. Distal view of specimen between crossed nicols. Paratype: UI-H-2093 (Nal 11) 2500×.

Fig. 4 *Syracosphaera bisecta* n. sp. Distal view, electronmicrograph of carbon replica. Holotype: UI-H-2094 (Nal 11) 10,000×.

Fig. 5 *Syracosphaera bisecta* n. sp. Distal view of portion of rim and center, electronmicrograph of carbon replica. Paratype: UI-H-2095 (Nal 6) 20,000×.

Fig. 6 *Syracosphaera bisecta* n. sp. Distal view, electronmicrograph of carbon replica. Paratype: UI-H-2096 (Nal 9) 10,000×.



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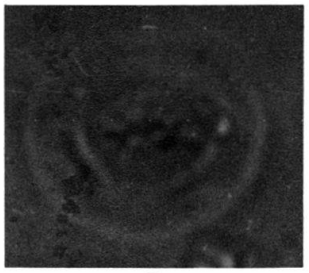

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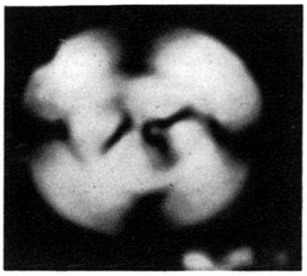

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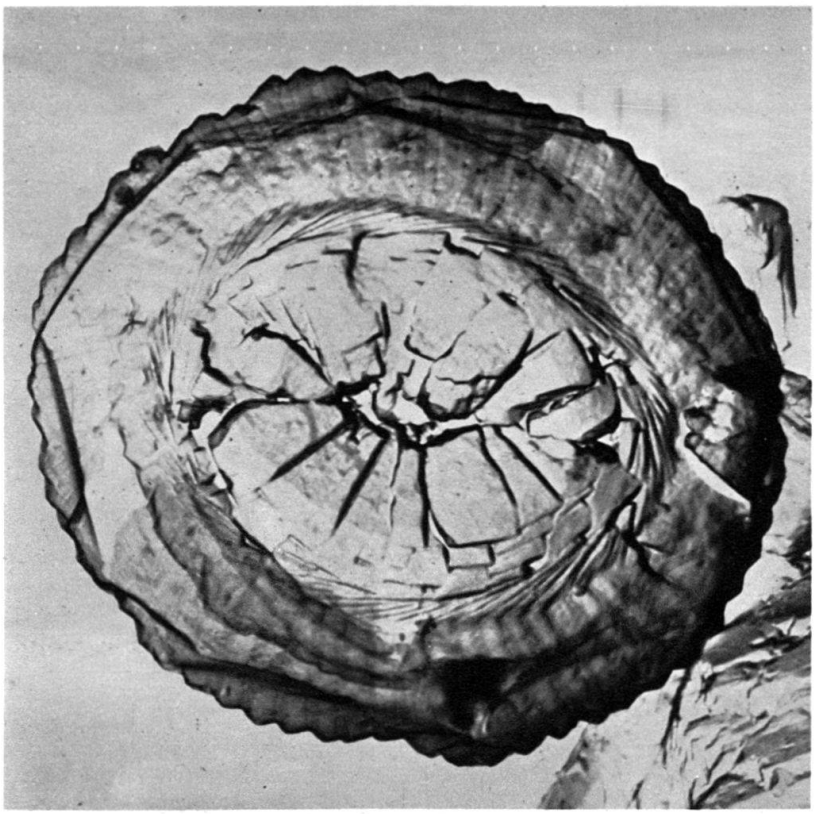

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Plate XI

Fig. 1 *Coronocyclus serratus* n. sp. Plan view of specimen in phase contrast. Paratype: UI-H-2097 (Nal 11) 2500×.

Fig. 2 *Coronocyclus serratus* n. sp. Plan view of specimen in ordinary light. Paratype: UI-H-2097 (Nal 11) 2500×.

Fig. 3 *Coronocyclus serratus* n. sp. Plan view of specimen between crossed nicols. Paratype: UI-H-2097 (Nal 11) 2500×.

Fig. 4 *Coronocyclus serratus* n. sp. Plan view, electronmicrograph of carbon replica. Holotype: UI-H-2098 (Nal 19) 10,000×.

Fig. 5 *Coronocyclus serratus* n. sp. Plan view of damaged specimen, electronmicrograph of carbon replica. Paratype: UI-H-2099 (Nal 19) 10,000×.

Fig. 6 *Discoaster tani* BRAMLETTE & RIEDEL. Plan view of specimen in ordinary light. Hypotype: UI-H-2100 (Nal 16) 2500×.

Fig. 7 *Micrantholithus attenuatus* BRAMLETTE & SULLIVAN. Plan view of specimen in ordinary light. Hypotype: UI-H-2101 (Nal 16) 2500×.

Fig. 8 *Discoaster saipanensis* BRAMLETTE & RIEDEL. Plan view of specimen in ordinary light. Hypotype: UI-H-2102 (Nal 16) 2500×.

Fig. 9 *Discoaster saipanensis* BRAMLETTE & RIEDEL. Plan view of specimen in ordinary light. Hypotype: UI-H-2103 (Nal 16) 2500×.

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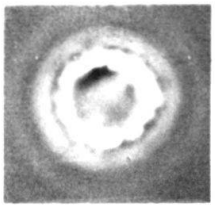

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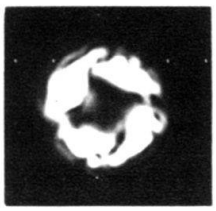

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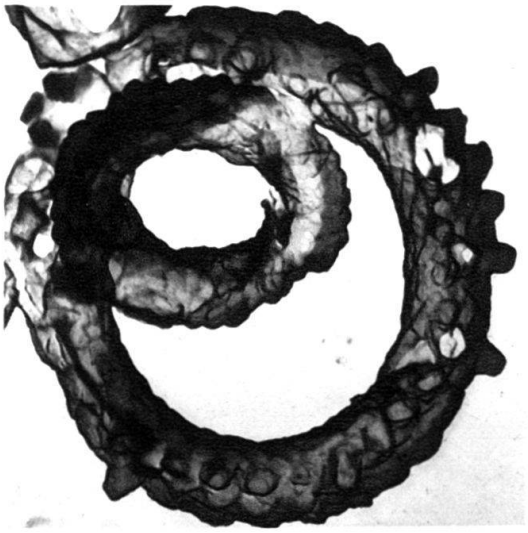

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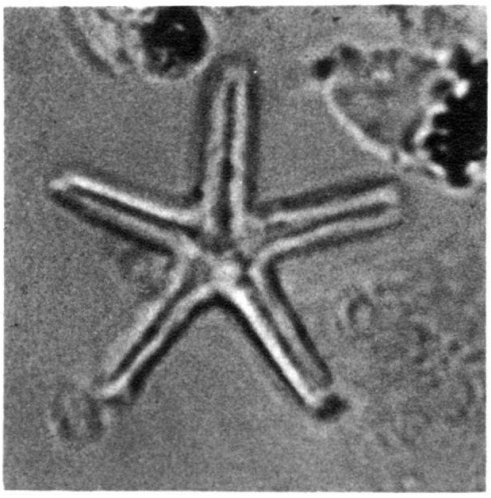

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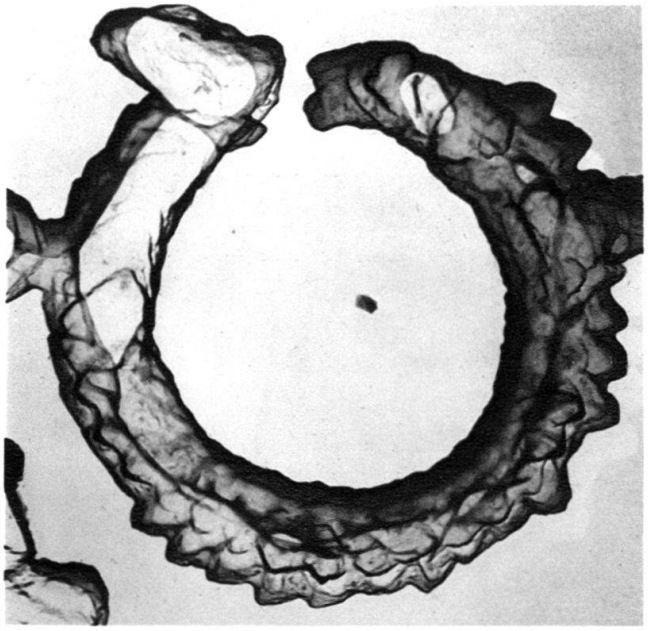

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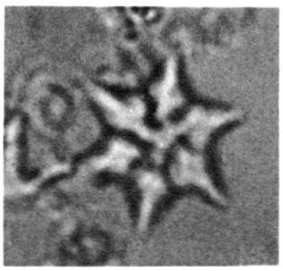

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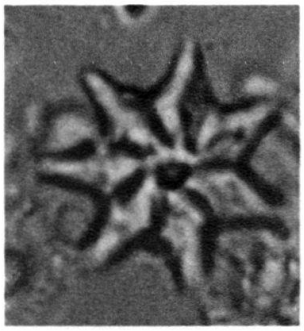

Plate XII

Fig. 1 *Isthmolithus recurvus* DEFLANDRE. Plan view, electronmicrograph of carbon replica. Hypotype: UI-H-2104 (Nal 11) 10,000×.

Fig. 2 *Isthmolithus recurvus* DEFLANDRE. Side view, electronmicrograph of carbon replica. Hypotype: UI-H-2105 (Nal 11) 10,000×.

Fig. 3 *Isthmolithus recurvus* DEFLANDRE. Plan view, electronmicrograph of carbon replica. Hypotype: UI-H-2106 (Nal 11) 10,000×.

Fig. 4 *Micrantholithus vesper* DEFLANDRE. Plan view, electronmicrograph of carbon replica. Hypotype: UI-H-2107 (Nal 11) 10,000×.

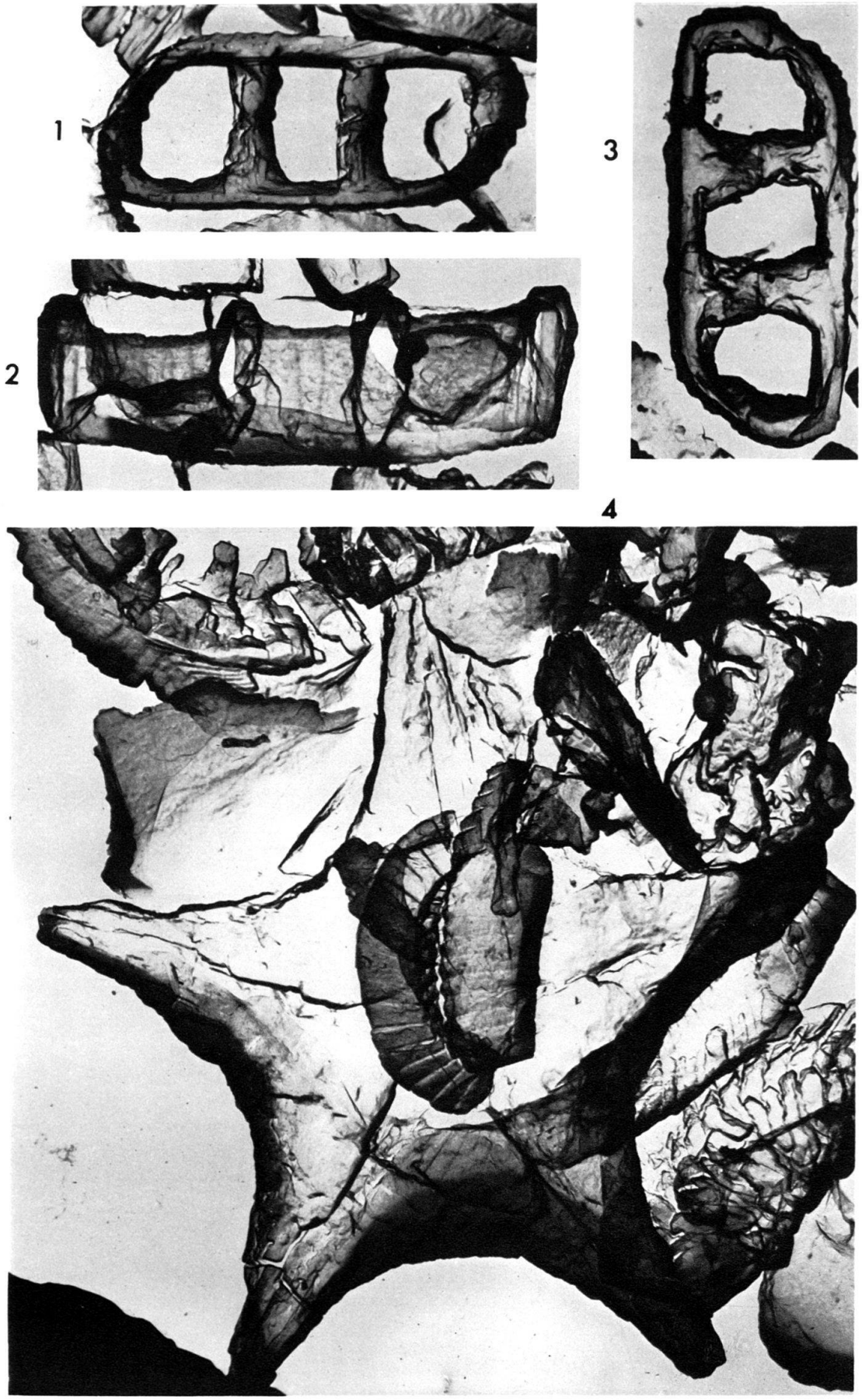
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Plate XIII

Fig. 1 *Discoaster saipanensis* BRAMLETTE & RIEDEL. Plan view, electronmicrograph of carbon replica. Hypotype: UI-H-2108 (Nal 19) 10,000×.

Fig. 2 *Discoaster binodosus hirundinus* MARTINI. Plan view, electronmicrograph of carbon replica. Hypotype: UI-H-2109 (Nal 9) 5000×.

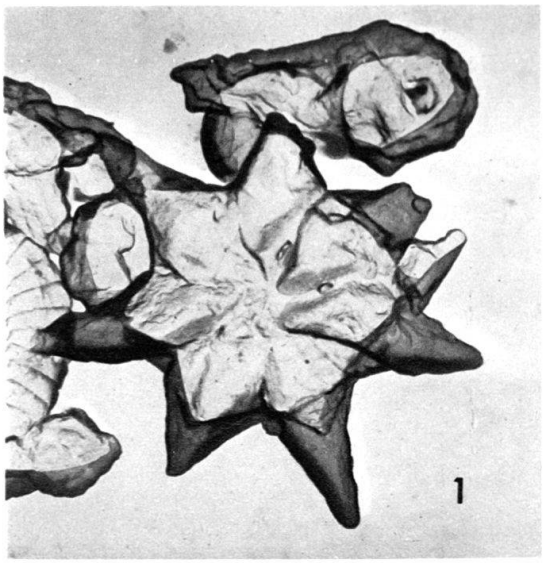
Fig. 3 *Isthmolithus recurvus* DEFLANDRE. Oblique view, electronmicrograph of carbon replica. Hypotype: UI-H-2110 (Nal 11) 10,000×.

Fig. 4 *Diademopetra luma* n. sp. Plan view, electronmicrograph of carbon replica. Holotype: UI-H-2111 (Nal 19) 10,000×.

Fig. 5 *Diademopetra luma* n. sp. Plan view of specimen in ordinary light. Paratype: UI-H-2112 (Nal 16) 2500×.

Fig. 6 *Sujkowskiella enigmatica* n. sp. Plan view of specimen in ordinary light. Paratype: UI-H-2113 (Nal 7) 2500×.

Fig. 7 *Sujkowskiella enigmatica* n. sp. Plan view, electronmicrograph of carbon replica. Holotype: UI-H-2114 (Nal 19) 10,000×.



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