# The wall structure of the agglutinated foraminifer *Eggerella advena*: its reassignment to the genus *Eggerelloides*, and description of *Eggerelloides belizensis* n.sp.

***LAMEED O. BABALOLA[1], NATALIA VÁZQUEZ RIVEIROS[2,3], MICHAEL A. KAMINSKI[1,4] and R. TIMOTHY PATTERSON[2]***

1. Geosciences Department, King Fahd University of Petroleum & Minerals, Dhahran, 21361, Saudi Arabia.
2. Department of Earth Sciences and Ottawa-Carleton Geoscience Center, Carleton University, Ottawa, Ontario, K1S 5B6, Canada.
3. Current address: Laboratoire des Sciences du Climat et de l'Environnement, Université Paris-Saclay, Gif-sur-Yvette, 91198, France.
4. AGH University of Science and Technology, Faculty of Geology, Geophysics and Environmental Protection, al. Mickiewicza 30, 30-059 Kraków, Poland.

## Abstract

The foraminiferal species *Eggerella advena* Cushman, 1922 possesses a noncalcareous imperforate agglutinated wall cemented by organic matter in the form of strands. This wall structure differs markedly from that of the type species of *Eggerella*, which has a calcareous-cemented wall transversed by simple straight and dichotomously branched pseudopores. We here confirm the transfer of *Eggerella advena* to the genus *Eggerelloides*. The new species *Eggerelloides belizensis* n.sp., from the Seymour-Belize Inlet Complex, British Columbia is described herein.

## INTRODUCTION

The species *Eggerella advena* Cushman (1922) is a dominant infaunal species found throughout the northern hemisphere, including Hudson Bay and elsewhere in the Canadian Arctic, as well as more temperate water regions on the North American continental shelves of the northeast Pacific and northwest Atlantic (Vilks, 1969, 1989; Alve & Nagy, 1986; Patterson, 1993; Murray, 2006; Murray & Alve, 2011; Vázquez Riveiros, 2006; Vázquez Riveiros & Patterson, 2008, 2009; Babalola, 2009; Babalola *et al*., 2013). The species is particularly dominant in dysoxic environments (Blais-Steven & Patterson, 1998; Patterson *et al*., 2000; Vázquez Riveiros & Patterson, 2009; Babalola *et al*., 2013). Because of its triserial coiling, the species has traditionally been placed in the genus *Eggerella* Cushman, 1933; however, its orange-brown test colour is unlike other species of the genus, which was redefined by Loeblich & Tappan (1987) as possessing a canaliculated test with calcareous cement. Avşar (2002) placed the species in the genus *Eggerelloides* Haynes, 1973, while Saidova (1975) assigned the species to her newly-described genus *Vernuilinulla*, without any illustration or mention of its wall structure. The present study attempts to accurately identify and resolve the generic assignment of this species by carrying out detailed observations of its wall structure and cement chemistry. We compare its wall structure and cement chemistry with that of *Eggerella bradyi* (Cushman), the type species of *Eggerella*.

A species that co-occurs with *Eggerelloides advenum* in British Columbia, identified as *Eggerella* sp. by Vázquez Riveiros & Patterson (2008, 2009), is herein formally described as a new species and assigned to the genus *Eggerelloides* by virtue of its wall chemistry.

## MATERIAL

The specimens from piston core VEC02A04, recovered from Frederick Sound, an arm of the Seymour-Belize Inlet Complex (Fig. 1), at 240 m water depth, were geochemically analysed. The sample locality was described in detail by Babalola *et al*. (2013). For comparison, specimens of *Eggerella bradyi* were examined from a locality on the Continental Rise (4815 m depth) off Nova Scotia investigated by Kaminski (1985). Specimens were broken with a dissecting needle, and examined using a scanning electron microscope (SEM) JEOL JSM-5900 in the Geosciences Department, KFUPM. Surface samples from Alison Sound and Belize Inlet (Fig. 1) were examined for foraminiferal distribution (details in Vázquez Riveiros & Patterson, 2009).

## SYSTEMATICS

Superfamily VERNEUILINOIDEA Cushman 1911

Family PROLIXOPLECTIDAE Loeblich & Tappan, 1985

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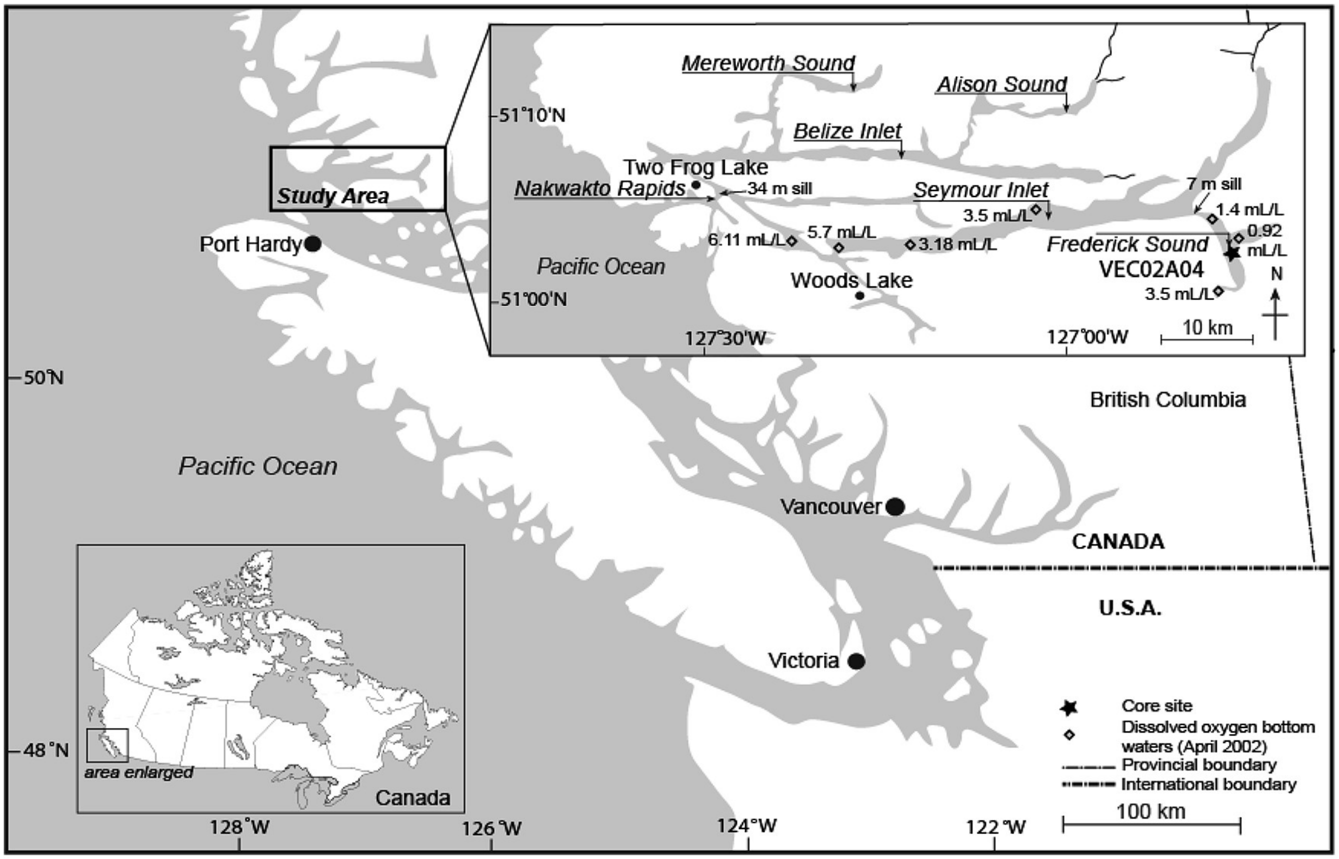


**Figure 1.** Map showing the Seymour-Belize Inlet Complex, British Columbia, Canada. Holotype and type series of *Eggerelloides belizensis* were recovered from Alison Sound; paratypes were recovered from Frederick Sound.

Genus ***Eggerelloides*** Haynes, 1973

***Eggerelloides advenum*** (Cushman) emended

Plate 1, figs 1–5.

*Verneuilina advena* Cushman, 1922, p. 141.

*Eggerella advena* (Cushman, 1922). –Cushman, 1937, p. 51, pl. 5, figs. 12-15 (fig. 13a,b is the lectotype). –Cushman, 1948, p. 32, pl. 3, fig. 12. –Loeblich & Tappan, 1953, p. 36, pl. 3, figs. 8-10.

*Eggerella arctica* Höglund, 1947, p. 193, pl. 16, fig. 4, textfigs. 166-168

**Non** *Verneuilina advena* (Cushman, 1922). –Höglund, 1947, p. 185, pl. 13, fig. 11, textfig. 169

**Non** *Verneuilinulla advena* (Cushman, 1922). –Loeblich & Tappan, 1994, pl. 19, figs 8–9.

**Description.** Test subfusiform, early stage trochospiral with 4 or 5 chambers, later triserial with globular chambers and slightly depressed sutures. Chambers are numerous, low and broad in early portion, increasing in relative height as added, those of final whorl approximately equal in height and breadth. Wall medium to coarsely agglutinated, with a prominent inner organic lining and a roughly finished outer surface. Wall is several grains thick, with agglutinated particles, mainly silt-sized quartz grains, held in organic cement that takes the form of strands. Sutures are distinct and depressed. Aperture, a small interiomarginal arch in the center of the slightly excavated apertural face.

**Remarks**. The species differs from *Eggerella bradyi* (=*Verneuilina bradyi* Cushman, 1911) in lacking calcareous cement. *Eggerella bradyi* possesses a calcareous-cemented wall perforated by simple straight and dichotomously branched pseudopores (pl. 1, fig. 6b,c). The wall of *Eggerelloides advenum* has an inner organic lining (pl. 1, fig. 1d), is several grains thick (pl. 1, figs. 1d, 2c), with open intergranular space. The organic cement is mostly visible at grain contacts as sparse glue-like strands of material connecting adjacent agglutinated grains (pl. 1, fig. 1c).

This small agglutinated species appears to occur in shallow sheltered environments at high latitudes in both hemispheres, with its type material from 10–40 m in Hudson Bay, Canada (Cushman, 1922). The species also been recorded in the NE Pacific inlets (Patterson, 1993; Blais-Stevens & Patterson, 1998; Patterson *et al*., 2000; Vázquez Riveiros & Patterson, 2008, 2009; Babalola *et al*., 2013), the Arctic (Cushman, 1948; Loeblich & Tappan, 1953; Vilks, 1969, 1989), West Greenland (Höglund, 1947), and the NE Atlantic shelves as far south as Cape Cod (Cushman, 1937). It was reported as *Verneuilinulla advena* from abyssal depths at low latitudes (Loeblich & Tappan, 1994; Hayward *et al*., 2007), but the illustrations depict a species with a long trochospirally coiled portion containing four chambers per whorl, the heights of the chambers are lower than the width, and the test has a more flattened apertural face. Our specimens clearly have a long triserial part consisting of six or more sets of chambers, and the chambers are higher than they are broad. A similar species found on the NW European Shelf, known as *Eggerella europea* Christiansen (reported by Höglund, 1947 as *Verneuilina advena*) and illustrated by Murray (2003), also very likely belongs in the genus in *Eggerelloides*.

***Eggerelloides belizensis*** Vázquez Riveiros, Babalola, Kaminski & Patterson n.sp.

Plate 2, figs 1–4.

*Eggerella advena* (Cushman, 1922). –Resig, 1963, p. 125, fig. 2.
*Eggerella* sp. Vázquez Riveiros & Patterson, 2008, p. 13, figs. 5.5a-d.
*Eggerella* sp. Vázquez Riveiros & Patterson, 2009, p. 2842, pl. 1, fig. 2

**Diagnosis.** A species of *Eggerelloides* with triangular cross-section and inflated last chambers.

**Description.** Test free, elongate, sharply tapering, early portion with 4 to 5 chambers in a whorl, later portion triserial, triangular in cross-section. Wall finely agglutinated with occasional larger grains; normally 4 to 5 whorls. Chambers numerous, low and broad in early portion, increasing slowly in relative height as added, normally three chambers in final whorl, very inflated and extending outwards of the axis of the test, giving the test a triangular outline in apertural view and an almost flat apertural face; sides straight, except for sutures, increasing at 25° from the axis. Sutures distinct and depressed. Aperture small, central, low arch at base of final chamber, sometimes with a narrow lip.

**Etymology.** The new species is named after Belize Inlet, British Columbia, Canada, and –ensis, denoting place, locality.

**Remarks.** *Eggerelloides belizensis* was found in association with *E. advena* (Cushman) in the study area. The latter is easily differentiated from *E. belizensis* by the tapering of its final chambers and the more elongated test, and by the last chambers being equal in height and width. In contrast, the chambers of *E. belizensis* are more inflated and shorter. The test of *E. advena* is also narrower, with a smaller angle with respect to the longitudinal axis than that of *E. belizensis*. *Eggerelloides belizensis* is more similar to *Eggerelloides scaber* (Williamson, 1858), a species known from European waters; however, it is differentiated by the more elongated test shape and globular chambers of the latter. *Eggerelloides belizensis* has been described from the shelf of Washington State as a short morphotype of *E. advena* present in deep waters (Resig, 1963). Harmon (1972) described two morphotypes of *E. advena*, one of which seems to be similar to *E. belizensis*, but he did not provide any

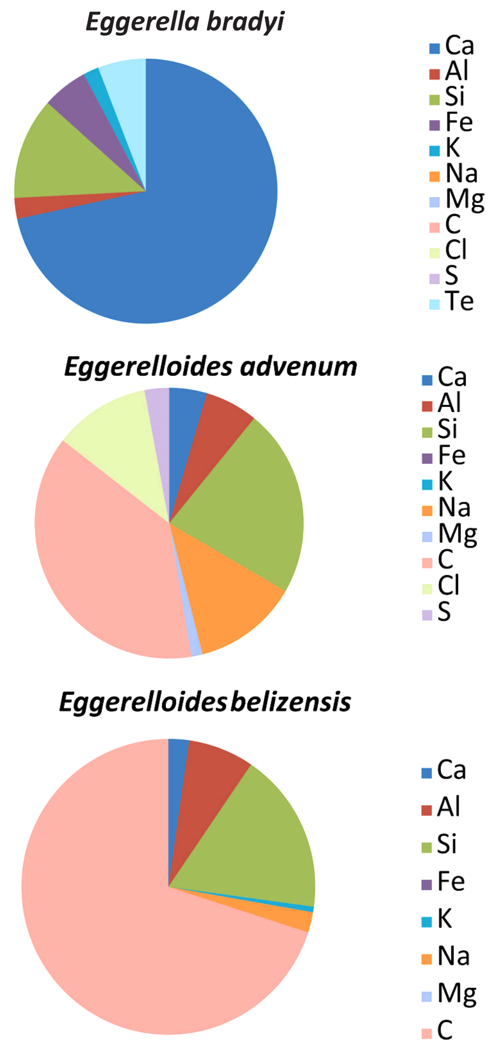


**Figure 2.** Elemental chemistry distribution patterns in *Eggerella bradyi*, *Eggerelloides advenum* and *E. belizensis*.

illustration of the described specimens. The specimens of *E. belizensis* and *E. advena* found within the Seymour-Belize Inlet Complex have the same size, indicating that *E. belizensis* is not a juvenile form. The chemical structure of the test of *E. belizensis* is similar to that of *E. advena*, supporting its assignment to the genus *Eggerelloides*.

**Type Locality.** Holotype and type series from a surface sample in Alison Sound, an arm of Belize Inlet in the Seymour-Belize Inlet Complex, British Columbia, Canada (51° 7.90' N, 127° 9.02' W), at a depth of 274 m. Paratypes are from Frederick Sound, an arm of the Seymour-Belize Inlet Complex, 240 m water depth.

**Type Level**. Holocene.

**Type Specimens.** Holotype and type series deposited at the Micropalaeontology Collection of the Museum Nationalle d'Histoire Naturelle, Paris, France (catalogue number MNHN.F.F63116). Paratypes deposited at the European Micropalaeontological Reference Centre, AGH University

**Table 1.** Wall chemistry of *Eggerella bradyi*, *Eggerelloides advenum* and *Eggerelloides belizensis*.

| Element (%) | *Eggerella bradyi* | *Eggerelloides advenum* | *Eggerelloides belizensis* |
|---|---|---|---|
| **Ca** | 52.14 | 2.47 | 1.20 |
| **Al** | 1.85 | 3.45 | 3.81 |
| **Si** | 9.04 | 12.20 | 9.27 |
| **Fe** | 4.07 | - | - |
| **K** | 1.39 | - | 0.32 |
| **Na** | – | 6.86 | 1.17 |
| **Mg** | - | 0.73 | - |
| **$O_2$** | 27.21 | 45.70 | 47.37 |
| **C** | – | 20.71 | 36.83 |
| **Cl** | – | 6.28 | - |
| **S** | – | 1.60 | - |
| **Te** | 4.29 | - | - |
| **Total** | **99.99** | **100** | **99.99** |

of Science & Technology, Kraków, in cabinet 7, drawer 7.

## TEST GEOCHEMISTRY

Specimens of *Eggerelloides advenum*, *E. belizensis* and *Eggerella bradyi* were analysed by SEM using Electron Dispersal Spectrum (EDS). Specimens were first broken with a dissecting needle to expose a cross section through the wall. The EDS results reveal that the wall chemistries of the examined specimens of the genera *Eggerella* and *Eggerelloides* are distinctively different (Table 1; Fig. 2a-c).

Compared to *Eggerelloides advenum* or *E. belizensis* (Ca = 2.47% and 1.20%, respectively), the *Eggerella bradyi* test wall is highly enriched in calcium (Ca = 52.14 wt. %). Carbon is abundant in the *Eggerelloides* wall (~21% to 37%), corroborating the presence of an organic cement and inner organic lining. This element is totally absent in all the test wall fragments of *Eggerella bradyi* examined. Both the *Eggerella* and *Eggerelloides* test walls are moderately enriched in Si (9.04, 12.20 and 9.27 wt. % for the three species), and contain detectable amounts of Al. The presence of Fe and Te in the *Eggerella bradyi* specimen further differentiates it from *Eggerelloides*. The S, Na and Cl present in the *E. advenum* specimen are likely impurities from salt water and $H_2S$ in the anoxic sediment from where the sample was obtained.

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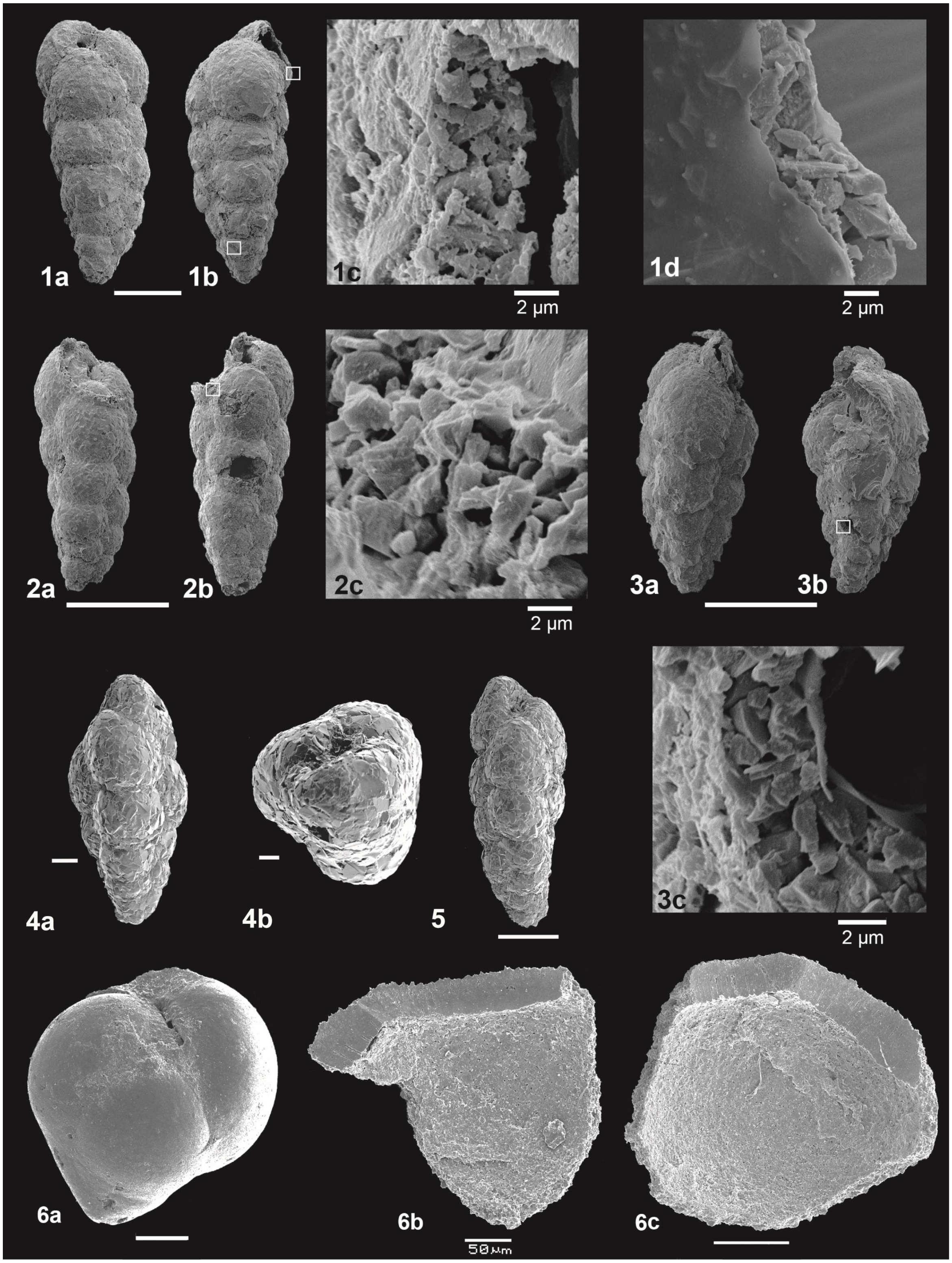


**Plate 1. 1 – 5**. *Eggerelloides advenum* (Cushman). **1a.** Lateral view of specimen from Frederick Sound. **1b.** Specimen broken to expose the agglutinated wall. **1c.** Detail of wall, showing strands of organic cement at the grain contacts. **1d.** Detail of wall, showing the smooth, imperforate inner organic layer (IOL). **2a,b.** Lateral views of second specimen from Frederick Sound. **2c.** Detail of wall. **3a,b.** Lateral views of third specimen from Frederick Sound. **3c.** Detail of wall showing IOL and empty intergranular space. Wall is several grains thick. **4a.** Lateral view of specimen from Alison Sound (Vázquez Riveiros & Patterson, 2008). **4b.** Apertural view of specimen **4a. 5.** Lateral view of second specimen from Alison Sound. **6.** *Eggerella bradyi* (Cushman), Nova Scotia Continental Rise, 4815 m. **6a.** Lateral view of whole specimen with final chamber removed. **6b,c.** Broken fragments of the final chamber, showing sparsely distributed pseudopores on the inner chamber surface, and straight, rarely bifurcating canaliculae. Scale bars are 100 mm unless indicated otherwise.

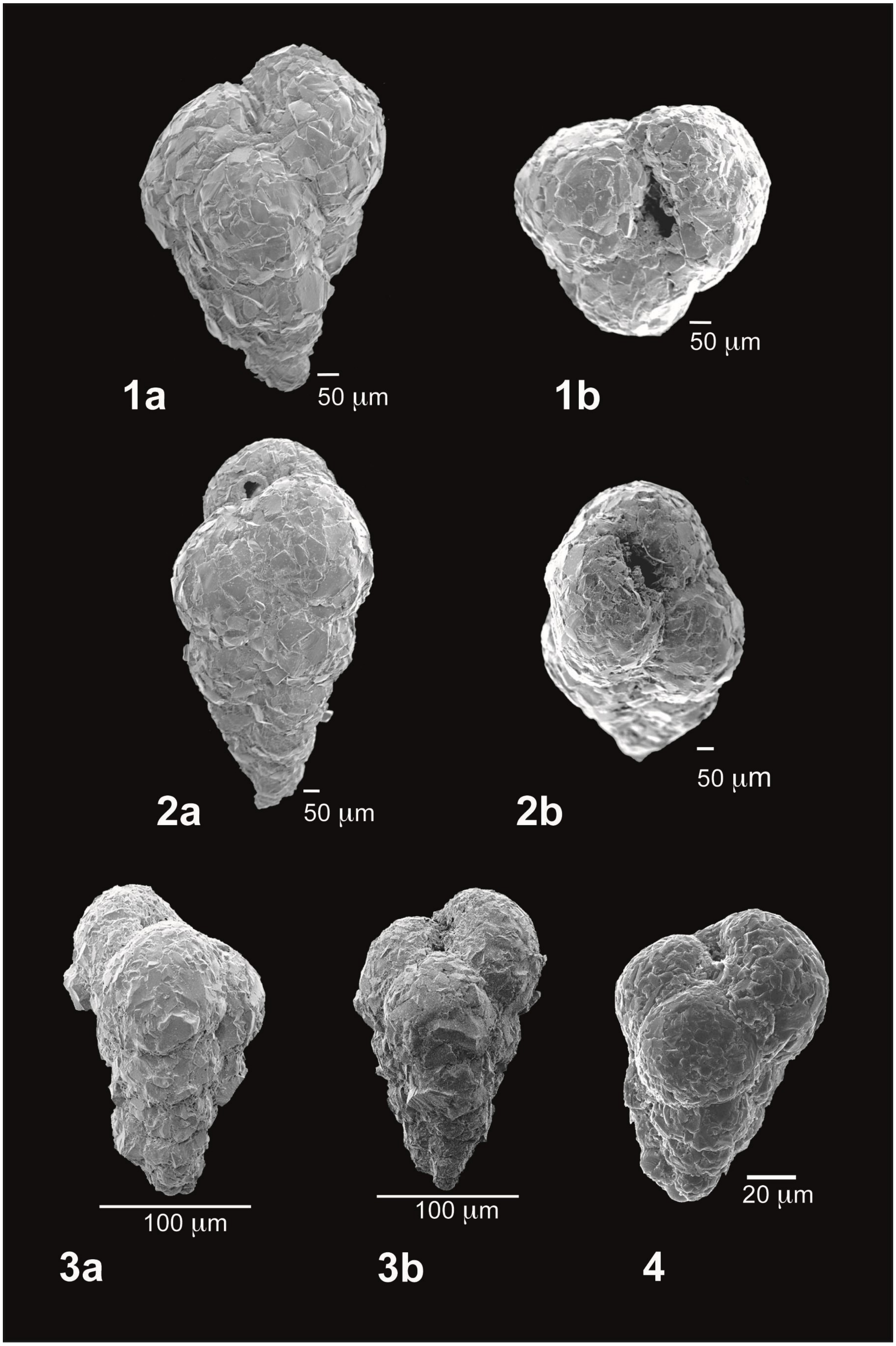


**Plate 2. 1 – 4.** *Eggerelloides belizensis* n.sp. **1a.** Lateral view from holotype deposited at the Museum National d'Histoire Naturelle, Paris (France), catalogue number MNHN.F.F63116, from sample ALS2 in Alison Sound. **1b.** Apertural view from holotype. **2a.** Lateral view of a second specimen from sample ALS3, Alison Sound, paratype. **2b.** Apertural view of specimen **2a. 3a,b.** Lateral views of a third specimen from Frederick Sound, paratype. **4.** Lateral view of a fourth specimen from Frederick Sound, paratype.