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EARLY OLIGOCENE FORAMINIFERA FROM KAP BREWSTER, EAST GREENLAND

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Abstract: Early Oligocene foraminiferal assemblages from the shallow-marine Krabbedalen Formation (Kap Dalton Group) at Kap Brewster, East Greenland, yielded 33 foraminiferal species, belonging to 23 genera and 17 families. Agglutinated foraminifera dominate the assemblage. Their large, well-cemented tests, are usually composed of coarse sand grains. Calcareous benthos is second in frequency, calcareous plankton (one species) and other microfossils are a rare admixture. The unusually large test size of some agglutinated foraminifera, particularly those of *Cyclammina cancellata* Brady and *Reophax pilulifer* Brady, are interpreted as a response to cooling of the Early Oligocene coastal sea by the East Greenland Current.

Abstrakt: Płytkomorskie osady formacji Krabbedalen (dolny oligocen) na Kap Brewster we Wschodniej Grenlandii dostarczyły zespołów otwornic reprezentowanych przez 33 gatunki należące do 23 rodzajów i 17 rodzin. Są to głównie otwornice aglutynujące piaszczyste, o dużych, mocnych skorupkach. Otwornice bentoniczne wapienne są rzadsze, wapienny plankton reprezentowany jest przez jeden gatunek. Duże rozmiary niektórych otwornic aglutynujących, zwłaszcza *Cyclammina cancellata* Brady i *Reophax pilulifer* Brady, mogą świadczyć o specyficznych warunkach środowiskowych morza szelfowego wschodniego obrzeża Grenlandii, już we wczesnym oligocenie ochładzanego zimnym prądem wschodniogrenlandzkim.

Key words: Foraminifera, Early Oligocene, East Greenland.

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INTRODUCTION

Small down-faulted outliers of Eocene–Oligocene deposits (Kap Dalton Group), post-dating Early Tertiary tholeiitic flood basalts with sediment intercalations (Blosseville Group), crop out along Blosseville Kyst, East Greenland, at Kap Dalton and at Kap Brewster (Figs 1, 2; Tab. 1).

The Tertiary rocks at Kap Brewster (Savoia Halvø, Scoresby Sund) were investigated and sampled by the first author during the 1971 Geological East Greenland Expedition organized by the Geological Survey of Greenland (Birkenmajer, 1972). Microfossil assemblages were recovered from samples of the Krabbedalen Formation (Lower Oligocene), the upper unit of the Kap Dalton Group (Tab. 1). Antonina Jednorowska had determined 37 foraminiferal species, predominantly agglutinated benthos (29 species), single specimens of calcareous benthos (7 species), and one species of calcareous plankton. The list of the species determined was published earlier by Birkenmajer and Jednorowska (1977).

The present paper supplements the above account with systematic description and illustrations of the foraminifera, including a revision of some previously determined species. We also give location of the microfaunal samples taken from the Krabbedalen Formation (Figs 2, 3).

GEOLOGICAL SETTING

(by K. Birkenmajer)

Lithostratigraphic units

Four main lithostratigraphic units have been recognized in the area of Kap Brewster–Savoia Halvø, central East Greenland (Hassan, 1953; Birkenmajer, 1972; Birkenmajer & Jednorowska, 1977): (1) ?Mesozoic deposits underlying plateau basalts; (2) plateau-basalts, with sediment intercalations (Blosseville Group, Paleocene–Eocene); (3) older post-basalt deposits (Kap Dalton Group, Eocene–Oligocene); (4) younger post-basalt deposits (Kap Brewster Formation, Miocene).

Savoia Halvø is cut by a major dip-slip normal fault (Muslingehjørnet fault) trending NNE (Fig. 2). It downthrows to the east by more than 1000 m. The pre-basalt, probably Mesozoic, deposits crop out in the western, upthrown Søstrene block below a thick complex of the basalt lavas (Blosseville Group). The Kap Dalton Group basement, formed by plateau basalts with some sediment inter-

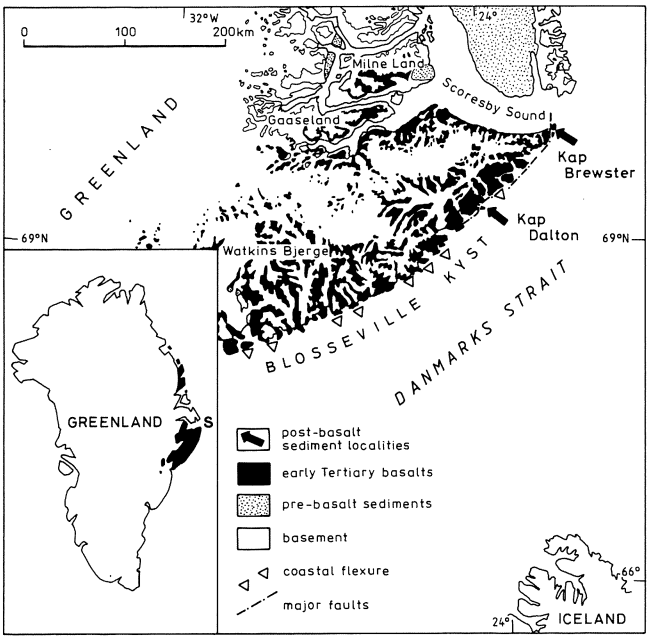

Fig. 1. Location map of Kap Brewster and Kap Dalton at Blosseville Kyst (geology based on Soper *et al.*, 1976a), and in Greenland (inset; S – Scoresby Sund; Tertiary basalts in black)

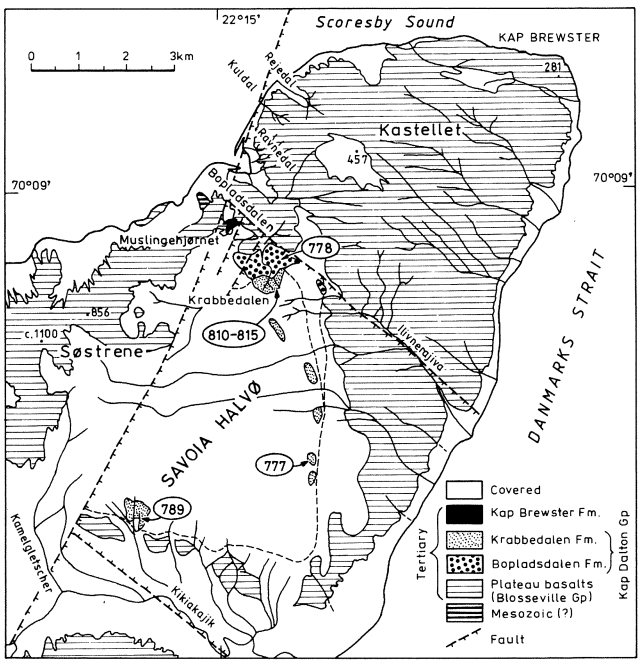

Fig. 2. Geological map of Savoia Halvø, central East Greenland (after Birkenmajer, 1972, slightly modified), sample localities in the Krabbedalen Formation marked by circled numbers. Altitudes in metres

calations (Blosseville Group), is exposed in the eastern, downthrown Kastellet block. The Kap Dalton Group deposits occur in a small, fault-bounded depression in the central part of Savoia Halvø. The Kap Brewster Formation deposits are situated along the Muslingehjørnet fault (Fig. 2).

Kap Dalton Group

The deposits described by Hassan (1953) as the Kap Dalton 'series' have been renamed the Kap Dalton Formation (Birkenmajer, 1972), its rank was later raised to that of a Group (Birkenmajer & Jednorowska, 1977). The Kap Dalton Group consists of two formations: (i) the Bopladsdalen Formation occurs at its base, and (ii) the Krabbedalen Formation forms its upper unit. They are separated from each other by a sedimentary hiatus.

Table 1

Palaeogene succession of the Blosseville Kyst, East Greenland (Birkenmajer & Jednorowska, 1977). Kap Dalton: modified after Soper *et al.* (1976b) and Soper & Costa (1976). Savoia Halvø: modified after Hassan (1953) and Birkenmajer (1972)

CHRONOSTRATIGRAPHY			LITHOSTRATIGRAPHY	
Series		Stage	KAP DALTON	SAVOIA HALVØ
OLIGOCENE	L.	CHATTIAN		
	E.	RUPELIAN	Kap Dalton Group: Krabbedalen Fm. / Bopladsdalen Fm.	Kap Dalton Group: Krabbedalen Fm. / Bopladsdalen Fm.
EOCENE	L.	BARTONIAN/PRIABONIAN		
	M.	BRUXELLIAN/LUTETIAN		
	E.	YPRESIAN/CUISIAN L./E.		
PALEOCENE	L.	LANDENIAN/SPARNACIAN L./E.	Blosseville Group	Blosseville Group
		HEERSIAN/THANETIAN		
	E.	MONTIAN/DANIAN		
L. CRETACEOUS		MAASTRICHTIAN	Kangedlugssuaq Group	„infra-basalt sediments"

Bopladsdalen Formation

The Bopladsdalen Formation (Bopladsdalen Member – Birkenmajer, 1972; Bopladsdalen Formation – Birkenmajer & Jednorowska, 1977) is about 80 m thick. It begins with a basal conglomerate up to 2 m thick (layer No. 4 of Hassan, 1953) which consists of very well rounded, mainly basalt pebbles, weakly cemented by poor basalt detritus sometimes containing mollusc-shell detritus and carbonized wood fragments. The conglomerate represents a fossil beach deposit.

This unit is followed by yellow-weathered, flaggy sandstones with marine and brackish mollusc shells, pieces of wood with *Teredo* borings, and with scattered basalt pebbles ('*Cyrena* beds', layers 5a-e of Hassan, 1953). The mollusc fauna is indicative of a middle to late Eocene age (Hassan, 1953). The lithologic character of the deposits, and their fauna, indicate a brackish-water to shallow-marine environment, probably a delta apron deposited in an estuary by a river flowing from the north or west.

The Bopladsdalen Formation represents a sediment wedge thickest in the north, and disappearing towards the south at a distance of barely 3 km (Birkenmajer, 1972).

Krabbedalen Formation

The Krabbedalen Formation (Krabbedalen Member – Birkenmajer, 1972; Krabbedalen Formation – Birkenmajer & Jednorowska, 1977) corresponds to the '*Coeloma* beds'

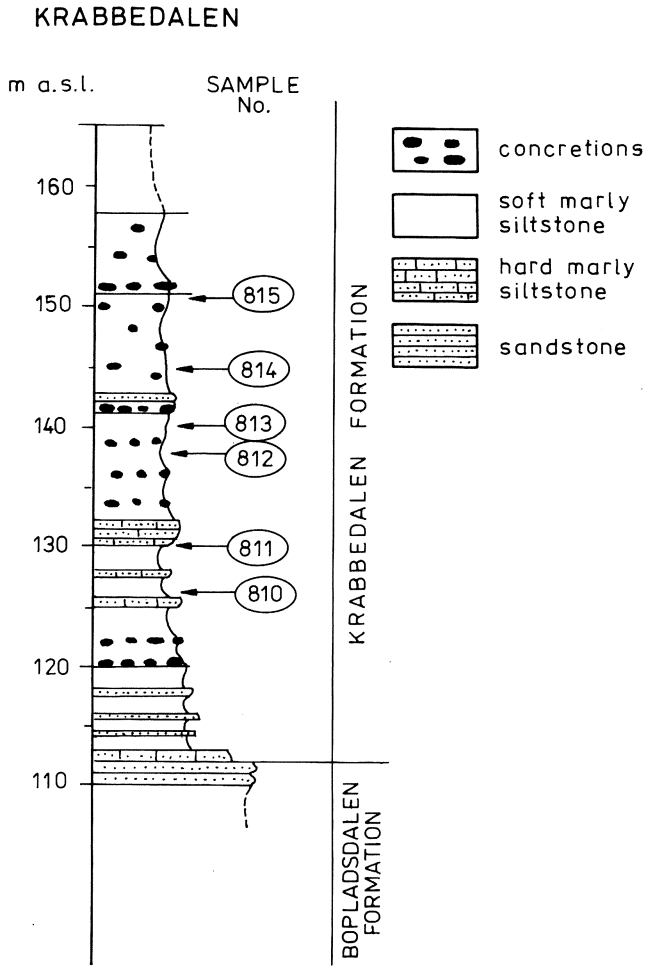

Fig. 3. Simplified lithostratigraphic column of the Krabbedalen Formation at Savoia Halvø with marked positions of foraminiferal samples

of Hassan (1953, layer No. 6). It fills a graben east of the Muslingehjørnet fault, with the best sections exposed at Krabbedalen (Figs 2, 3) where the formation is about 50 m thick. To the south of Krabbedalen, where the exposures are poor, the thickness of the formation may increase to 100 m or more.

The Krabbedalen Formation conformably overlies the Bopladsdalen Formation at the type locality, but to the south of Krabbedalen it comes directly in contact with the basalts of the Blosseville Group (Fig. 2). A hiatus between the two formations was thus suggested (Birkenmajer, 1972; Birkenmajer & Jednorowska, 1977), as in Kap Dalton (Tab. 1; Soper & Costa, 1976; Soper *et al.*, 1976a, b).

The Krabbedalen Formation consists of alternating grey to yellowish marly siltstones and hard calcareous siltstones often with single pebbles of basalt and other rocks. A rich shallow-marine macrofauna probably indicates an Early Oligocene age of the deposits (Hassan, 1953).

Our preliminary foraminiferal study suggested a latest Eocene to early Oligocene age for the higher part of the formation, based on the presence of *Globigerina ampliapertura* Bolli in the middle part of the section, and of an Oligocene species *Reophax tappuensis* Asano close to the top of the section (Birkenmajer & Jednorowska, 1977).

The present foraminiferal study does not contradict our previous age determination. It should be pointed out, however, that the age-range of *Cyclammina placenta* (Reuss) – stratigraphically the most valuable species in our foraminiferal assemblage – is slightly wider (Late Eocene–Oligocene), and that stratigraphic value of the only planktonic form in our assemblage, now determined as *Globigerina* cf. *ampliapertura* Bolli, has been weakened.

FORAMINIFERA FROM THE KRABBEDALEN FORMATION

(by A. Jednorowska)

Microfossil assemblage

The revised microfossil assemblage recovered from 9 samples of the Krabbedalen Formation includes 33 species of benthic foraminifera belonging to 23 genera and 17 families. Agglutinated foraminifera are the most numerous. Their large, strong tests, composed of coarse sand grains, are usually well preserved.

The samples Nos 777 and 778 (Tabs 1, 2) were almost devoid of microfauna. The remaining seven samples yielded more numerous microfossils, however their assemblages were rather poor in individuals.

Agglutinated benthos

Agglutinated tubiform foraminifera belonging to the genus *Rhabdammina* are fragmented, and preserved without characteristic branchings; thus they are specifically undeterminable (cf. Schröder, 1986). Fragmentary preservation of foraminifera of the genera *Bathysiphon* and *Rhizammina*, only allows a generic determination.

Among well preserved forms, the genus *Psammosphaera* is represented by two species: *P. fusca* Schultze (more frequent) and *P. parva* Flint (less frequent). The genus *Saccammina* is represented by three infrequently occurring species: *S. compressa* (Cushman et McCulloch), *S. difflugiformis* (Brady) and *S. sphaerica* Brady. Likewise infrequent are the species of the genus *Reophax* – *R. pilulifer* Brady (large specimens), *R. fusiformis* Williamson, and *R. tappuensis* Asano. Of the three species belonging to the genus *Haplophragmoides* – *H. advenus* Cushman, *H. columbiensis* Cushman and *H. planissimus* Cushman, only *H. columbiensis* is more frequent. *Adercotryma glomerata* (Brady) is numerous in only one sample. The species of the genus *Cribrostomoides* – *C. crassimargo* (Norman), *C. scitulus* (Brady) and *C.* cf. *subglobosus* (Brady), the genus *Discammina* – *D. compressa* (Goës) and *D. eocenica* Mallory, the species *Ammomarginulina foliacea* (Brady), and representatives of the genus *Ammobaculites*, are all infrequent.

The representatives of the genus *Cyclammina* are more numerous, the most frequent being *C. cancellata* Brady whose specimens are large, up to 2.5 mm in diameter. *Cyclammina clarki* (Hanna) and *C. incisa* Stache are second in frequency. *Cyclammina placenta* (Reuss) is again more frequent. *Trochammina advena* Cushman is the only representative of this genus.

Table 2

Distribution of foraminifera in the Krabbedalen Formation. For location of the samples – see Figs 2, 3

FORAMINIFERA	Sample No								
	777	778	789	810	811	812	813	814	815
Rhabdammina div. sp.			1	2	+50	13	31	17	5
Bathysiphon sp.	1		2	11	6	9	4	6	3
Rhizammina sp.					1			2	
Psammosphaera fusca				9	10	19	18	3	15
Psammosphaera parva					3		2	4	6
Saccammina compressa				1	3		1		
Saccammina difflugiformis						1			
Saccammina sphaerica								1	
Reophax pilulifer			1			1			
Reophax fusiformis						4	4		6
Reophax tappuensis							1		
Haplophragmoides advenus			1						4
Haplophragmoides columbiensis				1	2	4	5	1	7
Haplophragmoides planissimus								5	1
Adercotryma glomerata					1	4	1	4	48
Cribrostomoides crassimargo				1		5		1	
Cribrostomoides scitulus						1			1
Cribrostomoides cf. subgobosus									1
Discammina compressa						2			
Discammina eocenica				1				1	
Ammomarginulina foliacea								4	
Ammobaculites cubensis							1		
Ammobaculites sp.	1	1							
Cyclammina cancellata					8	5		11	8
Cyclammina clarki					2	4		3	3
Cyclammina incisa					3	1			1
Cyclammina placenta				1	11	1	5	2	10
Trochammina advena								1	
Quinqueloculina confusa							1		
Lenticulina sp.						1			
Globulina landesi							1	1	
Guttulina jarvisi						1			2
Guttulina ovalis			1						
Guttulina problema									2
Oolina inornata			1						
Globobulimina auriculata							3		1
Globobulimina pacifica							1		18
Valvulineria allomorphinoides		2	11		2		8		
Cibicides sp.					1		1		
Eponides sp.							1		

Calcareous benthos

The calcareous benthos represents a small fraction of the foraminiferal assemblage. These are usually represented by single, poorly preserved specimens, with the exception of *Globobulimina pacifica* Cushman and *Valvulineria allomorphinoides* (Reuss) which are more numerous. The calcareous benthos includes: *Quinqueloculina confusa* Reuss, *Lenticulina* sp., *Globulina landesi* (Hanna et Hanna), *Guttulina jarvisi* Cushman et Ozawa, *G. ovalis* Bornemann, *G. problema* (d'Orbigny), *Oolina inornata* d'Orbigny, *Globobulimina auriculata* (Bailey) and *G. pacifica* Cushman. Representatives of the genera *Cibicides* and *Eponides* are too poorly preserved to be specifically determinable.

Calcareous plankton

The calcareous plankton is represented by two damaged specimens of the genus *Globigerina*, one of which has been determined as *G.* cf. *ampliapertura* Bolli (*G. ampliapertura* Bolli – in Birkenmajer & Jednorowska, 1977).

Other microfossils

In addition to the foraminifera, the investigated samples yielded also single small bivalve and gastropod shells, rather frequent but damaged ostracods, fragments of sponges and echinoids. Two samples yielded frequent radiolaria.

Age of the foraminiferal assemblage

The representatives of the genera *Cyclammina* and *Reophax* are stratigraphically the most valuable forms in our assemblage:

Cyclammina cancellata Brady ranges from the upper part of the Eocene to Recent (Gradstein & Berggren, 1981);

C. incisa (Stache) ranges from Eocene to Miocene (Asano, 1958b; DeLise, 1967; Fairchild *et al.*, 1969; Smith, R. K., 1971; Birkenmajer & Łuczkowska, 1987);

C. clarki (Hanna) ranges from Eocene to Oligocene (Sullivan, 1962; Kleinpell & Weaver, 1963; Tipton *et al.*, 1973; Weaver & Molander, 1964; Fairchild *et al.*, 1969).

C. placenta (Reuss) has the shortest age-range of the Cyclamminas determined: it occurs from the Late Eocene to Oligocene inclusively (Mjatliuk, 1970; Gradstein & Berggren, 1981).

Reophax tappuensis Asano is known from the Oligocene (Asano, 1958b).

The age-ranges of the last two forms do not contradict a probably Lower Oligocene age of the Krabbedalen Formation as based on its mollusc and crab fauna (cf. Hassan, 1953).

Ecology

Ecological studies of Recent foraminifera indicate that agglutinated foraminifera more tolerant to seasonal seawater temperature and salinity changes (Hiltermann & Tüxen, 1974), in the Polar regions may occur in shallow-water environments (Vilks, 1969; Anderson, 1975; Lagoe, 1977). A shallow-marine character of the foraminiferal assemblage from the Krabbedalen Formation is indicated both by large, strong tests of agglutinated foraminifera built of coarse sand grains, and by the presence of shallow-water taxa. The latter are represented first of all by the genus *Ammobaculites*. The genera *Saccammina*, *Reophax*, *Haplophragmoides* and *Trochammina* often live in shallow seas (Haig, 1979; Jones & Charnock, 1985). The species *Saccammina compressa* (Cushman et McCulloch), *Haplophragmoides columbiensis* Cushman and *H. planissimus* Cushman were found along the coast of Alaska at depths not exceeding 30 m. Another shallow-water taxon is represented by *Cribrostomoides crassimargo* (Norman) (see Vilks, 1969).

The shallow-water character of the marine basin of the Krabbedalen Formation is also suggested by the following representatives of calcareous benthos: the family Miliolidae with the species *Quinqueloculina confusa* Reuss, the genus *Lenticulina*, the family Polymorphinidae with the genera *Globulina* and *Guttulina*, the genus *Valvulineria*, and the species *Globobulimina pacifica* Cushman (see Loeblich & Tappan, 1964; Haig, 1979). The genus *Oolina* is a shallow-water Arctic form (Lagoe, 1977).

The most conspicuous forms in our assemblage are the taxa of the genus *Cyclammina*, of which *C. cancellata* Brady exceeds dimensions of its type forms. Such oversized forms, originally believed to represent deep-water species (Bandy, 1960; Bandy & Rodolfo, 1964), also occur in shelf-waters (Jones & Charnock, 1985). It is also known that

some deep-water foraminifera inhabit shallow Polar marine basins where they find physical and chemical conditions similar to those of deep waters of other regions (see Schröder, 1986).

The genus *Cyclammina* occurs together with shallow-marine invertebrate fauna of the Spitsbergen Tertiary (Vonderbank, 1970). This genus is also characteristic for a shallow-marine Late Oligocene foraminiferal assemblage of the Ross Sea region, Antarctica (Leckie & Webb, 1983). From the Weddell Sea region of Antarctica, Anderson (1975) has described a shallow-marine foraminiferal assemblage consisting exclusively of agglutinated foraminifera. In this assemblage, the specimens of the genus *Cyclammina* reached up to 5 mm in diameter, and the genera *Rhabdammina* and *Reophax* were represented by oversized specimens as well. This was explained by Anderson as an effect of specific living conditions in euryhaline and eurythermal Antarctic marine environment.

It is known (Loeblich & Tappan, 1964) that lower temperature and fluctuating salinity may inhibit the normal life cycle in foraminiferal species which, instead of multiplying, add subsequent chambers to the test in effect abnormally increasing its size.

Cold shallow coastal waters of East Greenland could, during the Early Oligocene (cold East Greenland Current: Birkenmajer & Jednorowska, 1977), similarly affect *Cyclammina cancellata* Brady and *Reophax pilulifer* Brady causing abnormal increase of their tests.

SYSTEMATIC PALAEONTOLOGY

Order FORAMINIFERIDA Eichwald, 1830
Suborder TEXTULARIINA Delage et Hérouard, 1896
Superfamily ASTRORHIZACEA Brady, 1881
Family ASTRORHIZIDAE Brady, 1881
Subfamily ASTRORHIZINAE Brady, 1881
Genus *Rhabdammina* Sars, in Carpenter, 1869

Rhabdammina sp.
Fig. 4 (1, 2)

Remarks: Fragments of tubular tests, circular in cross-section, straight, without constrictions, consisting of coarse sand grains, are present im most samples. Lack of branching does not allow specific determination of the fragments.

Family BATHYSIPHONIDAE Avnimelech, 1952
Genus *Bathysiphon* Sars, in Sars, 1872

Bathysiphon sp.
Fig. 4 (4, 5)

Remarks: Small fragments of circular or slightly compressed tests, with constrictions, consisting of fine sand. Test surface smooth or slightly roughened, covered with numerous sponge spicules.

Family RHIZAMMINIDAE Rhumbler, 1895
Subfamily RHIZAMMININAE Rhumbler, 1895
Genus *Rhizammina* Brady, 1879

Rhizammina sp.
Fig. 4 (3)

Remarks: Small fragments of tubular tests consisting of fine sand, covered with coarse quartz grains and sponge spicules.

Family PSAMMOSPHAERIDAE Haeckel, 1894
Subfamily PSAMMOSPHAERINAE Haeckel, 1894
Genus *Psammosphaera* Schultze, 1875

Psammosphaera fusca Schultze
Fig. 4 (6)

1875. *Psammosphaera fusca* Schultze: Schultze, p. 113, pl. 2, figs 8a-f.
1986. *Psammosphaera fusca* Schultze: Schröder, p. 36, pl. 10, figs 1a, b.

Remarks: Tests sphaerical, consisting of large angular quartz grains, cemented by silica. Aperture invisible. Our specimens are nearly identical with the Recent Arctic ones (see Cushman, 1948; Todd & Low, 1967).

Psammosphaera parva Flint
Fig. 4 (7)

1899. *Psammosphaera parva* Flint: p. 268, pl. 9, fig. 1.

Remarks: Small sphaerical tests consisting of fine quartz grains, cemented by silica, with large quartz grains attached to the surface.

Family SACCAMMINIDAE Brady, 1884
Subfamily SACCAMMININAE Brady, 1884
Genus *Saccammina* Sars, in Carpenter, 1869

Saccammina compressa (Cushman et McCulloch)
Fig. 5 (4)

1939. *Proteonina compressa* Cushman et McCulloch: p. 42, pl. 1, fig. 109.

Remarks: Tests small, rounded, compressed, consisting of quartz grains of variable size, with cement. Aperture elliptical, situated at short neck. The living species is known from shallow water offshore Alaska.

Saccammina difflugiformis (Brady)
Fig. 5 (2)

1879. *Reophax difflugiformis* Brady: pl. 51, pl. 4, fig. 3a, b.
1946. *Proteonina difflugiformis* (Brady); Cushman, p. 15, pl. 1, figs 7, 8.

Remarks: Test consisting of a single chamber with rounded aperture situated at elongated neck. Chamber wall consisting of cemented coarse quartz grains. The Recent forms are known from shallow-marine areas of the Arctic; they are frequent along the coasts of Greenland (Cushman, 1948) and Alaska (Todd & Low, 1967).

Saccammina sphaerica Brady
Fig. 5 (3)

1884. *Saccammina sphaerica* Brady: p. 253-254, pl. 18, figs 11-13, 16.
1960. *Saccammina sphaerica* Brady: Barker, pl. 18, figs 11-15, 17.
1981. *Saccammina sphaerica* Brady: Gradstein & Berggren, p. 241, pl. 2, figs 4-6.
1986. *Saccammina sphaerica* Brady: Schröder, p. 37, pl. 10, figs

4a, b.

Remarks: Test sphaerical, consisting of rather coarse quartz grains, with cement. Aperture rounded, situated at short neck. Recent forms frequent in the Arctic: along the coasts of Greenland (Cushman, 1948), Aleutians (P. B. Smith, 1973), North Atlantic (Schröder, 1986).

Superfamily HORMOSINACEA Haeckel, 1894
Family HORMOSINIDAE Haeckel, 1984
Subfamily REOPHACINAE Cushman, 1910
Genus *Reophax* Montfort, 1808

Reophax pilulifer Brady
Fig. 5 (1)

1884. *Reophax pilulifer* Brady: p. 292, pl. 30, fig. 18.
1960. *Reophax pilulifer* Brady: Barker, pl. 30, figs 18-20.
1986. *Reophax pilulifer* Brady: Schröder, p. 45, pl. 15, figs 1-5.

Remarks: This taxon is represented in our material by two double-chamber fragments of similar dimensions as the type specimens in the British Museum of Natural History which range in size to 6.5 mm (M. A. Kaminski *personal communication*). Our fragments are 4 mm long, the width of the larger chamber is 2.6 mm. The species is known to range upward from the Cretaceous. Presently, it lives in marine basins at various depths (Cushman & McCulloch, 1939; Saidova, 1961).

Reophax fusiformis (Williamson)
Fig. 4 (8)

1858. *Proteonina fusiformis* Williamson: p. 1, pl. 1, fig. 1.
1960. *Reophax fusiformis* (Williamson): Barker, pl. 30, figs 7-11.
1969. *Reophax fusiformis* (Williamson): Vilks, p. 44, pl. 1, figs 8a, b.
1986. *Reophax fusiformis*(Williamson): Schröder, p. 44, pl. 15, fig. 9.

Remarks: Tests elongated, with chambers growing fast as added. Chamber wall consisting of rather large quartz grains. Aperture rounded, situated at elongated neck. Vilks (1969) considered the species *R. subfusiformis* Earland a junior synonym of *R. fusiformis* (Williamson). Our species is known from shallow-water environments (Cushman & McCulloch, 1939). This species was listed by Birkenmajer & Jednorowska (1977) under the name *Reophax subfusiformis* Earland.

Reophax tappuensis Asano
Fig. 5 (5)

1958b. *Reophax tappuensis* Asano: p. 71, pl. 13, figs 8, 9.

Remarks: Test elongated, curved, consisting of 5 chambers enlarging so fast that the last chamber represents almost a half of the test. Chamber wall consists of large and small angular quartz grains, with abundant cement. Our specimen, 3.3 mm in size, is larger than those described from Oligocene of Japan by Asano (1958b).

Superfamily LITUOLACEA de Blainville, 1827
Family HAPLOPHRAGMOIDIDAE Maync, 1952
Genus *Haplophragmoides* Cushman, 1910

Haplophragmoides advenus Cushman
Fig. 6 (3a, b)

1935. *Haplophragmoides advena* Cushman: p. 38, pl. 6, fig. 1.

Remarks: Test sphaerical, compressed, 10 almost equal chambers in the last whorl. Chamber wall consisting of fine sand with numerous larger quartz grains. Aperture in the form of a narrow curved slit at the base of the last chamber. Our specimens are similar to Recent ones. The species lives in shallow Alaskan waters (Cushman & McCulloch, 1939).

Haplophragmoides columbiensis Cushman
Fig. 6 (2a, b, 5)

1925. *Haplophragmoides columbiensis* Cushman: p. 39, pl. 2, fig. 2.

Remarks: Tests compressed, with 6-7 chambers in the last whorl, sutures depressed, umbilicus clearly marked in the middle of the test. Chamber wall consisting of angular quartz grains, with finer-grained cement. Our specimens are comparable with the Recent ones, but are larger than the latter. In the Arctic, the species lives in very shallow-marine environments (Cushman, 1944).

Haplophragmoides planissimus Cushman
Fig. 6 (1a, b)

1927b. *Haplophragmoides planissima* Cushman: p. 135, pl. 1, fig. 6.
1967. *Haplophragmoides planissimus* Cushman; Todd & Low, p. 15, pl. 1, fig. 27.

Remarks: Test flattened, without marked sutures, margin uneven. Test wall consisting of large quartz grains. Our specimens resemble most the Recent ones. This is a shallow-water species, living both in warm waters and in the Alaskan coastal waters as well (Cushman & McCulloch, 1939; Todd & Low, 1967).

Genus *Adercotryma* Loeblich et Tappan, 1952

Adercotryma glomerata (Brady)
Fig. 7 (5a, b)

1878. *Lituola glomerata* Brady: p. 433, pl. 20, fig. 1a-c.
1960. *Adercotryma glomeratum* (Brady): Barker, tabl. 34, figs 15-18.
1964. *Adercotryma glomerata* (Brady): Loeblich & Tappan, p. C225, pl. 135, figs 4a-c.
1969. *Adercotryma glomerata* (Brady): Vilks, p. 44, pl. 1, fig. 10.
1975. *Adercotryma glomerata* (Brady): Anderson, pl. 2, figs 4a, b.
1986. *Adercotryma glomerata* (Brady): Schröder, p. 47, figs 10, 11.

Remarks: Tests small (0.3-0.5 mm), more or less spherical, asymmetric, with 5-6 closely attached chambers in irregular whorl. Larger specimens show aperture located asymmetrically at the base of the last chamber. The species lives at different depths in the Recent seas. Determined previously as *Haplophragmoides rotundidorsatus* var. *gratus* Ter-Grigorianz (Birkenmajer & Jednorowska, 1977).

Genus *Cribrostomoides* Cushman, 1910

Cribrostomoides crassimargo (Norman)
Fig. 6 (4a, b)

1892. *Haplophragmium crassimargo* Norman: p. 17.
1960. *Alveolophragmium crassimargo* (Norman): Barker, pl. 35, figs 4a, b.
1964. *Cribrostomoides crassimargo* (Norman): Loeblich & Tappan, p. C225, pl. 136, figs 3a, b.
1969. *Cribrostomoides crassimargo* (Norman): Vilks, pp. 44-45, pl.1, figs 16a, b.

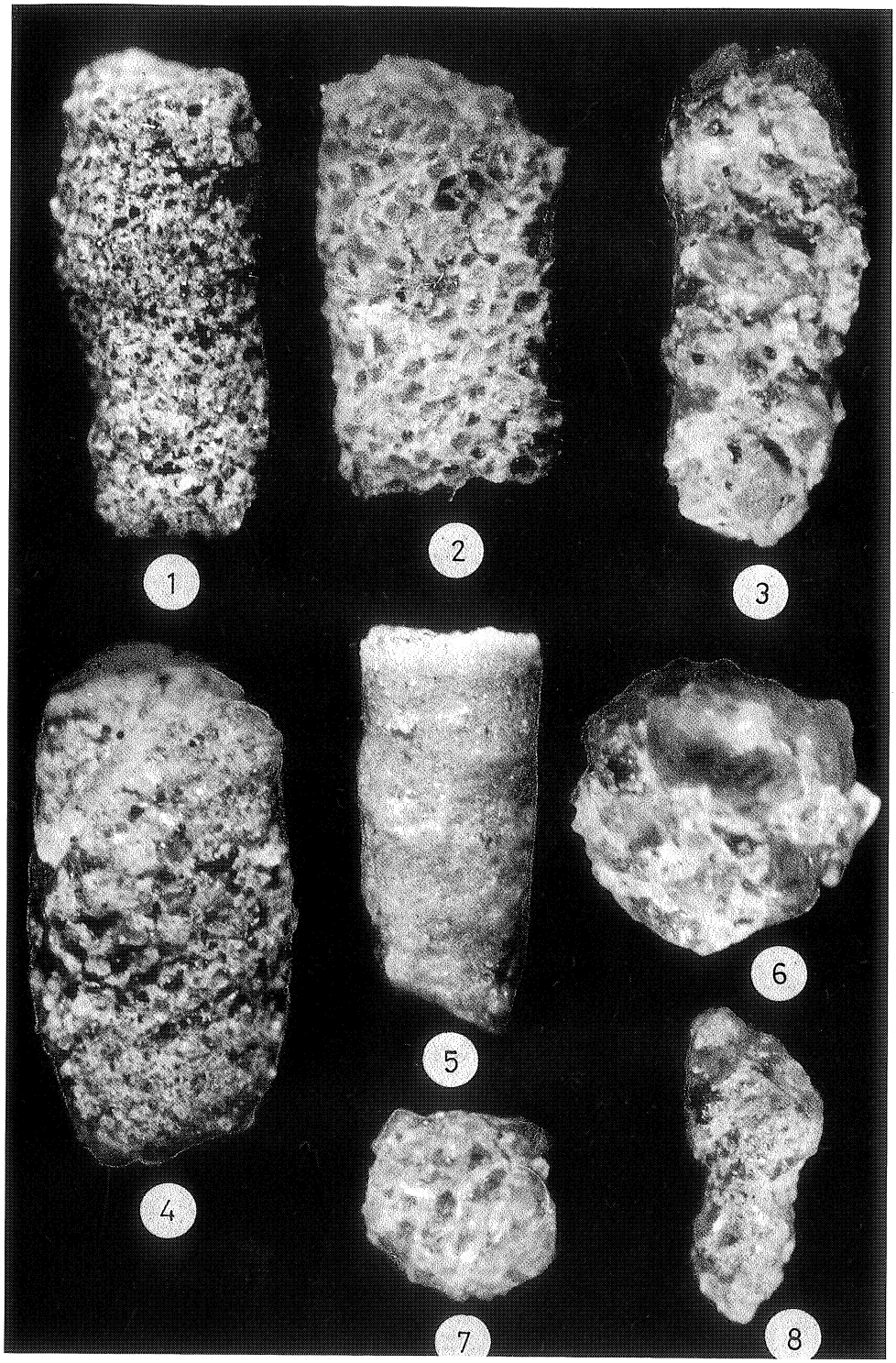

Fig. 4. Early Oligocene Foraminifera from Kap Brewster, East Greenland. **1** – *Rhabdammina* sp., sample 813, ×30; **2** – *Rhabdammina* sp., sample 812, ×30; **3** – *Rhizammina* sp., sample 814, ×30; **4** – *Bathysiphon* sp., sample 812, ×30; **5** – *Bathysiphon* sp., sample 812, ×30; **6** – *Psammosphaera fusca* Schultze, sample 812, ×30; **7** – *Psammosphaera parva* Flint, sample 811, ×60; **8** – *Reophax fusiformis* (Williamson), sample 815, ×30

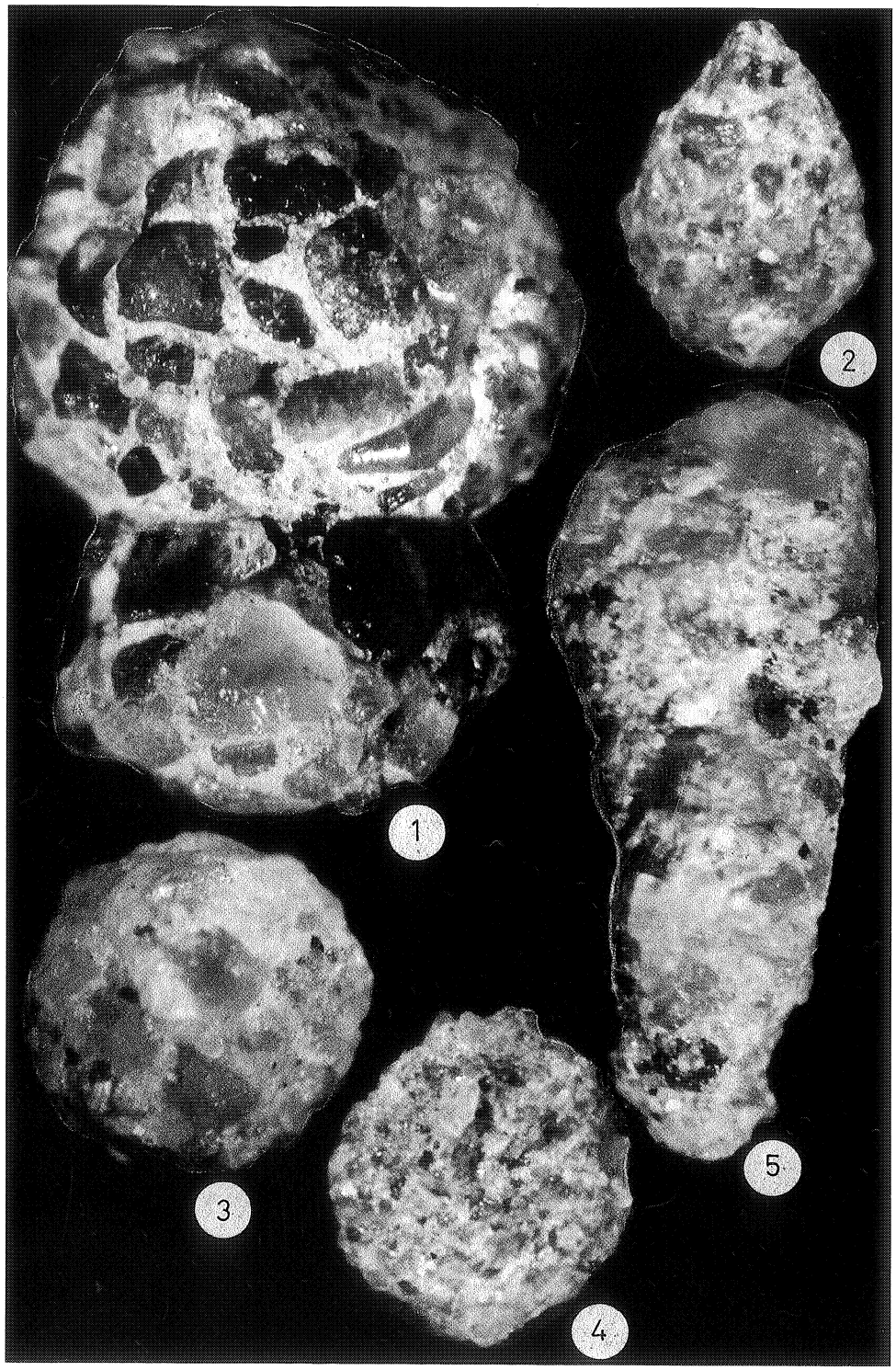

Fig. 5. Early Oligocene Foraminifera from Kap Brewster, East Greenland. **1** – *Reophax pilulifer* Brady, sample 789, ×30; **2** – *Saccammina difflugiformis* (Brady), sample 812, ×60; **3** – *Saccammina sphaerica* Sars, sample 814, ×60; **4** – *Saccammina compressa* (Cushman et McCulloch), sample 810, ×60; **5** – *Reophax tappuensis* Asano, sample 814, ×30

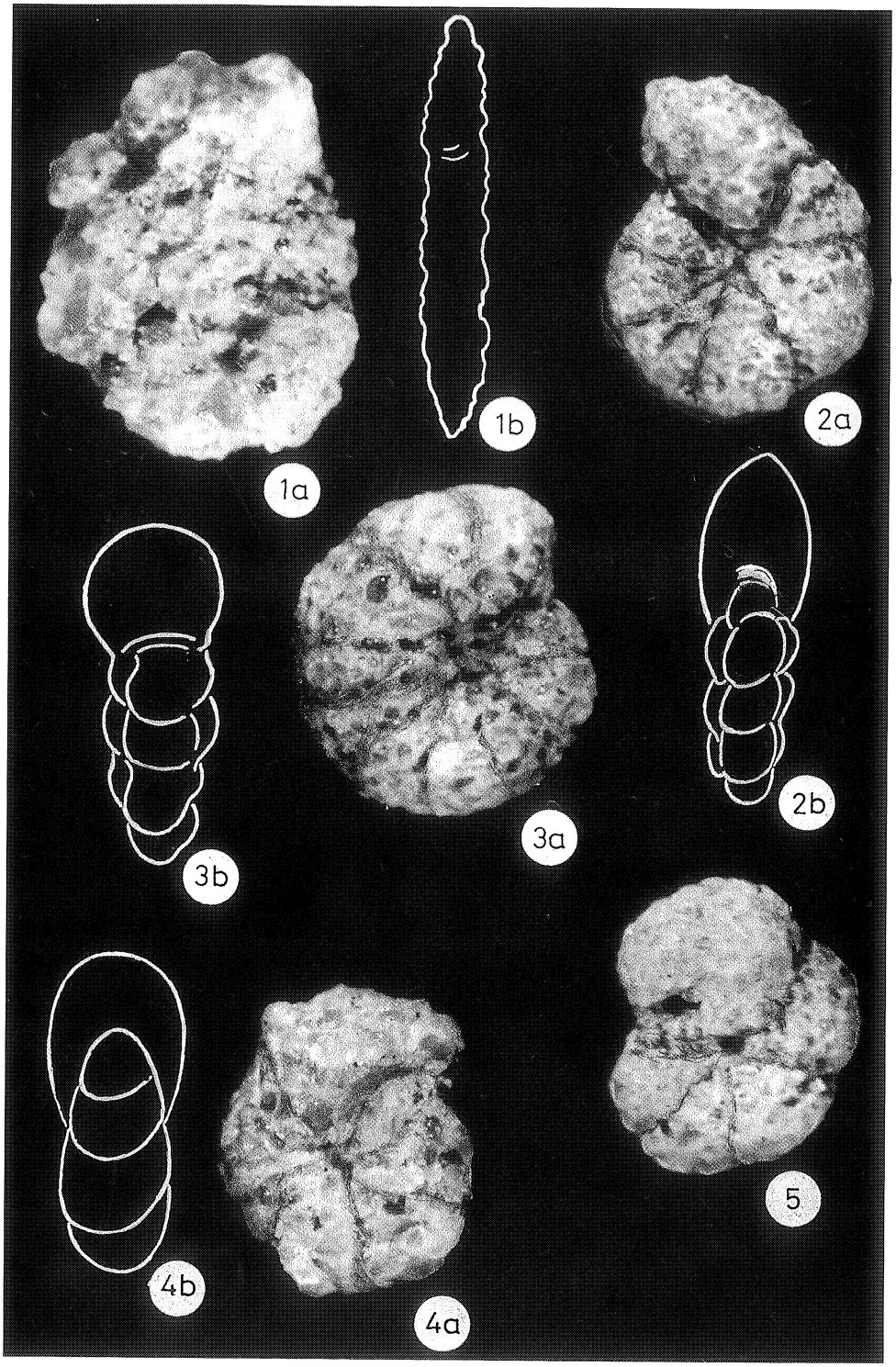

Fig. 6. Early Oligocene Foraminifera from Kap Brewster, East Greenland. **1a, b** – *Haplophragmoides planissimus* Cushman, sample 814, ×30; **2a, b, 5** – *Haplophragmoides columbiensis* Cushman, sample 812, ×30; **3a, b** – *Haplophragmoides advenus* Cushman, sample 789, ×30; **4a, b** – *Cribrostomoides crassimargo* (Norman), sample 812, ×30

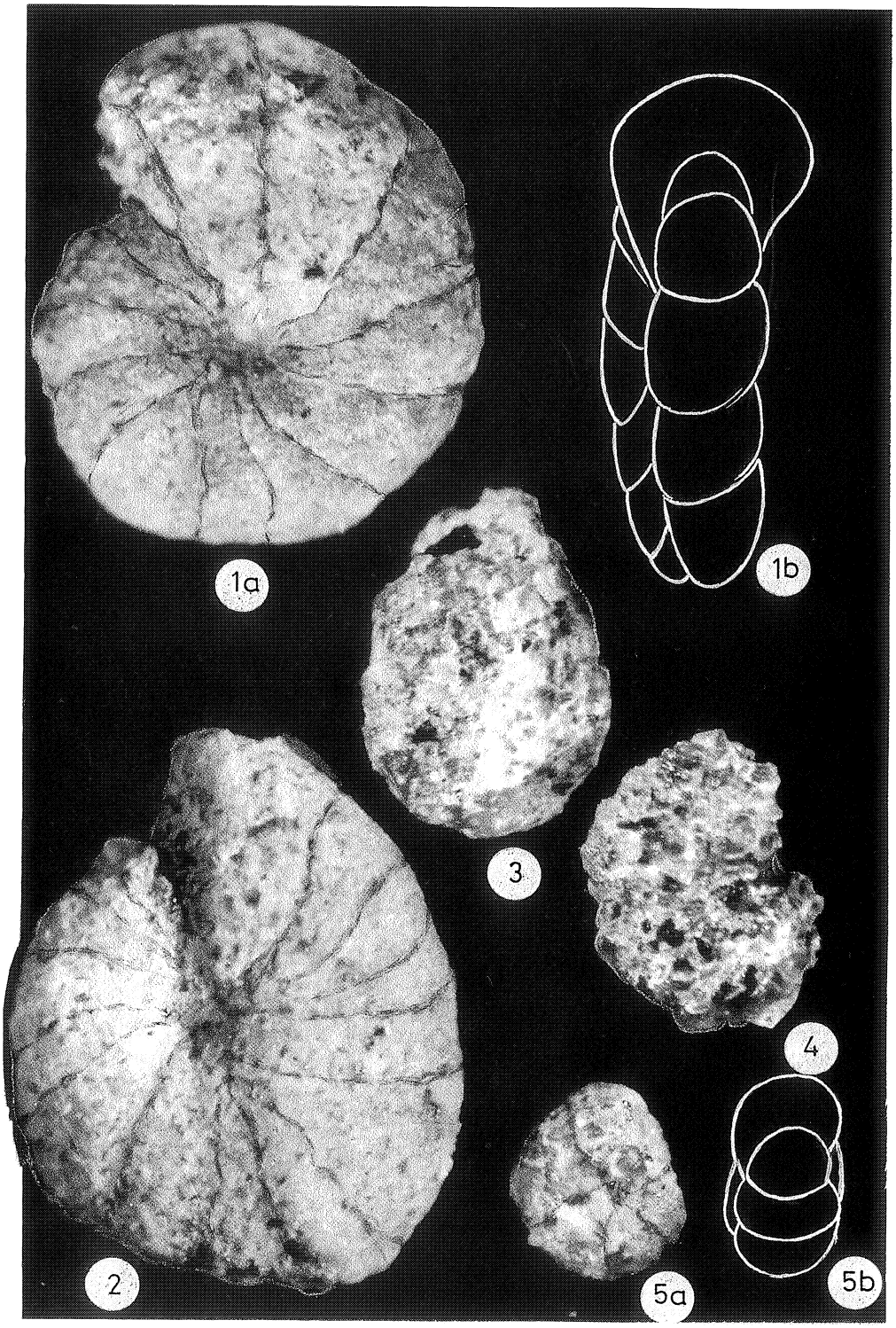

Fig. 7. Early Oligocene Foraminifera from Kap Brewster, East Greenland. **1a, b** – *Cyclammina cancellata* Brady, sample 812, ×30; **2** – *Cyclammina cancellata* Brady, sample 814, ×30; **3** – *Discammina eocenica* Mallory, sample 810, ×30; **4** – *Discammina compressa* (Goës), sample 812, ×30; **5a, b** – *Adercotryma glomerata* (Brady), sample 815, ×30

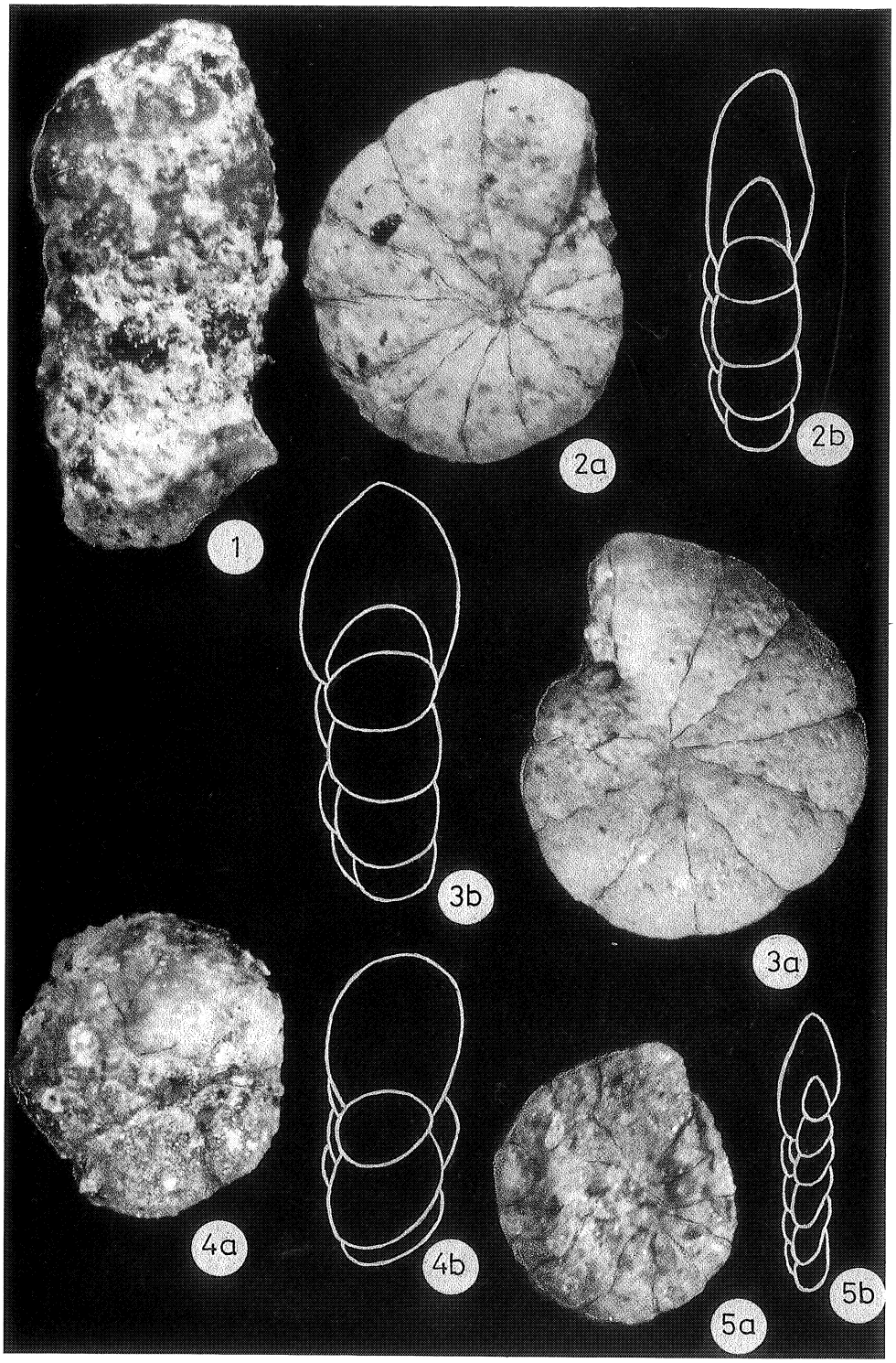

Fig. 8. Early Oligocene Foraminifera from Kap Brewster, East Greenland. **1** – *Ammobaculites cubensis* Cushman et Bermudez, sample 813, ×30; **2a, b** – *Cyclammina clarki* (Hanna), sample 812, ×30; **3a, b** – *Cyclammina incisa* (Stache), sample 812, ×30; **4a, b** – *Trochammina advena* Cushman, sample 814, ×60; **5a, b** – *Cyclammina placenta* (Reuss), sample 815, ×30

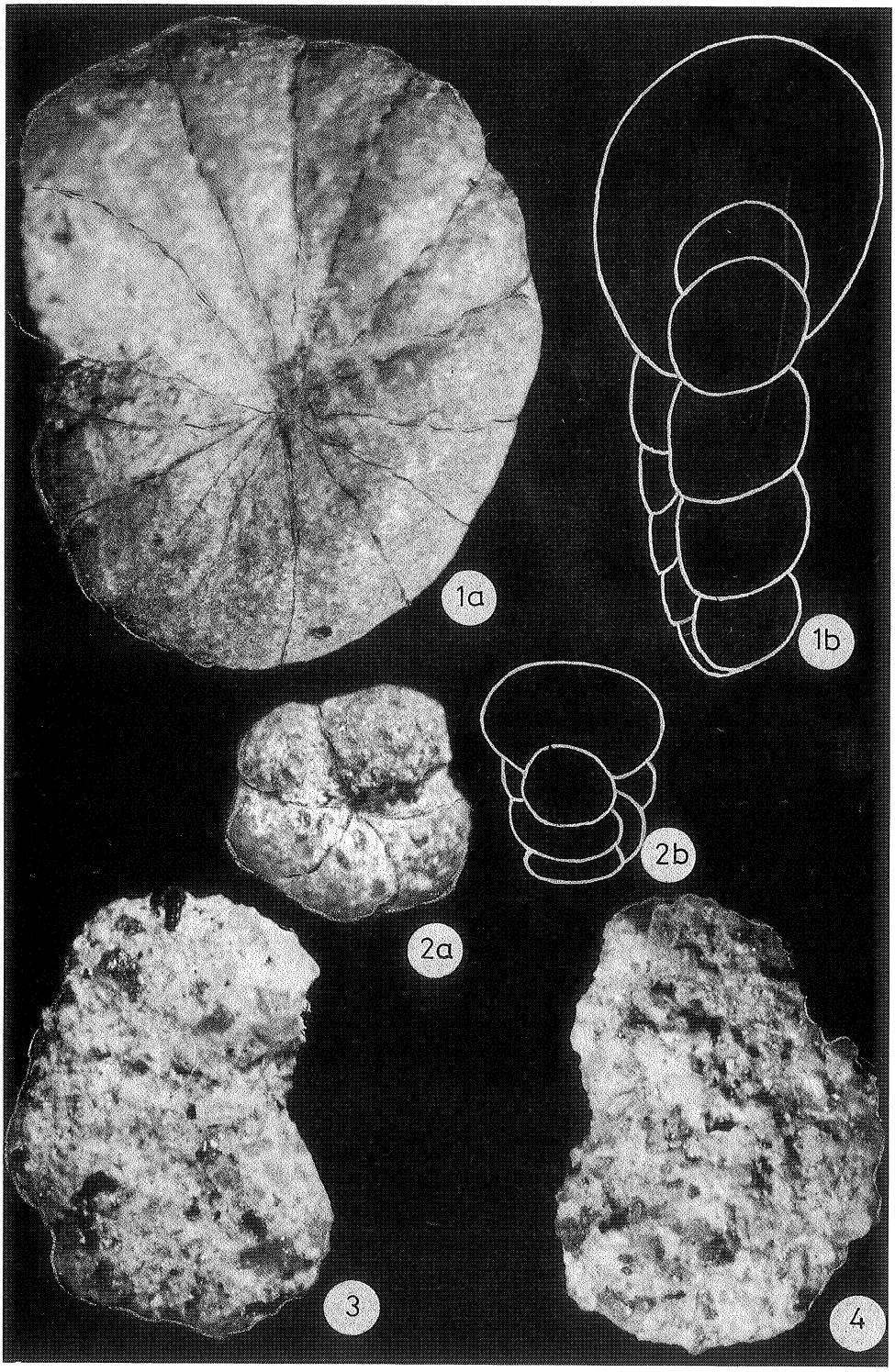

Fig. 9. Early Oligocene Foraminifera from Kap Brewster, East Greenland. **1a, b** – *Cyclammina cancellata* Brady, sample 813, ×30; **2a, b** – *Cribrostomoides* cf. *subglobosus* (Brady), sample 815, ×30; **3, 4** – *Ammomarginulina foliacea* (Brady), sample 814, ×30

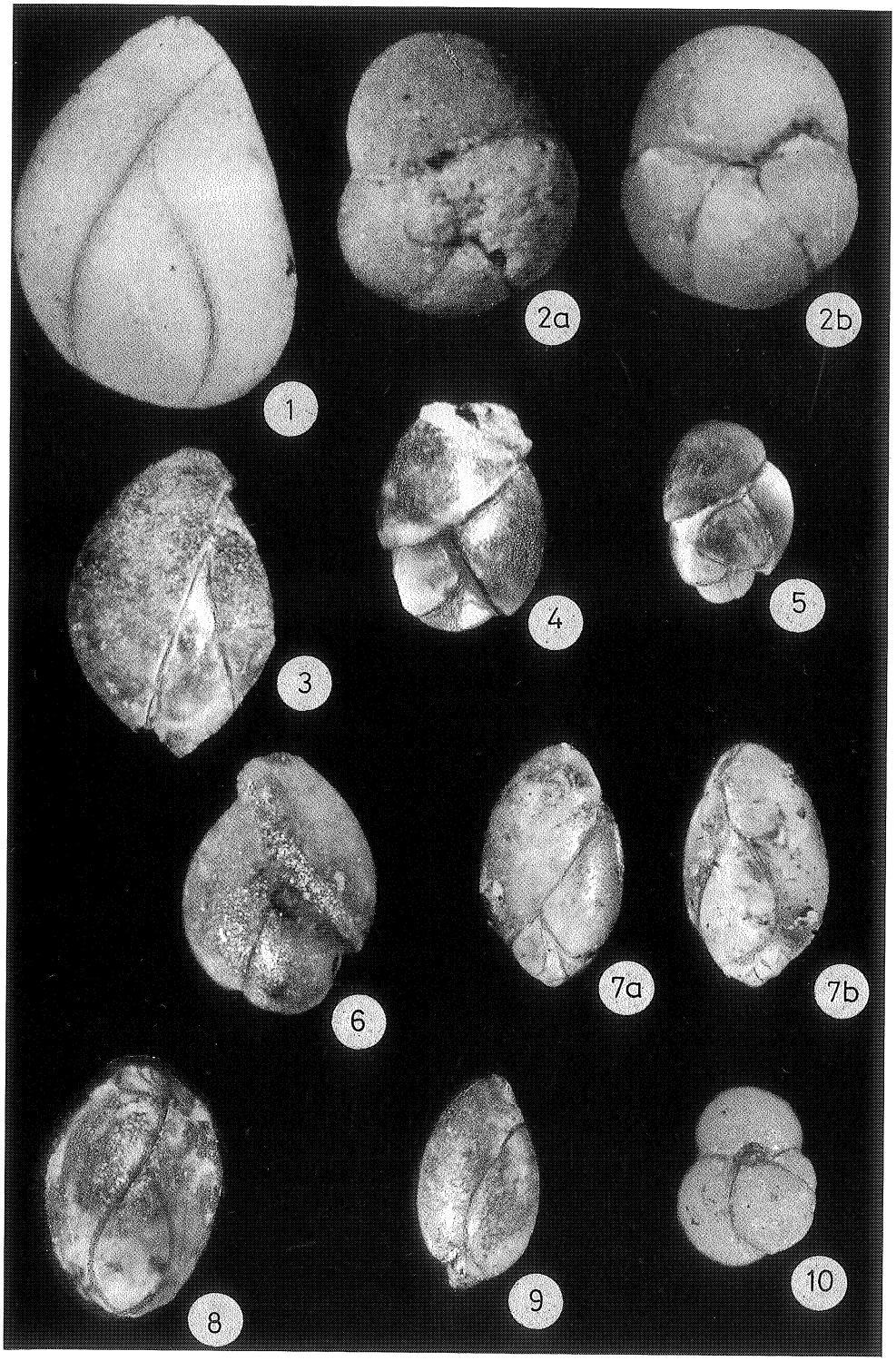

Fig. 10. Early Oligocene Foraminifera from Kap Brewster, East Greenland. **1** – *Globobulimina landesi* (Hanna et Hanna), sample 813, ×60; **2a, b** – *Valvulineria allomorphinoides* (Reuss), sample 813, ×60; **3** – *Guttulina ovalis* Bornemann, sample 789, ×60; **4, 5** – *Guttulina jarvisi* Cushman et Ozawa, sample 815, ×60; **6** – *Guttulina problema* (d'Orbigny), sample 815, ×60; **7a, b, 9** – *Globobulimina auriculata* (Bailey), sample 813, ×60; **8** – *Globobulimina pacifica* Cushman, sample 812, ×60a

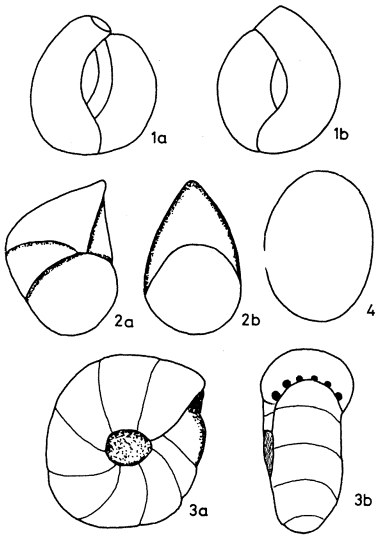

Fig. 11. Early Oligocene Foraminifera from Kap Brewster, East Greenland. **1a, b** – *Quinqueloculina confusa* Reuss, sample 813, × c. 35; **2a, b** – *Lenticulina* sp., sample 812, × c. 30; **3a, b** – *Cribrostomoides scitulus* (Brady), sample 815, × c. 18; **4** – *Oolina inornata* d'Orbigny, sample 778, × c. 30

1987. *Cribrostomoides crassimargo* (Norman): Łuczkowska, in Birkenmajer & Łuczkowska, pl. 1, figs 13a, b; pl. 2, figs 1a, b.

Remarks: Tests with moderately inflated chambers, consisting of rather coarse sand grains, with 6-7 chambers in the last whorl. Deep umbilicus well visible in the middle of the test. The species lives in shallow Arctic waters (Vilks, 1969).

We previously referred this species to *Haplophragmoides stavropolensis* Ter-Grigorianz (Birkenmajer & Jednorowska, 1977).

Cribrostomoides scitulus (Brady)
Fig. 11 (3a, b)

1881. *Haplophragmium scitulum* Brady: p. 50, pl. 34, figs 11-13.
1960. *Alveolophragmium scitulum* (Brady): Barker, pl. 34, figs 11-13.
1975. *Cribrostomoides scitulus* (Brady): LeRoy & Hodgkinson, pl. 4, figs 5, 6.
1981. *Cribrostomoides scitulus* (Brady): Gradstein & Berggren, p. 253, pl. 6, figs 8, 9.

Remarks: Our specimens correspond to descriptions of the above authors. A row of pores which occur at the base of the last chamber qualify our species to the genus *Cribrostomoides*. The species is known from Cretaceous and Eocene of the Northern Atlantic bottom cores (Gradstein & Berggren, 1981) and from the Recent seas.

Cribrostomoides cf. *subglobosus* (Sars)
Fig. 9 (2a, b)

Remarks: Test involute, with 6 chambers in the last whorl. Chambers inflated, separated with wide and deep sutures. Deep umbilicus in the middle of the test. Aperture in form of slit at the base of the last chamber.

From typical specimens of *C. subglobosus* (Sars) our specimen differs in having a more compressed test, and deeper and wider sutures. It is similar to *Haplophragmoides subglobosus* (Sars) of Cushman and McCulloch (1939: pl. 6, fig. 7). In the Krabbedalen Formation, the specimen was found in Sample 815.

Family DISCAMMINIDAE Mikhalevich, 1980
Genus *Discammina* Lacroix, 1832

Discammina compressa (Goës)
Fig. 7 (4)

1882. *Lituola irregularis* Roemer var. *compressa* Goës: p. 141, pl. 12, figs 421-423.
1964. *Discammina compressa* (Goës): Loeblich & Tappan, p. C226, pl. 136, fig. 10.

Remarks: Test flattened, slightly evolute, consisting of coarse sand grains. Sutures between chambers, externally invisible. Internal structure of the test labyrinthic, visible in passing light in immersion liquid. Our specimens correspond with their size (1.5 mm) and structure to those illustrated by Loeblich and Tappan (1964). The species is known from the Recent seas, where it lives at moderate depths.

Discammina eocenica Mallory
Fig. 7 (3)

1959. *Discammina? eocenica* Mallory: p. 109, pl. 1, fig. 18a-b.

Remarks: Test oval, flat. Test wall consisting of large quartz grains, with cement. Chamber septa externally invisible. Internal structure visible in passing light, in immersion liquid. The species has been described from the Middle Eocene.

Family LITUOLIDAE de Blainville, 1827
Subfamily AMMOMARGINULININAE Podobina, 1978
Genus *Ammomarginulina* Wiesner, 1931

Ammomarginulina foliacea (Brady)
Fig. 9 (3, 4)

1881. *Haplophragmium foliaceum* Brady: p. 50, 304, pl. 33, figs 20-25.
1960. *Ammomarginulina foliaceus* (Brady): Barker, pl. 33, figs 20-25.
1986. *Ammomarginulina foliacea* (Brady): Schröder, p. 51, pl. 21, figs 10-13.

Remarks: Test almost flat, planispiral in initial part, monoserial in straight terminal part. Sutures slightly curved. Test consisting of coarse sand grains shows rough, uneven surface. The species is known from the Recent seas.

Subfamily LITUOLINAE de Blainville, 1825
Genus *Ammobaculites* Cushman, 1910

Ammobaculites cubensis Cushman et Bermudez
Fig. 8 (1)

1937. *Ammobaculites cubensis* Cushman et Bermudez: p. 106, pl. 16, figs. 16-18.

Remarks: Initial, planispirally coiled part shows very indistinct sutures. Terminal straight part shows 3 chambers separated by indistinct sutures. Aperture terminal, at the end of the last chamber. Test wall roughened, consisting of rather coarse sand grains, with cement. The species is known from the Eocene.

Superfamily LOFTUSIACEA Brady, 1884
Family CYCLAMMINIDAE Marie, 1941
Genus *Cyclammina* Brady, 1879

Cyclammina cancellata Brady
Fig. 7 (1a, b, 2), Fig. 9 (1a, b)

1884. *Cyclammina cancellata* Brady: p. 62, pl. 37, figs 8-16.
1960. *Cyclammina cancellata* Brady: Barker, pl. 76, figs 8-16.
1964. *Cyclammina cancellata* Brady: Loeblich & Tappan, p. C228, pl. 142, figs 1-4.
1975. *Cyclammina cancellata* Brady: Anderson, pl. 2, figs 12a, b.
1981. *Cyclammina cancellata* Brady: Gradstein & Berggren, p. 254, pl. 7, figs 1-3.

Remarks: Recent species, widely distributed, known from Eocene and Oligocene strata of submarine cores in North Atlantic (Gradstein & Berggren, 1981), and from Lower Miocene glacio-marine strata of King George Island, West Antarctica (Birkenmajer & Łuczkowska, 1987). We previously referred this species to *Cyclammina pacifica* Beck and *C. pseudocancellata* Chalilov (Birkenmajer & Jednorowska, 1977).

Cyclammina clarki (Hanna)
Fig. 8 (2a, b)

1923. *Nonionina clarki* Hanna (*fide* Ellis & Messina, 1940-1970).
1928. *Cyclammina clarki* (Hanna): Cushman & Schenck, p. 303, pl. 42, fig. 1.

Remarks: Test biconvex, broad, with rounded margin. Sutures between chambers thin, faint. Test surface roughened, margin elevated, bow-like.

Cyclammina incisa (Stache)
Fig. 8 (3a, b)

1865. *Haplophragmium incisum* Stache: p. 165, pl. 21, fig. 1.
1931. *Cyclammina incisa* (Stache): Cushman & Laiming, p. 93, pl. 9, figs 6a, b.

Remarks: Test biconvex, rounded, broad, compressed. 10 uneven chambers separated with distinct sutures in the last whorl. Depressed umbilicus in the middle of the test. Chamber wall smooth, consisting of fine sand.

Cyclammina placenta (Reuss)
Fig. 8 (5a, b)

1851. *Nonionina placenta* Reuss: p. 72, pl. 5, figs 33a, b.
1965. *Cyclammina placenta* (Reuss): Ter-Grigorianz, pp. 219-220, pl. 2, figs 3a, b.
1970. *Cyclammina placenta* (Reuss): Mjatliuk, pp. 91-92, pl. 6, figs 29-33; pl. 25, figs 6a, b; pl. 26, figs 1-3; pl. 27, figs 5, 6.
1981. *Cyclammina placenta* (Reuss): Gradstein & Berggren, p. 254, pl. 7, figs 4-8.

Remarks: Test flat, with sharp keel. 12-14 narrow triangular chambers in the last whorl, separated by narrow depressed sutures. Depressed umbilicus in the middle of the test. Chamber wall smooth, consisting of fine sand with coarser grains. Apertural surface narrow, triangular.

Mjatliuk (1970) and Gradstein and Berggren (1981) included in the synonymy of the Late Eocene *Cyclammina placenta* (Reuss) the Oligocene species *Cyclammina acutidorsata* (Hantken). The species *Cyclammina placenta* (Reuss) is a guide fossil for the Late Eocene– Oligocene transition.

Superfamily TROCHAMMINACEA Schwager, 1877
Family TROCHAMMINIDAE Schwager, 1877
Subfamily TROCHAMMININAE Schwager, 1877
Genus *Trochamina* Parker et Jones, 1859

Trochammina advena Cushman
Fig. 8 (4a, b)

1922. *Trochammina advena* Cushman: p. 20, pl. 1, figs 2-4.

Remarks: Test thick, compact, with 4½ chambers in the last whorl. Sutures radiating, depressed. Deep umbilicus at the ventral side of the test. Chamber wall smooth, consisting of fine sand. The species lives in shallow seas of the Arctic (Todd & Low, 1967).

Suborder MILIOLINA Delage et Hérouard, 1896
Superfamily MILIOLACEA Ehrenberg, 1839
Family MILIOLIDAE Ehrenberg, 1839
Subfamily MILIOLINAE Ehrenberg, 1839
Genus *Quinqueloculina* d'Orbigny

Quinqueloculina confusa Reuss
Fig. 11 (1a, b)

1863. *Quinqueloculina confusa* Reuss: p. 42, pl. 2, fig. 8.

Remarks: Test smooth, elliptic, triangular in cross-section. Two last chambers broad, rounded. Species known from the Eocene.

Suborder LAGENINA Delage et Hérouard, 1896
Superfamily NODOSARIACEA Ehrenberg, 1838
Family NODOSARIIDAE Ehrenberg, 1838
Subfamily LENTICULININAE Chapman, Parr et Collins, 1934
Genus *Lenticulina* Lamarck, 1804

Lenticulina sp.
Fig. 11 (2a, b)

Remarks: Test triangular, consisting of three chambers, first chamber large, spherical. The form is very similar to *Lenticulina* cf. *crassa* (d'Orbigny) described by Kleinpell and Weaver (1963) from the Oligocene of California.

Family POLYMORPHINIDAE d'Orbigny, 1839
Subfamily POLYMORPHININAE d'Orbigny, 1839
Genus *Globulina* d'Orbigny, in De La Sagra, 1839

Globulina landesi (Hanna et Hanna)
Fig. 10 (1)

1924. *Polymorphina landesi* Hanna et Hanna: p. 60, pl. 13, figs. 16-17.
1930. *Globulina landesi* (Hanna et Hanna): Cushman & Ozawa, p. 71, pl. 15, fig. 9.

Remarks: Test fusiform, smooth, slightly asymmetrical. Three chambers are visible. Asterisk-like aperture at the end of the last chamber. This species was described from the Eocene, it is known from the Recent seas.

Genus *Guttulina* d'Orbigny, in De La Sagra, 1839

Guttulina jarvisi Cushman et Ozawa
Fig. 10 (4,5)

1930. *Guttulina jarvisi* Cushman et Ozawa: p. 39, pl. 7, figs 4-5.

Remarks: Test oval in outline. Chambers inflated, detached from one another. Chamber wall smooth. Aperture radial-shaped, at the terminus of the last chamber. This species was described from the Eocene and Oligocene, and is probably still living in the Pacific (Cushman & Stainforth, 1945).

Guttulina ovalis Bornemann
Fig. 10 (3)

1855. *Guttulina ovalis* Bornemann: p. 345, pl. 17, fig. 7.

Remarks: Test oval, sharpened at both sides, slightly asymmetrical. Chambers elongated, closely overlapping. Sutures distinct. Aperture asterisk-like, at terminus of the last chamber. This species is known from the Oligocene.

Guttulina problema (d'Orbigny)
Fig. 10 (6)

1826. *Polymorphina (Guttulina) problema* d'Orbigny: p. 266.
1930. *Guttulina problema* (d'Orbigny): Cushman & Ozawa, p. 19, pl. 2, figs 1-6; pl. 3, fig. 1.
1960. *Guttulina problema* (d'Orbigny): Barker, pl. 152, fig. 1.

Remarks: Test egg-shaped: sphaerical in initial part, slightly sharpened at the terminus. Only three inflated chambers, separated with deep sutures, are visible. Test wall smooth. This species known from the Cretaceous (Franke, 1928) to the Recent (at shallow depths – Barker, 1960).

Family GLANDULINIDAE Reuss, 1860
Subfamily OOLININAE Loeblich et Tappan, 1961
Genus *Oolina* d'Orbigny, 1839

Oolina inornata d'Orbigny
Fig. 11 (4)

1839. *Oolina inornata* d'Orbigny: p. 21, pl. 5, fig. 13.

Remarks: Test oval, rounded, with smooth non-lustrous surface. Apertural part damaged. This species is known from Recent seas.

Superfamily BULIMINACEA Jones, 1875
Family BULIMINIDAE Jones, 1875
Genus *Globobulimina* Cushman, 1927

Globobulimina auriculata (Bailey)
Fig. 10 (7a, b, 9)

1851. *Bulimina auriculata* Bailey: p. 12, pl. 1, figs 25-27.
1958a. *Globobulimina auriculata* (Bailey): Asano, pp. 9-10, pl. 2, figs 1a, b, 2a, b, 3.

Remarks: Test delicate, smooth. Three overlapping chambers occur in the last whorl. This is a shallow-water species (Cushman, 1944) known from the Tertiary to Recent.

Globobulimina pacifica Cushman
Fig. 10 (8)

1927a. *Globobulimina pacifica* Cushman: p. 67, pl. 14, fig. 12.

Remarks: Test subrounded, three overlapping chambers in the last whorl. Test wall smooth. This species is known from the Tertiary to Recent, shallow to deep water (Weaver, 1962; Tipton *et al.* 1973; P. B. Smith, 1973).

Superfamily DISCORBACEA Ehrenberg, 1838
Family BAGGINIDAE Cushman, 1927
Subfamily BAGGININAE Cushman, 1927
Genus *Valvulineria* Cushman, 1926

Valvulineria allomorphoides (Reuss)
Fig. 10 (2a, b)

1860. *Valvulina allomorphoides* Reuss: p. 223, pl. 11, fig. 6.
1936. *Valvulineria allomorphoides* (Reuss): Brotzen, pp. 153-155.

Remarks: Test rounded in outline, with 4 chambers in the last whorl, the last chamber occupies almost half of the test. Sutures distinct, straight. Aperture with lip, at the margin of the last chamber, reaching the umbilicus. This species is known from the Cretaceous.

We previously referred this species to *Baggina* cf. *californica* Cushman (Birkenmajer & Jednorowska, 1977).

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Streszczenie

OTWORNICE DOLNEGO OLIGOCENU Z KAP BREWSTER, WSCHODNIA GRENLANDIA

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W osadach formacji Krabbedalen na Kap Brewster we Wschodniej Grenlandii znaleziono bogaty zespół otwornic reprezentowany przez 33 gatunki, należące do 23 rodzajów i 17 rodzin.

Formacja Krabbedalen należy do grupy Kap Dalton (gr), którą tworzą osady eocenu–oligocenu przykrywające platformę bazaltową (grupa Blosseville; paleocen–eocen; Hassan, 1953; Birkenmajer, 1972; Birkenmajer & Jednorowska, 1977). Stanowi ona najwyższą część tej jednostki litostratygraficznej i odpowiada "warstwom z *Coeloma*" opisanych przez Hassana (1953, warstwa nr 6).

Najlepsze odsłonięcia osadów tej formacji występują w Krabbedalen, gdzie wypełniają one rów tektoniczny (Fig. 2, 3). Maksymalna ich miąższość przekracza 100 m. Formację tworzą szarożółte mułowce margliste przeławicone twardymi, silnie węglanowymi mułowcami z pojedynczymi otoczakami bazaltów i innych skał.

W opisanym zespole mikrofauny najliczniej są reprezentowane otwornice aglutynujące, charakteryzujące się dużymi rozmiarami, o skorupkach zbudowanych z grubych ziarn piasku. Formy rurkowate (*Rhabdammina*, *Bathysiphon* i *Rhizammina*) są najczęściej pokruszone i źle zachowane. Wśród form dobrze zachowanych, rodzaj *Psammosphaera* jest reprezentowany przez 2 gatunki: *P. fusca* Schultze (bardziej liczny) i *P. parva* Flint. Spośród form z rodzaju *Saccammina* oznaczono: *S. compressa* (Cushman et McCulloch), *S. difflugiformis* (Brady) i *S. sphaerica* Sars. Rodzaj *Reophax* jest reprezentowany przez *R. pilulifer* Brady (osobniki o dużych rozmiarach), *R. fusiformis* Williamson i *R. tappuensis* Asano. Spośród 3 gatunków należących do rodzaju *Haplophragmoides* – *H. advenus* Cushman, *H. columbiensis* Cushman i *H. planissimus* Cushman, tylko *H. columbiensis* jest liczny. Otwornice z gatunku *Adercotryma glomerata* (Brady) występują obficie tylko w jednej z prób. Rzadkie są formy należące do rodzaju *Cribrostomoides* (*C. crassimargo* (Norman), *C. scitulus* (Brady) i *C.* cf. *subglobosus* (Brady)), *Discammina* (*D. compressa* (Goës) i *D. eocenica* Mallory), *Ammomarginulina* (*A. foliacea* (Brady)), *Ammobaculites* i *Trachammina* (*T. advena* Cushman). Licznie występują natomiast otwornice z rodzaju *Cyclammina* (*C. cancellata* Brady, *C. clarki* (Hanna) i *C. incisa* Stache). Wśród nich gatunek *C. cancellata* Brady jest reprezentowany przez formy o średnicy skorupki do 2,5 mm.

Bentos wapienny tworzą formy małych rozmiarów, najczęściej o złym stanie zachowania i bardzo nieliczne, z wyjątkiem otwornic należących do *Globobulimina pacifica* Cushman i *Valvulineria allomorphinoides* (Reuss). Wśród otwornic wapiennych oznaczono ponadto: *Quinqueloculina confusa* Reuss, *Lenticulina* sp., *Globulina landesi* (Hanna et Hanna), *Guttulina jarvisi* Cushman et Ozawa, *G. ovalis* Bornemann, *G. problema* (d'Orbigny), *Oolina inornata* d'Orbigny, *Globobulimina auriculata* (Bailey), *G. pacifica* Cushman, *Cibicides* sp. i *Eponides* sp.

Otwornice planktoniczne są reprezentowane jedynie przez 2 formy z rodzaju *Globigerina*. Jedną z nich oznaczono jako *G.* cf. *ampliapertura* Bolli (*G. ampliapertura* Bolli – Birkenmajer & Jednorowska, 1977).

Oprócz otwornic w osadach formacji Krabbedalen występują pojedyncze muszle małży, ślimaków, małżoraczków, fragmenty elementów szkieletowych gąbek i jeżowców. W dwóch próbkach znaleziono liczny zespół radiolarii.

Płytkowodna makrofauna (małże i kraby) opisana przez Has-

sana (1953) datuje osady tej formacji na wczesny oligocen. Wstępne badania otwornicowe z najwyższej części formacji (Birkenmajer & Jednorowska, 1977) wskazywały na nieco starszy ich wiek, najmłodszy eocen–wczesny oligocen (obecność *Globigerina ampliapertura* Bolli w środkowej części profilu stratotypowego i *Reophax tappuensis* Asano w jego najwyższej części). Biorąc pod uwagę zasięgi stratygraficzne otwornic aglutynujących z rodzaju *Cyclammina* (szczególnie *C. placenta*) i *Reophax* (*R. tappuensis*), w niniejszej pracy autorzy potwierdzają wyniki wcześniejszych badań, określając wiek formacji na wczesny oligocen.

Opisany zespół otwornic z formacji Krabbedalen ma charakter płytkowodny. Jest to podkreślone przez obecność form o dużych rozmiarach i skorupkach otwornic aglutynujących zbudowanych z grubych ziarn piasku. Do form typowo płytkowodnych należy przede wszystkim rodzaj *Ammobaculites*. Formy z rodzajów *Saccammina*, *Reophax*, *Haplophragmoides* i *Trochammina* oraz gatunek *Cribrostomoides crassimargo* (Norman) są również znane ze środowisk płytkowodnych (Haig, 1979; Jones & Charnock, 1985; Vilks, 1969). Gatunki *Saccammina compressa* (Cushman et McCulloch), *Haplophragmoides columbiensis* Cushman i *H. planissimus* Cushman zostały opisane z wybrzeży Alaski, z głębokości nieprzekraczającej 30 m.

Płytkowodny charakter tego zespołu dokumentuje ponadto obecność reprezentantów bentosu wapiennego z rodziny Miliolidae (*Quinqueloculina confusa* Reuss, *Lenticulina* sp.) i Polymorphinidae (*Globulina* sp., *Guttulina* sp., *Valvulineria* sp., *Globobulimina pacifica* Cushman; Loeblich & Tappan, 1964; Haig, 1979). Rodzaj *Oolina* został opisany również ze środowisk płytkowodnych Arktyki (Lagoe, 1977).

Bardzo charakterystyczny element opisanego zespołu stanowią formy z rodzaju *Cyclammina*, w szczególności z gatunku *C. cancellata* Brady, o wyjątkowo dużych skorupkach. Otwornice aglutynujące o dużych rozmiarach skorupek zostały opisane ze środowisk zarówno głębokowodnych (Bandy, 1960; Bandy & Rodolfo, 1964), jak i szelfowych (Jones & Charnock, 1985). Niektóre z gatunków otwornic głębokowodnych mogą żyć w środowiskach znacznie płytszych w basenach polarnych, gdzie fizyczne i chemiczne parametry środowiska są zbliżone do tych jakie występują w głębokich basenach (Schröder, 1986). Przykładem takim jest rodzaj *Cyclammina*. Został on opisany z osadów trzeciorzędowych Spitsbergenu gdzie współwystępuje z płytkowodną makrofauną (Vonderbank, 1970). Jest on charakterystycznym elementem zespołu w płytkowodnych osadach górnego oligocenu w rejonie Morza Rossa (Leckie & Webb, 1983). Z Morza Weddella Anderson (1975) opisał zespół płytkowodny składający się prawie wyłącznie z otwornic aglutynujących, wśród których formy należące do *Cyclammina* charakteryzowały duże rozmiary skorupek (o średnicy do 5 mm). Według Andersona (1975) jest to efekt specyficznych warunków życia w środowisku euryhalinowym i eurytermalnym. Podobne cechy skorupek opisali Loeblich i Tappan (1964) interpretując je jako wpływ niskiej temperatury wody oraz zmian w zasoleniu na cykl życiowy otwornic.

Zimne wody przybrzeżne prądu wschodniogrenlandzkiego (Birkenmajer & Jednorowska, 1977) w czasie wczesnego oligocenu były prawdopodobnie przyczyną takich zmian w cyklu życiowym u *Cyclammina cancellata* Brady i *Reophax pilulifer* Brady, powodując u nich wzrost komór o wyjątowo dużych rozmiarach.