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# NEW SPECIES OF PALEOGENE DEEP-WATER AGGLUTINATED FORAMINIFERA FROM THE NORTH SEA AND NORWEGIAN SEA

**Felix M. GRADSTEIN[1] & Michael A. KAMINSKI[2]**

[1] *Saga Petroleum, N-1301 Sandvika, Norway*
[2] *Research School of Geological & Geophysical Sciences, Birkbeck College & University College London, Gower St. London WC1E 6BT, U. K.*

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**Abstract:** We describe the following five new taxa of agglutinated benthic foraminifera from Paleogene bathyal shales of the North Sea and Norwegian Sea: *Annectina biedai* n.sp. (Eocene–Oligocene), *Reophanus berggreni* n.sp. (Eocene–Lower Oligocene), *Ammoanita ingerlisae* n.sp. (lower part of upper Paleocene), *Conotrochammina voeringensis* n.sp. (Campanian–lower-middle Eocene), and *Cystammina sveni* n.sp. (Campanian–middle Eocene). Additionally, *Conotrochammina whangaia* Finlay is described from the Norwegian Sea region for the first time. *Insculptarenula* aff. *subvesicularis* in the Paleocene of the North Sea may be a new species in the plexus of Cretaceous through Paleogene globorotaliid-like trochamminids. *Insculptarenula subvesicularis* Homola & Hanzlikova from the Albian of the Carpathians is discussed. *Reophanus berggreni* n.sp., *Anectina biedai* n.sp. and *Conotrochammina voeringensis* n.sp. are not known from strata outside the North Sea–Norwegian Sea region. The stratigraphic ranges of the new taxa are useful additions to the subsurface biozonation of the North Sea and offshore Norway.

**Abstrakt:** W pracy przedstawiono opis pięciu nowych gatunków otwornic aglutynujacych z batialnych, paleoceńskich łupków Morza Północnego i Morza Norweskiego: *Annectina biedai* n.sp. (eocen–oligocen), *Reophanus berggreni* n.sp. (eocen–dolny oligocen), *Ammoanita ingerlisae* n.sp. (dolna część górnego paleocenu), *Conotrochammina voeringensis* n.sp. (kampan–dolna część środkowego eocenu) oraz *Cystammina sveni* n.sp. (kampan–środkowy eocen). Po raz pierwszy z tego regionu opisano gatunek *Conotrochammina whangaia* Finlay. *Insculptarenula* aff. *subvesicularis* występująca w osadach paleocenu Morza Północnego jest prawdopodobnie nowym gatunkiem z grupy trochamminidów globorotaliopodobnych, znanych z kredy i paleocenu. Przedstawiono uwagi taksonomiczne dotyczace *Insculptarenula subvesicularis* Homola & Hanzliková z albu Karpat. Taksony: *Reophanus berggreni* n.sp., *Anectina biedai* n.sp. i *Conotrochammina voeringensis* n.sp. znane są jedynie z osadów w rejonie Morza Północnego i Morza Norweskiego. Przedstawiono również biozonacje osadów paleogenu Morza Północnego i wybrzeży Morza Norweskiego.

**Key words:** agglutinated Foraminifera, biostratigraphy, new species; Paleogene, North Sea, Norwegian Sea.

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## INTRODUCTION

The Paleogene deep marine sequences of the Central North Sea and offshore mid-Norway contain diverse assemblages of deep-water agglutinated foraminifera (DWAF) that are important for regional subsurface correlation. Many of the foraminiferal species are well-known "cosmopolitan" forms first described from the Polish Carpathians[1], but a certain number of them appear to be restricted to the Norwegian Sea–North Sea region. The taxonomy of the cosmopolitan DWAF in the Paleogene of the North Sea and offshore Norway has been treated in some detail by Gradstein and Berggren (1981), Verdenius and van Hinte (1983), King (1989), Gradstein and Kaminski (1989), Charnock and Jones (1990), and Gradstein *et al.* (1994), but more taxa await systematic studies. Particularly from a population point of view much work remains to be done, such that species discrimination takes into acccount natural variability and regional clines. In this respect, we particularly consider the cyclamminids to be understudied, to the detriment of

1 This study is dedicated to the memory of Stanisław Geroch, teacher, friend, colleague and eminent specialist of Carpathian Agglutinated Foraminifera. The Carpathians are the cradle of deep water agglutinated foraminifera studies, a resource that Stan explored as no other. We are grateful for his advice and taxonomic identifications that greatly assisted the first author during his visits to Kraków over the past 15 years.

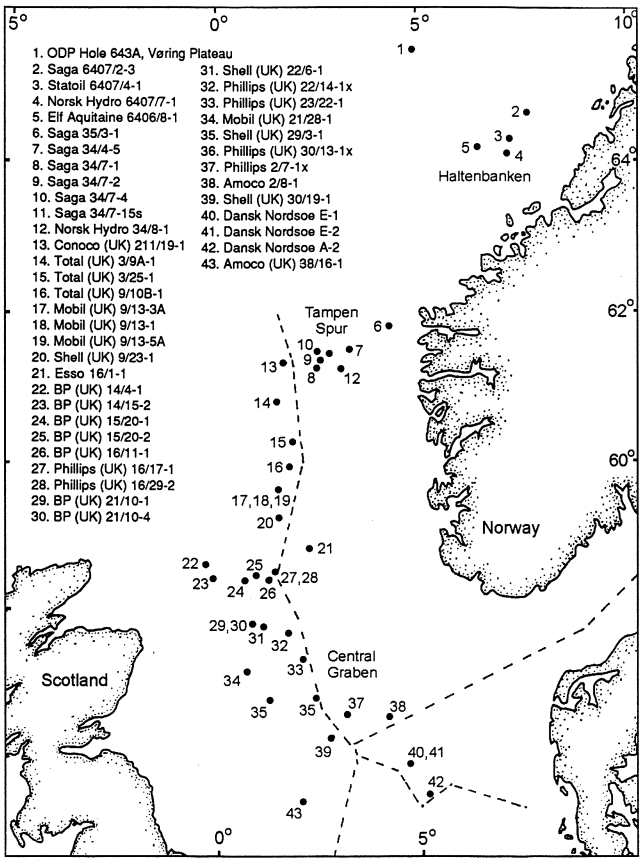



**Fig. 1.** Location of exploration wells in the North Sea and offshore Norway that recovered deep marine Palaeogene strata used to study the new agglutinated foraminiferal taxa

their zonal and correlative utility in subsurface stratigraphy. Discrimination between ontogenetic and phylogenetic developments may be a key issue in this respect.

In this study we propose new species of *Reophanus*, *Annectina*, *Cystammina, Conotrochammina* and *Ammoanita* and discuss other that occur in Upper Cretaceous or Paleogene deep-water sediments in the North Sea, offshore Norway, Labrador Shelf, Trinidad, and in the Atlantic and Indian Oceans. We focus on some common (non-cyclamminid) taxa that long have been treated in open nomenclature, and are now given formal status as part of a long-term study to increase our understanding of the taxonomy, biostratigraphy, paleobiogeography and paleoecology of deep-water agglutinated foraminifera.

The wells from which the types of new species were extracted are listed in Figure 1. Details on depths levels are in the text.

## SYSTEMATIC PALEONTOLOGY

In this paper, we used the suprageneric scheme of Loeblich and Tappan (1987) to classify our new species below the level of superfamily. We also note any changes to the definitions of genera and to their reported stratigraphic ranges based on our observations. The types of all the species are currently housed in the authors' collections. These will be deposited in the micropalaeontological collections of the Natural History Museum, London.

### Superfamily AMMODISCACEA Reuss, 1862
### Family AMMODISCIDAE Reuss, 1862
### Subfamily AMMOVERTELLININAE Saidova, 1981

### Genus *Annectina* Suleymanov, 1963

**Remarks:** Loeblich and Tappan (1987) reported this genus as "Paleocene", and "Holocene". The type species *Annectina paleocenica* Suleymanov, 1963 is probably a junior synonym of *Annectina grzybowskii* (= *Glomospira grzybowskii* Jurkiewicz, 1960), which ranges from the Campanian to the lower Eocene in the western Tethys. Our new species extends the known range of the genus into the Oligocene.

### ***Annectina biedai*** Gradstein & Kaminski, n.sp.
Fig. 2; Fig. 3 (1-2)

1990. *Glomospirella biedai* Samuel: Charnock & Jones, p. 156, pl. 14, fig. 8; pl. 2, fig. 10.
non 1977. *Glomospirella biedai* n.sp.: Samuel, p. 29, pl. 3, fig. 16; pl. 21, fig. 3.
?1989. *Ammodiscus* sp. B: King, pl. 9.1, fig. 5.

**Etymology:** In honour of Prof. Dr. Franciszek Bieda, a student of Józef Grzybowski, who later became Professor of Micropaleontology at the Jagiellonian University and at the Academy of Mining and Metallurgy, Kraków.

**Diagnosis:** A small, flat species of *Annectina* with a very small milioline-coiled initial portion.

**Holotype:** Housed in the Micropaleontology Collection of the British Museum of Natural History, London. The holotype is registered in slide PF62942.

**Material, localities and horizons:** The type level is at 1900 m in the Norwegian well Saga 2/2-4 well, Lower Oligocene. Paratypes are assigned from the Saga 2/2-4, between 1890 and 2400 m, Lower Oligocene through upper part of middle Eocene. Additional specimens have been observed in Norwegian North Sea wells Saga 35/12-1 at 2140 m, Saga 34/7-15s at 1400 m, 34/7-1 at 1380 m, Saga 4/4-5 at 1600 m, 34/8-1 at 1600 m, and offshore mid Norway wells Hydro 6407/2-3 at 1700 m and Elf Aquitaine 6408/8-1 at 1920 m. In the UK sector of the North Sea we observed specimens at 1620 m in well BP 21/10-4, at 4930 ft in Shell 22/6-1, Phillips (UK) 22/14-1x at 7090 ft, and at 6620 ft in Phillips 16/29-2. All these levels are assigned to middle Eocene through Lower Oligocene. We did not observe *A. biedai* in Labrador Sea and Labrador

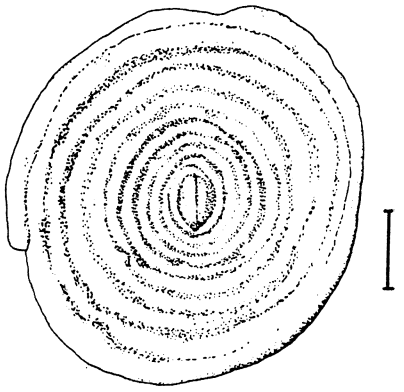


**Fig. 2.** Holotype of *Annectina biedai* Gradstein and Kaminski, n.sp.; Saga 2/2-4 well at 1900 m. Length of scale bar – 100 μm

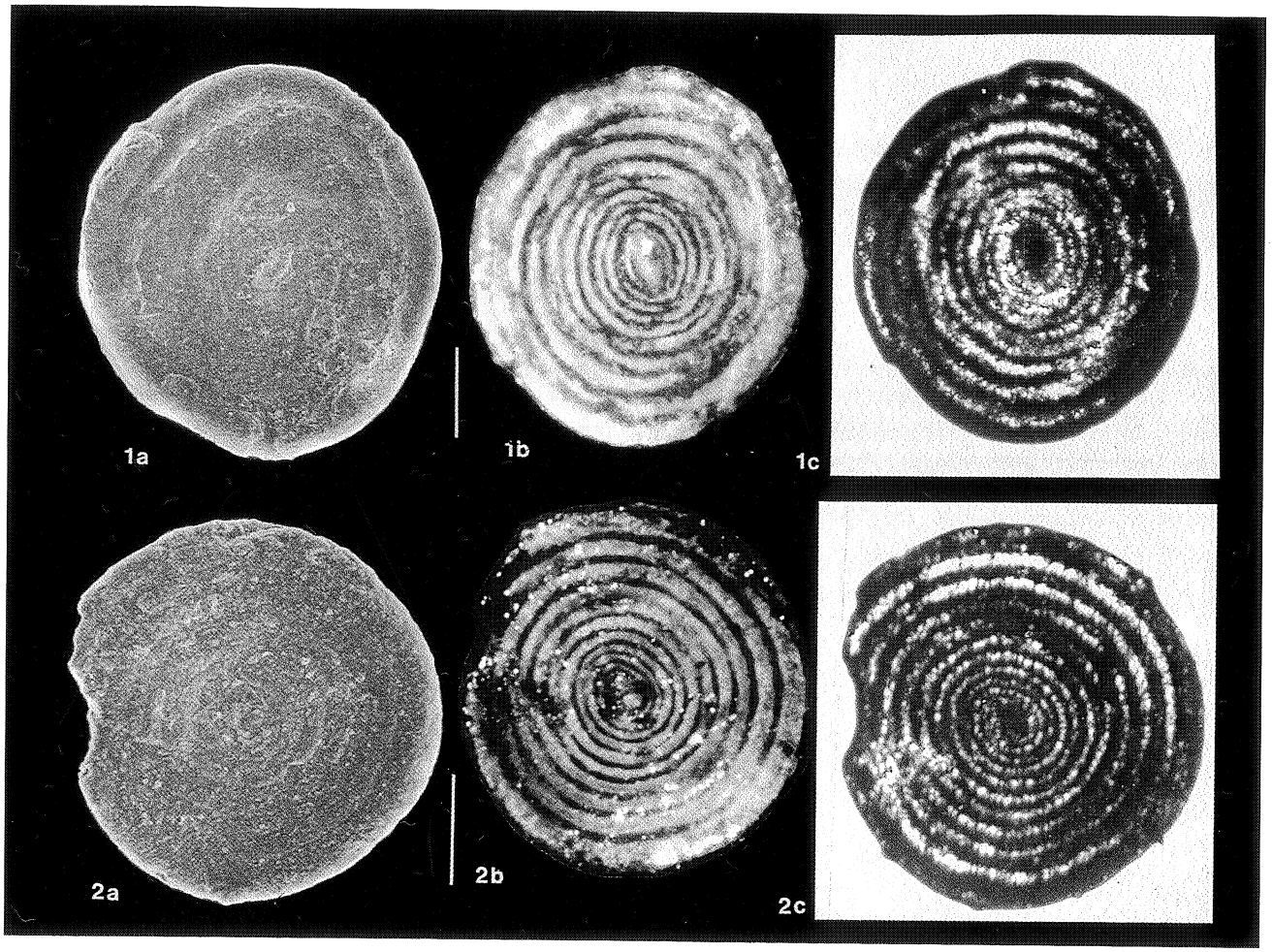



**Fig. 3.** SEM photographs. **1a-c** – *Annectina biedai* Gradstein and Kaminski, n.sp., holotype, Saga 2/2-4 well at 1900 m; **2a-c** – *Annectina biedai* Gradstein and Kaminski, n.sp., paratype, Saga 2/2-4 well at 2400 m. Length of scale bar – 100 μm

margin strata.

This species is common in the Lower Oligocene (Zone NSR7A of Gradstein & Bäckström, 1996) in the North Sea and offshore Norway. We lack definitive data on its total stratigraphic range, but specimens have been observed in the middle through upper Eocene. A similar form was also observed in the Paleogene of the Morrocan Rif (Kaminski *et al.*, 1996) and possibly in the upper Paleocene Basilika Formation in Spitsbergen (J. Nagy, *personal communication*, 1996).

**Description:** Test flat, slightly elliptical in outline, becoming circular during ontogeny. The initial portion is coiled in a triloculine manner, followed by a planispiral part consisting of numerous (as many as ten or more) whorls. The coil suture generally is not perfectly circular, but shows small wavy irregularities. The chamber is thin, and does not increase in thickness with ontogeny. The initial triloculine portion is very small in comparison to the diameter of the test. The surface of the planispiral portion is almost perfectly flat, without a depressed coil suture. Wall solid, very finely agglutinated, silicified. Aperture at the open end of the tube.

**Dimensions:** Specimens range between approximately 100 and 500 μm in diameter.

**Remarks:** This species was originally recorded as *"Glomospirella biedae"* in our previous studies (e.g., Gradstein & Bäckström, 1996; Kaminski *et al.*, 1996) and as *Glomospira biedai* by Charnock and Jones (1990). King (1989) illustrated *Ammodiscus* sp. B from the Oligocene of the North Sea, a form that is probably synonymous, although the author did not state the nature of the initial coiling. The use of the specific name *Glomospirella biedai* (or *G. biedae*) was formerly used incorrectly, owing to uncertainty regarding the constructional morphology of *Glomospirella biedai* Samuel, 1977. The holotype of *G. biedai*, housed in the collections of the Slovak National Museum in Bratislava (kindly photographed for us by Dr. Miroslav Bubik), is identical to *Annectina grzybowskii* (Jurkiewicz, 1960). Both species were originally described from the Paleocene of the Carpathian flysch, and we regard them to be fully synonymous. This new combination, and suppression of the species *G. biedai* Samuel left our Oligocene North Sea species without a valid name. As the name *"G. biedai"* has been used in the North Sea literature (albeit incorrectly) since 1990, in our opinion preserving the species name *"biedai"* best serves the stability of the nomenclature. Since our North Sea species clearly belongs in the genus *Annectina* rather than in *Glomospirella*, the species name *"biedai"* is available.

*Annectina biedai* n.sp. differs from *Annectina grzybowskii* in its thinner, more compressed test, larger number of whorls in the planispiral part, and in the smaller initial triloculine-coiled portion in comparison to the total diameter of the test. *Annectina grzybowkii* probably became extinct during the early Eocene, whereas *A. biedai* is found mostly in younger strata, becoming extinct in the Oligocene.

Superfamily HORMOSINACEA Reuss, 1862
Family HORMOSINIDAE Haeckel, 1894
Subfamily HORMOSININAE Haeckel, 1894

Genus *Reophanus* Saidova, 1970

**Remarks:** Loeblich and Tappan (1987) reported this genus as restricted to the Holocene. Our record extends its known stratigraphic range back into the Oligocene.

***Reophanus berggreni*** Gradstein & Kaminski, n.sp.
Fig. 4, Fig. 5 (1-6)

pars 1990. *Hormosinella carpenteri* (Brady): Charnock & Jones, p. 163, pl. 4, figs. 8–9; pl. 15, fig. 10.

**Etymology:** In honour of Dr. William Alfred Berggren, who picked the North Sea regional type slide from which we selected the holotype, and in recognition of his early efforts to understand the taxonomy and paleoecology of North Sea Paleogene Foraminifera.

**Diagnosis:** A robust, thick-walled hormosinid with a thick stolon, connecting two stout, massive chambers with finely agglutinated wall.

**Holotype:** UK 22/14-1x, 7090 ft. Housed in the Micropaleontology Collection of the British Museum of Natural History, London.

**Material, localities and horizons:** The type level is at 7090 ft in well Phillips (UK) 22/14-1x, Lower Oligocene. Paratypes are assigned from the well Phillips (UK) 16/29-2x, 7020 ft, and from Amoco Norway 2/8-1 at 7200-7500 ft. Aso found in the Shell (UK) 30/19-1 well.

This species occurs rarely but consistently in the coarse fraction (larger than 500 μm) in the Lower Oligocene (Zone NSR7A of Gradstein & Bäckström, 1996; fig. 2) in the North Sea and offshore Norway. We did not observe specimens of *R. berggreni* n.sp. in Labrador Sea and Labrador margin strata.

**Description:** Test multilocular, comprised of massive chambers arranged in a rectilinear series. Chambers are spherical to ovate, and connected by short, thick stolons. Wall is thick, finely agglutinated, comprised of fine agglutinated particles, several grains thick. Aperture at the open end of the stolon.

**Dimensions:** Specimens are >500 μm in diameter. Some specimens do not fit in a standard 28-ply microscope slide.

**Remarks:** This species is most often observed as individual chambers that possess stolons at either end of the test. In our collections, we only found one specimen (the holotype) that was not broken into individual chambers. Chambers are generally crushed or otherwise deformed. Although it is generally rare, we have observed *R. berggreni* n.sp. in numerous North Sea wells, usually in association with other large agglutinated species such as *Aschemocella* and *Ammodiscus latus* in strata assigned to the Lower Oligocene.

The specimens illustrated by Charnock and Jones (1990) as *Hormosinella carpenteri* (Brady) most probably belong in *R. berggreni* n.sp. Charnock and Jones lumped all globular forms from the Cenozoic of the North Sea under this name, including such morphologically and stratigraphically distinct species as *Hormosina excelsa* (Grzybowski), *Caudammina ovuloides* (Grzybowski), and *Hyperammina dilatata* (Grzybowski), an opinion that we do not share. The modern species *Hormosina carpenteri* differs in its larger dimensions, forming a long meandering catenate series of chambers, and in its more regular, tapering chambers. Because of its thick wall and meandering shape, it does not belong in the genus *Hormosinella*, which according to Loeblich and Tappan has delicate stolons between the chambers and a wall that is "agglutinated, very thin of a single layer of well-cemented grains".

*Reophanus berggreni* n.sp. differs from the recent species *Reophanus oviculus* (Brady), the type species of the genus, in the much larger dimensions of the chambers, which are more spherical in outline. In *R. oviculus* the chambers are oval, and taper into the connecting stolons, whereas in our new species the stolons often abruptly connect to the chambers. Whether this is an effect of diagenetic compaction is unclear. *Hormosinella distans* (Brady) differs in its smaller dimensions, longer and more delicate stolon, and in possessing a wall comprised of quartz grains a single layer thick. There is additionally a paleobathymetric separation between *H. distans* and *R. berggreni* n.sp., with the former species restricted to the abyssal zone in the Paleogene northern North Atlantic (e.g., Site 647; Kaminski *et al.*, 1989).

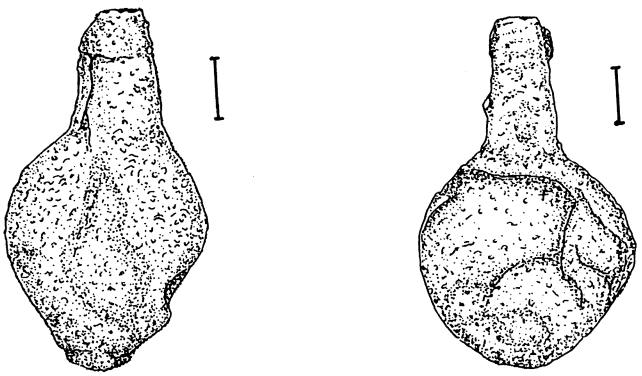


**Fig. 4.** Paratypes of *Reophanus berggreni* Gradstein and Kaminski, n.sp.; Amoco Norway, 2/8-1 at 1200 m. Length of scale bar – 500 μm

Superfamily TROCHAMMINACEA Schwager, 1877
Family TROCHAMMINIDAE Schwager, 1877

Genus *Ammoanita* Sieglie & Baker, 1987

**Remarks:** *Ammoanita* differs from *Trochammina* in its more restricted umbilical area, larger, more convex test, and more acute periphery, which may be keeled. The type species, *Ammoanita rosea* Seiglie & Baker, 1987, first described from the Campanian of Oman, may be synonymous with *Trochammina ruthvenmurrayi* Cushman & Renz, 1946. The genus ranges at least from the Tithonian, and a specimen from the Tithonian in Site 765 on the Argo Abyssal Plain, Indian Ocean was illustrated by Kaminski *et al.* (1992; pl. 6, fig. 5).

***Ammoanita ingerlisae*** Gradstein & Kaminski, n.sp.
Fig. 6, Fig. 7 (1–3)

1981. *Trochammina* aff. *albertensis* Wickenden: Gradstein & Berggren; pl. 9, figs. 3–8 (non figs. 1, 2).
1990. *Trochammina (Insculptarenula) subvesicularis* Hanzlikovà: Charnock & Jones, pl. 10, figs. 10-12.
1990. *Trochammina (Ammoanita) ruthvenmurrayi* Cushman & Renz: Charnock & Jones, pl. 22, figs. 2d-f.
1994. *Trochammina* cf. *subvesicularis* Hanzlikovà: Gradstein *et al.*, pl. 1, figs. 4 (non fig. 5).

**Etymology:** In honour of Inger Lise Kristiansen, who introduced the authors to Paleogene palynostratigraphy, as applied in offshore Norway.

**Diagnosis:** A trochospirally coiled, low planoconvex test with sharp periphery, numerous (mostly 6–8) chambers in the last whorl that slowly increase in size, and narrow umbilical depression. The external test morphology has features both of *Globorotalia kugleri*, *Morozovella formosa*, and *M. conicotruncata*.

**Holotype:** Conoco 211/19-1, 5840 ft. Housed in the Micropaleon-

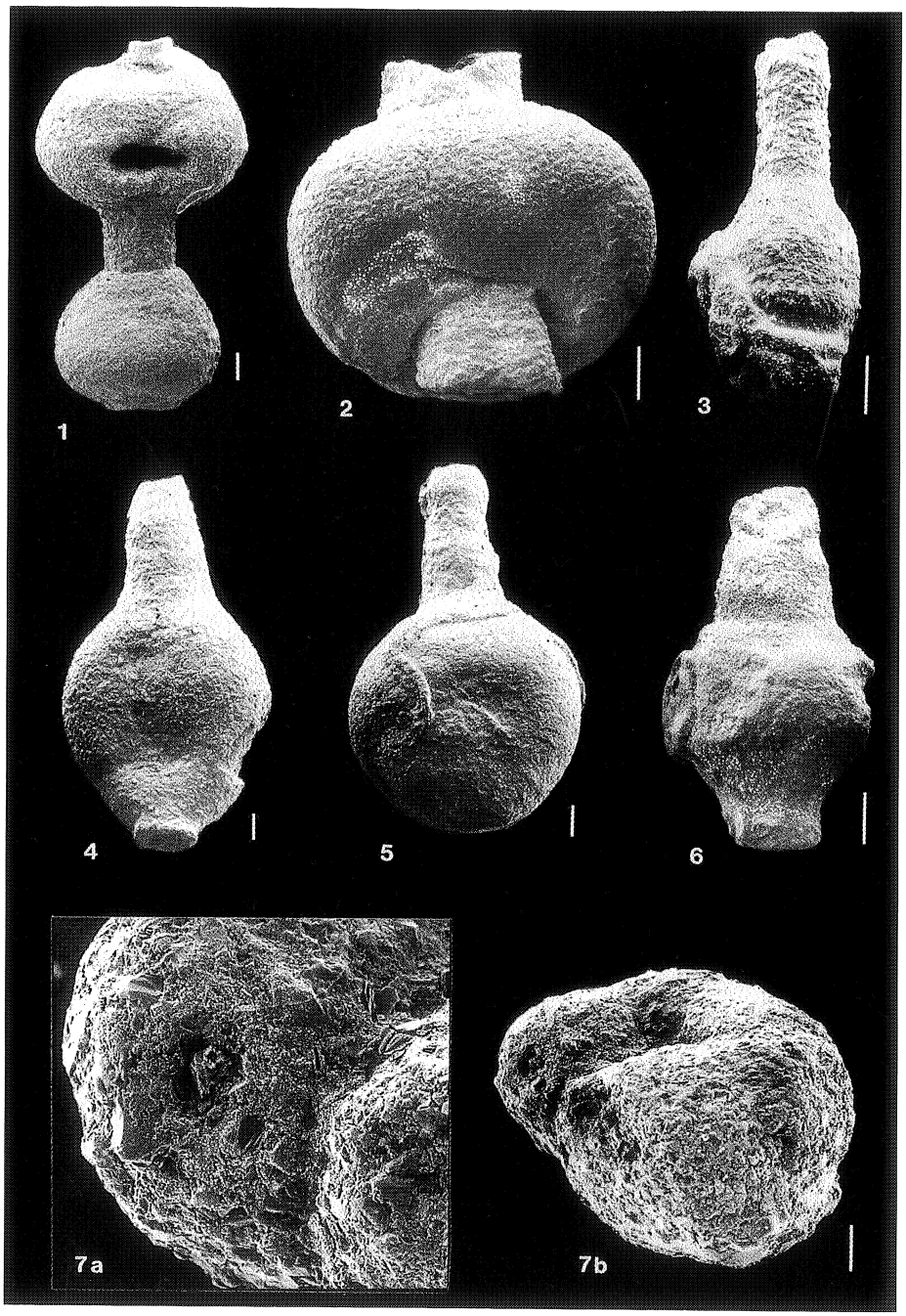



**Fig. 5.** SEM photographs. **1** – *Reophanus berggreni* Gradstein and Kaminski, n.sp., holotype, Phillips (UK) 22/14-1x at 7090 ft; **2** – *Reophanus berggreni* Gradstein and Kaminski, n.sp.; paratype, Phillips (UK) 22/14-1x at 7090 ft; **3** – *Reophanus berggreni* Gradstein and Kaminski, n.sp., paratype, Phillips (UK) 16/29-2x at 7020 ft; **4** – *Reophanus berggreni* Gradstein & Kaminski, n.sp., paratype, Amoco Norway 2/8-1 at 1200 m; **5** – *Reophanus berggreni* Gradstein & Kaminski, n.sp., Amoco Norway 2/8-1 at 1200 m; **6** – *Reophanus berggreni* Gradstein & Kaminski, n.sp., Phillips (UK) 16/29-2x at 6960 ft; **7a, b** – *Conotrochammina whangaia* Finlay, 1940, SAGA 6306/10-1 at 1170 m (7a x 220). Legth of scale bar – 100 μm

tology Collection of the British Museum of Natural History, London.

**Material, localities and horizons:** The type level is the interval of green clays between 5450 and 5850 ft in well Conoco (UK) 211/19-1, Viking Graben. Additional North Sea material derives from Shell (UK) 9/23-1, swc 6080 ft, Mobil (UK) 9/13-3A between 5450 - 5840 ft, BP (UK) 15/20-1 at 1890 m, Shell (UK) 30/19-1, core10290 ft, Danish North Sea well A-2, core 5841-5896 ft, Saga 6407/2-3, swc. 1975 m, Saga 34/7-8 at 1760 m, and Saga 34/4-5 at 1920 m. Also found in the Lizard Spring Formation, Trinidad.

In the North Sea and offshore Norway the species is known from the lower part of the *Trochammina ruthvenmurrayi–Reticulophragmium pauperum* Zone (Zone NSR2A) of Gradstein *et al.* (1988, 1994; fig. 2), upper Paleocene. In Trinidad rare specimens occur in the Lizard Springs Formation, (P4; *Morozovella velas-*

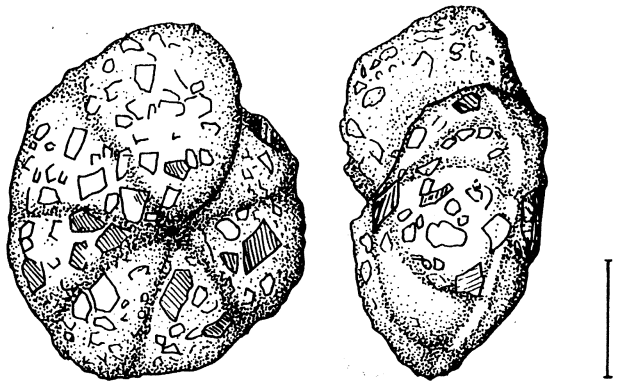


**Fig. 6.** Paratype of *Ammoanita ingerlisae* Gradstein and Kaminski, n.sp.; Conoco 211/19-1 at 5840 ft. Length of scale bar – 100 μm

*coensis* Zone), upper Paleocene. Not observed in the flysch-type agglutinated assemblages of the Atlantic Ocean, Labrador Shelf, Alpine–Carpathian region, northern Spain or northern Morocco.

**Description:** Test trochospirally coiled, with two to four whorls; spiral side flat to slightly convex; umbilical side low convex, with narrow umbilical depression; periphery acute. Outline circular to slightly lobate. Chambers are numerous, increasing slowly in size, 6 to 9 in the last whorl, 8 on average. Sutures limbate, and can be slightly depressed or smooth; on the umbilical side the sutures are slightly curved backward; on the spiral side the sutures are tangentially situated. Wall finely aggutinated, with scattered coarser grains (see Fig. 6), and often well silicified. Aperture extraumbilical, poorly visible, a slit at the base of the final chamber.

**Dimensions:** Specimens range between 150 and 350 μm in diameter.

**Remarks:** We place this species in the genus *Ammoanita* Seiglie & Baker, 1987 because of its angular chambers and acute periphery. In our understanding, the genus *Ammoanita* has the same morphological relationship to *Trochammina* as *Globorotalia* has to *Globigerina*. The type species, *A. rosea* from bathyal facies in the Campanian through lower Maastrichtian of Oman (Seiglie & Baker, 1987) was synonymized with the species *A. ruthvenmurrayi* (Cushman & Renz) by Charnock & Jones (1990). In our view, *A. rosea* is more biconvex than *A. ruthvenmurrayi*, which is distinctly spiroconvex, with a flattened umbilical side. The two species overlap in stratigraphic range, and may be related through evolution, with the spiral side becoming more convex in *A. ruthvenmurrayi*. The latter ranges into late Paleocene, and is widespread in the North Sea and offshore Norway, where we have observed it in over 30 wells. Even as early as 1981, some U. K. consulting companies referred to this taxon as "*Trochammina globorotaliaformis*".

There is some evidence to suggest there are two generations in *A. ingerlisae* n.sp. The microsphaeric generation is the typical form described above. However, co-occurring with the typical forms are specimens that are slightly more lobate in outline, possess fewer chambers (five in the last whorl), and which sometimes have a less convex ventral side. These appear to have a larger proloculus and may represent the megalosphaeric generation. Curiously, the morphological differences are akin to those observed between the alternating generations of the modern species *Trochammina hadai* from Japan (see Matsushita & Kitazato, 1990). However, more detailed morphometrics need to be carried out.

*Ammoanita ingerlisae* is less common than, but co-occurs with, *A. ruthvenmurrayi* (previously placed in the genus *Trochammina*) and is probably related to it by evolution. The latter is not really biconvex, but has a strongly convex spiral side with more whorls and almost flat umbilical side. In our material, *A. ingerlisae* is, on average, smaller than *A. ruthvenmurrayi*. Charnock and Jones (1990) referred to some specimens of the new species as *Trochammina subvesicularis*. We agree with Charnock and Jones (1990) that occasional specimens occur in the North Sea Paleocene (e.g., in well 211/19-1, side wall core at 5840 ft.), which are planoconvex and have as few as 5.5 (or even 4.5) chambers in the last whorl (Gradstein *et al.*, 1994, pl. 1, fig. 5; Charnock & Jones, 1990, pl. 22, fig. 3). Such specimens we refer to as *Insculptarenula* aff. *subvesicularis* (see under *I.* aff. *subvesicularis*). Detailed morphological populations studies of the Campanian through Paleocene plexus of *A. ingerlisae, A. rosea* and *A. ruthvenmurrayi* may shed further light on this evolutionary taxonomy.

Charnock and Jones (1990) also mention occasional specimens of their *T. subvesicularis* in Albian mudstones, offshore mid Norway. According to our observations in these strata such Albian specimens have a tighter coil than *A. ingerlisae* and, on average more (not less) chambers in the last whorl; in local well completion reports such specimens are referred to as *Trochammina (Ammoanita) "globorotaliiformis"*, and constitute a useful mid-upper Albian index. This *T. "globorotaliiformis"* may be a new taxon, or a variant of *T. abrupta* Geroch.

*Trochamina abrupta* Geroch of the middle Cretaceous Verovice Beds of Poland is less planoconvex, has more radial sutures, wider chambers, and a wider spire than *A. ingerlisae* n.sp. *Trochammina subvesicularis* Hanzliková, from the Albian (not Paleocene, see below) of Czechoslovakia has fewer chambers in the last whorl and is more strongly planoconvex, with a lobate periphery. Its chambers increase more rapidly in height.

In the North Sea and offshore Norway *A. ingerlisae* is an easily recognizable, elegantly built, albeit rare species, typical for the lower upper Paleocene (Zone NSR2A) bathyal shales.

## Genus *Insculptarenula* Loeblich & Tappan, 1985

**Remarks:** Loeblich and Tappan (1985) described the genus *Insculptarenula* to include predominantly Cretaceous trochamminids that have a flat or concave spiral side, and a convex ventral side with triangular chambers and straight sutures. We understand this genus to encompass the predominently Cretaceous "crassaform" species, such as *Trochammina gyroides* Cushman & Waters, 1927, *T. quinqueloba* Geroch *T. subvesicularis* Hanzliková, etc.

### ***Insculparenula* aff. *subvesicularis*** (Hanzliková)
Fig. 8

non 1955. *Trochammina subvesicularis* Hanzliková: Homola & Hanzliková, p. 402, pl. 7, figs. 1–3.
1981. *Trochammina subvesicularis* Hanzliková: Gradstein & Berggren, p. 258, pl. 9, figs. 7, 8.
1990. *Trochammina (Insculptarenula) subvesicularis* Hanzliková: Charnock & Jones, pl. 10, figs. 10–12; pl. 22, fig. 3.
1994. *Trochammina* cf. *subvesicularis* Hanzliková: Gradstein *et al.*, pl. 1, fig. 5.

**Diagnosis:** Test trochospirally coiled, with few whorls; spiral side flat; umbilical side low convex, with narrow umbilical depression; periphery acute. Outline circular to slightly lobate. Chambers triangular to trapezoidal, increase slowly in size, 4 1/2 to 5 1/2 in the last whorl. Sutures depressed; on the umbilical side the sutures are essentially straight. Wall finely aggutinated and often well silicified. Aperture extraumbilical, poorly visible, a small slit at the base of the final chamber.

**Holotype:** The types of *I.* aff. *subvesicularis* are housed in the authors' collections at Saga Petroleum, Sandvika, and at University College London.

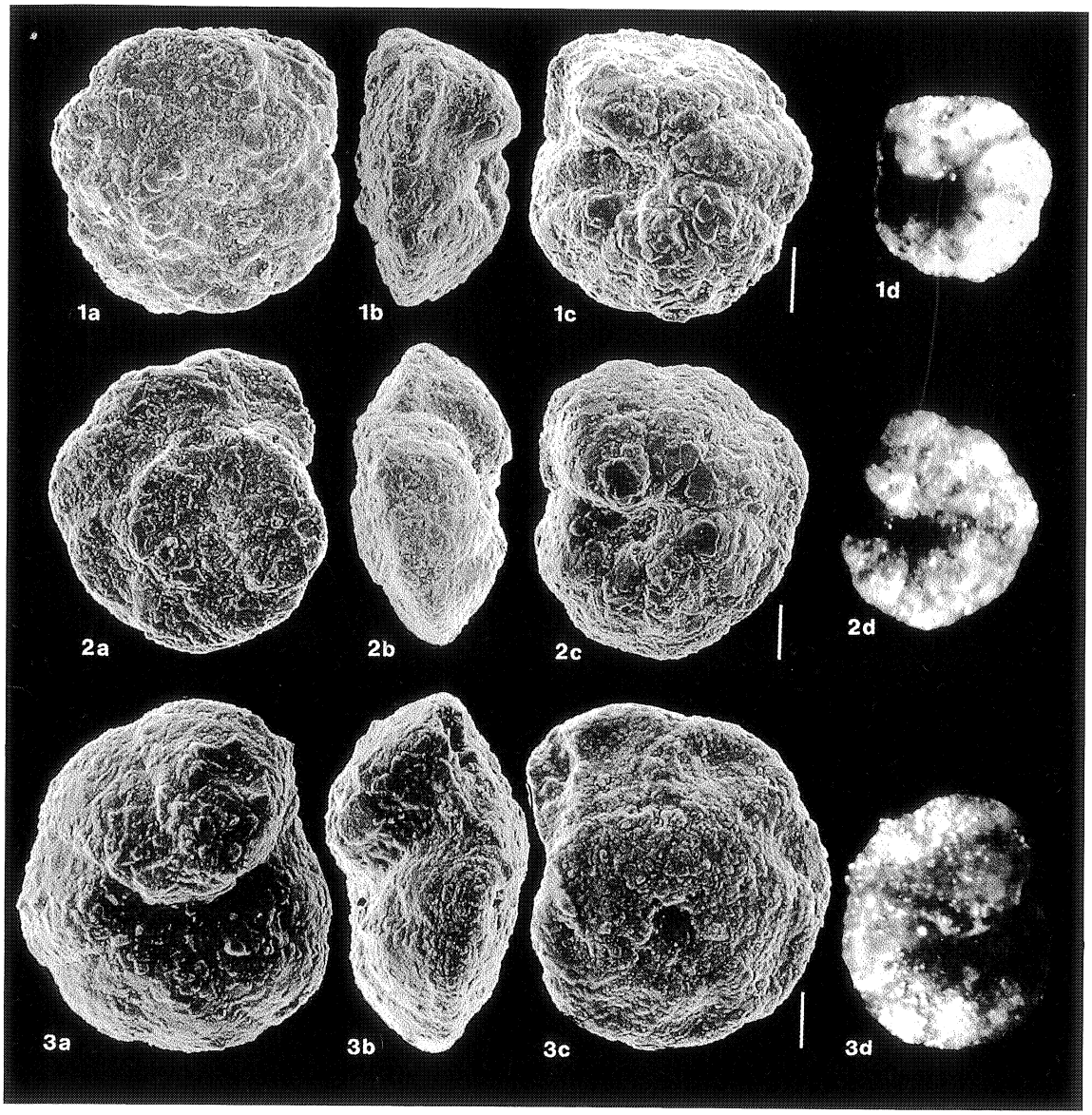



**Fig. 7.** SEM and reflected light photographs (magnifications as on original). **1a-d** – *Ammoanita ingerlisae* Gradstein & Kaminski, n.sp., holotype, Conoco 211/19-1 at 5840 ft (1d x 140); **2a-d** – *Ammoanita ingerlisae* Gradstein & Kaminski, n.sp., Conoco 211/19-1 at 5840 ft (2d x 140); **3a-d** – *Ammoanita ingerlisae* Gradstein & Kaminski, n.sp., Lizard Springs, Trinidad (3d x 140). Length of scale bar – 50 μm

**Material, localities and horizons:** The type level is the interval of green clays between 5450 and 5850 ft in well Conoco (UK) 211/19-1, Viking Graben. Additional North Sea material derives from well Mobil (UK) 9/13-3A at 5450 ft, BP (UK) 15/20-1 at 1890 m, Hydro 35/9-2 at 1290 m, Saga 6407/2-3 at 2075 m, and Saga 34/7-9 at 1770 m. The taxon co-occurs in levels with *Ammoanita ruthvenmurray* and *A. ingerlisae* n.sp., assigned to the lower part of the *A. ruthvenmurrayi–Reticulophragmium paupera* Zone, (Zone NSR2A), early late Paleocene.

**Remarks:** This form differs from the typical *Insculptarenula subvesicularis* in its less convex umbilical chambers. With its triangular, jutting last chamber, *I.* aff. *subvesicularis* reminds us of the planktonic foraminifer *Globorotalia crassaformis*. References to *Insculptarenula subvesicularis* by Gradstein *et al.* (1994), and Charnock and Jones (1990) should be assigned to *A.* aff. *subvesicularis* or *A. ingerlisae* n.sp. (see above).

The true *I. subvesicularis* (Hanzliková) apparently belongs to the Cretaceous group of 4–5 chambered deep marine *"Trochammina"* species that possess a highly convex umbilical side, such as *I. quinqueloba* (Geroch), *I. gyroidinaeformis* (Krashenninikov), and *I. praegyroidiniformis* (Bystrova & Kossitskaja), a group which in itself requires more detailed taxonomic revision (M. Bubik, *personal communication*, 1996).

*Insculptarenula praegyroidiniformis* (Bystrova & Kossitskaja), from the Jurassic–Cretaceous boundary beds of Northern Siberia and Spitsbergen is higher conical, with a concave spiral side; the top of the chambers on the umbilical side is flattened, and there is a wider umbilical depression.

*Insculptarenula quinqueloba* (Geroch) from the Upper Jurassic and Lower Cretaceous of Poland, Atlantic and Indian Oceans has fewer chambers per whorl, radial sutures and a more planoconvex test with a more broadly rounded, and more lobate periphery.

*Insculptarenula gyroidinaeformis* (Krashenninikov) from Upper Cretaceous of the Indian Ocean and Magura flysch unit,

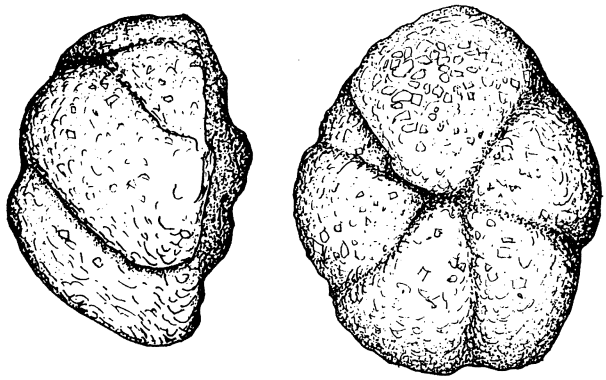


**Fig. 8.** *Insculptarenula* aff. *subvesicularis* (Hanzlikovà), x 170; Mobil 9/13-3A at 5480 ft. Redrawn after Gradstein *et al.* (1994)

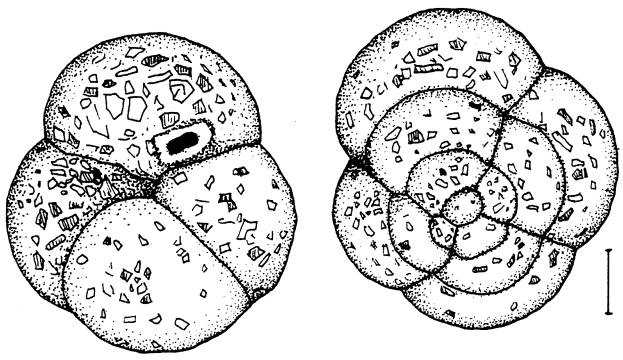


**Fig. 9.** Paratype of *Conotrochammina voeringensis* Gradstein and Kaminski, n.sp.; ODP Hole 643A, Vøring slope. Sample 643A-52X-1, 83–88 cm. Length of scale bar – 40 μm. Redrawn after Kaminski *et al.* (1990)

Poland has 5 chambers in the last whorl, and a closed umbilicus. This taxon should be compared to *I. quinqueloba*, to determine if it the stratigraphic range of the latter should be extended upwards.

*Insculptarenula gyroides* (Cushman & Waters, 1927) from the Maastrichtian Navarro Formation in Texas differs in possessing six chambers in the final whorl that are higher on the ventral side, and have longer more obliquely curved sutures on the dorsal (spiral) side.

## Family CONOTROCHAMMINIDAE Saidova, 1981

### Genus *Conotrochammina* Finlay, 1940

**Remarks:** Loeblich and Tappan (1987) reported the stratigraphical range of this genus (type species *Conotrochammina whangaia* Finlay, 1940) as Paleocene. However, *C. whangaia* is also known from the Maastrichtian in the central North Atlantic. Our finding of a new species at Site 643 extends its range into the Eocene.

### ***Conotrochammina voeringensis*** Gradstein & Kaminski, n.sp.
Fig. 9, Fig. 10 (1–3)

1990. *Conotrochammina* sp.: Kaminski *et al.*, p. 370, pl. 8, figs. 1, 2.
1990. *Trochammina* sp. 1: Charnock & Jones, p. 187, pl. 11, figs. 4–6; pl. 22, fig. 5.

**Etymology:** Named after the Vøring Plateau, where we first observed well-preserved specimens in the Eocene at ODP Site 643.
**Diagnosis:** A small, fine-grained strongly trochospiral form with sutures on the spiral side commonly aligned, and radiating outward across whorls like spokes. Aperture small, areal, oval, surrounded by a lip.
**Holotype:** Ocean Drilling Program Hole 643A, Vøring Slope, Norwegian Sea, Sample 643A-52X-1, 83–88 cm.
**Material, localities and horizons:** The types are from ODP Site 643A, Sample 643A-52X-1, 83–88 cm, Vøring Slope, Norwegian Sea, where it was observed over an interval of about 70m downward from Core 52X-1 to Core 57X-3. The species also occurs in on Haltenbanken in well Saga 6406/2-1 at 2500 m. Additional material is from greenish shales assigned to the lower part of the *A. ruthvenmurrayi–R. paupera* Zone, in Viking Graben well Conoco (UK) 211/19-1, swc. 5632 ft. Also observed in Saga 34/4-5 at 1930 m, Saga 34/4-6 at 1630 m, Saga 34/7-9 at 1620 m, Saga 25/6-2 at 1760 m, Saga 2/2-5 at 2590 m, and Mobil (UK) 9/13-3A in the interval of 5450–5840 ft. Common in "flysch-type" agglutinated assemblages in the Paleogene of the North Sea, ranging from Campanian to early/middle Eocene (Charnock & Jones, 1990, p. 187).
**Description:** Test small, high trochospire, consisting of 3 or 4 whorls, with 4 chambers per whorl. Chambers globular, with depressed sutures. On the spiral side sutures are often almost perfectly aligned, radiating outward like spokes across the whorls. The coil suture is depressed on the spiral side. Umbilicus is closed and slightly depressed. Aperture is an oval, areal opening, surrounded by a lip. Its position is is extraumbilical, exactly in the axis of trochospiral coiling. Wall medium to finely agglutinated, finely finished.
**Dimensions:** 100–250 μm.
**Remarks:** Forms assigned to *C. voeringensis* previously may have been referred to *Trochammina globigeriniformis*, var. *altiformis* Cushman & Renz (1946). The latter has fewer whorls, attains larger size, is coarser grained and has a basal, rather than an areal aperture. The new taxon differs from *C. whangaia* Finlay, the type species, in its smaller dimensions, fine grained wall, closed umbilicus, an in the presence of a lip surrounding the aperture.

### ***Conotrochammina whangaia*** Finlay, 1940
Fig. 5 (7a–b)

1940. *Conotrochammina whangaia* Finlay, p. 448, pl. 62, figs. 1–2.
1988. *Conotrochammina whangaia* Finlay: Kaminski *et al.*, p. 193, pl. 7, figs. 19–20.

**Description:** Test large, coiled in a high trochospire of 3–4 whorls, with 4–5 chambers in the last whorl. Umbilicus open; aperture a round areal opening in the centre of the apertural face. Wall relatively thick, medium to coarse grained.
**Material and locality:** Observed in ditch cuttings samples in wells 6306/10-1 at 1170 m and 6507/2-3 at 2020 m, offshore mid Norway, "inshore" from the Vøring Plateau.
**Remarks:** Specimens from the Norwegian margin are identical to those from the Danian of the Lizard Springs Formation, Trinidad. The species also has been observed in the Maastrichtian of Gabon, the Danian of the Moroccan Rif, and in the Danian of the Polish Carpathians (Kuhnt & Kaminski, 1990). Our finding of *C. whangaia* in an offshore Norway well is the first record of this species in the Norwegian Sea. It was found in strata assigned to the lower part of the *T. ruthvenmurray–R. paupera* Zone (Zone NSR2A), lower part of the upper Paleocene.

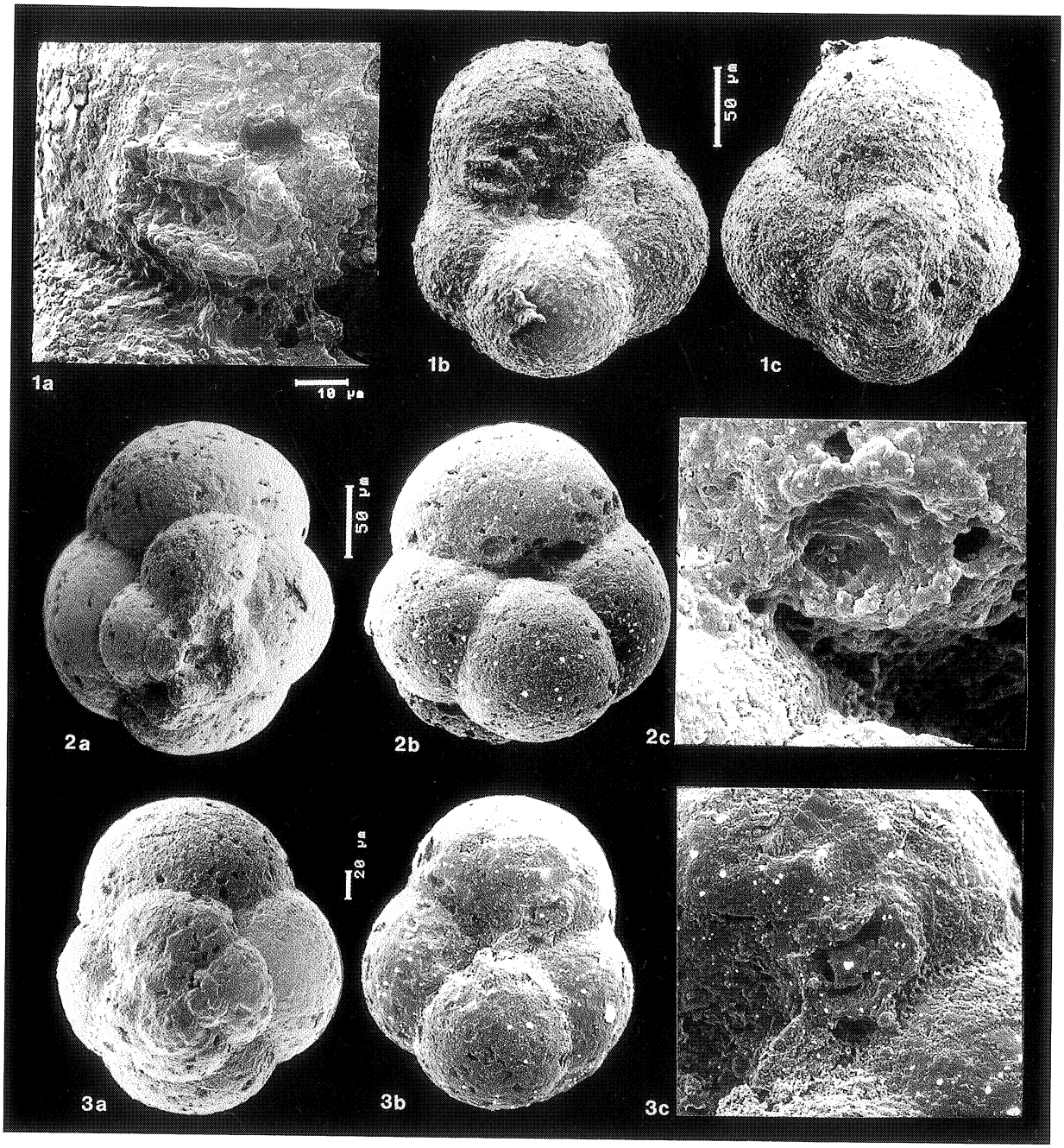



**Fig. 10.** SEM photographs. **1a-c** – *Conotrochammina voeringensis* Gradstein & Kaminski, n.sp., holotype, ODP Hole 643, Voering Plateau, Sample 643A, 57R-3, 83–85 cm; **2a-c** – *Conotrochammina voeringensis* Gradstein & Kaminski, n.sp., paratype, SAGA 34/7-9 at 1620 m; **3a-c** – *Conotrochammina voeringensis* Gradstein & Kaminski, n.sp., paratype, SAGA 34/4-6 at 1630 m (2c & 3c in the same scale like 1c)

Family AMMOSPHAEROIDINIDAE Cushman, 1927

Genus *Cystammina* Neumayer, 1889

***Cystammina sveni*** Gradstein & Kaminski n.sp.
Fig. 11, Fig. 12 (1–6)

1981. *Praecystammina* aff. *globigerinaeformis* Krashenninikov: Gradstein & Berggren, p. 258–259, pl. 9, figs. 11–15.
1982. *Cystammina globigerinaeformis* (Krashenninikov): Miller *et al.*, p. 21, pl. 2, figs. 13, 17, 21.
1989. *Ammosphaeroidina* sp.: Kaminski *et al.*, pl. 5, fig. 4.
1990. *Cystammina pauciloculata* (Brady): Charnock & Jones, pl. 16, fig. 4a–c.
1990. *Praecystammina* sp.: Kaminski *et al.*, p. 370, pl. 7, figs. 4a, b, 5.

**Etymology:** In honour of Sven Bäckström, Oslo, who assisted with the acquisition of Norwegian sample material for our study of cosmopolitan agglutinated foraminifera.

**Diagnosis:** Test compact, involute, with oval to spherical outline, strongly embracing chambers that rapidly increase in size. Chambers are rounded, not elongate, with 2 to 3 visible on one side and 3 or 3 to 4 on the other; aperture an areal slit, often with upturned corners, with rim or downward pointing overhanging lip; test wall finely agglutinated, smoothly finished.

**Holotype:** Saga 6406/8-1, 2560 m is housed in the Micropaleon-

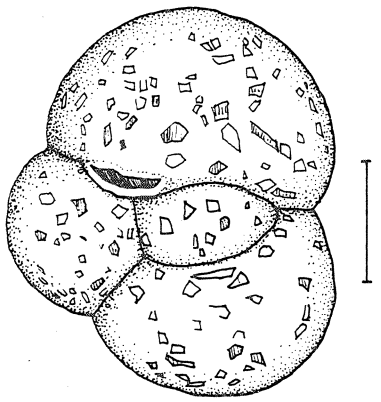
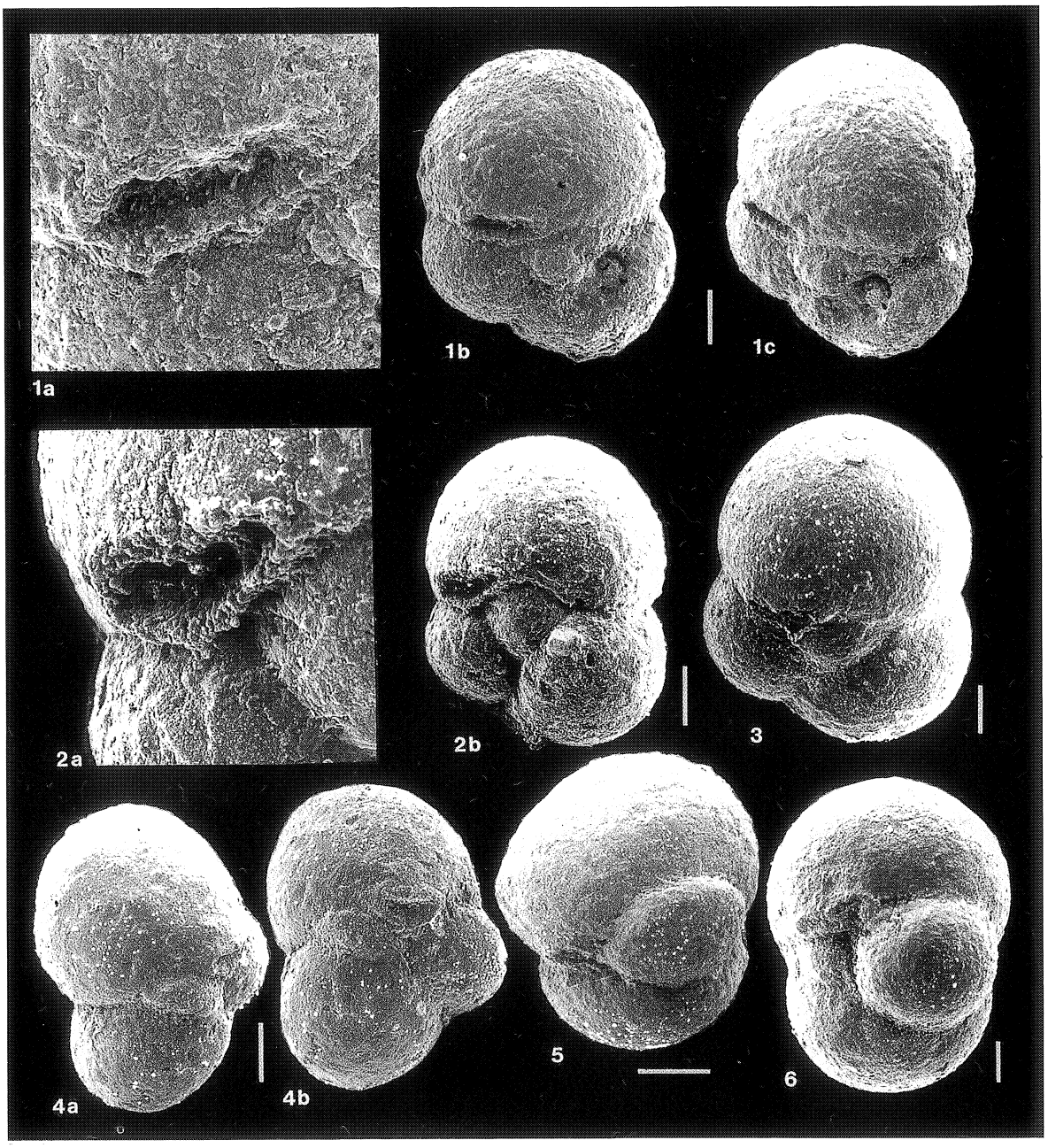


**Fig. 11.** Paratype of *Praecystammina sveni* n.sp.; ODP Hole 643A, Vøring Slope. Sample 643A-56X-3, 56–61 cm. Length of scale bar – 100 μm. Redrawn after Kaminski *et al.* (1990)

tology Collection of the British Museum of Natural History, London. The holotype is registered in slide PF62946.

**Material, localities and horizons:** The type level is the interval of Paleocene green clays at 2560 m in well Saga 6406/8-1. Additional syntypic material illustrated herein is from Paleocene green clays between 5450 and 5850 ft in well Conoco (UK) 211/19-1, Viking Graben. Additional specimens were found from the Paleocene in wells Statoil 7120/7-3 at 1320-1380 m, 7117/9-2 at 1380 m and 7119/9-1 at 1450 m, western Barents Sea (Nagy *et al.*, in press). Offshore mid Norway the species was found in the lower Eocene of ODP Hole 643A, Cores 643A-54X to -56X, and in Hydro 6407/7-1 at 1730 m and Saga 6407/2-3 at 1820 m. In the Viking and Central grabens it occurs in wells Hydro 34/8-1 at 1898 m, Saga 34/4-5 at 1920 m, Mobil (UK) 9/13-1 at 6600 m, Mobil (UK) 9/13-3A at 5810 m, Mobil (UK) 9/13-5 at 7260 m, Total (UK) 9/10B-1 at 2345 m, Total (UK) 3/25-1 at 2430 m, Danish North Sea A-2 at 5940 ft, Danish North Sea E-1 at 6680 ft, BP (UK) 15/20-1 at 1770 m, BP 15/20-2 at 1905 m, Shell (UK) 22/6-1 at 7660 ft, Phillips (UK) 22/14-1x at 7650 ft, Shell (UK) 29/3-1 at



8790 ft, Shell (UK) 30/19-1 at 8890 ft, and Saga 2/2-4 at 2620 m. In the North Sea and offshore Norway, the species occurs in the *Trochammina ruthvenmurrayi–Reticulophragmium paupera* Zone, *Subbotina patagonica* Zone and lower *Ammomarginulina aubertae* Zone of Gradstein *et al.* (1988), upper Paleocene to lower part of Middle Eocene (Fig. 8). Its range extends downward in Upper Cretaceous strata (Campanian).

In Trinidad rare specimens occur in the upper Paleocene (Zone P4) of the Lizard Springs Formation. It is also observed in flysch-type agglutinated assemblages of Maastrichtian to early Eocene age in the Atlantic region, Labrador Shelf, Alpine–Carpathian region, northern Spain, and northern Morocco; and in upper Paleocene to middle Eocene abyssal assemblages at DSDP Site 112 and at ODP Site 647 in the Labrador Sea.

The species is typical for Campanian to Paleocene middle bathyal or deeper marine sediments, with rare specimens in upper bathyal strata. It ranges into the middle Eocene in abyssal assemblages from DSDP/ODP sites.

**Description:** Test globose, streptospiraly coiled with 3 or 3.5 chambers per whorl. The chambers are elongate to spherical, rapidly increase in size and strongly embrace in a tight, involute manner; there are 2 or 2–3 chambers visible on one side and 3 or 3–4 on the other. The wall is smooth, very finely agglutinated, and often well silicified; the aperture is an areal slit with a distinct lip.

**Dimensions:** Specimens range between 100 and 350 μm in diameter.

**Remarks:** *Cystammina sveni* n.sp., in the North Sea and offshore Norway resembles *C. pauciloculata* (Brady). The latter is less tightly coiled, with 4 to 5 chambers visible form the exterior and has more elongate chambers. Transitional morphotypes between the two taxa occur, and the two taxa may be phylogenetically related, with *C. pauciloculata* extending to the Recent. *Cystammina sveni* n.sp. probably derived from the Upper Cretaceous *Praecystammina globigerinaeformis* Krashenninikov.

*Praecystammina globigerinaeformis* Krashenninikov differs from *C. sveni* n.sp. in having a less tightly coiled, more evolute test, chamber that increase in size more slowly, more (3–5) chambers visible per whorl, and an aperture that is round in juveniles, becoming oval to a slit like in more developed specimens.

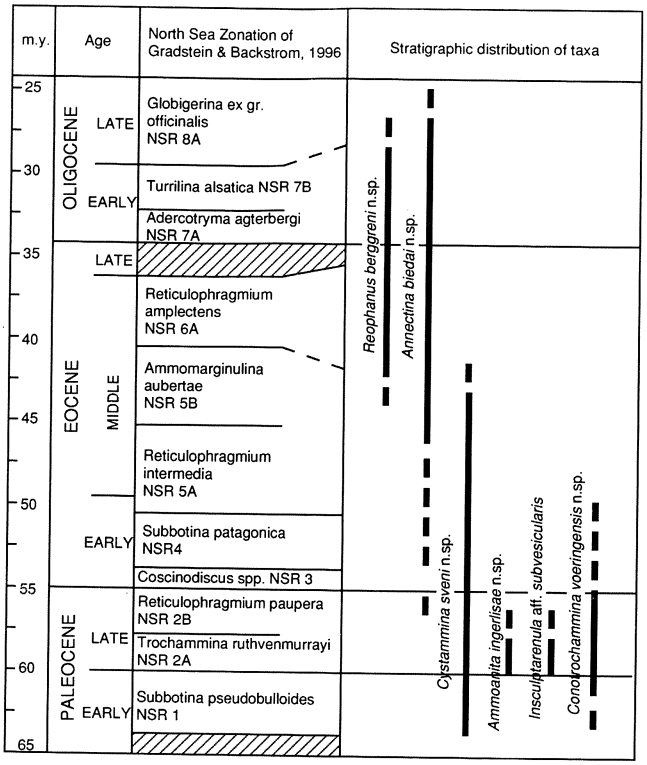



**Fig. 13.** Stratigraphical distribution of the new species in the Palaeogene of the North Sea and offshore Norway. The zonation is after Gradstein & Bäckström (1996)

## CONCLUSIONS

The five new species of deep-water agglutinated foraminifera described herein have distinct stratigraphic ranges in the Paleogene of the Central North Sea and offshore Central Norway (Fig. 13). The stratigraphic ranges of taxa are expressed in terms of the probabilistic NSR (North Sea RASC) biozonation for the Cenozoic of the northern North Sea and Haltenbanken (Gradstein & Bäckström, 1996). At present, our observations of *Annectina biedai* n.sp. and *Reophanus berggreni* n.sp. are limited to the North Sea area. The two Paleocene species (*C. sveni* n.sp. and *C. voeringensis* n.sp.) have also been observed as far north as the western Barents Sea (J. Nagy & M. A. Kaminski, *unpublished observations*). Another species of *Conotrochammina* (*C. whangaia*) has been observed in the North Sea for the first time, emphasizing the bipolar (cosmopolitan) nature of this New Zealand species. At least one of the new species (*Ammoanita ingerlisae* n.sp. may be widely distributed of the Atlantic and western Tethys.

Extensive drilling in offshore mid Norway has established that the deep water agglutinated biofacies in many wells extends back to the Turonian, and that from the Campanian to Eocene, a remarkably homogeneous agglutinated fauna may have persisted regionally. Future studies may document the pre-Paleogene ranges and distribution of the taxa involved, and provide links to the Cretaceous deep water assemblages from Central Europe and circum North Atlantic sites.

### Acknowledgements

We thank John Whittaker, Miroslav Bubik, Sven Bäckström, Ewa Malata, and Jenő Nagy for advice and comparative sample material. We also thank Jim Davey (UCL) for assistance with the SEM, and Mrs. Schudl (Kiel), for assistance with the photography. Jenő Nagy, Miroslav Bubik, and Tor Eidvin commented on a version of this paper. This is contribution no. 56 of the Deep-Water Agglutinated Foraminiferal Project.

**Fig. 12.** SEM photographs. **1a-c** – *Praecystammina sveni* Gradstein & Kaminski, n.sp., holotype, Saga 6406/8-1 at 2560 m; **2a, b** – *Praecystammina sveni* Gradstein & Kaminski, n.sp., paratype, Mobil 35/11-1 at 1330 m; **3** – *Praecystammina sveni* Gradstein & Kaminski, n.sp., paratype, Saga 6406/8-1 at 2560 m; **4a, b** – *Praecystammina sveni* Gradstein & Kaminski, n.sp., Conoco 211/19-1 at 5630 ft, SWC; **5** – *Praecystammina sveni* Gradstein & Kaminski, n.sp., Conoco 211/19-1 at 5630 ft; **6** – *Praecystammina sveni* Gradstein & Kaminski, n.sp., paratype, Saga 6406/8-1 at 2560 m (1a & 2a x 650). Legth of scale bar – 50 μm

## REFERENCES


Charnock, M. A. & Jones, R. W., 1990. Agglutinated Foraminifera from the Palaeogene of the North Sea. In: Hemleben *et al.* (eds.), *Paleoecology, Biostratigraphy, Paleoceanography and Taxonomy of Agglutinated Foraminifera*, NATO ASI Series C, 327, Kluwer Academic Publ., pp. 139–244.

Finlay, H. J., 1940. New Zealand Foraminifera: Key Species in Stratigraphy – no. 4. *Transact. Royal Soc. New Zealand*, 69: 448–472.

Gradstein, F. M. & Berggren, W. A., 1981. Flysch-type agglutinated foraminifera and the Maestrichtian to Paleogene history of the Labrador and North Seas. *Marine Micropal.*, 6: 211–268.

Gradstein, F. M., Kaminski, M. A., & Berggren, W. A., 1988. Cenozoic foraminiferal biostratigraphy, Central North Sea. In: Rögl, F. & Gradstein, F. M. (eds.), *Proceedings 2nd Workshop on Agglutinated Foraminifera, Vienna 1986. Abh. Geol. Bundesanst.*, 41, pp. 97–108.

Gradstein, F. M. & Kaminski, M. A., 1989. Taxonomy and biostratigraphy of new and emended species of Cenozoic deep-water agglutinated foraminifera from the Labrador and North Seas. *Micropaleontology*, 35, 1: 72–92.

Gradstein, F. M., Kaminski, M. A., Berggren, W. A., Kristiansen, I. L., & D'Iorio, M., 1994. Cainozoic biostratigraphy of the North Sea and Labrador Shelf. *Micropaleontology*, 40 (suppl): 1–152.

Gradstein, F. M. & Bäckström. S. A., 1996. Cainozoic biostratigraphy and palaeobathymetry, northern North Sea and Haltenbanken. *Norsk Geol. Tidsskrift*, 76: 3–32.

Homola, V. & Hanzliková, E., 1955. Biostratigraphical, tectonical and lithological studies in the Tesin district, *Sborn. Ústr. Úst. Geol.*, 21 (1954): 1–502 (in Czech with English summary).

Kaminski, M. A., Gradstein, F. M., Berggren, W. A., Geroch, S. & Beckmann, J.-P., 1988. Flysch-type agglutinated foraminiferal assemblages from Trinidad: Taxonomy, stratigraphy and paleobathymetry. In: Rögl, F. & Gradstein, F.M. (eds.), *Proceedings of the 2nd Workshop on Agglutinated Foraminifera, Vienna 1986, Abh. Geol. Bundesanst.*, 41, pp. 155–228.

Kaminski, M. A. Gradstein, F. M. & Berggren, W. A., 1989. Paleogene benthic foraminiferal stratigraphy and paleoecology at Site 647, southern Labrador Sea. In: Arthur, M. A. Srivastava S., *et al.* (eds.), Proc. *O. D. P., Scient. Rests*, 105: 705–730.

Kaminski, M. A., Gradstein, F. M., Goll, R. M., & Greig, D., 1990. Biostratigraphy and paleoecology of deep water agglutinated foraminifera at ODP Site 643, Norwegian–Greenland Sea. In: Hemleben *et al.*, (eds.), *Paleoecology, Biostratigraphy, Paleoceanography and Taxonomy of Agglutinated Foraminifera*, NATO ASI Series C, 327, Kluwer Acad. Publ., pp. 345–386.

Kaminski, M. A., Gradstein, F. M. & Geroch, S., 1992. Uppermost Jurassic to Lower Cretaceous deep-water benthic foraminiferal assemblages from Site 765 on the Argo Abyssal Plain. In: Gradstein, F. M., Ludden, J. N. *et al.* (eds.), *Proc. O. D. P., Scient. Rests.*, 123: 239–269.

Kaminski, M. A., Kuhnt, W. & Radley, J. D., 1996. Palaeocene–Eocene deep water agglutinated foraminifera from the Numidian Flysch (Rif, Northern Morocco): their significance for the palaeoceanography of the Gibraltar Gateway. *J. Micropal.*, 15: 1–19.

King, C., 1989. Cenozoic of the North Sea. In: Jenkins, D. G. & Murray, J. W. (eds.), *Stratigraphical atlas of fossil foraminifera, second edition.* Ellis Horwood, Ltd. Chichester, pp. 418–489.

Kuhnt, W. & Kaminski, M. A., 1990. Paleoecology of Late Cretaceous to Paleocene deep-water agglutinated foraminifera from the North Atlantic and western Tethys. In: Hemleben *et al.*, (eds.), *Paleoecology, Biostratigraphy, Paleoceanography and Taxonomy of Agglutinated Foraminifera*, NATO ASI Series C, 327, Kluwer Acad. Publ., pp. 433–506.

Loeblich, A. R. & Tappan, H., 1987. *Foraminiferal Genera and their Classification.* van Nostrand Reinhold, New York, 970 pp.

Matsushita, S. & Kitazato, H., 1990. Seasonality in the benthic foraminiferal community and the life history of *Trochammina Hadai* Uchio in Hamana Lake, Japan. In: Hemleben *et al.*, (eds.), *Paleoecology, Biostratigraphy, Paleoceanography and Taxonomy of Agglutinated Foraminifera*, NATO ASI Series C, 327, Kluwer Acad. Publ., pp. 695–715.

Miller, K. G., Gradstein, F. M. & Berggren, W. A., 1982. Late Cretaceous to early Tertiary agglutinated benthic foraminifera in the Labrador Sea. *Micropaleontology*, 28: 1–30.

Nagy, J., Kaminski, M. A., Johnsen, K., & Mitlehner, A. G. (in press). *Foraminiferal, palynomorph, diatom biostratigraphy and paleoenvironments of the Torsk Formation: a reference section for the Paleocene–Eocene transition in the western Barents Sea.* Grzybowski Foundation Spec. Publ., 5.

Samuel, O., 1977. Agglutinated foraminifers from Paleogene flysch formations in West Carpathians of Slowakia. *Zapadne Karpaty, Serie Paleontol.*, 2–3: 7–70.

Seiglei, G. A. & Baker, M. B., 1987. *Ammoanita rosea*, new genus and new species of deep water Trochamminidae, Foraminiferidae. *Proc. Biol. Soc.* Washington, D. C., 100, 3: 491.

Verdenius, J. G. & van Hinte, J. E., 1983. Central Norwegian–Greenland Sea: Tertiary Arenaceous Foraminifera, Biostratigraphy and Environment. In: Verdenius, J. G., van Hinte, J. E. & Fortuin, A. R. (eds.), *Proceedings First Workshop on Arenaceous Foraminifera, Amsterdam.* IKU Publ., 108, Trondheim, pp. 173–224.


## Streszczenie

### NOWE GATUNKI GŁĘBOKOWODNYCH OTWORNIC AGLUTYNUJĄCYCH Z OSADÓW MORZA PÓŁNOCNEGO I MORZA NORWESKIEGO

*Felix M. Gradstein & Michael A. Kaminski*


Paleogeńskie osady z centralnej części Morza Norweskiego i wybrzeży środkowej Norwegii zawierają zróżnicowane gatunkowo zespoły głębokowodnych otwornic aglutynujących, wykorzystywane do regionalnej korelacji stratygraficznej. Wiele z nich jest formami „kosmopolitycznymi", opisanymi po raz pierwszy z polskich Karpat fliszowych, ale część z nich znana jest tylko z rejonu Morza Norweskiego i Morza Północnego. Opisy taksonomiczne większości otwornic aglutynujących tego obszaru zostały już opublikowane wcześniej (Gradstein & Berggren, 1981; Verdenius & van Hinte, 1983; King, 1989; Gradstein & Kaminski, 1989; Charnock & Jones, 1990; Gradstein *et al.*, 1994). W tej pracy przedstawiono opisy form należących do cyclaminidów, skupiając się dodatkowo na ich znaczeniu dla lokalnej i regionalnej korelacji stratygraficznej. Próby do badań pochodziły z kilkudziesięciu otworów wiertniczych, których położenie przedstwiono na Fig. 1.

Wyróżniono pięć nowych gatunków otwornic aglutynujacych (Figs. 2–7, 9–12): *Annectina biedai* n.sp. (eocen–oligocen), *Reophanus berggreni* n.sp. (eocen–dolny oligocen), *Ammoanita ingerlisae* n.sp. (dolna część górnego paleocenu), *Conotrocham-*

*mina voeringensis* n.sp. (kampan–dolna część środkowego eocenu) oraz *Cystammina sveni* n.sp. (kampan–środkowy eocen).

Opisano również inne taksony (spoza rodziny Cyclaminidae), wyróżniane wcześniej w randze otwartej nomenklatury zoologicznej, nadając im status formalny. Opisano po raz pierwszy z tego regionu gatunek *Conotrochammina whangaia* Finlay. Takson ten jest kosmopolityczny, bowiem znany jest on z osadów tego wieku również z rejonu Nowej Zelandii i Trinidadu. Takson *Insculptarenula* aff. *subvesicularis* (Fig. 8) występujący w osadach paleocenu Morza Północnego jest prawdopodobnie nowym gatunkiem z grupy trochamminidów globorotaliopodobnych, opisanych z innych obszarów w osadach kredy i paleocenu.

Przedstawiono również uwagi taksonomiczne dotyczące gatunku *Insculptarenula subvesicularis* Homola et Hanzliková, opisanego z osadów albu Karpat, a także *Reophanus berggreni* n.sp., *Anectina biedai* n.sp. i *Conotrochammina voeringensis* n.sp., znanych jedynie z osadów w rejonie Morza Północnego.

Przedstawiono zasięgi stratygraficzne nowych gatunków na tle biozonacji osadów paleogenu Morza Północnego i Morza Norweskiego (Fig. 13).

Intensywne wiercenia prowadzone u wybrzeży środkowej Norwegii pozwoliły udokumentować w pewnych rejonach ciągłość biofacji głębokowodnych otwornic aglutynujących od turonu. Na tych obszarach stwierdzono obecność bardzo podobnych zespołów otwornic aglutynujących w osadach od kampanu do eocenu. Dalsze badania pozwolą zapewne powiązać ewolucję wyróżnionych taksonów z zespołami znanymi z osadów w Europie Środkowej oraz z szeregu wierceń w północnej części Atlantyku.