

Karreriella perforata n. sp. : a new Pliocene agglutinated benthic foraminifer with a perforated wall structure from the southern Bering Sea

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Abstract

We describe a new agglutinated benthic foraminiferal species from the Pliocene of Hole U1341B drilled in the southern Bering Sea during IODP Expedition 323. The calcareous-cemented species *Karreriella perforata* n.sp. is coarsely canalculated, with regularly-spaced straight, unbranched pores that are open to the test surface. This feature of the test wall is rare among agglutinated foraminifera, and is interpreted as a morphological adaptation to enable survival in the strongly hypoxic environment present in the deep Bering Sea.

INTRODUCTION

The Bering Sea is the third largest marginal sea in the world surpassed only by the Mediterranean and South China Seas (Hood 1983). Integrated Ocean Drilling Program (IODP) Expedition 323 drilled two sites on the Bowers Ridge in the southwestern part of the Bering Sea, an extinct arc system that extends 300 km north from the Aleutian Island arc (Fig. 1). The primary objective of scientific drilling at Site U1341, located at a water depth of 2177 m, was to build up a high-resolution record of the Pliocene–Pleistocene palaeo-oceanography in the southern part of the Bering Sea. Drilling at Site U1341 recovered nearly 600 m of organic-rich diatomaceous sediment with occasional laminated intervals (Expedition 323 Scientists, 2011). Modern agglutinated foraminifera from all Expedition 323 sites are described by Kender & Kaminski (in press). The site is located just below the modern Oxygen Minimum Zone (OMZ), which causes the formation of laminated sediments in parts of the section. Fluctuations in the intensity or depth of the OMZ and productivity on a variety of timescales should be reflected by benthic foraminiferal records at this site, compared with shallower sites (Takahashi *et al.*, 2005).

The diatomaceous noncalcareous claystones recovered from the Pliocene interval of Hole U1341B contain a benthic foraminiferal assemblage consisting exclusively of agglu-

tinated foraminifera (Kaminski *et al.*, 2013). One of the most abundant species in this assemblage is a small enigmatic species of *Karreriella* that has a perforate wall structure, with pores that open to the test surface. This species is also present at low abundance in the modern fauna of Site U1341 (Kender & Kaminski, in press). The purpose of this paper is to provide an adequate description of this new species and interpret its palaeoenvironmental significance.

METHODS OF STUDY

Samples (approx. 20 cubic centimeters volume) were collected from the working halves of IODP Expedition 323 cores during the post-expedition sampling meeting using a metal spatula. Samples were gently sieved over a 63 µm screen, using just a water spray. Sample residues were then air-dried and benthic foraminifera were picked into cardboard microslides using a fine brush. Specimens were imaged using a JSM-5900LV SEM at KFUPM in Dhahran. A second set of samples was prepared for high-resolution field-emission SEM. Specimens were cut to reveal the wall structure, coated with a thin film of gold using a sputter coater, and examined under low accelerating voltage using a Hitachi S-4800 FESEM at the University of Iowa.

SYSTEMATIC PALAEOONTOLOGY

The classification of the agglutinated foraminifera follows Kaminski (2014).

Suborder TEXTULARIINA Delage & Hérouard, 1896

Superfamily EGGERELLACEA Cushman, 1937

Family EGGERELLIDAE Cushman, 1937

Subfamily EGGERELLINAE Cushman, 1937

Genus KARRERIELLA Cushman, 1933

Karreriella perforata Kaminski & Kender, n.sp.

Plate 1, figs 1-3

Material. Numerous specimens from the Pliocene of Hole U1341B, approx. 330–590 metres below sea floor (mbsf).

Derivation of name. Owing to the fact that the canaliculae are open to the test surface.

Description. Test free, elongate, initially trochospiral with up to five chambers per whorl, later reduced to twisted triserial and finally becoming biserial in just the final one or two pairs of chambers. Chambers in the terminal biserial part are globular, with depressed sutures. Wall finely agglutinated, monolamellar, consisting mostly of quartz grains cemented with calcareous material, with a smooth outer surface, cana-

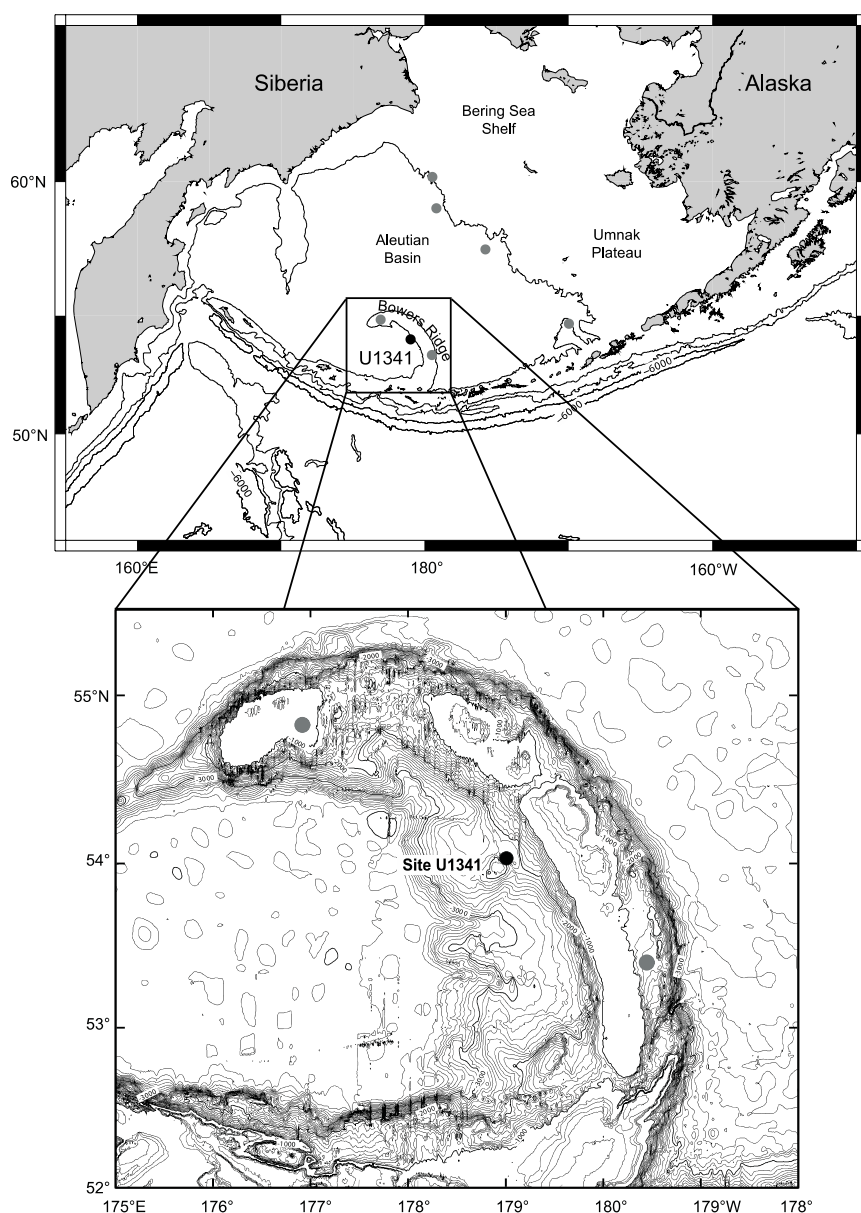


Figure 1. Location of IODP Site 1341 in the southern Bering Sea. Circles indicate the position of IODP Exp. 323 Sites. Base map modified from Expedition 323 Scientists (2011).

cemented with calcareous material, with a smooth outer surface, canaliculated with pores that are open to the exterior. Aperture areal, a rounded opening slightly above the base of the apertural face in the triserial stage, becoming more areal and increasingly oval in the biserial adult stage, produced, and surrounded by a distinct lip constructed of finely agglutinated particles.

Remarks. This species bears some resemblance to *Meidamonella novangliae* (= *Gaudryina baccata* var. *novangliae* Cushman, 1922), but differs in possessing a much reduced biserial part and an oval (rather than slit-like) aperture. The agglutinated wall is several grains thick, in cross-section shows no obvious signs of layering, and has a terrazzo outer surface (consisting of grains in the 5–10 micron size range with the flat sides oriented normal to the test surface). The larger agglutinated grains are surrounded by canaliculae that are open to the surface. The canaliculae are round or rounded-triangular in outline, 1–2 µm in diameter, and are more or less evenly dispersed. At higher magnification some of the openings appear to be surrounded by rims of fine agglutinated grains or calcareous cement. On the chambers of the final whorl, the openings are only situated on the lower (proximal) half of the chamber, which will remain open to the exterior. The upper half of the chamber (which would be covered by chambers of the next whorl, thereby forming septa between chambers) does not display open pores.

Type Level. Pliocene, Sample U1341B-70X, CC (approx. 590 mbsf).

Type Specimens. Deposited in the European Micropalaeontological Reference Centre (EMRC), Micropress Europe, at the AGH University of Science & Technology in Kraków, Poland, in Cabinet 7, drawer 7.

DISCUSSION

The agglutinated foraminifera from Hole U1341B display morphological features that can be associated with hypoxic environments: These include small test size and a thin wall, and the presence of a highly perforate test (Bernhard, 1986). In the case of agglutinated taxa, the perforations are in the form of canaliculae that are normally closed at the surface by a thin imperforate layer of agglutinated grains. In the case of *Karreriella perforata* n.sp., the canaliculae are open at the test surface. The test surface does not appear to be damaged by abrasion or dissolution, and the pores are only present on the lower half of the chambers of the last whorl, which is the part of the chamber that would not be covered by the chambers of the next whorl. This leads us to the conclusion that the open pores represent a primary feature.

Although open canaliculae have been observed previously in the genus *Clavulina* (Murray, 1973; Coleman, 1980; Mikhalevich, 2011), *Karreriella perforata* n.sp. presents perhaps the clearest example of such a feature that has ever been described in an agglutinated foraminifera. In specimens of *Clavulina pacifica* studied by Coleman (1980), pores were smaller (1 µm) and not evenly distributed, being restricted to the depressions around the agglutinated grains.

The presence of comparatively densely-packed regularly-distributed pores in an agglutinated foraminifer recalls the perforate wall structure of calcareous benthic foraminifera such as among the bolivinids, and is likely to be an adaptation for survival in severely hypoxic conditions. Previous studies have suggested that calcareous benthic species with high test-porosity may serve as indicator for oxygen-depleted environmental conditions (Sen-Gupta & Machain-Castillo, 1993; Kaiho, 1994). Studies of *Bolivina pacifica* and *Fursenkoina mexicana* by Kuhnt *et al.*, (2013) suggest that these foraminifera may optimise their oxygen-uptake by increasing their pore density as a morphological adaption to oxygen depletion. If this is also the case in agglutinated foraminifera, then the density and distribution of pores on the test surface could serve as a new proxy for interpreting past oxygen levels in sediments where only agglutinated species are preserved. This idea remains to be tested at other localities.

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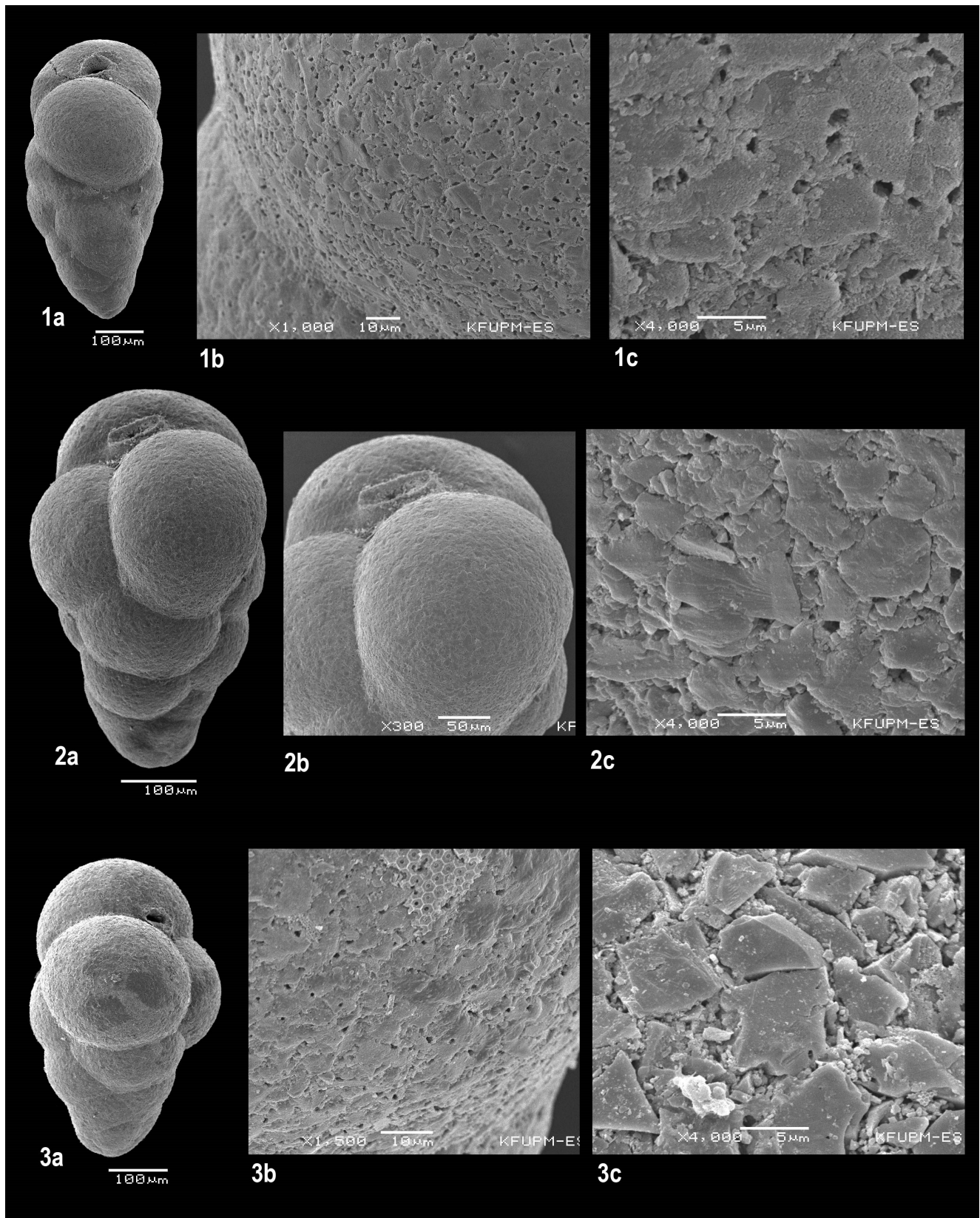


Plate 1. 1–3. *Karrieriella perforata* Kaminski & Kender, n.sp. 1a. Holotype specimen (EMRC 7-7a) with a pair of biserial chambers, U1341B-52H-2, 130–132 cm; 1b. Detail of a penultimate chamber, showing regularly-distributed canaliculae; 1c. Enlargement showing the terrazzo surface of agglutinated grains. 2a. Juvenile paratype (EMRC 7-7a) showing open canaliculae on the lower half of the chambers, U1341B-70X, CC; 2b. Detail of aperture showing finely agglutinated lip 2c. Detail showing terrazzo surface of agglutinated grains and open canaliculae, some of which are surrounded by a rim of agglutinated grains. 3a. Juvenile paratype (EMRC 7-7a), U1341B-70X, CC; 3b. Enlargement of the lower part of a chamber showing open canaliculae. 3c. Upper noncanalicate portion of a chamber of the last whorl.

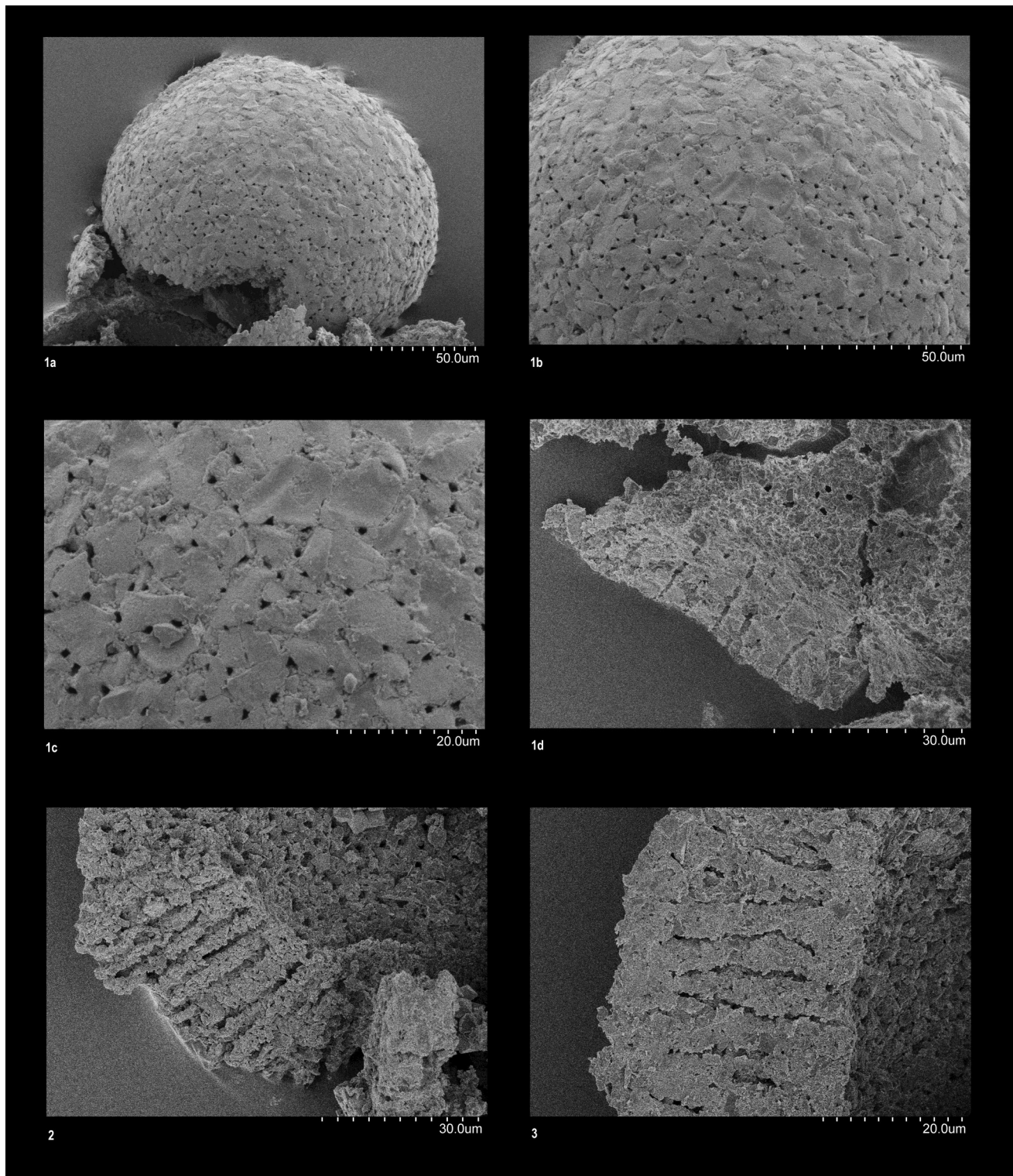


Plate 2. 1–3. *Karreriella perforata* Kaminski & Kender, n.sp. 1a–c. Dissected final chamber showing open canaliculae on the lower half of the chamber, U1341B-70X, CC. 1d. Cross-section through a cut fragment showing the straight to slightly sinuous canaliculae, U1341B-70X, CC. Accelerating voltage 2 kV, scale: 1a = 50 μ m, 1b = 50 μ m, 1c = 20 μ m, 1d = 30 μ m. 2. Cross-section through a cut broken fragment showing dense straight canaliculae, and the interior of the chamber, with open canaliculae, U1341B-70X, CC. Scale = 30 μ m. 3. Cross-section through a broken fragment at the point where it attaches to another chamber. Canaliculae are straight to slightly sinuous, and the wall shows no obvious signs of layering. Wall is about 30 μ m thick, with canaliculae 1–2 μ m in diameter. U1341B-70X, CC. Scale = 20 μ m.