

## **PLECTOERATIDUS SUBARCTICUS, N.GEN., N.SP., A NEW AGGLUTINATED FORAMINIFER FROM THE UPPER CRETACEOUS OF THE WESTERN BARENTS SEA**

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**Abstract:** We describe the new foraminiferal genus and species *Plectoeratidus subarcticus* n.gen. n.sp., from the Upper Cretaceous deep-water deposits of the Kviting and Kveite formations in the western Barents Sea. The genus is characterised by its planispiral-biserial-uniserial chamber arrangement, terminal aperture and lateral compression. The biometric analysis of test ontogenesis has been applied to document its dimorphism attributed to megalospheric and microspheric generations. This taxon may represent an evolutionary transition between the Cretaceous genera *Spiroplectamina* or *Bolivinopsis* and the Cenozoic genus *Eratidus*. The taxon appears to be endemic to the flysch-type agglutinated foraminiferal assemblages in the Norwegian Sea area.

**Key words:** Foraminifera, Late Cretaceous, new genus, new species, biometrics.

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### **INTRODUCTION**

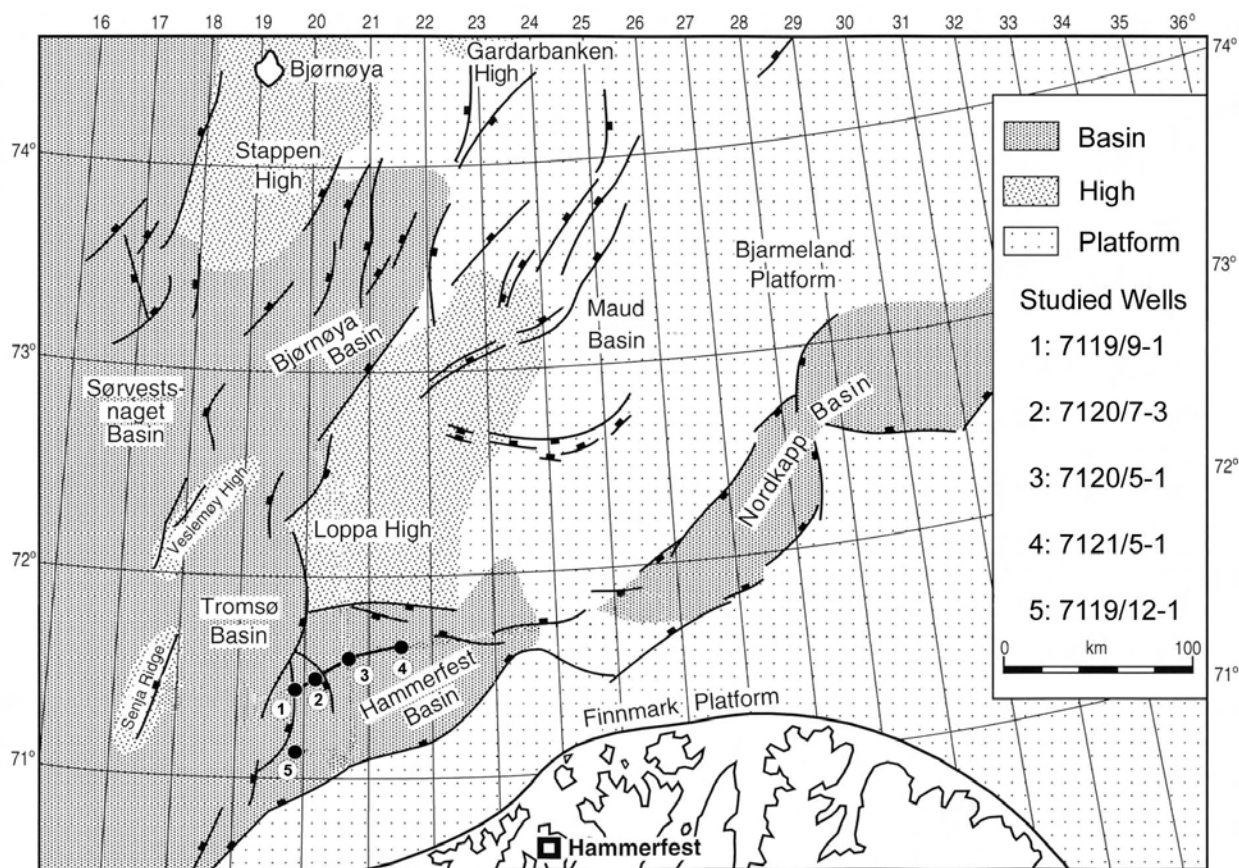
The Kviting and Kveite formations of the western Barents Sea contain rich and well-preserved assemblages of Deep-Water Agglutinated Foraminifera consisting of a mixture of Tethyan and Boreal species (Setoyama *et al.*, 2008). Nagy *et al.* (1997, 2000, 2004) studied the foraminifera from the Paleogene Torsk Formation recovered from exploration wells drilled in the western Barents Sea, and established a regional biozonation. Although the underlying Upper Cretaceous formations have been sampled and studied by petroleum companies operating in the area, no foraminiferal studies have ever been published.

Our current goal is to study the Cretaceous micropalaeontology of the western Barents Sea to establish the regional biostratigraphy and investigate the role this seaway played in faunal interchange between the Arctic and Atlantic Oceans. This is the first in a series of studies that will investigate the foraminiferal content and biostratigraphy of the Kviting and Kveite formations in the western Barents Sea. The purpose of this paper is to describe a distinctive new taxon from the western Barents Sea that may shed light on the evolution of the modern agglutinated foraminiferal genus *Eratidus*.

### **LITHOSTRATIGRAPHY AND MICROFOSSIL ASSEMBLAGES**

The lithostratigraphic definition of the Mesozoic and Cenozoic sequences of the Barents Sea was outlined by Worsley *et al.* (1988). The Lower Cretaceous, clay-dominated Nygrunnen Group covers unconformably the mid-Cretaceous Kolmule Formation and is restricted to south-western basinal areas. The Nygrunnen group comprises the Kveite and Kviting formations.

The Kveite Formation consists of greenish-grey to grey shales and claystones interbedded by thin limestones and siltstones with occasional tuffaceous and/or glauconitic components. Thick sequences of this unit are found in the Tromsø Basin and the Ringvassøy-Loppa Fault Complex thinning eastwards into the Hammerfest Basin and changing laterally into the more sandy and carbonaceous Kviting Formation. A deep open shelf with normal circulation was suggested as the depositional environment of the Kveite Formation (Worsley *et al.*, 1988). In our study, this formation is recorded in wells 7119/9-1, 7119/12-1 and 7120/7-3. The foraminiferal assemblage is diverse and abundant. The assemblage is generally dominated by agglutinated foraminifera, especially by tubular forms, and taxonomically similar



**Fig. 1.** Location of the studied wells in the western Barents Sea (from Nagy *et al.*, 2004, modified)

to Late Cretaceous Tethyan assemblages of the *Caudammina gigantea* Zone (Geroch & Nowak, 1984) with taxa such as *Caudammina* spp., *Paratrochamminoides* spp., *Haplophragmoides* spp., *Recurvoides* spp. and *Gerochammina* spp. (Setoyama *et al.*, 2008).

The Kviting Formation is composed of calcareous sandstones interbedded with sandy and glauconitic mudstones. This formation has been found only in the central and eastern parts of the Hammerfest Basin. The depositional environment of this unit was indicated as a deep to shallow shelf with normal circulation (Worsley *et al.*, 1988). This formation is found in wells 7120/5-1 and 7121/5-1. Its foraminiferal assemblage is comprised almost exclusively of agglutinated foraminifera, but less diverse and less abundant than that of the Kveite Formation. The assemblage is dominated by *Haplophragmoides* spp. and *Recurvoides* spp. rather than tubular forms as in the Kveite Formation, and the preservation of foraminiferal specimens is more variable than in the Kveite Formation.

## MATERIAL AND METHODS

We examined picked slides from samples collected at 10-m intervals in five exploration wells drilled in the western Barents Sea (Fig. 1). Ditch cutting samples were washed

over a 63  $\mu\text{m}$  sieve using standard industrial procedures, and foraminifera were picked into cardboard slides. We examined picked slides and selected specimens of the new species, which were mounted into separate reference slides and deposited in the collections of the Department of Palaeontology, Natural History Museum, London and of the Grzybowski Foundation, Geological Museum, Jagiellonian University, Kraków. Photographs were made using Canon PowerShot A640 digital camera mounted on a Zeiss Stemi-2000C stereomicroscope. Biometric studies were done on the type specimens based on the analysis of test ontogenesis (ATO) (Tyszka, 2004). The ATO method focuses on measurements of dimensions (e.g. heights and widths) of successive chambers. We measured the internal parts of chambers encircled by internal surfaces of the wall. In order to study ontogenetic trends, we plotted these variables against each other as well as against chamber number. The chamber numbering system does not refer to the first chamber (proloculus) due to reasons discussed elsewhere (Tyszka, 2004). We referred to the first biserial chamber as "chamber nr 1", counting all ontogenetically younger chambers forwards (1, 2, 3 ...) and all older chambers backwards (0, -1, -2 ...). The ATO method enables separation of closely-related taxa and/or identification of intraspecific polymorphism (e.g., dimorphism expressed in two generations of the same species).



## SYSTEMATIC PALAEOONTOLOGY

Superfamily SPIROPLECTAMMINACEA Cushman,  
1927

Family SPIROPLECTAMMINIDAE Cushman, 1927

Subfamily SPIROPLECTAMMININAE Cushman, 1927

Genus *Plectoeratidus* Kaminski, Setoyama & Tyszka,  
n.gen.

Type species *Plectoeratidus subarcticus* Kaminski,  
Setoyama & Tyszka, n.sp.

**Description:** Test small, elongate, flattened, early portion planispirally enrolled, with numerous broad low chambers enlarging rapidly and forming about one and a half to two whorls, later uncoiled biserial, and finally rectilinear, with broad and centrally arched chambers, rectilinear portion of the test of lesser diameter than the coil. Wall agglutinated, very thin, silicified, so that the inner structure of an entire specimen is visible in immersion in transmitted light. Aperture single, areal in the biserial portion, later terminal.

**Remarks:** Differs from the Eocene–Holocene genus *Eratidus* in possessing a biserial stage before becoming terminally uniserial, and from *Ammobaculoides* and *Spiroplectella* in its much compressed test shape that is more reminiscent of *Eratidus*. *Plectoeratidus* differs from *Bolivinopsis*, which lacks any uniserial part and shows a much more elongated biserial stage with an interiomarginal arch-like aperture.

**Range:** Campanian–Maastrichtian (possibly Early Oligocene according to Charnock & Jones, 1990).

*Plectoeratidus subarcticus* Kaminski, Setoyama  
& Tyszka, n.sp.  
Fig. 2A–E

1990. *Eratidus foliaceus* (Brady): Charnock & Jones, p. 181, pl. 9, fig. 10 and pl. 20, fig. 9a,b.

**Derivation of name:** From its occurrence in the subarctic Barents Sea shelf, offshore Norway.

**Type locality:** western Barents Sea, Well 7119/9-1, 1540 m.

**Type level:** Campanian–Maastrichtian, *Caudammina gigantea* Zone (*sensu* Geroch & Nowak, 1984)

**Occurrence:** In the western Barents Sea, specimens were recovered from the *Caudammina gigantea* Zone. This species occurs often, but in a small number in our samples. We recorded twenty five specimens in well 7119/9-1, seven in 7119/12-1, seventeen in 7120/7-3, twelve in 7120/5-1 and none in 7121/5-1.

**Description:** Test free, small, originally compressed, comprised of an initial planispiral part of two whorls with about 12–16 chambers, followed by a biserial stage of up to three pairs of chambers and then a rectilinear stage consisting of a few (typically one or two) chambers. Chambers in the planispiral portion are globular or lenticular in shape and increase in size rapidly. Chambers in the biserial and uniserial portion increase in size slowly with some variations (Figs 2, 3), and are up to two and a half times as broad as they are high. Chambers in the rectilinear portion may be more arched or tapered toward the aperture. There is no obvious difference in the test morphology between the megalospheric and microspheric generation, although the biometric studies based on ATO method (see Biometrics) indicate that the two generations have different growth rates. Megalospheric forms tend to show a higher growth rate of chambers (Fig. 4). The aperture in the initial planispiral portion is areal, located near the base of the final chamber. In the biserial portion, the aperture is areal. In the rectilinear part the aperture is terminal, slit-like, and a short neck may be present. Wall thin, coarsely agglutinated, comprised mostly of quartz particles, with much silicified cement.

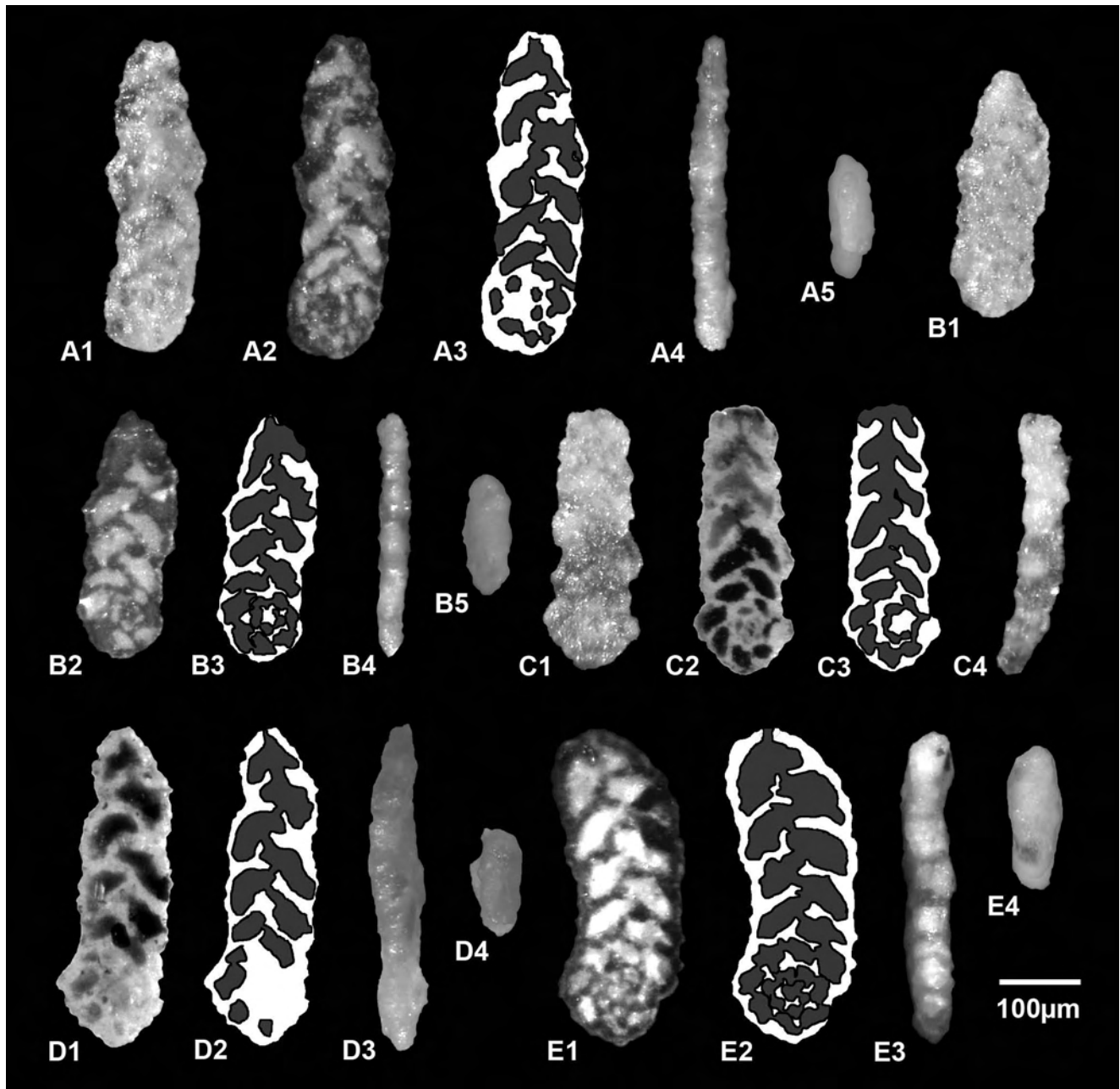
## Dimensions:

Specimen No.	Holo-type	Paratype				
		1	2	3	4	5
Total length (µm)	440	350	370	450	440	335
Width across the planispire (µm)	130	120	140	150	170	140
Maximum width (µm)	150	130	140	150	170	140
Maximum thickness (µm)	30	45	55	40	70	40
No. of chambers in the spiral part	>8	>12	>11	>3	16	>7
No. of chambers in the biserial part	8	6	4	8	8	5
No. of chambers in the uniserial part	1	1	2+	1	0	1

**Biometrics:** The ATO method (see description above) documents two ontogenetic trends plotted in Figs 3 and 4. Three specimens, paratype 1, 4 and 5 (Fig. 2B, E, F), show steeper slopes of correlation lines defined by a factor ranging between 0.3–0.4. The other specimens (Fig. 2A, C, D) present more gentle slopes with factors between 0.09 and 0.17 (Fig. 4). This distinct difference in slopes allows separation of two morphotypes most likely representing two generations of the same species. Paratype 4 (Fig. 2E) is the most instructive because it presents a large, well-visible proloculus (ca 17 µm). This is likely to be a megalospheric form that also shows a steeper slope representing rapidly growing biserial chambers with chamber heights increasing relatively faster than their widths (Fig. 3). By analogy, other specimens revealing steep correlation lines are also interpreted as megalospheric forms. In contrast, microspheric specimens show more gentle slopes defined by chambers nearly equal in size, both in the biserial and uniserial parts.

**Remarks:** This species bears superficial resemblance to *Eratidus gerochi* Kaminski & Gradstein, which is known from the Eocene of the Carpathians and the Labrador Margin (Kaminski & Gradstein, 2005). It differs in its planispiral–biserial–uniserial coiling. Charnock and Jones (1990) illustrated a specimen from the Lower Oligocene of the North Sea as *Eratidus foliaceus* (Brady) that clearly possesses a biserial part following the initial coiled portion of the test. However, the modern species *E. foliaceus* described by Brady (1881) has much broader chambers and lacks an intermediate biserial stage. We observed additional specimens of *Plectoeratidus subarcticus* in samples from the Upper Cretaceous of exploration wells drilled in the southern Norwegian Sea west of the Shetland Islands.

*Ammobaculoides phaulus* described by Loeblich and Tappan (1950) from the Lower Cretaceous of Kansas also resembles *P. subarcticus* in its flattened test and chamber arrangement, but shows a more rounded periphery and somewhat smaller size. This species might be included into *Plectoeratidus* based on further detailed studies of the type specimens. The phylogenetic origins of our new genus are obscure. The genus *Spiroplectammina* has planispiral–biserial coiling and an organically-cemented wall, and this genus is known from the Lower Carboniferous. However, this genus lacks the compressed morphology that *Plectoeratidus* displays. It is not unreasonable to suggest that *Plectoeratidus* evolved from a *Spiroplectammina*-like ancestor. The planispiral–biserial genus *Bolivinopsis* is another possible candidate because this genus displays compressed morphology. However, the Late Cretaceous representative of this genus *Bolivinopsis rosula* is a species described from the Chalk Sea, and has a calcareous-cemented wall. We speculate that *Plectoeratidus* is more likely descended from a *Spiroplectammina*-like form. For this reason, we place it in the Subfamily Spiroplectammininae Cushman, 1927.



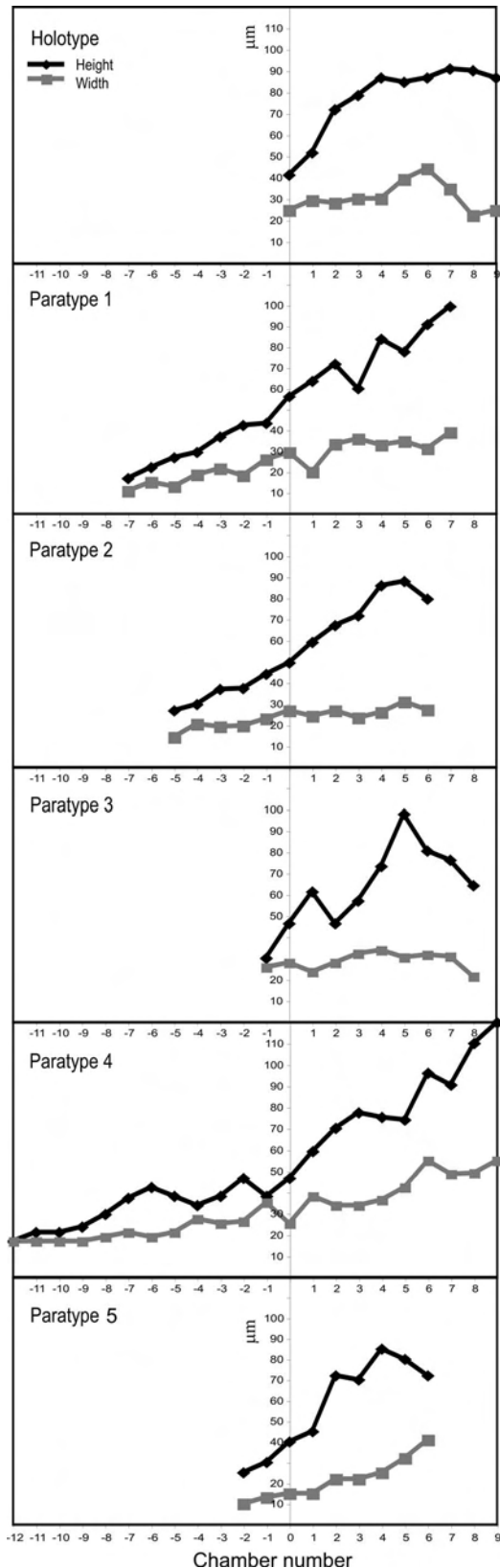
**Fig. 2.** **A** – *Plectoeratidus subarcticus* n.gen., n.sp., Holotype (BMNH PF68304), Well 7119/9-1, 1540 m. Microspheric specimen with two uniserial chambers, showing terminal position of the aperture, **B** – *Plectoeratidus subarcticus* n.gen., n.sp., Paratype 1 (BMNH PF68305), Well 7119/9-1, 1570 m. ?Microspheric specimen with well-developed biserial chambers and a terminal aperture on a produced neck, **C** – *Plectoeratidus subarcticus* n.gen., n.sp., Paratype 2 (UJ 212P1), Well 7119/9-1, 1530 m. Microspheric specimen with two uniserial chambers and well-developed initial spire. Aperture is broken, **D** – *Plectoeratidus subarcticus* n.gen., n.sp., Paratype 3 (UJ 212P2), Well 7120/7-3, 1390 m. ?Microspheric specimen with tapered last chamber, showing terminal aperture, **E** – *Plectoeratidus subarcticus* n.gen., n.sp., Paratype 4 (UJ 212P3), Well 7119/12-1, 830–840 m. Megalospheric specimen with three and a half pairs of biserial chambers, and an arched final chamber with a terminal aperture

**Type specimens:** The holotype (BMNH PF68304) and one paratype (BMNH PF68305) are deposited in the collections of the Department of Paleontology, Natural History Museum, London. Additional paratypes are deposited in the collections of the Grzybowski Foundation, Geological Museum, Institute of Geological Sciences of the Jagiellonian University, Kraków. Paratypes: UJ 212P1; UJ 212P2; UJ 212P3; UJ 212P4 (see Figs 2–4).

## DISCUSSION AND CONCLUSIONS

The genus *Plectoeratidus* is a distinctive form with compressed planispiral-biserial-uniserial morphology that occurs consistently, but in low numbers in the Upper Cretaceous formations of the Norwegian Sea. It may be endemic to the Norwegian Sea basins (including the Barents Sea and





**Fig. 3.** Chamber heights and widths plotted against chamber number for the six type specimens. “Chamber nr 0” is referred to the last chamber in the planispiral portion of every test

North Sea), as we have not found it in sediments of equivalent age from the Labrador Sea or North Atlantic DSDP/ODP sites. This genus may represent an evolutionary transition between Cretaceous forms assigned to *Spiroplectamina* or *Bolivinopsis*, and the Cenozoic genus *Eratidus*.

*Plectoeratidus subarcticus* is associated with flysch-type agglutinated foraminiferal assemblages dominated by tubular astrorhizids with subordinate numbers of hormosinids and organically-cemented lituolids. This is typical boreal DWAF association indicating normal marine, outer shelf to bathyal preferences. An abyssal habitat of *P. subarcticus* is less likely due to the Late Cretaceous palaeotectonic position of the Barents Sea, which is floored entirely by continental crust. This species does not comprise more than 2% of the whole foraminiferal assemblage, suggesting a non-opportunistic (K-selected) life strategy. This strategy and its low population density may have facilitated the semi-isolation of small populations, which encouraged the evolution of this distinctive species.

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**REFERENCES**

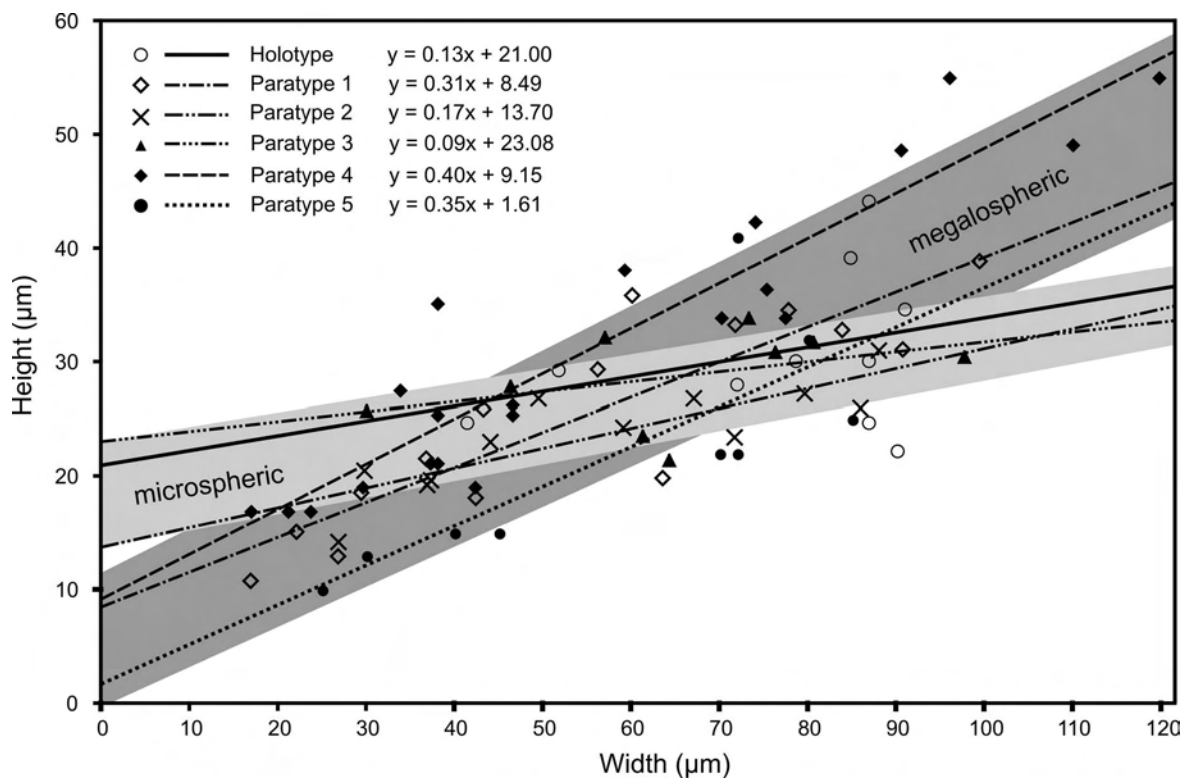
Brady, H. B., 1881. On some of the reticularian Rhizopoda of the Challenger Expedition. Part III. 1. Classification. 2. Further notes on new species. 3. Note on *Biloculina* mud. *Quarterly Journal of Microscopical Science*, new ser. 21: 31–71.

Charnock, M. A. & Jones, R. W., 1990. Agglutinated foraminifera from the Paleogene of the North Sea. In: Hemleben, C., Kaminski, M. A., Kuhnt, W., & Scott, D. B. (eds), *Paleoecology, Biostratigraphy, Paleoceanography and Taxonomy of Agglutinated Foraminifera*, NATO ASI Series, C327, Kluwer Academic Publishers, pp. 139–244.

Geroch, S. & Nowak, W., 1984. Proposal of zonation for the late Tithonian–late Eocene, based upon arenaceous foraminifera from the outer Carpathians, Poland. In: Oertli, H. (Ed.) Benthos ‘83; *2nd International Symposium on Benthic Foraminifera Pau (France), April 11–15, 1983*. Elf Aquitaine, ESSO REP and TOTAL CFP, Pau & Bourdeaux, pp. 225–239.

Kaminski, M. A. & Gradstein, F. M., 2005. *Cenozoic cosmopolitan deep-water agglutinated foraminifera*. Grzybowski Foundation Special Publication, 10: 547 pp.

Loeblich, A. R. Jr. & Tappan, H., 1950. Foraminifera from the type Kiowa Shale, Lower Cretaceous, of Kansas. Kansas, Univ. Paleontological Contributions, Lawrence, Kansas, p. 8.



**Fig. 4.** Chamber heights plotted against widths with linear regression lines for the six type specimens. Coloured areas indicate dimorphic trends of the chamber growth rate separating supposed megalospheric from microspheric forms

- Nagy, J., Kaminski, M. A., Johnsen, K. & Mitlehner, A., 1997. Benthic foraminiferal and dinoflagellate cyst stratigraphy and paleoenvironments of the Palaeogene Torsk Formation: A reference section for the western Barents Sea. In: Hass, C. & Kaminski, M. A. (eds), *Contributions to the Micropalaeontology & Paleoceanography of the northern North Atlantic*. Grzybowski Foundation Special Publication, 5: 15–38.
- Nagy, J., Kaminski, M. A., Kuhnt, W. & Andersen, M., 2000. Foraminifera reflecting deltaic to bathyal facies in high latitude Paleogene strata. In: Hart, M. B., Kaminski, M. A. & Smart, C. W. (eds), *Proceedings of the Fifth International Workshop on Agglutinated Foraminifera*. Grzybowski Foundation Special Publication, 7: 333–361.
- Nagy, J., Kaminski, M. A., Gradstein, F. M. & Johnson, K., 2004. Quantitative foraminiferal and palynomorph biostratigraphy of the Paleogene in the southwestern Barents Sea. In: Bubik, M., & Kaminski, M. A., (eds), *Proceedings of the Sixth International Workshop on Agglutinated Foraminifera*. Grzybowski Foundation Special Publication, 8: 359–379.
- Setoyama, E., Kaminski, M. A., Tyszka, J., Cetean, C. & Bubik, M., 2008. Carpathian flysch-type foraminifera in Upper Cretaceous sediments of the Barents Sea. First Polish Geological Congress, Abstracts. Polish Geological Society, p. 105.
- Tyszka, J., 2004. Analysis of test ontogenesis (ATO) in small foraminifera: implications from *Pseudonodosinella*. In: Bubik M. & Kaminski M. A. (eds), *Proceedings of the Sixth International Workshop on Agglutinated Foraminifera*. Grzybowski Foundation Special Publication, 8: 471–483.
- Worsley, D., Johansen, R. & Kristensen, S. E., 1988. The Mesozoic and Cenozoic succession of Tromsøflaket. In: Dalland, A., Worsley, D., & Ofstad, K. (eds), *A lithostratigraphic scheme for the Mesozoic and Cenozoic succession offshore mid- and northern Norway*. NPD Bulletin, 4: 42–61.