A deep-sea foraminiferal assemblage scattered through the late Cenozoic of Antarctic Peninsula and its biostratigraphic and biogeographic implications

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Abstract.—Our knowledge of the foraminiferal fossil record of Antarctica is notoriously patchy but still offers us an overview of its Cenozoic faunas. Few occurrences have been reported for the continent, with deep-sea assemblages described mainly for its eastern portion. Here we describe 21 taxa of large agglutinated foraminifers from the Miocene Hobbs Glacier Formation and the Plio-Pleistocene Weddell Sea Formation on Seymour Island, West Antarctica, including the gigantic *Ammodiscus vastus* new species. Most of them consist of genera or species typical of deep-sea agglutinated assemblages. All specimens are completely filled and partially covered by lithified micrite. This, along with the postfill fragmentation of some tests, indicates their re-elaboration from older deposits. Because all of these foraminifers share the same taphonomic features and most of them represent taxa associated with deep-sea settings, they probably represent a flysch-type assemblage from an unknown deposit that was eroded and had its microfossils scattered through post-Paleogene sediments. A Paleocene age for this putative assemblage is indicated by the presence of *Reticulophragmiun garcilassoi* (Frizzell, 1943), a Paleocene index fossil, and by its association with the Cretaceous–Paleocene *Ammodiscus pennyi* Cushman and Jarvis, 1928. If taken as a coherent foraminiferal assemblage, it represents one of the few deep-sea assemblages known for West Antarctica, and the first flysch-type assemblage recognized for the Antarctic Cenozoic. In addition, it would show that the Paleocene foraminiferal communities of the West Antarctica's deep-sea floor were more like their Pacific counterparts than their Atlantic equivalents.

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Introduction

Although overall scarce and patchy, the foraminiferal fossil record of Antarctica still provides enough information to give us a glimpse of its Cenozoic fauna. For West Antarctica, the reported assemblages represent mainly communities of shallow, inner-shelf settings that are Eocene to Pleistocene in age (e.g., Birkenmajer and Łuczkowska, 1987; Gaździcki and Webb, 1996; Gaździcki and Majewski, 2012; Caramés and Concheyro, 2013; Majewski and Gaździcki, 2014), whereas those from deeper paleoenvironments are represented by some Miocene assemblages (Birkenmajer and Łuczkowska, 1987) and a couple of Paleocene ones (Huber, 1988; see paleoenvironmental revisions by Olivero et al., 2007 and Marenssi et al., 2012). For East Antarctica, it is the opposite, for very few occurrences from shallow, marine settings are known (see Quilty et al., 2010; Majewski et al., 2012, 2017) and some outer-shelf to abyssal assemblages have been recovered from offshore deposits (see Thomas, 1989; Majewski et al., 2018). Notwithstanding this uneven but paleoecologically diverse record, occurrences of flysch-type assemblages—the most common and well-studied assemblage type of deep-sea agglutinated foraminifers—has remained unknown for both West and East Antarctica, including nearby offshore areas.

A flysch-type assemblage is mostly composed of large, morphologically simple, and coarsely agglutinated foraminifers, usually of cosmopolitan species, and is associated with ancient deep-sea deposits, especially turbidite flysch sequences (Gradstein and Berggren, 1981). This type of assemblage was present below the carbonate compensation depth (CCD) in bathyal and abyssal zones, in settings with relatively high inputs of sediment and organic matter, and is virtually exclusive for Late Cretaceous and Paleogene deposits (Kaminski and Gradstein, 2005), with only one known early Miocene exception (Beldean and Filipescu, 2011). The other types of deep-sea agglutinated assemblages are also restricted to the Cretaceous–Paleogene interval, and are differentiated both by their paleodepths and presence or absence of certain taxa: (1) slope marl assemblage, similar to flysch-type assemblage but restricted to the bathyal zone, above the CCD; (2) abyssal assemblage, composed of small and finely-agglutinated foraminifers, in the abyssal zone below the CCD, in settings of extremely low inputs of sediment and organic matter; and (3) Scaglia-type assemblage, similar to abyssal assemblage but in the bathyal zone of seamounts, above the CCD (see Kaminski and Gradstein, 2005 for thorough characterizations of these assemblages).

Flysch-type and similar deep-sea assemblages are not products of taphonomic bias toward the preservation of agglutinated tests, that is, their concentration is not due to the dissolution of calcareous tests. Instead, they represent exclusively agglutinated communities that thrived in deep-sea settings and the abundance

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and diversity of which were correlated to complex physical and chemical dynamics, e.g., variation in inputs of sediment, organic matter, and oxygen (e.g., Koutsoukos, 2000; Bindiu-Haitonic and Filipescu, 2016).

Here we describe large agglutinated foraminifers that, although consisting of typical deep-sea and flysch-type taxa, are found in the shallow, glacial-marine strata of the Miocene Hobbs Glacier Formation and the Plio-Pleistocene Weddell Sea Formation on Seymour Island, West Antarctica. They represent re-elaborated remains in these deposits, meaning that they were exhumed and displaced after a previous definitive burial in another deposit and then passed through a second definitive burial in these formations (see Fernández López, 1991 for details on the concepts of re-elaboration and resedimentation, which differentiate processes that are indiscernible when the concept of reworking is used in a broad sense). In an attempt to uncover their depositional history, we also characterize their taphonomic features and compare them with those from the indigenous, presumably autochthonous foraminiferal assemblages of the same deposits, previously reported in Badaró and Petri (2019). Lastly, we make taxonomic comparisons with other assemblages to recognize taxa that are biostratigraphically and biogeographically significant.

Geological setting

Hobbs Glacier Formation (HGF) crops out on James Ross and Seymour islands, with slightly different lithologies on each. On James Ross Island, the formation is characterized by a massive to laminated muddy diamictite in its lower part and a tuffaceous sandstone in its upper part, with crossbedding indicating paleocurrents predominantly to NE and E (Pirrie et al., 1997a). On Seymour Island, the formation displays a matrix-supported diamictite (Marenssi et al., 2010) with a silty matrix replacing the typical clay matrix, except for the Sey-03 section, where the latter is found in its typical form (Badaró and Petri, 2019).

The marine fauna of the Hobbs Glacier Formation is represented by foraminifers, bryozoans, veneroid bivalves, serpulid polychaetes, and cirripedian crustaceans, but re-elaborated remains from the underlying La Meseta Formation are plentiful (Pirrie et al., 1997a; Jonkers et al. 2002; Concheyro et al., 2007; Marenssi et al., 2010). The Miocene age of the formation is indicated by dinoflagellate and bryozoan index fossils, as well as by strontium isotopes from barnacle shells that indicate a late Miocene age (9.9 ± 0.97 Ma, Tortonian Stage) (Dingle and Lavelle, 1998).

In contrast, the Weddell Sea Formation (WSF) crops out only on Seymour Island and its depositional setting remains uncertain. It has been called 'Weddell Formation' since the early 1980s (e.g., Malagnino et al., 1981), but was formally defined only more recently (Gaździcki et al., 2004). Its diamictites, often with fine-grained matrices and a high density of clasts, were previously considered to be glacial marine (e.g., Zinsmeister and DeVries, 1983), but the depositional setting was reinterpreted by Gaździcki et al. (2004) as fully glacial due to the lack of clearly indigenous marine fossils and presence of glacier striae oriented in various directions. Nevertheless, Badaró and Petri (2019) argued for at least some events of

marine influence, in view of the presence of indigenous foraminifers and trace fossils.

The minimum age of the Weddell Sea Formation is given by the presence of sedimentary clasts coming from the Pliocene Cockburn Island Formation (which crops out in the nearby, homonymous island), and its maximum age remains indeterminate (Gadzicki et al., 2004). Cockburn Island Formation was established as late Pliocene by radiometric and biostratigraphic data, which include the presence of the foraminifer *Ammoelphidiella antarctica* Conato and Segre, 1974 (also identified in re-elaborated clasts on Seymour Island), apparently restricted to the Pliocene (Webb, 1988; Gaździcki and Webb, 1996). However, the glacial interpretation of Gaździcki et al. (2004) would denote a late Pliocene to Pleistocene maximum age for the Weddell Sea Formation, because deposition would have occurred after the first marine regression of the latest Pliocene-Pleistocene regressive cycle. On the other hand, the at least occasional marine influence argued by Badaró and Petri (2019) would imply a slightly earlier maximum age for its deposition, for it would have occurred under a relatively high sea level.

Materials and methods

Foraminifers occur in the muddy and sandy matrices of diamictites of the Hobbs Glacier and Weddell Sea formations on Seymour Island (Fig. 1), extracted from samples of the following stratigraphic sections: Sey-03 (64°14′05.2″S, 56°37′12.7″W), Sey-07 (64°14′20.1″S, 56°38′16.5″W), Sey-10 (64°15′26.8″S, 56°39′22.2″W), Sey-13 (64°15′31.6″S, 56°38′52.9″W), and Sey-14 (64°14′28.6″S, 56°37′09.3″′W) (Fig. 2). In the Sey-03 section, the re-elaborated specimens are associated with the indigenous, and probably autochthonous, specimens described by Badaró and Petri (2019), with levels of occurrence indicated in Figure 2.

Eighty-six samples of ~500 g each were analyzed, corresponding to 86 of 121 sampled levels. The unanalyzed samples are those from the even levels of the Sey-13 section, which was sampled in more detail (every 20 cm) than the other sections. Because we choose to process a large quantity of rock for each sampled level, which resulted in an equally large quantity of sediment to be systematically examined under a stereomicroscope, this was necessary to allow us to complete these procedures in a reasonable amount of time. This decision was based on a pilot study in which we discovered that fossil remains were scarce in the samples and that it was necessary to process large amounts to find only a few foraminiferal tests.

The poorly consolidated samples were primarily disaggregated with water, but moderately consolidated pieces were disintegrated after reprocessing using the kerosene method described by Thomas and Murney (1985). A few highly lithified sedimentary clasts, probably originally from much older glacial cycles, could not be disaggregated. The disaggregated material was then passed through sieves of 1 mm, 0.5 mm, and 0.063 mm. All specimens were found in sediments concentrated in the 0.5 mm sieve. Although some tests are slightly over 0.5 mm in maximum diameter, many are considerably larger.

To clean the micrite that we found encrusting the tests, we selected a few poorly preserved, undetermined specimens to test the effectiveness of 10% hydrochloric acid in removing it. Some
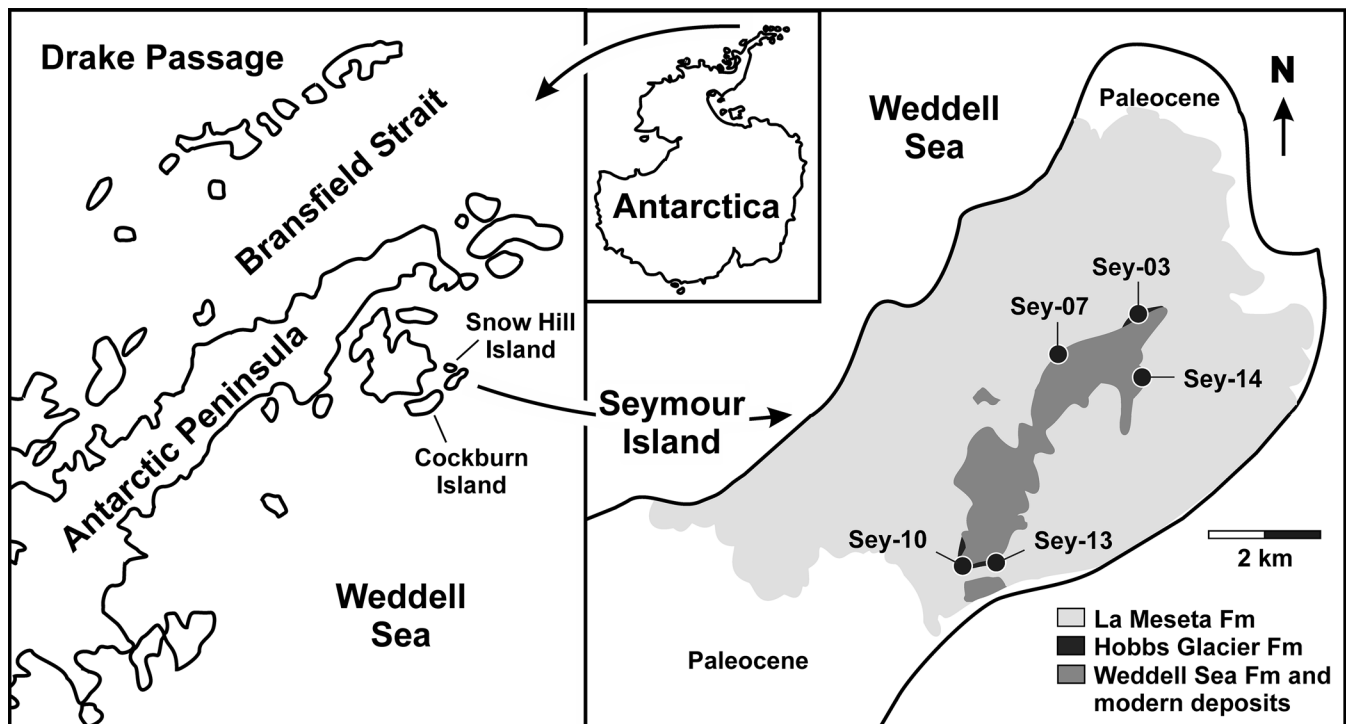
Figure 1. Location of Seymour Island and geologic map of its northeastern portion, showing the localities of the sampled outcrops (see text for coordinates). Modified from Montes et al. (2013), with additional data from Marenssi et al. (2010) and Rocha Campos et al. (2017).

specimens showed very little improvement after an hour of exposure, whereas others suffered severe damage after a much shorter period, as though the micrite was serving as a structural support for the tests. So, in view of the paucity of specimens, removing this material proved to be unfeasible.

High-resolution images and elemental spectra of selected specimens were acquired through an electron microscope (Quanta 250, FEI). Both scanning electron microscopy (SEM) and energy-dispersive X-ray spectroscopy (EDS) were performed under low vacuum on uncoated specimens. Spectral measurements were taken from areas comprising most of the test surface or the encrusted sediment, and not from isolated dots.

Samples were collected by Antonio C. Rocha Campos (Universidade de São Paulo) and his team during the austral summers of 2011 and 2012, during the 29th and 30th Brazilian Antarctic operations. The stratigraphic and sample notation used herein is that adopted by Rocha Campos's team during their campaigns.

The systematic arrangement in the text follows the classification of Loeblich and Tappan (1987), also considering modifications proposed by Loeblich and Tappan (1989, 1992), Sen Gupta (1999), Mikhalevich (2004), and Kaminski (2004). It also incorporates the morphological- and molecular-based supraordinal classification of Pawlowski et al. (2013). Synonymy lists are generally based on Kaminski and Gradstein (2005), who revised several cosmopolitan deep-sea taxa. We have included only described species, but cited species are mentioned in remarks when needed for comparative purposes.

Repository and institutional abbreviation.—Microfossil slides containing the specimens are deposited in the micropaleontological collection (GP/5E) of the Laboratório de Paleontologia Sistemática of the Instituto de Geociências, Universidade de São Paulo (LPS-IGc-USP), under the numbers 4308, 4310, 4313, 4317, 4342, 4347, 4348, 4353, and 4363–4365.

Systematic paleontology

Phylum Foraminifera d'Orbigny, 1826
Class 'Monotalamids' Pawlowski, Holzmann, and Tyszka, 2013
Order Astrorhizida Lankester, 1885
Suborder Astrorhizina Lankester, 1885
Superfamily Astrorhizoidea Brady, 1881
Family Rhabdamminidae Brady, 1884
Subfamily Bathysiphoninae Avnimelech, 1952
Genus *Bathysiphon* Sars, 1872

Type species.—*Bathysiphon filiformis* Sars, 1872, by original designation.

Bathysiphon sp. indet. 1
Figure 3.1

Occurrence.—Levels Sey-03-03 (WSF) and Sey-14-07 (HGF).

Description.—Test tubular, subcircular to elliptical in cross section. Wall finely agglutinated.

Materials.—Seven specimens: five from WSF (GP/5E-4310), two from HGF (GP/5E-4353).
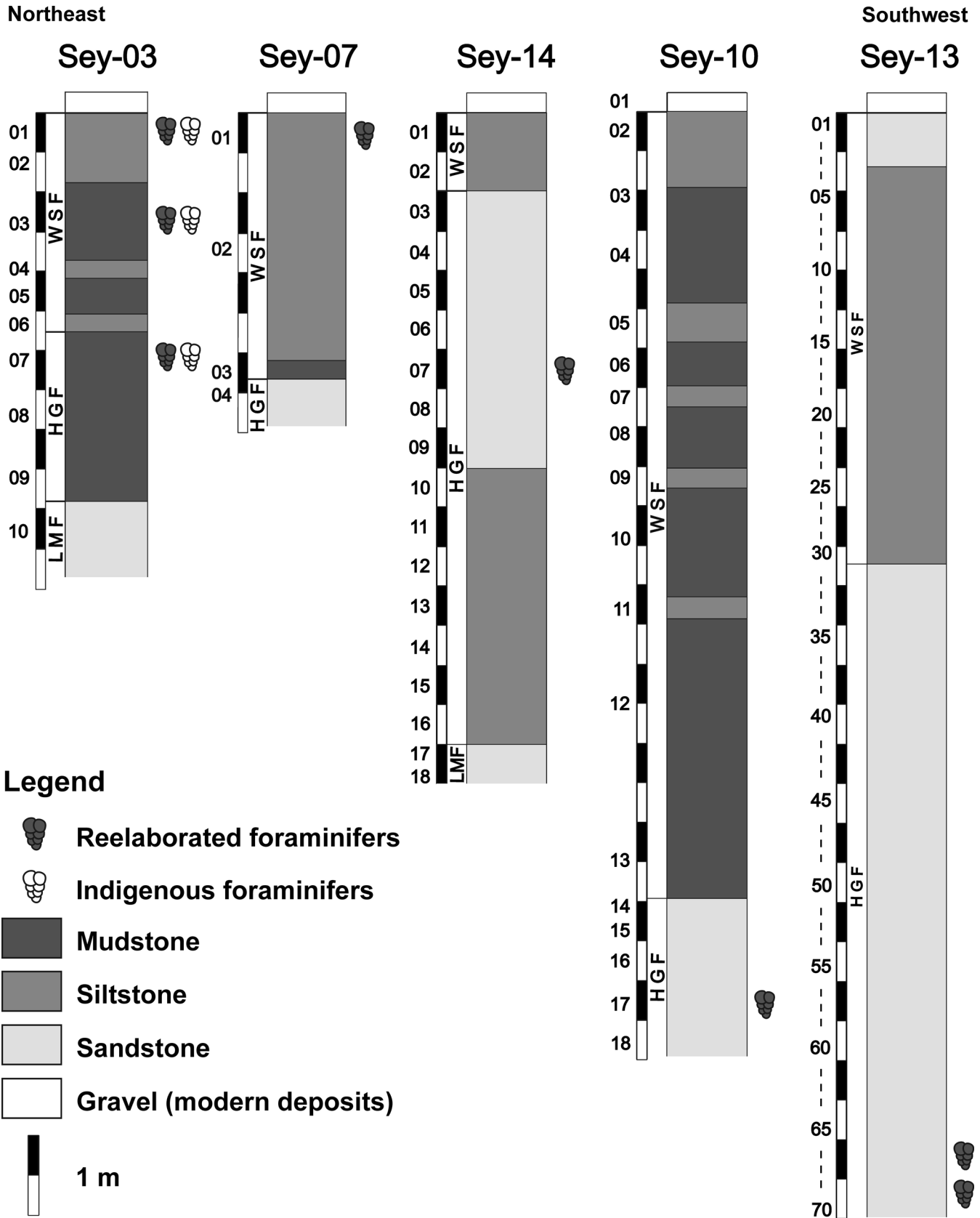
Figure 2. Simplified stratigraphic sections of the Hobbs Glacier Formation (HGF) and Weddell Sea Formation (WSF) on Seymour Island, showing the matrix lithologies of the diamictites. Numbers represent sampled levels; stratigraphic depths are indicated by the scale bars coupled with the sections.
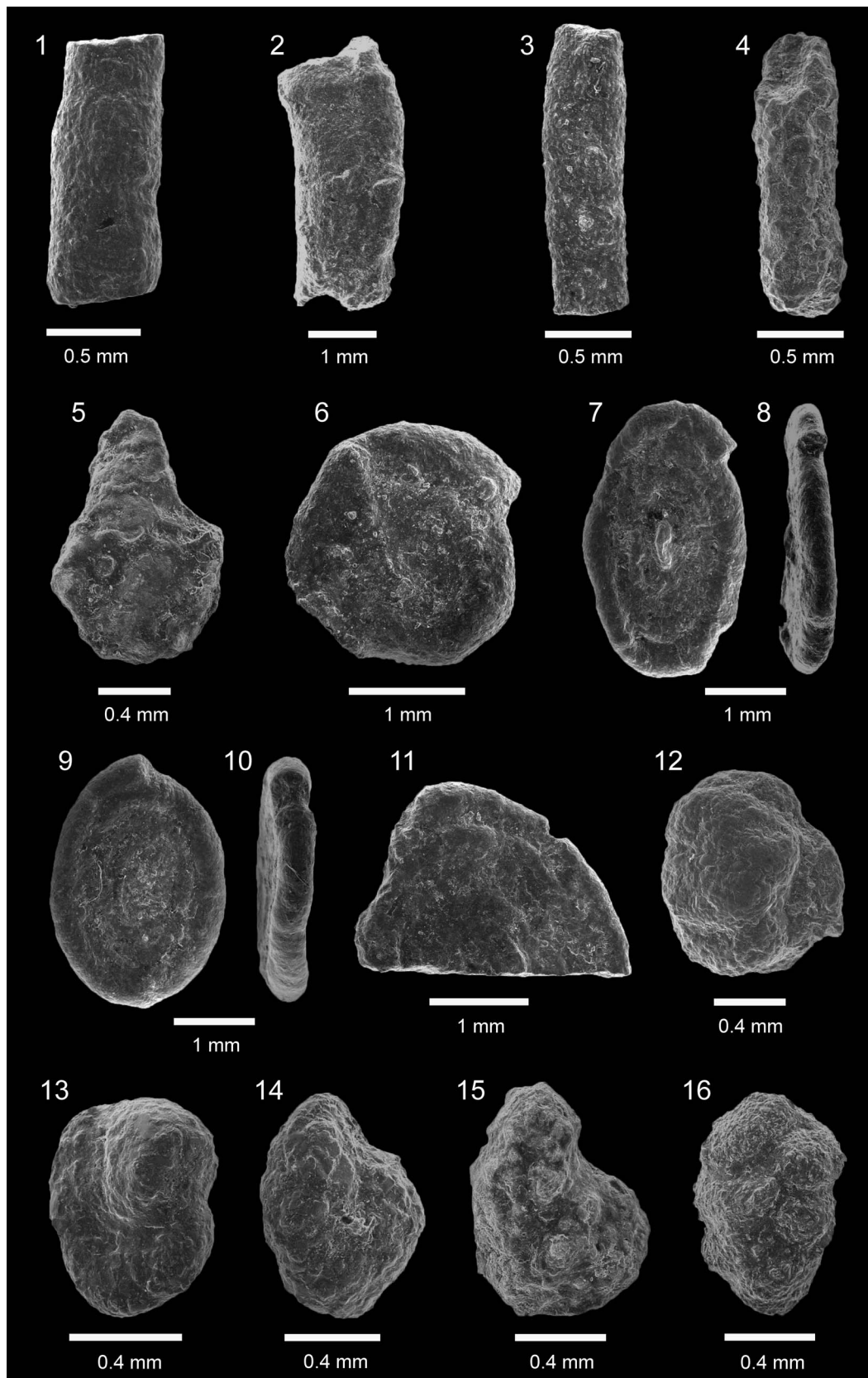
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Figure 3.   Large agglutinated foraminifers from the Hobbs Glacier and Weddell Sea formations on Seymour Island: (**1**) *Bathysiphon* sp. indet. 1, Sey-14-07 (HGF), GP/5E-4353; (**2**) *Bathysiphon* sp. indet. 2, Sey-03-07 (HGF), GP/5E-4313; (**3**) *Nothia robusta* (Grzybowski, 1898), Sey-03-07 (HGF), GP/5E-4313; (**4**) *Psammosiphonella cylindrica* (Glaessner, 1937), Sey-03-07 (HGF), GP/5E-4313; (**5**) *Saccammina grzybowskii* (Schubert, 1902), Sey-03-01 (WSF), GP/5E-4308; (**6**) *Ammodiscus pennyi* Cushman and Jarvis, 1928, Sey-03-07 (HGF), GP/5E-4313; (**7–11**) *Ammodiscus vastus* n. sp.: (**7, 8**) holotype, Sey-03-07 (HGF), GP/5E-4363; (**9, 10**) paratype, Sey-03-07 (HGF), GP/5E-4364; (**11**) paratype, Sey-03-03 (WSF), GP/5E-4365; (**12**) *Glomospira charoides* (Jones and Parker, 1860), Sey-07-01 (WSF), GP/5E-4317; (**13**) ?*Gobbettia* sp. indet., Sey-03-07 (HGF), GP/5E-4313; (**14**) *Haplophragmoides* sp. indet., Sey-13-17 (WSF), GP/5E-4342; (**15**) *Sculptobaculites barri* Beckmann, 1991, Sey-03-01 (WSF), GP/5E-4308; (**16**) *Verneuilinoides durus* McNeil, 1997, Sey-03-01 (WSF), GP/5E-4308. Scanning electron micrographs.

Remarks.—The test is composed solely of inorganic grains. There is no sign of poriferan sclerites or other biogenic materials, which are common in some species of the genus (Gooday and Claugher, 1989). It is similar in size to rhabdamminids of the López de Bertodano Formation, but these are coarser grained (Huber, 1988).

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Bathysiphon sp. indet. 2
Figure 3.2
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Occurrence.—Level Sey-03-07 (HGF).

Description.—Test tubular, elliptical in cross section. Wall moderately agglutinated. Discrete, irregular constriction near one end.

Materials.—One specimen (GP/5E-4313).

Remarks.—The specimen could represent a large morphotype of *Bathysiphon* sp. indet. 1.

<center>

Genus *Nothia* Pflaumann, 1964
</center>

Type species.—*Rhizammina grilli* Noth, 1951, by original designation.

<center>

Nothia robusta (Grzybowski, 1898)
Figure 3.3
</center>

1898 *Dendrophrya robusta* Grybowski, p. 273, pl. 10, fig. 7.
1902 *Dendrophrya robusta* var. *maxima* Friedberg, p. 460, pl. 22, fig. 4.

Holotype.—Eocene, Krosno, Poland (Grzybowski, 1898, pl. 10, fig. 7).

Occurrence.—Level Sey-03-07 (HGF).

Description.—Test tubular, unbranched, elliptical in cross section. Wall finely to moderately agglutinated. Median longitudinal groove along one side of test.

Materials.—Five specimens (GP/5E-4313).

Remarks.—It is virtually impossible to distinguish single, unbranched specimens of *Nothia* from those of *Bathysiphon*, because the former is characterized by its branching potential (Loeblich and Tappan, 1987), which can only be attested for unbranched individuals by observing their association with virtually identical branched ones. Nevertheless, our specimens

present a longitudinal median groove, which is a diagnostic feature of *Nothia robusta* (see Kaminski and Gradstein, 2005).

<center>

Genus *Psammosiphonella* Avnimelech, 1952
</center>

Type species.—*Bathysiphon arenacea* Cushman, 1927, by original designation.

<center>

Psammosiphonella cylindrica (Glaessner, 1937)
Figure 3.4
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1937 *Rhabdammina cylindrica* Glaessner, p. 354, pl. 1, fig. 1.
1970 *Hyperammina cylindrica cylindrica*; Mjatliuk, p. 57, pl. 1, fig. 12, pl. 2, figs. 7, 8, pl. 3, fig. 1.

Holotype.—Paleocene or Eocene, Psekups River, Russia (Glaessner, 1937, pl. 1, fig. 1).

Occurrence.—Level Sey-03-07 (HGF).

Description.—Test tubular, circular in cross section. Wall coarsely agglutinated.

Materials.—One specimen (GP/5E-4313).

Remarks.—The circular cross section of this specimen makes it different from the other rhabdamminids described herein, the elliptical cross sections of which could be interpreted as evidence of compaction.

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Suborder Saccamminina Lankester, 1885
Superfamily Saccamminoidea Brady, 1884
Family Saccamminidae Brady, 1884
Subfamily Saccammininae Brady, 1884
Genus *Saccammina* Carpenter, 1869
</center>

Type species.—*Saccammina sphaerica* Brady, 1871, by subsequent designation (Cushman, 1928).

<center>

Saccammina grzybowskii (Schubert, 1902)
Figure 3.5
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1898 *Reophax difflugiformis* Brady in Grzybowski, p. 277, pl. 10, figs. 11, 12.
1902 *Reophax grzybowskii* Schubert, p. 20, pl. 1, fig. 13a, b.
1912 *Pelosina complanata* Franke, p. 107, pl. 3, fig. 1a, b.
1943 *Placentammina gutta* Majzon, p. 152, pl. 2, fig. 5a–c.
1948 *Pelosina dubia* Cushman and Renz, p. 5, pl. 1, fig. 7.

Holotype.—Oligocene, Lake Garda, Italy (Schubert, 1902, pl. 1, fig. 13a, b).

Occurrence.—Level Sey-03-01 (WSF).

Description.—Test highly compressed. Body discoid. Neck well-defined, long, broad. Body surface slightly corrugated. Wall finely agglutinated.

Materials.—One specimen (GP/5E-4308).

Remarks.—We parsimoniously assign this specimen to *Saccammina grzybowskii* recognizing that it does not have the narrower neck typical of the species, rather, as the revised diagnosis of Kaminski and Gradstein (2005, p. 132) stated, only a "produced neck." Therefore, there is no need to emend its diagnosis or to designate a new species for this morphotype, which could merely represent an ecophenotype or subspecies.

The specimen is similar to *Saccammina* sp. indet. from the Late Cretaceous of the eastern Alps (Butt, 1981, pl. 16, fig. F) and to '*Lagenammina grzybowski*' from the Late Cretaceous of Trinidad (Bolli et al., 1994, fig. 18.10, but not the conical specimen in fig. 18.9), which are nearly identical in shape (discoid body, long and relatively broad neck) and size (~740 and 700 μm in length, respectively). It is also similar to the specimen of '*L. grzybowski*' illustrated by Kaminski et al. (1988, pl. 2, fig. 7), also from the Late Cretaceous of Trinidad, the neck of which is considerably broader at its base and tapers toward its distal end. The discoid morphology of all of these specimens indicates that they belong to the genus *Saccammina*, and not to the conical *Lagenammina* Rhumbler, 1911 (Loeblich and Tappan, 1987); the produced neck and test coarseness are diagnostic of *Saccammina grzybowski* (see Kaminski and Gradstein, 2005).

Our specimen closely resembles *Saccammina sphaerica*, as earlier reported by Webb (1975, p. 834, pl. 1, fig. 7) for the Paleocene of the southern Tasman Sea, which is also represented by a single specimen. With a discoid body and a distinct neck, it can be attributed to *Saccammina grzybowskii*, and its corrugated surface and considerably broader neck makes it rather similar to the Seymour Island specimen.

At 1,220 μm in length, our specimen is considerably larger than the topotypes from the Oligocene of Italy (to 620 μm length) and the specimens from the Paleocene of Trinidad (to 550 μm length) (Kaminski and Gradstein, 2005) and Miocene of Romania (to 400 μm length) (Beldean and Filipescu, 2011). The Tasman Sea specimen is larger than these other occurrences, at ~750 μm in length.

Class Tubothalamea Pawlowski, Holzmann, and Tyszka, 2013
 Order Spirillinida Hohenegger and Piller, 1975 emend.
  Pawlowski, Holzmann, and Tyszka, 2013
   Superfamily Ammodiscacea Reuss, 1862
    Family Ammodiscidae Reuss, 1862
     Subfamily Ammodiscinae Reuss, 1862
      Genus *Ammodiscus* Reuss, 1862

Type species.—*Ammodiscus infimus* Bornemann, 1874, by subsequent designation (Loeblich and Tappan, 1954).

Ammodiscus pennyi Cushman and Jarvis, 1928
Figure 3.6

1928 *Ammodiscus pennyi* Cushman and Jarvis, p. 87, pl. 12, figs. 4, 5.

Holotype.—Paleocene, Lizard Springs, Trinidad (Cushman and Jarvis, 1928, pl. 12, figs. 4, 5).

Occurrence.—Level Sey-03-07 (HGF).

Description.—Test circular in outline. Three whorls. Last whorl irregular, but still of planispiral plan. Wall finely agglutinated. Broad secondary chamber, with overall homogeneous diameter in last whorl.

Materials.—Two specimens (GP/5E-4313).

Remarks.—The specimens are larger, more irregular, and has one to two whorls less than those of *Ammodiscus pennyi* from the underlying López de Bertodano Formation (Huber, 1988, fig. 16.7).

Ammodiscus vastus new species
Figure 3.7–3.11

Type specimens.—Holotype (Fig. 3.7, 3.8), Miocene, level Sey-03-07 (HGF), Seymour Island, Antarctica, LPS-IGc-USP, GP/5E-4363. Paratypes: six from level Sey-03-07 (HGF), GP/5E-4364; three from level Sey-03-03 (WSF), GP/5E-4365.

Diagnosis.—Larger than other species of genus, except for modern *Ammodiscus mestayeri* Cushman, 1919. Test distinctly elliptical in outline, reaching or exceeding 3 mm in major axis diameter. Secondary chamber diameter increasing by approximately one tenth with each whorl. Up to six whorls, potentially more in larger, older specimens.

Occurrence.—Miocene to Plio-Pleistocene, Hobbs Glacier Formation (level Sey-03-07) and Weddell Sea Formation (level Sey-03-03), northeast of Seymour Island, West Antarctica.

Description.—Test large, elliptical in outline, biconcave. Prolocolus large. Secondary chamber increasing gradually in diameter. To six whorls in adult, probably surpassing this in larger, older specimens. Wall finely agglutinated, dark gray-blue in color. Aperture semicircular. No true constrictions nor striations, but could display few sparse annular irregularities.

Etymology.—From the Latin *vastus*, meaning enormous or immense, recognizing it as one of the largest species of *Ammodiscus*.

Dimensions.—Larger complete specimen (holotype) of 3,328 μm in major axis diameter and 430 μm width. Largest incomplete specimen (paratype, Fig. 3.11) of ~1,863 μm in minor axis diameter, but major axis diameter estimated at ~3,700 μm.

Remarks.—Among the fossil species of the genus, *Ammodiscus vastus* n. sp. is comparable in size only to the Eocene-Miocene

Ammodiscus latus Grzybowski, 1898 and the Campanian-Paleocene *Ammodiscus pennyi*, the largest specimens of which rarely reach 2 mm and never surpass 2.5 mm diameter (Webb, 1973; Kaminski and Gradstein, 2005; Holbourn et al., 2013; Waśkowska and Kaminski, 2017). Among modern species, *Ammodiscus vastus* n. sp. is surpassed in size only by *Ammodiscus mestayeri* Cushman, 1919, which reaches 4.5 mm diameter (Cushman, 1919), although larger specimens of *Ammodiscus incertus* (d'Orbigny, 1839) and *Ammodiscus tenuis* (Brady, 1881) reach slightly smaller sizes, to 3 mm diameter (Brady, 1884).

Ammodiscus vastus n. sp. shares one or more morphological traits with the Cretaceous-Eocene *Ammodiscus cretaceous* (Reuss, 1845), with the Maastrichtian-Eocene *Ammodiscus glabratus* Cushman and Jarvis, 1928, and, especially, with the Late Cretaceous–Eocene *Ammodiscus peruvianus* Berry, 1928, which is also distinctly elliptical in outline. However, *Ammodiscus vastus* n. sp. shows distinctive features, differing from: (1) *Ammodiscus cretaceous* by having fewer whorls, a secondary chamber increasing more gradually in diameter, and being distinctly elliptic instead of slightly elliptic in outline, as is the case of some *Ammodiscus cretaceous* specimens (Muftah, 1995, p. 176, pl. 1, fig. 6; Kaminski and Gradstein, 2005, p. 145, 146, pl. 14); (2) *Ammodiscus glabratus* by having fewer whorls, a more defined coil suture, and a secondary chamber increasing more gradually in diameter (Kaminski and Gradstein, 2005, p. 148–150, pl. 15); and (3) *Ammodiscus peruvianus* by having fewer whorls and a secondary chamber increasing slightly more gradually in size (Kaminski and Gradstein, 2005, p. 157, 158, pl. 18). Furthermore, *Ammodiscus vastus* n. sp. is considerably larger than these species, ~250% greater in size than the largest specimens of *Ammodiscus peruvianus* (see Kaminsk and Gradstein, 2005).

Ammodiscus vastus n. sp. differs from most of the modern *Ammodiscus* spp. especially in its elliptical outline and larger maximum size. Further differences can be illustrated by the following examples: (1) its complete lack of striations makes it readily distinct from *Ammodiscus anulatus* Fiorini, 2009 (p. 95, pl. 1) and *Ammodiscus reesi* LeRoy in LeRoy and Hodgkinson, 1975 (p. 425, 426, pl. 2, fig. 7); (2) its fewer whorls distinguish it from *Ammodiscus anguillae* Höglund, 1947 (Jones, 1994, p. 43, pl. 38, figs. 1, 3) as well as from the minute *Ammodiscus antarcticus* Saidova, 1975 (p. 69, 70, pl. 95, fig. 9). The larger *Ammodiscus mestayeri* displays even fewer whorls than *Ammodiscus vastus* n. sp., and its test is biconvex due to its width being greater in the proloculus and in the initial portion of the secondary chamber (Cushman, 1919, p. 597, 598, pl. 74, figs. 1, 2). In relation to the slightly smaller *Ammodiscus incertus* and *Ammodiscus tenuis*, the former has several more whorls, and the latter displays an extra whorl and the relative width of its secondary chamber is much smaller, giving it a less robust appearance (Brady, 1884, p. 332, 333, pl. 38, figs. 1–6).

Our specimens can be readily distinguished from those of *Ammodiscus cretaceous* and *Ammodiscus peruvianus* from the Late Cretaceous of the nearby Bellinghausen Abyssal Plain (Rögl, 1976, pl. 2, figs. 22, 23), which, in addition to basic morphological differences, are > 10 times smaller.

The relatively large procoluli of the specimens suggest that they are macrospheric forms. This would imply that microspheric forms could have been even larger than the collected specimens.

<div align="center">

Subfamily Usbekistaniinae Vyalov, 1968
Genus *Glomospira* Rzehak, 1885

</div>

Type species.—*Trochammina squamata* var. *gordialis* Jones and Parker, 1860, by monotypy.

<div align="center">

Glomospira charoides (Jones and Parker, 1860)
Figure 3.12

</div>

1860 *Trochammina squamata* var. *charoides* Jones and Parker, p. 304 (unillustrated).
1943 *Glomospira saturniformis* Majzon, p. 31, pl. 5, fig. 9.
1954 *Glomospira favilla* Emiliani, p. 133, pl. 13, fig. 15a–c.
1959 *Glomospira subcharoides* Khalilov, p. 25, pl. 1, fig. 1a–c.
1960 *Glomospira pileolus* Subbotina, p. 179, pl. 1, figs. 13a–14c.
1964 *Glomospira iranensis* Kavary in Kavary and Frizzel, p. 10, pl. 1, figs. 2–7.
1969 *Glomospira subarctica* Chamney, p. 16, pl. 2, figs. 7–9.
1972 *Glomospira praecharoides* Soliman, p. 36, pl. 1, figs. 1, 2, pl. 2, fig. 1.
1987 *Glomospira fulgida* Maslun, p. 69, pl. 2, fig. 3.

Holotype.—Holocene, Mediterranean Sea (Jones and Parker, 1860); lectotype figured by Berggren and Kaminski (1990, pl. 1, fig. 2).

Occurrence.—Level Sey-07-01 (WSF).

Description.—Chamber tubular and broad, twisted in vertical axis but streptospiral in final morphology. Wall coarsely agglutinated. Aperture broad.

Materials.—Two specimens (GP/5E-4317).

Remarks.—The specimens from WSF have no significant differences from typical *Glomospira charoides*, except for being considerably larger (to 1,352 µm diameter) than the largest specimens known (to 400 µm diameter; Kaminski and Gradstein, 2005). Very small specimens were reported for the Southern Ocean by Saidova (1975).

<div align="center">

Class Globothalamea Pawlowski, Holzmann, and Tyszka, 2013
Subclass Textulariia Mikhalevich, 1980
Order Lituolida Lankester, 1885
Suborder Lituolina Lankester, 1885
Superfamily Lituoloidea de Blainville, 1827
Family Haplophragmoididae Maync, 1952
Genus *Gobbettia* Dhillon, 1968

</div>

Type species.—*Gobbettia wilfordi* Dhillon, 1968, by original designation.

?*Gobbettia* sp. indet.
Figure 3.13

Occurrence.—Level Sey-03-07 (HGF).

Description.—Test elliptical in outline, umbilicated. Planispiral, but somewhat irregularly coiled. Wall coarsely agglutinated. Chambers increasing rapidly in size. Last chamber inflated. Sutures radial, slightly depressed, slightly distinct. Aperture indistinct.

Materials.—One specimen (GP/5E-4313).

Remarks.—The minor irregularity in the planispiral coiling seems to be a common feature of *Gobbettia* (Loeblich and Tappan, 1987).

Genus *Haplophragmoides* Cushman, 1910

Type species.—*Nonionina canariensis* d'Orbigny, 1839, by original designation.

Haplophragmoides sp. indet.
Figure 3.14

Occurrence.—Level Sey-13-17 (WSF).

Description.—Test planispiral, involute, roughly elliptical in outline. Nine chambers in last whorl, rapidly increasing in size. Sutures barely visible. Periphery rounded. Aperture as equatorial slit at base of apertural face.

Materials.—One specimen (GP/5E-4342).

Remarks.—Despite its relatively large size, the simple morphology and elliptical outline suggest the specimen is a juvenile, as is the case for at least one species of the genus (Kaminski et al., 2016)

Genus *Sculptobaculites* Loeblich and Tappan, 1984

Type species.—*Ammobaculites goodlandensis* Cushman and Alexander, 1930, by original designation.

Sculptobaculites barri Beckmann, 1991
Figure 3.15

1991 *Sculptobaculites barri* Beckmann, p. 823, pl. 1, figs. 6–9.

Holotype.—Paleocene, Moruga, Trinidad (Beckmann, 1991, pl. 1, figs. 6–9).

Occurrence.—Level Sey-03-01 (WSF).

Description.—Early stage planispiral; later state uncoiled, relatively short, extending tangentially from planispiral portion. Wall coarsely agglutinated. Sutures nearly indistinct in both planispiral and uncoiled stages. Aperture terminal, subcircular.

Materials.—One specimen (GP/5E-4308).

Remarks.—The specimen is similar to those from the Paleocene of Trinidad (Kaminski and Gradstein, 2005, pl. 86, fig. 5), but less laterally compressed.

Suborder Verneuilinina Mikhalevich and Kaminski in Kaminski, 2004
Superfamily Verneuilinoidea Cushman, 1911
Family Verneuilinidae Cushman, 1911
Subfamily Verneuilinoidinae Suleymanov, 1973
Genus *Verneuilinoides* Loeblich and Tappan, 1949

Type species.—*Verneuilina schizea* Cushman and Alexander, 1930, by original designation.

Verneuilinoides durus McNeil, 1997
Figure 3.16

1997 *Verneuilinoides durus* McNeil, p. 33, pl. 10, figs. 5–8.

Holotype.—Paleocene, Beaufort-Mackenzie Basin, Canadian Arctic (McNeil, 1997, pl. 10, figs. 5–8).

Occurrence.—Level Sey-03-01 (WSF).

Description.—Test triserial, elongated, lobulated in section. Wall coarsely agglutinated. Chambers moderately inflated; peripheral outline slightly subacute. Four chambers in each one of the series. Sutures depressed, slightly distinct to indistinct. Aperture an interiomarginal arch.

Materials.—Four specimens (GP/5E-4308).

Remarks.—The specimens resemble the holotype of *Verneuilinoides durus* (see McNeil, 1997, pl. 10, figs. 5–8), and they are remarkably similar to *Verneuilinoides* aff. *V. durus* from the Late Cretaceous of the Barents Sea, Norway (Setoyama et al., 2011, pl. 10, fig. 11a–c). This wider, shorter morphotype makes them distinct from the otherwise similar *Verneuilinoides paleogenicus* (Lipman, Burtman, and Khokhlova, 1960) from the Paleocene of western Siberia (Podobina, 2000, pl. 1, fig. 8a–c), and from the cosmopolitan *Verneuilinoides neocomiensis* (Myatlyuk, 1939), a common species in the Early Cretaceous of the Atlantic and Pacific oceans (Maync, 1973, pl. 1, figs. 29, 30; Kaminski et al., 1992, pl. 7, fig. 13; Holbourn et al., 2013, p. 610, fig. 1).

Suborder Loftusiina Kaminski and Mikhalevich in Kaminski, 2004
Superfamily Loftusioidea Brady, 1884
Family Cyclamminidae Marie, 1941
Subfamily Alveolophragmiinae Saidova, 1981
Genus *Alveolophragmium* Shchedrina, 1936

Type species.—*Alveolophragmium orbiculatum* Shchedrina, 1936, by original designation.

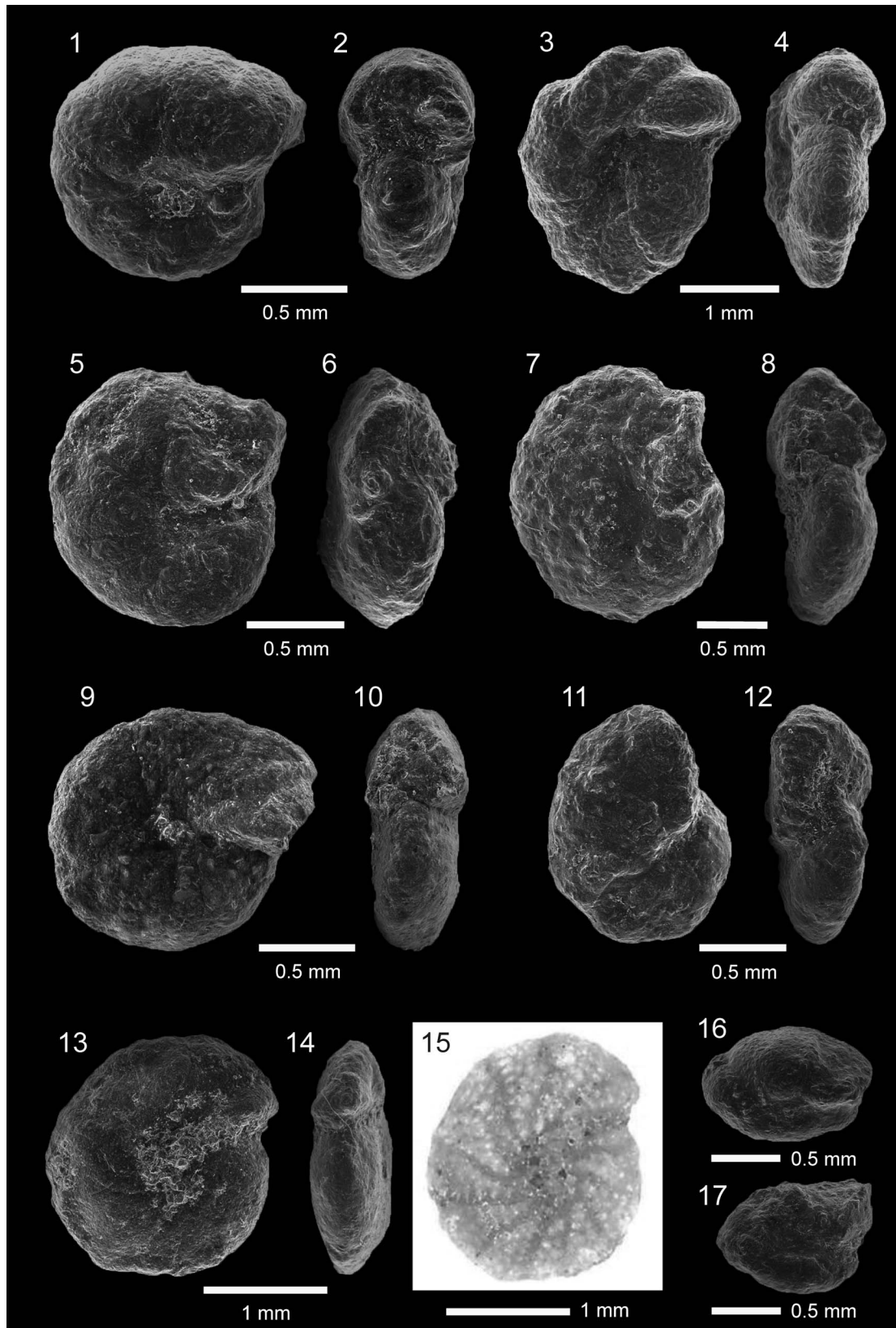*Alveolophragmium orbiculatum* Shchedrina, 1936
Figure 4.1, 4.2

1936 *Alveolophragmium orbiculatum* Shchedrina, p. 312, figs. 1–3.

Holotype.—Holocene, Kara Sea, Siberian Arctic (Shchedrina, 1936, figs. 1–3).

Occurrence.—Levels Sey-03-07 (HGF) and Sey-13-69 (HGF).

Description.—Test almost circular in outline, biumbilicated. Wall finely to moderately agglutinated. Twelve chambers in last whorl. Sutures radial to sigmoid, slightly depressed, slightly distinct.

Materials.—Five specimens: three from Sey-03-07 (GP/5E-4313), two from Sey-13-69 (GP/5E-4348).

Remarks.—Our specimens are very similar to those from the early Miocene of Chile (Finger, 2013, pl. 1, fig. 12a, b), despite being almost twice as large.

Genus *Reticulophragmium* Maync, 1955

Type species.—*Alveolophragmium venezuelanum* Maync, 1952, by original designation.

Reticulophragmium cf. *R. acutidorsatum* (Hantken, 1868)
Figure 4.3, 4.4

Holotype.—Oligocene, Budapest, Hungary (Hantken, 1868, pl. 1, fig. 1a, b).

Occurrence.—Level Sey-13-17 (WSF).

Description.—Test lenticular in outline, laterally compressed. Periphery acute. Wall moderately agglutinated. Eleven chambers in last whorl, increasing slowly in size. Sutures oblique, depressed, slightly distinct. Aperture indistinct.

Materials.—Two specimens (GP/5E-4342).

Remarks.—The specimens are similar to those of *Reticulophragmium acutidorsatum* from the Oligocene of Austria (Kaminski and Gradstein, 2005, pl. 122, figs. 2, 3), but they have a more acute periphery and three chambers fewer in the last whorl (although still falling within the range of *Reticulophragmium acutidorsatum*).

Reticulophragmium garcilassoi (Frizzell, 1943)
Figure 4.5, 4.6

1943 *Cyclammina garcilassoi* Frizzell, p. 338, pl. 55, fig. 11.

1987 *Cyclammina radiata* Serova, p. 79, pl. 4, fig. 5a, b.

Holotype.—Paleocene, Piura, Peru (Frizzell, 1943, pl. 55, fig. 11a, b).

Occurrence.—Levels Sey-13-67 (HGF) and Sey-13-69 (HGF).

Description.—Test lenticular, circular to lobate in outline. Peripheral margin subacute. Chambers 12–14 in last whorl. Aperture indistinct.

Materials.—Three specimens: two from Sey-13-67 (GP/5E-4347), one from Sey-13-69 (GP/5E-4348).

Remarks.—The characteristic internal alveolar structure is faintly visible, probably due to the sedimentary filling.

Reticulophragmium sp. indet.
Figure 4.7, 4.8

Occurrence.—Levels Sey-13-67 (HGF) and Sey-13-69 (HGF).

Description.—Test lenticular, circular in outline. Peripheral margin subacute. Chambers ~13 in last whorl. Aperture as narrow slit in base of last chamber.

Materials.—Two specimens: one from Sey-13-67 (GP/5E-4347), one from Sey-13-69 (GP/5E-4348).

Remarks.—The micrite cover prevents observation of other features, e.g., the umbilical area, suture details, and the distribution pattern of alveoles, but the overall shape of the test is very similar to some morphotypes of *Reticulophragmium pauperum* (Chapman, 1904) emend. Ludbrook, 1977 from the Paleocene of Australia (Kaminski and Gradstein, 2005, pl. 126, fig. 1a, b). This taxon could represent poorly preserved specimens of *Reticulophragmium* cf. *R. acutidorsatum*.

Subfamily Cyclammininae Marie, 1941
Genus *Cyclammina* Brady, 1879

Type species.—*Cyclammina cancellata* Brady, 1879, by original designation.

Cyclammina cancellata Brady, 1879
Figure 4.9, 4.10

1879 *Cyclammina cancellata* Brady, p. 62.
1884 *Cyclammina cancellata* Brady, p. 351, pl. 37, figs. 8–16.
1917 *Cyclammina compressa* Cushman, p. 653 (unillustrated).

1917 *Cyclammina pauciloculata* Cushman, p. 653 (unillustrated).

Holotype.—Holocene, undefined locality (Brady, 1884, pl. 37, figs. 8–16).

Occurrence.—Level Sey-07-01 (WSF).

Description.—Test almost circular in outline, laterally compressed. Peripheral margin rounded. Wall coarsely agglutinated. Sutures sigmoid, slightly depressed, distinct. Umbilicus depressed. Chambers 12–15 in last whorl, increasing slowly in size. Aperture as interiomarginal slit.

Materials.—Four specimens (GP/5E-4317).

Remarks.—Our specimens are not directly comparable with those from the early Miocene of Chile (Finger, 2013, p. 109, pl. 1, figs. 15–18) and King George Island (Birkenmajer and Łuczkowska, 1987, pl. 2, fig. 2a, b). They show lateral compression, as do those from Chile, but their shell width and suture morphology resemble those from King George Island.

<center>*Cyclammina placenta* (Reuss, 1851)
Figure 4.11, 4.12</center>

1851 *Nonionina placenta* Reuss, p. 72, pl. 5, fig. 33a, b.
1943 *Cyclammina pacifica* Beck, p. 591, pl. 98, fig. 23.

Holotype.—Oligocene, Berlin, Germany (Reuss, 1851, pl. 5, fig. 33a, b).

Occurrence.—Level Sey-03-07 (HGF).

Description.—Test elliptical in outline, laterally compressed. Chambers nine in last whorl, increasing rapidly in size. Periphery slightly lobulated. Umbilicus depressed on both sides. Planispiral but showing convolution that discretely tends to left side at ~30°. Sutures straight to slightly waved. Aperture as interiomarginal slit.

Materials.—One specimen (GP/5E-4313).

Remarks.—Regarding the overall morphology and especially the asymmetry in the coiling plan, the specimens are similar to those from the Eocene of the United States (Kaminski and Gradstein, 2005, pl. 119, fig. 6a, b).

<center>Superfamily Recurvoidoidea Alekseychik-Mitskevich, 1973
Family Ammosphaeroidinidae Cushman, 1927
Subfamily Recurvoidinae Alekseychik-Mitskevich, 1973
Genus *Budashevaella* Loeblich and Tappan, 1964</center>

Type species.—*Circus multicameratus* Voloshinova and Budasheva, 1961, by original designation.

<center>*Budashevaella* cf. *B. laevigata* (Voloshinova and Budasheva, 1961)
Figure 4.13–4.15</center>

Holotype.—Miocene, Sakhalin Island, Russia (Voloshinova and Budasheva, 1961, pl. 9, fig. 2a–c).

Occurrence.—Level Sey-07-01 (WSF).

Description.—Test discoid. Chambers 13 in last whorl. Finely agglutinated. Sutures depressed, straight to slightly sigmoid. Chamber periphery rounded to slightly subacute. Apertural face somewhat triangular, with indistinct aperture.

Materials.—Two specimens (GP/5E-4317).

Remarks.—Despite being considerably larger, our specimens are similar to those of *Budashevaella laevigata* from the Triassic of Romania (Beldean and Filipescu, 2011, p. 8, pl. 4, fig. 1) by their outline, slight asymmetry in the planispiral coiling, and the number and morphology of the chambers. The internal alveolar structure is visible under transmitted light (Fig. 4.15).

<center>Genus *Recurvoides* Earland, 1934</center>

Type species.—*Recurvoides contortus* Earland, 1934, by original designation.

<center>*Recurvoides* cf. *R. torquis* Schröder-Adams and McNeil, 1994
Figure 4.16</center>

Holotype.—Oligocene–Miocene, Beaufort-Mackenzie Basin, Canadian Arctic (Schröder-Adams and McNeil, 1994, pl. 4, figs. 1–4).

Occurrence.—Level Sey-07-01 (WSF).

Description.—Test elliptical in outline. Initial stage streptospiral; later stage planispiral. Wall finely agglutinated. Chambers 12 in last whorl, subtriangular, increasing slowly in size. Sutures slightly distinct. Aperture indistinct.

Materials.—Ten specimens (GP/5E-4317).

Remarks.—*Recurvoides torquis* differs from *Recurvoides contortus*—a cosmopolitan species, common in Recent bathyal to abyssal deposits (Kaminski and Gradstein, 2005), including those of Antarctica (Pflum, 1966; Jones and Pudsey, 1994)—by its elliptical outline, instead of oval; its early streptospiral coiling, instead of inclined by ~90° to the last spiral part; and a final planispiral coiling, instead of nonplanispiral to slightly trochospiral. Additionally, our specimens differ from *Recurvoides contortus* by their smooth surface and planispiral or almost planispiral last whorl.

<center>*Recurvoides* sp. indet.
Figure 4.17</center>

Occurrence.—Level Sey-03-07 (HGF).

Description.—Test ellipsoidal in outline, elongated. Initial stage streptospiral; later stage nearly planispiral. Wall finely

agglutinated. Chambers 10 in planispiral part, subtriangular, increasing slowly in size. Sutures slightly distinct.

Materials.—Three specimens (GP/5E-4313).

Remarks.—This taxon could represent poorly preserved specimens of *Recurvoides* cf. *R. torquis*.

Results

Most of the large agglutinated foraminifers come from the Sey-03 section, from strata of both the Hobbs Glacier and Weddell Sea formations, but they also occur in levels of the WSF in section Sey-07 and of the HGF in sections Sey-10, Sey-13, and Sey-14 (Figs. 3, 4); for precise stratigraphic positions, confront Figure 2 with the data of occurrence for each taxon as specified in the Systematic paleontology section. No taxa are present at > 10 individuals and some are represented by single specimens. Cases in which a given species is also found in another Antarctic deposit, ancient or Recent, are indicated in the remarks in the form of a morphological comparison.

All foraminifers described herein are internally filled and partially covered by lithified micrite, and a few exhibit postfill fragmentation, indicating that they were previously entombed in consolidated deposits and were then re-elaborated into Miocene and Plio-Pleistocene sediments. Nevertheless, micrite-free surficial areas show that the agglutinated walls are well preserved (i.e., with no signs of abrasion or bioerosion), which is a sign of a rapid, definitive burial preceding their re-elaboration, as well as of a quick reburial after any previous exhumation.

Due to sedimentary filling, the internal alveolar structure of cyclamminids is faintly visible even when the specimens are wet in oil and being observed under intense light. Similarly, the external features of some specimens are obscured by a cover of micrite.

A few undetermined specimens, which are also considerably large, were found in the 7th level of the Sey-03 section and in the 5th, 6th, and 7th levels of the Sey-14 section. These tests are clearly agglutinated, coiled, and multichambered, but they are fragmented and/or covered by micrite in the apertural or umbilical areas, preventing further taxonomic assignments.

Energy-dispersive X-ray spectroscopy, conducted on re-elaborated specimens as well as in previously described indigenous specimens, show that the element titanium is present only in former (Fig. 5), in small amounts both in the test surface and in the encrusting sediment. The atomic percentage varies from 0.02–0.03%. Because titanium was found associated with elements such as calcium, iron, silicon, and oxygen, it is not possible to infer which are the titanium-bearing minerals, ilmenite ($FeTiO_3$), perovskite ($CaTiO_3$), titanite ($CaTiSiO_5$), or the polymorphs anatase, brookite, and rutile (TiO_2). Other differences between the spectra are not significant, since they are related to the specific composition of each particular test (i.e., secreted calcareous or agglutinated siliciclastic grains).

Discussion

Taphonomy and comparisons with other assemblages.—It is very implausible that the specimens were re-elaborated from the known underlying deposits, in which large agglutinated foraminifers do occur. Except for *Ammodiscus pennyi*, none of our taxa is found in the Cretaceous portion of the López de Bertodano Formation, where the most common species are *Cyclammina* cf. *C. complanata* Chapman, 1904, *Alveolophragmium macellari* Huber, 1988, and *Hyperammina elongata* Brady, 1878; and there is no taxonomic correlation with the Paleocene portion of the same formation, where agglutinated taxa, e.g., *Hyperammina elongata* and *Reophax* sp. indet., are uncommon or rare (Huber, 1988). Even in the case of *Ammodiscus pennyi*, our specimens display significant morphological and size differences, strongly suggesting that, despite belonging to the same species, they represent different populations and environments from those of the underlying deposits.

It is also extremely unlikely that they originated from the underlying La Meseta Formation, because the only indigenous agglutinated foraminifers known for this Eocene deposit represent small and fragile textulariids (Badaró, 2019). Besides these, only a single, poorly preserved trochamminid was reported (Gaździcki and Majewski, 2012), which could have been re-elaborated from the López de Bertodano Formation because similar *Trochammina* species are found in this unit (Huber, 1988).

The re-elaborated taxa rarely occur in other Antarctic deposits, whereas the indigenous species tend to be found in deposits of various ages and in different areas of the continent. In summary: (1) *Psammosphaera fusca* Schulze, 1875 is common in the Recent deposits of the Weddell Sea and King George Island, and is also found in Cretaceous and Miocene deposits of West Antarctica; (2) *Favulina hexagona* (Williamson, 1848) occurs in Miocene deposits of the King George Island; (3) *Oolina globosa* (Montagu, 1803) is found in the Pliocene–Recent interval of the Antarctic Peninsula; (4) *Globocassidulina subglobosa* (Brady, 1881) is found in the Eocene–Pliocene interval of West Antarctica; and (5) *Rosalina globularis* d'Orbigny, 1826 occurs only in Recent deposits of the King George Island, but is found throughout the Oligocene–Recent interval in East Antarctica (see Badaró and Petri, 2019 for further geographic and stratigraphic details). In contrast, the only re-elaborated species found in another Antarctic deposit are *Ammodiscus pennyi, Cyclammina cancellata*, and *Glomospira charoides* (see Systematic paleontology section), not including the rhabdamminids, for which roughly similar but coarser morphotypes can be found in the López de Bertodano Formation (Huber, 1988). Thus, the peculiar distribution of the large agglutinated taxa, both geographically and stratigraphically restricted, also suggest that they did not originate from the deposits that harbor the most typical taxa of the Antarctic Cenozoic.

The large agglutinated specimens differ from the indigenous specimens of the Hobbs Glacier and Weddell Sea formations, as described in Badaró and Petri (2019), in paleoecologic and taphonomic ways. The benthic forms of the latter represent small and shallow infaunal taxa (*Favulina hexagona*, *Globocassidulina* cf. *G. subglobosa*, *Oolina globosa*, *Psammosphaera fusca*, and *Rosalina* cf. *R. globularis*), and they are in pristine condition (i.e., tests are hollow, not fragmented, and with no encrusting sediment), except for *Rosalina* cf. *R. globularis*, the signs of abrasion and dissolution of which suggest it was reworked in previous glacial cycles (for further
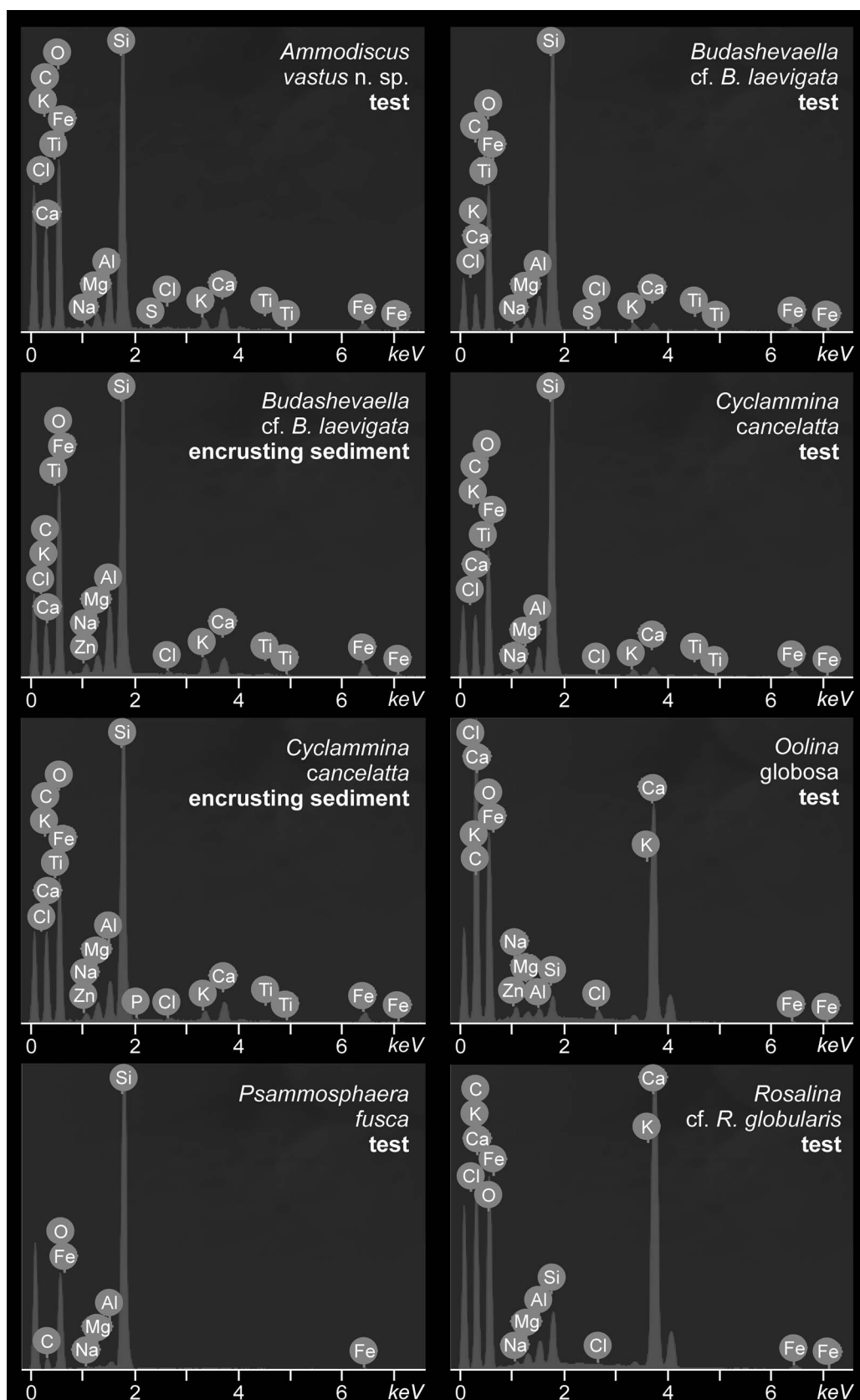
Figure 5. Energy-dispersive X-ray spectroscopy (EDS) of selected re-elaborated and indigenous foraminifers from the Hobbs Glacier and Weddell Sea formations on Seymour Island.

details, see Badaró and Petri, 2019 and references therein). On the other hand, the large agglutinated forms comprise both erect epifaunal taxa (rhabdamminids) and surficial epifaunal to shallow infaunal taxa (ammodiscids, cyclamminids, haplophragmoidids, and recurvoidoids), and their taphonomic features (i.e., sedimentary fill and post-fill fragmentation), clearly indicate that they were entombed in, and then exhumed from, older deposits. Furthermore, there is a substantial diachrony between the taxa of the Hobbs Glacier Formation, in which the Neogene–Quaternary *O. globosa* co-occurred with the Paleocene index fossil *Reticulophragmium garcilassoi* and the Late Cretaceous–Paleocene *Ammodiscus pennyi*.

Even though we can consider features such as sedimentary fill and postfill fragmentation as consistent signs of re-elaboration in foraminiferal assemblages (Reolid, 2008), the only unambiguous evidence for such a process is the diachronism between biostratigraphically well-defined taxa (Herrero and Canales, 2002). In this case, not only the paleoecologic constrast but the taphonomic and diachronic disparities alike indicate the re-elaborated origin of the large agglutinated specimens.

Nevertheless, additional evidence of the different origins of the large agglutinated and small calcareous specimens is that the element titanium is found exclusively in the former. The presence of this element could be interpreted in two ways. First, it could be seen as the result of different taphonomic histories, with titanium reacting with the re-elaborated tests sometime during their fossil diagenesis, certainly before they were mixed with the indigenous tests. In this case, titanium ions might have originated from the alteration of igneous rocks, which are common in the Antarctic Peninsula due to major magmatic events occurring in the late Paleozoic and Mesozoic (Jordan et al., 2020). The second interpretation is that titanium might have reacted with the tests while they were lying on the seafloor, when they were still alive or during their biostratinomic phase. This seems an equally probable possibility, because dissolved titanium is depleted in shallow waters but is enriched in deep waters (Orians et al., 1990). This would explain the presence of titanium both in the test surface and in the encrusted micrite. It is worth mentioning that even though some agglutinated species actively select titanium for constructing their tests (Cole and Valentine, 2005; Makled and Langer, 2010), the fact that this element was also found in the encrusted sediment allows us to exclude this inference for these particular specimens.

Notwithstanding these interpretations, the presence of titanium exclusively in the large agglutinated tests and in the encrusting sediment indicates that these have a different origin than that of the small calcareous specimens. The second interpretation corroborates the hypothesis that these tests originated from a deep-sea setting.

This hypothetical originally deep-sea assemblage can be readily distinguished from Scaglia-type and abyssal assemblages due to the large size and coarseness of its components. We can also infer that this assemblage was probably of the flysch-type, because it would have contained large tubular morphotypes (the rhabdamminids and ammodiscids as a whole) as well as species that, although not exclusive, are common in several flysch-type assemblages (*Nothia robusta*, *Psammosiphonella cylindrica*, *Saccammina grzybowski*). Because the difference between flysch-type and slope assemblages can lie

in the presence or absence of key taxa or in the ratio of organic-cemented and calcareous-cemented species (see Kaminski and Gradstein, 2005; Beldean and Filipescu, 2011), one cannot fully reject the possibility that the original assemblage was of the slope type.

Possible source deposits.—Although it is clear that the foraminifers were re-elaborated from older, consolidated deposits, it is not possible to postulate a specific unit as the most probable source. There are, however, two basic possibilities.

The first is their origin from a different facies, or perhaps a different formation, correlated with the Paleocene deposits of the James Ross Island archipelago. This hypothesis is nevertheless weakened by the fact that the regional stratigraphy is relatively well-defined and none of the early Paleogene units seems likely to contain any still unknown deep-water facies (see Macellari, 1988; Sadler, 1988; Pirrie et al., 1997b; Montes et al., 2013), since the three Paleocene deposits—i.e., the upper López de Bertodano, Sobral, and Cross Valley formations—are interpreted as inner-shelf, possibly estuarine paleoenvironments (Olivero et al., 2007; Marenssi et al., 2012). Yet, it is worth mentioning that Sadler (1988) interpreted the Cross Valley Formation as a paleocanyon, a view that would provide a suitable environment for the development of deep-sea agglutinated communities, at least from the uniformitarian perspective (Kuhnt et al., 2000; Gooday and Jorissen, 2012).

The second possibility is their origin from the most inner parts of West Antarctica. In this case, the Transantarctic Mountains provide a concrete example of glacial remobilization and transportation of microfossils from the mountain range to the very edge of the Antarctic Peninsula: an assemblage of the Cambrian Tommotian fauna was initially recovered from King George Island (Wrona, 1989, 2004), found in reworked clasts at a time putatively correlated to the Cambrian limestones of the mountains, and very similar assemblages were recently described from its central area (Claybourn et al., 2019). It is evident that these microfossils were able to endure such long travel only because they were still encased in sedimentary clasts, otherwise they will have been obliterated beyond the point of recognition. The large foraminifers described herein would have endured the same process, but perhaps in a more friable matrix, which would account for preservation of relatively few tests. Nevertheless, Cretaceous–Paleocene deposits have not been identified in the Transantarctic Mountains, and there are conflicting interpretations on its tectonic history—including the formation of Paleogene seaways and protomountains, crucial aspects to explain ocean-floor uplifting and subsequent re-elaboration of an agglutinated assemblage from it (see Bjil et al., 2011; Burton-Johnson and Riley, 2015; Bowman et al., 2016 and references therein). Within this same line of reasoning, an alternative source would be an accretionary terrain such as the one found in Alexander Island, which contains Cretaceous turbidites, albeit metamorphosed (Tranter, 1992; Burton-Johnson and Riley, 2015). But as in the case of the Transantartic Mountains, if any Paleocene sedimentary succession exists in the region, it is yet to be discovered.

Biostratigraphic and biogeographic implications.—If one assumes the unifying taphonomic and taxonomic features of

Table 1. Main benthic foraminiferal assemblages of the Hobbs Glacier (HGF) and Weddell Sea (WSF) formations on Seymour Island. I = indigenous, reported by Badaró and Petri ([2019](#)); R = re-elaborated, described herein.

Level, formation	Taxonomic composition
Sey-03-01, WSF	*Saccammina grzybowskii,*[R] *Sculptobaculites barri,*[R] *Verneuilinoides durus,*[R] *Favulina hexagona,*[I] *Psammosphaera fusca* [I]
Sey-03-03, WSF	*Ammodiscus vastus* n. sp.,[R] *Bathysiphon* sp. indet. 1,[R] *Globocassidulina* cf. *G. subglobosa* [I]
Sey-03-07, HGF	*Alveolophragmium orbiculatum,*[R] *Ammodiscus pennyi,*[R] *Ammodiscus vastus* n. sp.,[R] *Bathysiphon* sp. indet. 2,[R] *Cyclammina placenta,*[R] *Nothia robusta,*[R] *Psammosiphonella cylindrica,*[R] *Recurvoides* sp. indet.,[R] ?*Gobbettia* sp. indet.,[R] *Oolina globosa,*[I] *Rosalina* cf. *R. globularis* [I]
Sey-07-01, WSF	*Budashevaella* cf. *B. laevigata,*[R] *Cyclammina cancellata,*[R] *Glomospira charoides,*[R] *Recurvoides* cf. *R. torquis* [R]
Sey-13-17, WSF	*Haplophragmoides* sp. indet.,[R] *Reticulophragmium* cf. *R. acutidorsatum* [R]
Sey-13-67, HGF	*Reticulophragmium garcilassoi,*[R] *Reticulophragmium* sp. indet.[R]
Sey-13-69, HGF	*Alveolophragmium orbiculatum,*[R] *Reticulophragmium garcilassoi,*[R] *Reticulophragmium* sp. indet.[R]
Sey-14-07, HGF	*Bathysiphon* sp. indet. 1[R]

our specimens—which indicate the same depositional history and an association of deep-sea taxa—as evidence of their single source, the Paleocene age of *Reticulophragmium garcilassoi* must be extended to the other taxa, and the co-occurrence of the Cretaceous-Paleocene *Ammodiscus pennyi* further corroborates this interpretation. In fact, there is no substantial diachrony between them to invalidate such a hypothesis, except for the occurrence of *Cyclammina cancellata* and *Cyclammina placenta*, the first occurrences of which are considered as Eocene (Kaminski and Gradstein, 2005; Holbourn et al., 2013). Furthermore, *Ammodiscus pennyi*, *Cyclammina placenta*, *Reticulophragmium garcilassoi*, and *Sculptobaculites barri* co-occur in the Paleocene of New Guinea (Milner, 1997), although Kaminski and Gradstein (2005) stated that this occurrence of *Cyclammina placenta* needs further scrutiny. In the same fashion, the distinct morphotype of *Saccammina grzybowskii* from Seymour Island seems remarkably similar to the one found in the Paleocene of the southern Tasman Sea (which is also associated with *Ammodiscus pennyi*), although comparable specimens are also found in the Late Cretaceous of Trinidad and the eastern Alps (see remarks in the Systematic paleontology section).

It is difficult to interpret the possibly diachronic presence of these cyclamminids. Both *Cyclammina cancellata* and *Cyclammina placenta* are absent in the underlying deposits, and only *Cyclammina cancellata* occurs in another pre-Quaternary deposit of West Antarctica, this being the early Miocene Cape Melville Formation on King George Island (Birkenmajer and Łuczkowska, 1987). Because these cyclamminids are also filled with sediment and display postfill fragmentation, like the other large agglutinated taxa, they certainly experienced similar, if not the same, diagenetic process; because this process spared the associated pristine, small foraminifers that are considered to be contemporaneous with Miocene and Plio-Pleistocene deposition (Badaró and Petri, 2019), the cyclamminids must be considered as older elements, possibly pre-Miocene. Consequently, the best explanation is that they were in fact Paleocene in age, which, for the case of *Cyclammina placenta*, would be in accordance with the aforementioned occurrence of this taxon in the Paleocene of New Guinea. The alternative explanation seems convoluted and unlikely, for it would require the existence of a second unknown deposit, post-Paleocene in age.

Regarding foraminiferal faunas, the Austral Biogeographic Province was already established by the Campanian-Paleocene,

and it is well-characterized in deposits from Antarctica, southern Australia, New Zealand, and southern South America (Huber, 1988, 1991). By the Eocene, the communities of the West Antarctic continental shelf still showed strong affinities with those from southern South America and southern Oceania (Gaździcki and Majewski, 2012), but by the Oligocene and early Miocene, very few benthic and planktonic taxa were shared with New Zealand, whereas still preserving similarities with those from southern South America (Gaździcki, 1989; Majewski and Gaździcki, 2014).

This makes it rather interesting that the putative Paleocene assemblage from Seymour Island shares more similarities with those from the South Pacific (i.e., New Guinea and the Tasman Sea) than with those from the South Atlantic (Tjalsma, 1977; Decima and Bolli, 1978; Dailey, 1983; Widmark, 1997). It seems to suggest that the dispersion of deep-sea foraminifers was driven by different factors than those influencing the communities of shallower environments in the Paleogene Southern Ocean. However, it is necessary to find an in situ assemblage to better substantiate this hypothesis by further investigation.

Conclusion

The complex taphonomy of the deposits makes it difficult to recognize details of the depositional history of their large agglutinated foraminifers. Even though they are unified by virtually identical taphonomic features and by consisting of typical deep-sea forms and some flysch-type taxa, they occur scattered through several strata and it is impossible to affirm, with certainty, their origin from a single deep-sea assemblage. On the other hand, although it is not possible to exclude the hypothesis that at least some particular taxa were re-elaborated from the Cretaceous portion of the López de Bertodano Formation, this seems highly unlikely, because the more abundant and robust taxa of that unit are absent in the Hobbs Glacier and Weddell Sea formations. Moreover, there are important morphological and size differences between specimens of the same taxa occurring in both these Cretaceous and Neogene-Quaternary deposits. The fact that the re-elaborated taxa rarely occur in other Antarctic deposits, whereas the indigenous taxa are also found in deposits of different ages and areas of the continent, also strongly suggests the foreign origin of the former.

Therefore, the most parsimonious interpretation is that a flysch-type assemblage, representing a foraminiferal community of the Southern Ocean deep-sea floor, was slowly and gradually

re-elaborated from an unknown—and by now probably completely vanished—Paleocene deposit. This represents one of the few deep-sea foraminiferal communities known for West Antarctica and, more significantly, the first flysch-type assemblage reported for the Antarctic Cenozoic. It also suggests that, in spite of the establishment of the Austral Biogeographic Province in the Late Cretaceous-Paleocene interval, the deep-sea foraminiferal communities of Antarctica still share more similarities with their Pacific counterparts.

Acknowledgments

References

Alekseychik-Mitskevich, L.S., 1973, [K klassifikatsii foraminifer semeystva Haplophragmiidae]: Trudy Vserossiyskiy Neftyanoy Nauchno-issledovatel'skiy Geologorazvedochnyy Instituta, v. 343, p. 12–44. [in Russian]

Avnimelech, M., 1952, Revision of the tubular Monothalamia: Contributions from the Cushman Foundation for Foraminiferal Research, v. 3, p. 60–68.

Badaró, V.C.S., 2019, Indigenous agglutinated foraminifera from the Eocene La Meseta Formation, Seymour Island, West Antarctica: Polish Polar Research, v. 40, p. 129–137.

Badaró, V.C.S., and Petri, S., 2019, Miocene and Plio-Pleistocene foraminiferal assemblages from Seymour Island, Antarctica: Antarctic Science, v. 31, p. 254–262, https://doi.org/10.1017/S0954102019000294.

Beck, R.E., 1943, Eocene Foraminifera from Cowlitz River Lewis County, Washington: Journal of Paleontology, v. 17, p. 584–614.

Beckmann, J.P., 1991, New taxa of Foraminifera from the Cretaceous and basal Tertiary of Trinidad, West Indies: Eclogae Geologae Helvetiae, v. 84, p. 819–835.

Beldean, C., and Filipescu, S., 2011, 'Flysch-type' agglutinated Foraminifera from the Lower Miocene of the Transylvanian Basin (Romania), in Kaminski, M.A., and Filipescu, S., eds., Proceedings, International Workshop on Agglutinated Foraminifera, 8th, Cluj-Napoca, Romania, 7–13 September 2008: Kraków, Grzybowski Foundation, p. 1–18.

Berggren, W.A., and Kaminski, M.A., 1990, Abyssal agglutinates: Back to basics, in Hemleben, C., Kaminski, M.A., Kuhnt, W., and Scott, D.B., eds., Paleoecology, Biostratigraphy, Paleoceanography and Taxonomy of Agglutinated Foraminifera: Dordrecht, The Netherlands, Kluwer Academic Publishers, p. 53–76.

Berry, E.W., 1928, The smaller foraminifera of the middle Lobitos Shales of northwestern Peru: Eclogae Geologae Helvetiae, v. 21, p. 390–405.

Bindiu-Haitonic, R., and Filipescu, S., 2016, Paleocene 'flysch-type' agglutinated Foraminifera from the northern part of the eastern Carpathians (Romania): Studia UBB Geologia, v. 60, no. 2, p. 17–30, https://dx.doi.org/10.5038/1937-8602.60.2.1294.

Birkenmajer, K., and Łuczkowska, E., 1987, Foraminiferal evidence for a lower Miocene age of glaciomarine and related strata, Moby Dick Group, King George Island (South Shetlands Islands, Antarctica): Studia Geologica Polonica, v. 90, p. 81–123.

Bjil, P.K., Pross, J., Warnaar, J., Stickley, C.E., Huber, M., Guerstein, R., Houben, A.J.P., Sluijs, A., Visscher, H., and Brinkhuis, H., 2011, Environmental forcings of Paleogene Southern Ocean dinoflagellate biogeography: Paleoceanography and Paleoclimatology, v. 26, p. 1–12, https://doi.org/10.1029/2009PA001905.

Bolli, H.M., Beckmann, J.P., and Saunders, J.B., 1994, Benthic foraminiferal biostratigraphy of the south Caribbean region: Cambridge, UK, Cambridge University Press, 408 p.

Bornemann, L.G., 1874, Ueber die Foraminiferengattung Involutina: Zeitschrift der Deutschen Geologischen Gesellschaft, v. 26, p. 702–740.

Bowman, V., Ineson, J., Riding, J., Crame, J., Francis, J., Condon, D., Whittle, R., and Ferraccioli, F., 2016, The Paleocene of Antarctica: Dinoflagellate cyst biostratigraphy, chronostratigraphy and implications for the palaeo-Pacific margin of Gondwana: Gondwana Research, v. 38, p. 132–148, https://doi.org/10.1016/j.gr.2015.10.018.

Brady, H.B., 1871, On Saccammina carteri, a new foraminifer from the Carboniferous limestone of Northumberland: Annals and Magazine of Natural History, v. 7, p. 177–184.

Brady, H.B., 1878, On the reticularian and radiolarian Rhizopoda (Foraminifera and Polycystina) of the North-Polar Expedition of 1875–76: Annals and Magazine of Natural History, ser. 5, v. 1, p. 425–440.

Brady, H.B., 1879, Notes on some of the reticularian Rhizopoda of the 'Challenger' Expedition: Quarterly Journal of Microscopical Science, v. 19, p. 20–67.

Brady, H.B., 1881, Notes on some of the reticularian Rhizopoda of the 'Challenger' Expedition, Part 3: Quarterly Journal of Microscopical Science, v. 21, p. 31–71.

Brady, H.B., 1884, Report on the Foraminifera dredged by H.M.S. Challenger during the Years 1873–1876: H.M.S. Challenger Reports, Zoology, v. 9, p. 1–814.

Burton-Johnson, A., and Riley, T.R., 2015, Autochthonous v. accreted terrane development of continental margins: A revised in situ tectonic history of the Antarctic Peninsula: Journal of the Geological Society, v. 172, p. 822–835, https://doi.org/10.1144/jgs2014-110.

Butt, A., 1981, Depositional environment of the Upper Cretaceous rocks in the northern parts of the eastern Alps: Cushman Foundation for Foraminiferal Research, v. 20, p. 5–121.

Caramés, A., and Concheyro, A., 2013, Late Cenozoic Foraminifera from diamictites of Cape Lamb, Vega Island, Antarctic Peninsula: Ameghiniana, v. 50, p. 114–135, https://doi.org/10.5710/AMGH.7.2.2013.588.

Carpenter, W.B., 1869, On the rhizopodal fauna of the deep sea: Proceedings of the Royal Society of London, v. 18, p. 59–62.

Chamney, T.P., 1969, Barremian Textulariina, Foraminifera from Lower Cretaceous beds, Mount Goodenough section, Aklavik Range, District of Mackenzie: Geological Survey of Canada Bulletin, v. 185, p. 1–41.

Chapman, F., 1904, On some Cainozoic foraminifera from Brown's Creek, Otway Coast: Records of the Geological Survey of Victoria, v. 1, p. 227–230.

Claybourn, T.M., Jacquet, S.M., Skovsted, C.B., Topper, T.P., Holmer, L.E., and Brock, G.A., 2019, Mollusks from the upper Shackleton Limestone (Cambrian Series 2), central Transantarctic Mountains, East Antarctica: Journal of Paleontology, v. 93, p. 437–459, https://doi.org/10.1017/jpa.2018.84.

Cole, K.E., and Valentine, A.M., 2005, Titanium biomaterials: Titania needles in the test of the foraminiferan Bathysiphon argenteus: Dalton Transactions, v. 3, p. 430–432, https://doi.org/10.1039/b508989a.

Conato, V., and Segre, A.G., 1974, Depositi marini quaternari e nuovi foraminiferi dell'Antartide (Terra Victoria, Valle Wright): Atti della Societa Toscana di Scienze Naturali Residente in Pisa, v. 81, p. 6–23.

Concheyro, A., Salani, F.M., Adamonis, S., and Lirio, J.M., 2007, Los depósitos diamictíticos cenozoicos de la cuenca James Ross, Antártida: Una síntesis estratigráfica y nuevos hallazgos paleontológicos: Revista de la Asociación Geológica Argentina, v. 62, p. 568–585.

Cushman, J.A., 1910, A monograph of the foraminifera of the North Pacific Ocean, Part 1: Astrorhizidae and Lituolidae: Bulletin of the United States National Museum, v. 71, no. 1, p. 1–134.

Cushman, J.A., 1911, A monograph of the foraminifera of the North Pacific Ocean, Part 2: Textulariidae: Bulletin of the United States National Museum, v. 71, no. 2, p. 1–108.

Cushman, J.A., 1917, New species and varieties of foraminifera from the Philippines and adjacent waters: Proceedings of the United States National Museum, v. 51, p. 651–662.

Cushman, J.A., 1919, Recent foraminifera from off New Zealand: Proceedings of the United States National Museum, v. 56, p. 593–640.

Cushman, J.A., 1927, Recent Foraminifera from off the west coast of America: Bulletin of Scripps Institution of Oceanography, Technical Series, v. 1, p. 119–188.

Cushman, J.A., 1928, Foraminifera: their classification and economic use: Cushman Laboratory for Foraminiferal Research Special Publication, v. 1, p. 1–401.

Cushman, J.A., and Alexander, C.I., 1930, Some vaginulinas and other foraminifera from the Lower Cretaceous of Texas: Contributions from the Cushman Laboratory for Foraminiferal Research, v. 6, p. 1–10.

Cushman, J.A., and Jarvis, P.W., 1928, Cretaceous Foraminifera from Trinidad: Contributions from the Cushman Laboratory for Foraminiferal Research, v. 4, p. 85–103.

Cushman, J.A., and Renz, H.H., 1948, Eocene foraminifera of the Navet and Hospital Hill formations of Trinidad, B.W.I.: Cushman Laboratory for Foraminiferal Research Special Publication, v. 24, p. 1–42.

Dailey, D.H., 1983, Late Cretaceous and Paleocene benthic foraminifers from Deep Sea Drilling Project site 516, Rio Grande Rise, western South Atlantic Ocean: Initial Reports of the Deep Sea Drilling Project, v. 72, p. 757–782.

de Blainville, H.M.D., 1827, Manuel de Malacologie et de Conchyliologie: Paris, F. G. Levrault, 647 p.

Decima, F.P., and Bolli, H.M., 1978, Late Cretaceous and Paleocene benthic foraminifers from Deep Sea Drilling Project site 516, Rio Grande Rise, western South Atlantic Ocean: Initial Reports of the Deep Sea Drilling Project, v. 72, p. 757–782.

Dhillon, D.S., 1968, A new genus of the Haplophragmoidinae from Malaysia: Contributions from the Cushman Foundation for Foraminiferal Research, v. 19, p. 140–141.

Dingle, R.V., and Lavelle, M., 1998, Antarctic peninsular cryosphere: Early Oligocene (c. 30 M) initiation and a revised glacial chronology: Journal of the Geological Society, v. 155, p. 422–437.

d'Orbigny, A.M.D., 1826, Tableau méthodique de la classe des Céphalopodes: Annales des Sciences Naturelles, v. 7, p. 245–314.

d'Orbigny, A.M.D., 1839, Foraminifères des Iles Canaries, *in* Barker-Webb, P., and Berthelot, S., eds., Histoire Naturelle des Iles Canaries, Tome 2, Part 2: Paris, Béthune, p. 119–146.

Earland, A., 1934, Foraminifera, part 3: The Falklands sector of the Antarctic (excluding South Georgia): Discovery Reports, v. 10, p. 1–208.

Emiliani, C., 1954, The Oligocene microfaunas of the central part of the northern Apennines: Palaeontographica Italica, v. 48, p. 77–184.

Fernández López, S., 1991, Taphonomic concepts for a theoretical biochronology: Revista Espanõla de Paleontología, v. 6, p. 37–49.

Finger, K.L., 2013, Miocene foraminifera from the south-central coast of Chile: Micropaleontology, v. 59, p. 341–492.

Fiorini, F., 2009, *Ammodiscus anulatus*, a new species of benthic foraminifera from the Colombian Basin: Micropaleontology, v. 55, p. 94–96.

Franke, A., 1912, Die Foraminiferen des Unter-Eocantones der Ziegelei Schwarzenbeck: Jahrbuch des Königlich Preussischen Geologischen Landesanstalt, v. 32, p. 106–111.

Friedberg, W., 1902, Die Foraminiferen der Inoceramenschichten aus der Umgebung von Rzeszów und Dębica: Rozprawy Wydziału Matematyczno-Przyrodniczego Akademii Umiejętności, v. 3, p. 601–668.

Frizzell, D.L., 1943, Upper Cretaceous foraminifera from northwestern Peru: Journal of Paleontology, v. 17, p. 331–353.

Gaździcki, A., 1989, Planktonic foraminifera from the Oligocene Polonez Cove Formation of King George Island, West Antarctica: Polish Polar Research, v. 10, p. 47–55.

Gaździcki, A., and Majewski, W., 2012, Foraminifera from the Eocene La Meseta Formation of Isla Marambio (Seymour Island), Antarctic Peninsula: Antarctic Science, v. 24, p. 408–416.

Gaździcki, A., and Webb, P.N., 1996, Foraminifera from the *Pecten* conglomerate (Pliocene) of Cockburn Island, Antarctic Peninsula: Palaeontologia Polonica, v. 55, p. 147–174.

Gaździcki, A., Tatur, A., Hara, U., and Del Valle, R.A., 2004, The Weddell Sea Formation: Post-Late Pliocene terrestrial glacial deposits on Seymour Island, Antarctic Peninsula: Polish Polar Research, v. 25, p. 189–204.

Glaessner, M.F., 1937, Studien über Foraminiferen aus der Kreide und dem Tertiär des Kaukasus: I-Die Foraminiferen der altesten Tertiärschichten des Nordwest-kaukasus: Problemy Paleontologii, v. 2/3, p. 349–408.

Gooday, A.J., and Claugher, D., 1989, The genus *Bathysiphon* (Protista, Foraminiferida) in the northeast Atlantic: SEM observations on the wall structure of seven species: Journal of Natural History, v. 23, p. 591–611.

Gooday, A.J., and Jorissen, F.J., 2012, Benthic foraminiferal biogeography: Controls on global distribution patterns in deep-water settings: Annual Review of Marine Science, v. 4, p. 237–262, https://doi.org/10.1146/annurev-marine-120709-142737.

Gradstein, F.M., and Berggren, W.A., 1981, Flysch-type agglutinated foraminifera and the Maestrichtian to Paleogene history of the Labrador and North seas: Marine Micropaleontology, v. 6, p. 211–269.

Grzybowski, J., 1898, Otwornice pokładów naftonośnych okolicy Krosna: Rozprawy Wydziału Matematyczno-Przyrodniczego Akademii Umiejętności, v. 33, p. 257–305.

Hantken, M., 1868, [A kis-czelli tályag foraminiferái]: Magyar Foldtani Társulat Munkálatai, Pest, v. 4, p. 75–96. [in Ukrainian]

Herrero, C., and Canales, M.L., 2002, Taphonomic processes in selected Lower and Middle Jurassic foraminifera from the Iberian range and Basque-Cantabrian Basin (Spain): Journal of Foraminiferal Research, v. 32, p. 22–42, https://doi.org/10.2113/0320022.

Höglund, H., 1947, Foraminifera in the Gullmar Fjord and the Skagerak: Uppsala, Sweden, Appelbergs Boktryckeri, 328 p., 32 pls.

Hohenegger, J., and Piller, W., 1975, Wandstrukturen und Großgliederung der Foraminiferen: Sitzungberichten der Österreichische Akademie der Wissenschaften, v. 184, p. 67–117.

Holbourn, A., Henderson, A.S., and MacLeod, N., 2013, Atlas of Benthic Foraminifera: Oxford, UK, Wiley-Blackwell/Natural History Museum, 642 p.

Huber, B.T., 1988, Upper Campanian-Paleocene foraminifera from the James Ross Island region, Antarctic Peninsula, *in* Feldmann, R.M., and Woodburne, M.O., eds., Geology and Paleontology of Seymour Island, Antarctic Peninsula: Geological Society of America, Memoir 169, p. 163–252.

Huber, B.T., 1991, Foraminiferal biogeography of the Late Cretaceous Southern high latitudes, *in* Thomson, M.R.A., Crame, J.A., and Thomson, J.W., eds., Geological Evolution of Antarctica: Cambridge, UK, Cambridge University Press, p. 609–615.

Jones, R.W., 1994, The Challenger foraminifera: Oxford, UK, Oxford University Press, 149 p., 115 pls.

Jones, R.W., and Pudsey, C.A., 1994, Recent benthonic foraminifera from the western Antarctic Ocean: Journal of Micropalaeontology, v. 13, p. 13–23.

Jones, T.R., and Parker, W.K., 1860, On the rhizopodal fauna of the Mediterranean, compared with that of the Italian and some other Tertiary deposits: Quarterly Journal of the Geological Society of London, v. 16, p. 292–307.

Jonkers, H.A., Lirio, J.M., Delvalle, R.A., and Kelley, S.P., 2002, Age and environment of Miocene-Pliocene glaciomarine deposits, James Ross Island, Antarctica: Geological Magazine, v. 139, p. 577–594.

Jordan, T.A., Riley, T.E., and Siddoway, C.S., 2020, The geological history and evolution of West Antarctica: Nature Reviews Earth & Environment, v. 1, p. 117–133.

Kaminski, M.A., 2004, The year 2000 classification of the agglutinated foraminifera, *in* Bubík, M., and Kaminski, M.A., eds., Proceedings, International Workshop on Agglutinated Foraminifera, 6th, Prague, Czech Republic, 1–7 September 2001: Kraków, Grzybowski Foundation, p. 237–255.

Kaminski, M.A., and Gradstein, F.M., 2005, Atlas of Paleogene Cosmopolitan Deep-Water Agglutinated Foraminifera: Kraków, Grzybowski Foundation, 548 p.

Kaminski, M.A., Gradstein, F.M., and Berggren, W.A., 1988, Flysch-type agglutinated foraminiferal assemblages from Trinidad: Taxonomy, stratigraphy and paleobathymetry: Abhandlungen der Geologischen Bundesanstalt, v. 41, p. 155–227.

Kaminski, M.A., Gradstein, F.M., and Geroch, S., 1992, Uppermost Jurassic to Lower Cretaceous deep-water benthic foraminiferal assemblages from site 765 on the Argo Abyssal Plain: Proceedings of the Ocean Drilling Program, Scientific Results, v. 123, p. 239–269.

Kaminski, M.A., Waśkowska, A., and Chan, S., 2016, *Haplophragmoides arcticus*, n. sp.—A new species from the Pleistocene of the Central Arctic Ocean: Micropaleontology, v. 62, p. 509–513.

Kavary, E., and Frizzell, D.L., 1964, Upper Cretaceous and lower Cenozoic foraminifera from west-central Iran: Missouri University School of Mines & Metallurgy Bulletin, Technical Series, v. 102, p. 3–89.

Khalilov, D.M., 1959, [Novyye vidy foraminifer Valanzhin-Goterivskikh otlozheniy severo-vostochnogo Azerbaydzhana]: Izvestiya Akademii Nauk Azerbaydzhanskoy SSR, Seriya Geologo-Geograficheskikh Nauk, v. 6, p. 25–36. [in Russian]

Koutsoukos, E.A.M., 2000, 'Flysch-type' foraminiferal assemblages in the Cretaceous of northeastern Brazil, *in* Hart, M.B., Kaminski, M.A., and Smart, C.W., eds., Proceedings, International Workshop on Agglutinated Foraminifera, 5th, Plymouth, UK, 6–16 September 1997: Kraków, Grzybowski Foundation, p. 243–260.

Kuhnt, W., Collins, E., and Scott, D.B., 2000, Deep water agglutinated foraminiferal assemblages across the Gulf Stream: Distribution patterns and taphonomy, *in* Hart, M.B., Kaminski, M.A., and Smart, C.W., eds., Proceedings, International Workshop on Agglutinated Foraminifera, 5th, Plymouth, UK, 6–16 September 1997: Kraków, Grzybowski Foundation, p. 261–298.

Lankester, E.R., 1885, Protozoa, *in* Encyclopedia Britannica, 9th ed., v. 19: Edinburgh, Adam and Charles Black, p. 830–866.

LeRoy, D.O., and Hodgkinson, K.A., 1975, Benthonic Foraminifera and some Pteropoda from a deep-water dredge sample, northern Gulf of Mexico: Micropaleontology, v. 21, p. 420–447.

Lipman, R.K., Burtman, E.S., and Khokhlova, I.A., 1960, [Stratigrafiya i fauna paleogenovykh otlozheniy Zapadno-Sibirskoy nizmennosti]: Trudy Vsesoyuznogo Geologicheskogo Instituta, n. ser., v. 28, p. 1–231. [in Russian]

Loeblich, A.R., Jr., and Tappan, H., 1949, New Kansas Lower Cretaceous foraminifera: Journal of the Washington Academy of Sciences, v. 39, p. 90–92.

Loeblich, A.R., Jr., and Tappan, H., 1954, Emendation of the foraminiferal genera *Ammodiscus* Reuss, 1862, and *Involutina* Terquem, 1862: Journal of the Washington Academy of Sciences, v. 44, p. 306–310.

Loeblich, A.R., Jr., and Tappan, H., 1964, Sarcodina, chiefly 'Thecamoebians' and Foraminiferida, *in* Moore, R.C., ed., Treatise on Invertebrate Paleontology, Part C, Protista 2, 2 Volumes: Boulder, Colorado, and Lawrence, Kansas, Geological Society of America (and University of Kansas Press), 900 p.

Loeblich, A.R., Jr., and Tappan, H., 1984, Some new proteinaceous and agglutinated genera of Foraminiferida: Journal of Paleontology, v. 58, p. 1158–1163.

Loeblich, A.R., Jr., and Tappan, H., 1987, Foraminiferal Genera and Their Classification, 2 Volumes: New York, Van Nostrand Reinhold, 970 p., 847 pls.

Loeblich, A.R., Jr., and Tappan, H., 1989, Implications of wall composition and structure in agglutinated foraminifers: Journal of Paleontology, v. 63, p. 769–777.

Loeblich, A.R., Jr., and Tappan, H., 1992, Present status of foraminiferal classification, in Takayanagi, Y., and Saito, T., eds., Studies in Benthic Foraminifera: Tokay, Japan, Tokay University Press, p. 93–102.

Ludbrook, N.H., 1977, Early Tertiary Cyclammina and Haplophragmoides (Foraminiferida: Lituolidae) in southern Australia: Transactions of the Royal Society of South Australia, v. 101, p. 165–198.

Macellari, C.E., 1988, Stratigraphy, sedimentology, and paleoecology of Upper Cretaceous/Paleocene shelf-deltaic sediments of Seymour Island: Geological Society of America Memoirs, v. 169, p. 25–53.

Majewski, W., and Gaździcki, A., 2014, Shallow water benthic foraminifera from the Polonez Cove Formation (lower Oligocene) of King George Island, West Antarctica: Marine Micropaleontology, v. 111, p. 1–14, https://doi.org/10.1016/j.marmicro.2014.05.003.

Majewski, W., Olempska, E., Kaim, A., and Anderson, J.B., 2012, Rare calcareous microfossils from middle Miocene strata, Weddell Sea off Antarctic Peninsula: Polish Polar Research, v. 33, p. 245–257.

Majewski, W., Tatur, A., Witkowski, J., and Gaździcki, A., 2017, Rich shallow-water benthic ecosystem in late Miocene East Antarctica (Fisher Bench Fm, Prince Charles Mountains): Marine Micropaleontology, v. 133, p. 40–49, https://doi.org/10.1016/j.marmicro.2017.06.002.

Majewski, W., Bart, P.J., and McGlannan, A.J., 2018, Foraminiferal assemblages from the ice-proximal paleo-settings in the Whales Deep Basin, eastern Ross Sea, Antarctica: Palaeogeography, Palaeoclimatology, Palaeoecology, v. 493, p. 64–81, https://doi.org/10.1016/j.palaeo.2017.12.041.

Majzon, L., 1943, [Adatok egyes Kárpátaljai Flisrétegekhez, tekintettel a Globotruncanákra]: A Magyar Királyi Földtani Intézet, Évkönyve, v. 37, p. 1–170. [in Ukrainian]

Makled, W.A., and Langer, M.R., 2010, Preferential selection of titanium-bearing minerals in agglutinated Foraminifera: Ilmenite ($FeTiO_3$) in Textularia hauerii d'Orbigny from the Bazaruto Archipelago, Mozambique: Revue de Micropaléontologie, v. 53, p. 163–173, https://doi.org/10.1016/j.revmic.2009.11.001.

Malagnino, E.C., Olivero, E.B., Rinaldi, C.A., and Spikermann, Y.J.P., 1981, Aspectos geomórfologicos de la Isla Vicecomodoro Marambio, Antártida, in Irigoyen, M., ed., Proceedings 2, Congreso Geológico Argentino, 8th, San Luis, Argentina, 20–26 September 1981: Buenos Aires, Asociación Geológica Argentina, p. 883–896.

Marenssi, S.A., Casadío, S., and Santillana, S.N., 2010, Record of late Miocene glacial deposits on Isla Marambio (Seymour Island), Antarctic Peninsula: Antarctic Science, v. 22, p. 193–198, https://doi.org/10.1017/S0954102009990629.

Marenssi, S.A., Santillana, S., and Bauer, M., 2012, Estratigrafía, petrografía sedimentaria y procedencia de las formaciones Sobral y Cross Valley (Paleoceno), Isla Marambio (Seymour), Antártida: Andean Geology, v. 39, p. 67–91.

Marie, P., 1941, Les Foraminifères de la craie à Belemnitella mucronata du Bassin de Paris: Mémoires du Muséum National d'Histoire Naturelle de Paris, n. ser., v. 12, p. 1–296.

Maslun, N.V., 1987, [Agglutiniruyushchie foraminifery pogranichnykh Eocene-Oligotsenovykh otlozhenyj Karpat]: Paleontologicheskiy Sbornik, v. 27, p. 66–70. [in Russian]

Maync, W., 1952, Alveolophragmium venezuelanum n. sp. from the Oligo-Miocene of Venezuela: Contributions from the Cushman Foundation for Foraminiferal Research, v. 3, p. 141–144.

Maync, W., 1955, Reticulophragmium, n. gen., a new name for Alveolophragmium Stschedrina, 1936 (pars): Journal of Paleontology, v. 29, p. 557–558.

Maync, W., 1973, Lower Cretaceous foraminiferal fauna from Gorringe Bank, eastern North Atlantic: Initial Reports of the Deep Sea Drilling Project, v. 13, p. 1075–1135.

McNeil, D.H., 1997, New foraminifera from the Upper Cretaceous and Cenozoic of the Beaufort-MacKenzie Basin of Arctic Canada: Cushman Foundation for Foraminiferal Research Special Publication, v. 35, p. 1–95.

Mikhalevich, V.I., 1980, [Sistematika i evolyutsiya foraminifera v svete novykh dannykh po ikh tsitologii i ul'trastrukture]: Trudy Zoologicheskogo Instituta, v. 94, p. 42–61. [in Russian]

Mikhalevich, V.I., 2004, On the heterogeneity of the former Textulariina (Foraminifera), in Bubik, M., and Kaminski, M.A., eds., Proceedings, International Workshop on Agglutinated Foraminifera, 6th, Prague, Czech Republic, 1–7 September 2001: Kraków, Grzybowski Foundation, p. 317–349.

Milner, G.J., 1997, Paleogene foraminiferal studies in the western Pacific [Ph.D. thesis]: Perth, University of Western Australia, 302 p.

Mjatliuk, E.V., 1970, [Foraminifery flishevykh otlozheniy vostochnykh Karpat (Mel-Paleogen)]: Trudy Vsesoyuznogo Neftyanogo Nauchno-Issledovatel'skogo Geologo-razvedochnogo Instituta, v. 282, p. 1–225. [in Russian]

Montagu, G., 1803, Testacea Britannica, or, British Shells, 2 Volumes: London, J. White, 606 p., 16 pls.

Montes, M., Nozal, F., Santillana, S., Marenssi, S., and Olivero, E., 2013, Mapa geológico de la Isla Marambio (Seymour): Buenos Aires, Instituto Geológico y Minero de España/Instituto Antártico Argentino, scale 1:20.000.

Muftah, A.M., 1995, Agglutinated foraminifera from the Danian sediments of the northeastern Sirte Basin, in Kaminski, M.A., and Geroch, S., eds., Proceedings, International Workshop on Agglutinated Foraminifera, 4th, Kraków, 12–19 September 1993: Kraków, Grzybowski Foundation, p. 173–180.

Myatlyuk, E.V., 1939, [Foraminifera of the Upper Jurassic and the Lower Cretaceous of the region of the Middle Volga River and the Great Syrte.] Trudy VNIGRI [Vsesoyuznogo Neftyanogo Nauchno-Issledovatel'skogo Geologo-razvedochnogo Instituta], v. 120, 1–76. [in Russian]

Noth, R., 1951, Foraminiferen aus Unter- und Oberkreide des österreichischen Anteils an Flysch, Helvetikum und Vorlandvorkommen: Jahrbuch der Geologischen Bundesanstalt Sonderband. v. 3, p. 1–91.

Olivero, E.B., Ponce, J.J., Marsicano, C.A., and Martinioni, D.R., 2007, Depositional settings of the basal López de Bertodano Formation, Maastrichtian, Antarctica: Revista de la Asociación Geológica Argentina, v. 62, p. 521–529.

Orians, K.J., Boyle, E.A., and Bruland, K.W., 1990, Dissolved titanium in the open ocean: Nature, v. 348, p. 322–325.

Pawlowski, J., Holzmann, M., and Tyszka, J., 2013, New supraordinal classification of foraminifera: Molecules meet morphology: Marine Micropaleontology, v. 100, p. 1–10, https://doi.org/10.1016/j.marmicro.2013.04.002.

Pflaumann, U., 1964, Geologisch-mikropaläontologische Untersuchungen in der Flysch-Oberkreide zwischen Wertach und Chiemsee in Bayern: München, Ludwig Maximilian Universität, 180 p.

Pflum, C.E., 1966, The distribution of foraminifera in the eastern Ross Sea, Amundsen Sea, and Bellingshausen Sea, Antarctica: Bulletins of American Paleontology, v. 50, p. 151–209.

Pirrie, D., Crame, J.A., Riding, J.B., Butcher, A.R., and Taylor, P.D., 1997a, Miocene glaciomarine sedimentation in the northern Antarctic Peninsula region: The stratigraphy and sedimentology of the Hobbs Glacier Formation, James Ross Island: Geological Magazine, v. 136, p. 745–762.

Pirrie, D., Crame, J.A., Lomas, S.A., and Riding, J.B., 1997b, Late Cretaceous stratigraphy of the Admiralty Sound region, James Ross Basin, Antarctica: Cretaceous Research, v. 18, p. 109–137.

Podobina, V.M., 2000, Palaeogene agglutinated foraminífera of the West Siberian geographical province, in Hart, M.B., Kaminski, M.A., and Smart, C.W., eds., Proceedings, International Workshop on Agglutinated Foraminifera, 5th, Plymouth, UK, 6–16 September 1997: Kraków, Grzybowski Foundation, p. 387–396.

Quilty, P.G., 2010, Foraminifera from late Pliocene sediments of Heidemann Valley, Vestfold Hills, East Antarctica: Journal of Foraminiferal Research, v. 40, p. 193–205, https://doi.org/10.2113/gsjfr.40.2.193.

Reolid, M., 2008, Taphonomic features of Lenticulina as a tool for paleoenvironmental interpretation of midshelf deposits of the Upper Jurassic (Prebetic Zone, southern Spain): Palaios, v. 23, p. 482–494, https://doi.org/10.2110/palo.2007.p07-032r.

Reuss, A.E., 1845, Die Versteinerungen der böhmischen Kreideformation: Stuttgart, E. Schweizerbart'sche Verlagsbuchhandlung und Druckerei, 58 p.

Reuss, A.E., 1851, Über die fossilen Foraminiferen und Entomostraceen der Septarianthone der Umgegend von Berlin: Zeitschrift der Deutschen Geologischen Gesellschaft, v. 3, p. 49–91.

Reuss, A.E., 1862, Entwurf einer systematischen Zusammenstellung der Foraminiferen: Sitzungsberichte der Kaiserlichen Akademie der Wissenschaften, Mathematisch-Naturwissenschaftliche Classe, Abteilung 1, Mineralogie, Botanik, Zoologie, Anatomie, Geologie und Paläontologie, v. 44, p. 355–396.

Rhumbler, L., 1911, Die Foraminiferen (Talamophoren) der Plankton-Expedition: zugleich Entwurf eines natürlichen Systems der Foraminiferen auf Grund selektionistischer und mechanisch-physiologischer Faktoren: Ergebnisse der Plankton-Expedition der Humboldt-Stiftung, v. 3. p. 1–331.

Rocha Campos, A.C., Kuchenbecker, M., Duleba, W., Santos, P.R., and Canile, F.M., 2017, A (tidal-marine) boulder pavement in the late Cenozoic of Seymour Island, West Antarctica: Contribution to the palaeogeographical and palaeoclimatic evolution of West Antarctica: Antarctic Science, v. 29, p. 555–559, https://doi.org/10.1017/S0954102017000335.

Rögl, F., 1976, Late Cretaceous to Pleistocene foraminifera from the southeast Pacific Basin, DSDP Leg 35: Initial Reports of the Deep Sea Drilling Project, v. 35, p. 539–555.

Rzehak, A., 1885, Bemerkungen über einige foraminiferen der Oligocän Formation: Verhandlungen des Naturforschenden Vereines in Brünn, v. 23, p. 123–129.

Sadler, P. M., 1988, Geometry and stratification of the uppermost Cretaceous and Paleogene units on Seymour Island, northern Antarctic Peninsula: Geological Society of America Memoirs, v. 169, p. 303–320.

Saidova, K.M., 1975, [Bentosnyye foraminifery Tikhogo okeana-Bentosnyye foraminifery Tikhogo Okeana], 3 Volumes: Moscow, Akademiya Nauk SSSR, 875 p. [in Russian]

Saidova, K.M., 1981, [O sovremennom sostoyanii sistemy nadvidovykh takso-
    nov kaynozoyskikh bentosnykh foraminifer]: Moscow, Akademiya Nauk
    SSSR, 73 p. [in Russian]
Sars, G.O., 1872, Undersøgelser over Hardangerfjordens fauna I: Förhadlingar i
    Videnskabsselskabet i Christiania, v. 1871, p. 246–286.
Schröder-Adams, C.J., and McNeil, D.H., 1994, New paleoenvironmentally
    important species of agglutinated foraminifera from the Oligocene and Mio-
    cene of the Beaufort Sea, Arctic Canada: Journal of Foraminiferal Research,
    v. 24, p. 178–190.
Schubert, R.J., 1902, Neue und interessante foraminiferen aus dem südtiroler
    Altteriär: Beiträge zur Paläontologie und Geologie Österreich-Ungarns
    und des Orients, v. 14, p. 9–26.
Schulze, R.E., 1875, Zoologische Ergebnisse der Nordseefahrt vom 21 Juli bis 9
    September 1872, *in* Meyer, H.A. et al., eds., Jahresberichte der Kommission
    zur wissenschaftlichen Untersuchung der Deutschen Meer in Kiel für die
    Jahre 1872 1873, II und III Jahrgang: Berlin, Wiegandt, Hempel, &
    Parey, p. 99–114.
Sen Gupta, B.K., 1999, Systematics of modern foraminifera, *in* Sen Gupta,
    B.K., ed., Modern Foraminifera: Dordrecht, The Netherlands, Kluwer Aca-
    demic Publishers, p. 7–36.
Serova, M.Ya., 1987, [Foraminifery i biostratigrafia Severnoy Patsifiki na rubiez-
    hie Mela i Paleogena]: Moscow, Izdatelstvo 'Nauka,' 144 p. [in Russian]
Setoyama, E., Kaminski, M.A., and Tyszka, J., 2011, Late Cretaceous aggluti-
    nated foraminifera and implications for the biostratigraphy and palaeobio-
    geography of the southwestern Barents Sea, *in* Kaminski, M.A., and
    Filipescu, S., eds., Proceedings, International Workshop on Agglutinated
    Foraminifera, 8th, Cluj-Napoca, Romania, 7–13 September 2008: Kraków,
    Grzybowski Foundation, p. 251–309.
Shchedrina, Z.G., 1936, *Alveolophragmium orbiculatum* nov. gen., nov. sp.:
    Zoologischer Anzeiger, v. 114, p. 312–319.
Soliman, H.A., 1972, New Upper Cretaceous foraminifera from Soviet Carpa-
    thian (USSR): Revue de Micropaleontologie, v. 15, p. 35–44.
Subbotina, N.N., 1960, [Mikrofauna oligotsenovykh I Miotsenovykh otlozhenii
    r. Vorotyshche (Predkarpat'e)]: Trudy VNIGRI [Vsesoyuznogo Neftyanogo
    Nauchno-Issledovatel'skogo Geologo-razvedochnogo Instituta], v. 153,
    p. 157–243. [in Russian]
Suleymanov, I.S., 1973, [Nekotoryye voprosy sistematiki semeystva Verneuli-
    nidae Sushman, 1927 v svyazi s usloviyami obitaniya]: Doklady Akademii
    Nauk Uzbekskoy SSR, v. 8, p. 35–36. [in Russian]
Thomas, E., 1989, Development of Cenozoic deep-sea benthic foraminiferal
    faunas in Antarctic Waters, *in* Crame, J.A., ed., Origins and Evolution of
    the Antarctic Biota: Oxford, UK, Geological Society, p. 283–296.
Thomas, F.C., and Murney, M.G., 1985, Techniques for extraction of foramin-
    ifers and ostracodes from sediment samples: Canadian Technical Report of
    Hydrography and Ocean Sciences, v. 54, p. 1–24.
Tjalsma, R.C., 1977, Cenozoic foraminifera from the South Atlantic, DSDP leg
    36: Initial Reports of the Deep Sea Drilling Project, v. 36, p. 493–518.
Tranter, T.H., 1992, Underplating of an accretionary prism: An example from
    the LeMay Group of central Alexander Island, Antarctic Peninsula: Journal
    of South American Earth Sciences, v. 6, p. 1–20.
Voloshinova, N.A., and Budasheva, A.I., 1961, [Lituolidy i trokhamminidy iz
    Tretichnykh otlozheniy ostrova Sakhalina i poluostrova Kamchatki]:
    Trudy Vsesoyuznogo Neftyanogo Nauchno-Issledovatel'skogo Geologo-
    razvedochnogo Instituta, v. 170, p. 169–233. [in Russian]
Vyalov, O.S., 1968, [Certain considerations on classification of siliceous foram-
    inifera]: Dopovidi Akademiyi Nauk Ukrayins′koyi RSR, v. 1, p. 3–6. [in
    Ukrainian]
Waśkowska, A., and Kaminski, M.A., 2017, '*Ammodiscus' latus* Grzybowski,
    1898: Its taxonomy, variability, and affinity to the genus *Trochamminoides*
    Cushman, 1910, *in* Kaminski, M.A., and Alegret, L., eds., Proceedings,
    International Workshop on Agglutinated Foraminifera, 9th, Zaragoza,
    Spain, 3–7 September 2012: Kraków, Grzybowski Foundation, p. 229–238.
Webb, P.N., 1973, Paleocene foraminifera from Wangaloa and Dunedin: New
    Zealand Journal of Geology and Geophysics, v. 16, p. 109–157.
Webb, P.N., 1975, Paleocene foraminifera from DSDP site 283, South Tasman
    Basin: Initial Reports of the Deep Sea Drilling Project, v. 29, p. 833–843.
Webb, P.N., 1988, Upper Oligocene-Holocene foraminifera of the Ross Sea
    region: Revue de Paléobiologie, Special Volume, v. 2, p. 589–603.
Widmark, J.G.V., 1997, Deep-sea benthic foraminifera from Cretaceous-Paleo-
    gene boundary strata in the South Atlantic—Taxonomy and paleoecology:
    Fossils & Strata, no. 43, p. 1–94.
Williamson, W.C., 1848, On the Recent British species of the genus *Lagena*:
    Annals and Magazine of Natural History, ser. 2, v. 1, p. 1–20.
Wrona, R., 1989, Cambrian limestone erratics in the Tertiary glacio-marine
    sediments of King George Island, West Antarctica: Polish Polar Research,
    v. 10, p. 533–553.
Wrona, R., 2004, Cambrian microfossils from glacial erratics of King George
    Island, Antarctica: Acta Palaeontologica Polonica, v. 49, p. 13–56.
Zinsmeister, W.J., and DeVries, T.J., 1983, Quaternary glacial marine
    deposits on Seymour Island: Antarctic Journal of the United States,
    v. 18, p. 64–65.