AMEGHINIANA - 2013 - Tomo 50 (1): 114 – 135 ISSN 0002-7014

LATE CENOZOIC FORAMINIFERA FROM DIAMICTITES OF CAPE LAMB, VEGA ISLAND, ANTARCTIC PENINSULA

ANDREA CARAMÉS[1] AND ANDREA CONCHEYRO[1, 2, 3]

[1]IDEAN - Consejo Nacional de Investigaciones Científicas y Técnicas

[2]Departamento de Ciencias Geológicas, Facultad de Ciencias Exactas y Naturales, Universidad de Buenos Aires. Pabellón II. Ciudad Universitaria. CP 1428. Ciudad Autónoma de Buenos Aires, Argentina

[3]Instituto Antártico Argentino. *carames@gl.fcen.uba.ar; andrea@gl.fcen.uba.ar*

Abstract. Foraminiferal assemblages recovered from Cape Lamb sediments on Vega Island are examined and illustrated herein. The foraminifera were discovered in Cenozoic debris and palagonitic breccia lithofacies that crop out at the southwestern tip of Cape Lamb. Among all the Cenozoic diamictite deposits recognized in this island, the studied sediments are the youngest and the most fossiliferous. Pectinids, brachiopods, and microfaunas are exceptionally well preserved and indicate little or no transport. The foraminiferal assemblage is dominated by infaunal species, with the most abundant including *Globocassidulina biora*, *Cribroelphidium* sp. aff. *E. excavatum*, and *Cassidulinoides parkerianus,* and the epifaunal *Cibicides refulgens.* These foraminifera suggest a normal inner shelf marine environment. Microfossils and macrofauna, stratigraphical evidence observed in the field and published isotopic ages from the nearby Cape Lamb suggest a Pleistocene age for this deposit.

Key words. Foraminifera. Diamictite. James Ross Island Basin. Late Cenozoic. Antarctica..

Resumen. FORAMINÍFEROS DEL CENOZOICO TARDÍO, CABO LAMB, ISLA VEGA, PENÍNSULA ANTÁRTICA. Se examina e ilustra la microfauna de foraminíferos recuperada de sedimentitas del Cabo Lamb, Isla Vega. La asociación estudiada se halló en una acumulación cenozoica compuesta por fragmentos rocosos y brechas palagoníticas, que aflora en el extremo sudoeste del cabo Lamb. Estas sedimentitas, son las diamictitas cenozoicas más jóvenes y más fosilíferas reconocidas en la isla y al presentar una excepcional preservación de pectínidos y braquiópodos, llamaron la atención como probables hospedadoras de microfaunas que habrían sufrido poco transporte. La asociación de foraminíferos es dominada por especies infaunales como *Globocassidulina biora*, *Cribroelphidium* sp. aff. *E. excavatum* y *Cassidulinoides parkerianus*, y el epifaunal *Cibicides refulgens*. Los foraminíferos sugieren un ambiente marino normal de plataforma interna. Microfósiles, macrofauna, evidencias estratigráficas que surgen de las observaciones de campo y edades isotópicas obtenidas para depósitos muy próximos al de Cabo Lamb, sugieren una edad Pleistocena.

Palabras clave. Foraminíferos. Diamictita. Cuenca Isla James Ross. Cenozoico Tardío. Antártida.

The geology of the James Ross Island Group has been extensively studied during the last century in order to improve stratigraphic and paleoenvironmental knowledge of the region and to compare this information with data obtained from several other Antarctic sites. Particularly, the Cretaceous sediments have been extensively described, while the Cenozoic diamictites have received little attention, although determination of the stratigraphic relationships between diamictites and the interbedded volcanic rocks known as the James Ross Island Volcanic Group Island (JRVGI) would help to date Cenozoic glaciations in the Antarctic Peninsula.

The first mention of diamictites in the James Ross Basin considered them as basal tills and remobilized debris flow deposits related to glacial and/or glaciomarine sequences (Andersson, 1906; Bibby, 1966; Nelson, 1975). Later, formal lithostratigraphic considerations were provided by Pirrie *et al.* (1997) and Lirio *et al.* (2003), and hence they proposed different interpretations for these deposits according to the different lithofacies.

Recently, several authors have focused their studies on the Cenozoic sequences exposed at the James Ross, Cockburn, Seymour and Vega Islands in order to obtain more information on the volume of the Cenozoic Antarctic Ice Sheet and its role in the climatic variability. Among the main contributions are those carried out by Harwood (1986), Gaździcki and Webb (1996), Dingle *et al.*(1997), Gaździcki *et al.* (2004), Ivany *et al.* (2006), Smellie *et al.* (2006) and Hambrey and Smellie (2006). Concheyro *et al.* (2007) summarized the known information for these deposits; later, Hambrey *et al.* (2008), Smellie *et al.* (2008), Nelson *et al.* (2009), Smellie *et al.* (2009), Marenssi *et al.* (2010), Nývlt *et al.* (2011) and Salzmann *et al.* (2011) analysed in detail the distribution of the diamictites and their genesis.

AMGHB2-0002-7014/12$00.00+.50

The Cape Lamb debris deposits were discovered during the 2007 summer Antarctic expedition by the Czech-Argentine group and it comprises two diamictite horizons interbedded with a conglomerate breccia. Preliminary reports mentioned the presence of bivalves, brachiopods and gastropods, as well as foraminifera, ostracods, serpulids, spirorbids, echinoderm spines, echinoidean plates, bryozoans and dinoflagellates (Lirio *et al*., 2007; Caramés *et al*., 2008).

The aim of this paper is to describe an interesting Late Cenozoic Antarctic foraminiferal assemblage collected at Cape Lamb, Vega Island, Antarctic Peninsula, and provide some paleoecological interpretations.

GEOLOGICAL BACKGROUND

Cape Lamb comprises an ice-free area located in the southwestern sector of Vega Island, James Ross Basin (Rinaldi, 1982; Elliot, 1988; del Valle *et al.,* 1992) (Figs. 1, 2).

The general stratigraphy includes Maastrichtian marine sedimentary rocks assigned to the Santa Marta, Snow Hill Island and López de Bertodano Formations (Rinaldi, 1982; Olivero *et al.,* 1991; Pirrie *et al*., 1991; Marenssi and Santillana, 1998; Marenssi *et al*., 2001; Olivero, 2012) overlain by Cenozoic diamictites, volcanics and volcaniclastic deposits of the James Ross Volcanic Group (Nelson, 1975; Salani, 1999; Smellie, 1999).

Marenssi *et al.* (2001) provided a comprehensive study dealing with the geology of Cape Lamb, proposing a stratigraphic scheme for the Cretaceous and Cenozoic units (Fig. 3).

Although information dealing with diamictites exposed at Vega Island has been limited, some of the deposits at Sand-

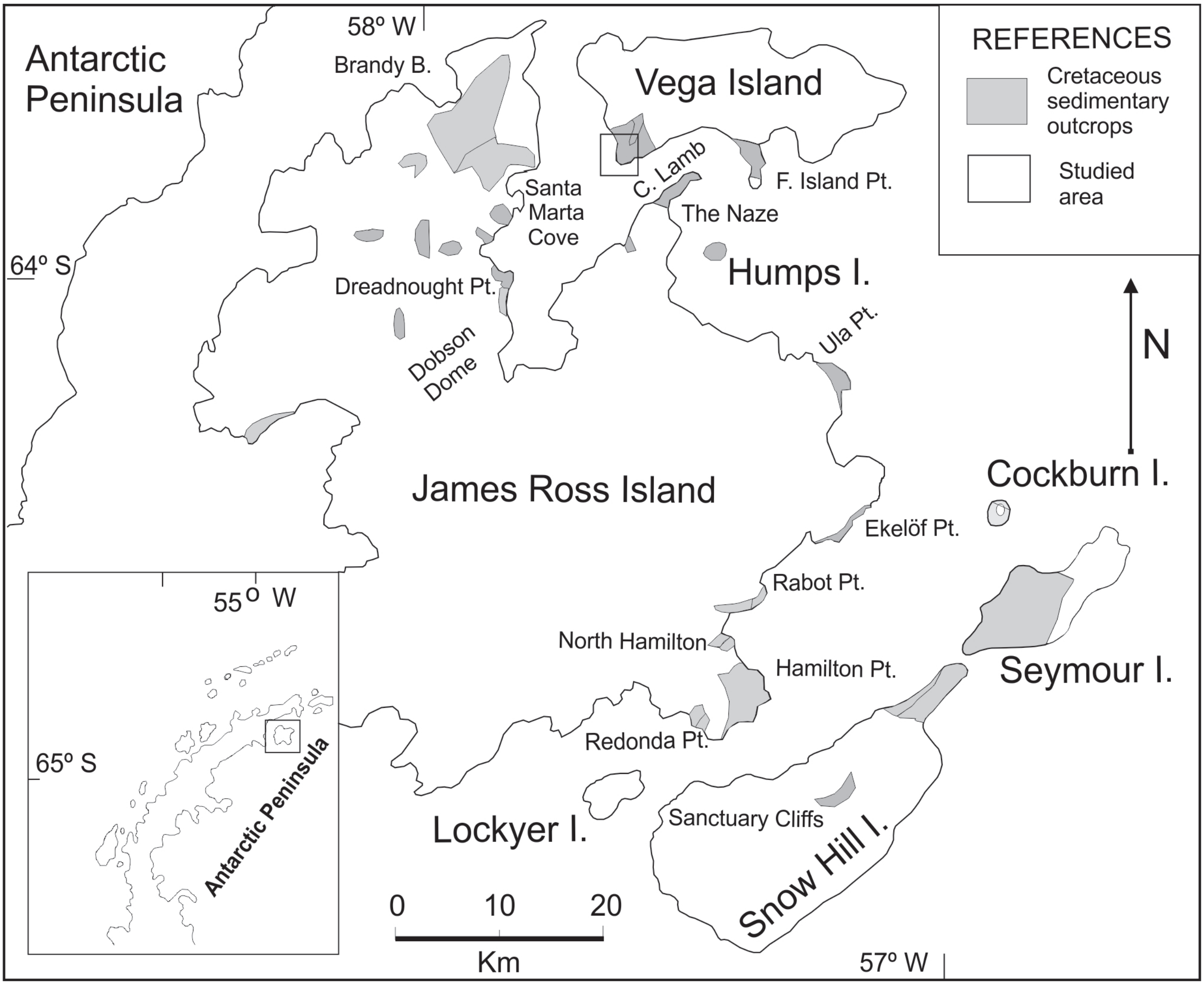


Figure 1. Location of the Cape Lamb diamictite deposit area, Vega Island, Antarctic Peninsula/ *Mapa de localización de la diamictita Cabo Lamb, isla Vega, península Antártica.*

wich and Leal Bluffs have been mentioned by Marenssi *et al.* (2001), Hambrey and Smellie (2006), Smellie *et al.* (2006, 2008), Concheyro *et al.* (2007), and Nelson *et al.* (2009).

The better known Cenozoic diamictites of Cape Lamb are located at Sandwich Bluff and Leal Bluff, with thicknesses between 0.90 m to 22 m, respectively. They exhibit a lenticular geometry and comprise poorly sorted massive matrix-supported conglomerates composed of metamorphics, granitoids, quartz, acidic volcanics and mainly basic vulcanite clasts (Marenssi *et al.*, 2001).

According to Smellie *et al.* (2006) sedimentary Cenozoic outcrops on Vega Island consist of a multi-story conglomerate, diamictite and minor sandstones, which resemble till deltas or subaqueous morainic banks; and also contain a boulder pavement that indicates sliding at the base of a glacier (Hambrey and Smellie, 2006).

Lirio *et al.* (2007) recognized another diamictite deposit interbedded with volcanic rocks of the JRVGI, and named it the Cape Lamb diamictite. This is the unit from which the studied foraminiferal assemblage was recovered.

MICROPALEONTOLOGICAL BACKGROUND OF THE JAMES ROSS BASIN

Pioneer studies about Cenozoic foraminifera from the James Ross Basin described and illustrated some foraminifera from Cenozoic deposits in the Cockburn Island Formation (Holland, 1910; Gaździcka and Gaździcki, 1994). Later, Gaździcki and Webb (1996) re-examined this microfauna, increased the number of taxa and added information on paleoenvironmental interpretations. Microfossils and bryozoans were also found on James Ross Island in diamictites of the late Miocene Hobbs Glacier Formation at Hamilton Cape and Rabot Point (Pirrie *et al.*, 1997). This assemblage was detailed by Bertels-Psotka *et al.* (2001) and Concheyro *et al.* (2007).

Figure 2. Cape Lamb aerial photograph, Vega Island, showing the irregular coastline and the proximity to The Naze, Terrapin Hill and northeastern sector of James Ross Island; Antarctic Peninsula shown in background/ *Fotografía aérea de Cabo Lamb, isla Vega, mostrando la línea de costa irregular, la península El Morro, el cerro Terrapin, el sector noreste de la isla James Ross, y en el horizonte, la península Antártica.*

Jonkers *et al.* (2002) and Lirio *et al.* (2003) described the foraminifera and ostracod assemblages of several localities of the James Ross Island, particularly the late Miocene Belén Formation, the late Pliocene Gage Formation and the late Pliocene–early Pleistocene microfauna of the Terrapin Formation.

Scarce foraminifera, reworked nannoflora and palynomorphs were mentioned from Sandwich and Leal Bluff, northern area of Cape Lamb, Vega Island, (Lirio *et al.*, 2007; Caramés *et al.*, 2008; Concheyro *et al.*, 2010).

SITE DESCRIPTION AND SAMPLES

The Cape Lamb diamictite outcrop is exposed at the southernmost tip of Cape Lamb, Vega Island (63°54′S–57°37′W), situated few meters above sea level; it is 10 m thick and is discontinuously exposed along 100 m of outcrop (Fig. 3).

Three different lithofacies are identified, corresponding to the base, middle and top of the section (Fig. 4).

The basal lithofacies consists of a 0.50 m thick matrix-supported greenish or brownish diamictite that lies unconformably over a hyaloclastic breccia. It is constituted, at the base, by poorly sorted subangular volcanic pebbles immersed in a fine to medium sandy matrix. Parallel lamination is frequent followed by some horizons with convolute stratification disrupting the normal bedding, as shown in Sample 2. This lithofacies contains encrusting bryozoans on shelly fragmented macrofauna or volcanic clasts, echinoid spines, abundant benthic foraminifera and large pectinoids, sometimes with articulated shells in life position. The uppermost 0.5 m consist of a chaotic deposit formed by almost desintegrated scallop shells, disturbed by convoluted stratification.

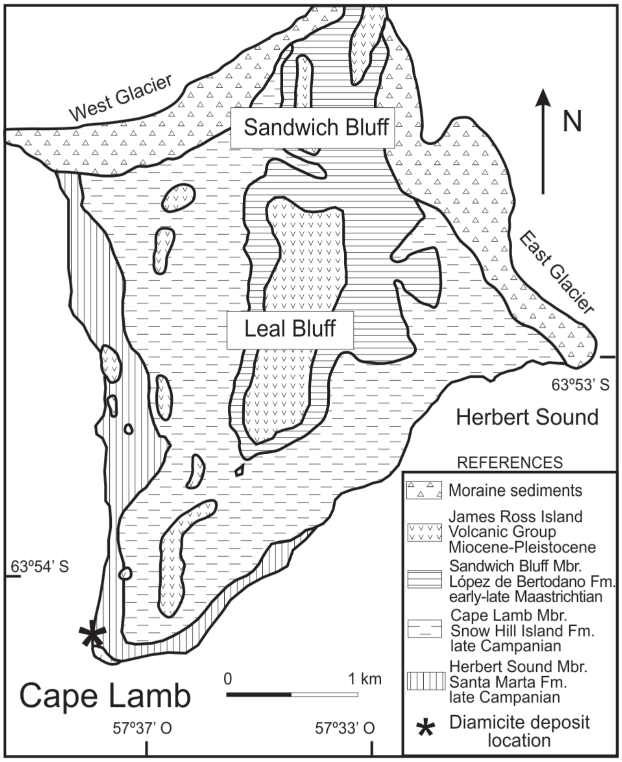


Figure 3. Geological map of Cape Lamb, Vega Island, Antarctic Peninsula (modified from Marenssi *et al.*, 2001)/ *Mapa geologico de Cabo Lamb, isla Vega, península Antártica (modificado de Marenssi* et al., *2001).*

The middle lithofacies unconformably overlies the disrupted diamictite. It includes a 6 m thick barren yellow brownish hyaloclastic breccia exhibiting an upwards-thinning bedding, and mainly composed of pyroclastic sands with zoned plagioclase and palagonitic glass, visible in Sample 7. Upwards in the section (Samples 3 and 6), it contains fragmented, articulated pectinids, entire and fragmented terebratulid brachiopods, encrusting bryozoans and echinoid spines. Microfossils are represented by rare foraminifera and palynomorphs that are mostly reworked (Caramés *et al.,* 2008).

The upper lithofacies consists of 0.30 m greenish fine sandstone with abundant fragmented bivalves, encrusted bryozoans, serpulids and spirorbids, a rich foraminiferal microfauna and scarce ostracods, including *Oculocytheropteron* sp., *Xestoleberis* sp., and *Loxoreticulatum fallax* (G.W. Müller) (Ballent, pers. comm., 2010). The latter species is recorded as a fossil during the Pleistocene and are also found in Antarctic and Subantarctic waters today. It also carries echinoderm spines and mostly reworked palynomorphs (Caramés *et al.*, 2008).

The top of the sedimentary section is unconformably overlain by a basaltic caprock.

MATERIAL AND METHODS

Five samples were studied. Sample size was aproximately 100 g. All samples were disaggregated in 5% hydrogen peroxide (100 vol) solution and washed over 74 µm and 297 µm sieves. The washed samples were dried and the biogenic components were picked. Paleoecological methods include the use of α index values (Alpha diversity index; Fisher *et al.*, 1943) and H(S) (Shannon-Weiner Diversity index, Shannon, 1948) on samples with enough foraminifera tests. The life position to each species was assigned considering morphologies and ecological behavior of living foraminifera according to Bernhard (1986), Corliss and Chen (1988), Hunt and Corliss (1993), Murray (2006) and Majewski (2010).

SYSTEMATIC PALEONTOLOGY

A total of 34 benthic taxa were recognized, almost all with calcareous tests, except for one which has an agglutinated test. No planktonic species were recovered from any sample. Species occurrence and their distribution are shown in the range chart (Fig. 1).

The suprageneric and generic taxonomic classification used follows Loeblich and Tappan (1987) with the addition of the genus *Conolagena.* Open nomenclature has been used for taxa that do not closely correspond to published descriptions. The synonymy list of each species includes the original description and some antarctic records with figured specimens. These lists omit papers in which the species were only mentioned. However, these were considered in Figure 6 showing the records of Cape Lamb species in other sites from West Antarctica (WA) and East Antarctica (EA).

Figured specimens are housed in the micropaleontological collections of the Facultad de Ciencias Exactas y Naturales, Universidad de Buenos Aires (under the acronym LM-FCEN), their catalogue numbers being LM-FCEN 3130-3182 (Figs. 7, 8).

Order Foraminiferida Eichwald, 1830
Suborder Textulariina Delage and Hérouard, 1896
Superfamily Rzehakinoidea Cushman, 1933
Family Rzehakinidae Cushman, 1933
Genus ***Miliammina*** Heron-Allen and Earland, 1930

Type species. *Miliammina earlandi* Loeblich and Tappan, 1955.

Miliammina earlandi Loeblich and Tappan, 1955

Figure 7.1a–b

1916. *Miliolina oblonga* (Montagu) var. *arenacea* Chapman, p. 59, pl. 1, fig.7.

1930. *Miliammina oblonga* (Chapman); Heron-Allen and Earland, p. 41, pl. 1, figs. 1–6, 22–23; Igarashi *et al.*, 2001, p. 159, pl. 2, fig. 11a–b.

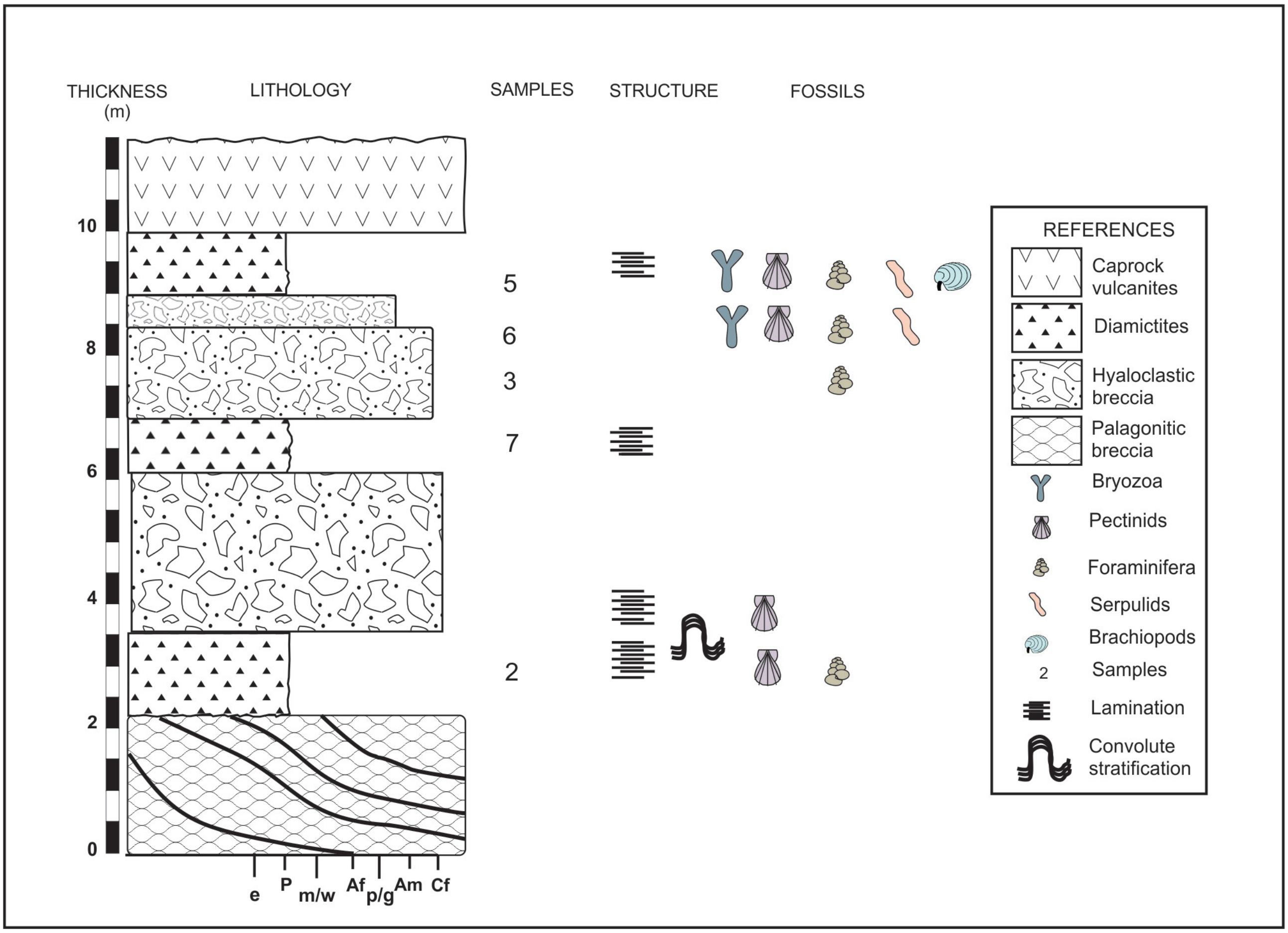


Figure 4. Geological section of Cape Lamb diamictite deposit, Cape Lamb, Vega Island, Antarctic Peninsula/ *Perfil geológico del depósito diamictítico Cabo Lamb, cabo Lamb, isla Vega, península Antártica.*

1933. *Miliammina oblonga* Heron-Allen and Earland, p. 92, pl. 3, fig. 17, pl. 5, figs.1–5, 7, 8.
1955. *Miliammina earlandi* Loeblich and Tappan, p. 12, pl. 1, figs. 15a–c, 16; Murray and Pursey, 2004, p. 79, pl. 1, figs. 8–9.
1974. *Miliammina arenacea* (Chapman), Fillon, p. 140, pl. 3, fig. 1–3; Anderson, 1975, p. 90, pl. 2, fig. 3a–b; Finger and Lipps, 1981, p. 129, pl. 1, fig. 10; Gaździcki and Majewski, 2003, fig. 3.6a–b; Majewski, 2005, p. 188, fig. 12.6a–b, 7; Majewski and Anderson, 2009, p. 146, fig. 3.2.

Remarks. Although some authors still use the specific name *M. arenacea,* we follow Loeblich and Tappan (1955) who proposed *M. earlandi* as the correct name for the type species of the genus *Miliammina* due to the loss of the type species of *Miliolina oblonga arenacea* (Chapman), citation errors when the genus *Miliammina* was defined (Heron-Allen and Earland, 1930) and homonymy problems. *Miliammina oblonga arenacea* (Chapman) was originally described from the Ross Sea (WA).

Suborder Spirillinina Hohenegger and Piller, 1975
Family Patellinidae Rhumbler, 1906

Genus ***Patellina*** Williamson, 1858

Type species. *Patellina corrugata* Williamson, 1858.

Patellina corrugata Williamson, 1858

Figure 7.2

1858. *Patellina corrugata* Williamson, p. 46, pl. 3, figs. 86–89; Anderson, 1975, p. 92, pl. 9, figs. 1a–b, 2; Igarashi *et al.*, 2001, p. 159, pl. 6, fig. 4a–c; Majewski, 2005, p. 189, fig. 16.6.
1974. *Patellina antarctica* Williamson; Fillon, p. 140, pl. 5, figs. 1–2.

Remarks. *Pattellina corrugata* is considerably smaller than *Patellina antarctica* Parr and possesses a more concave ventral side. In our opinion, the specimens from the Pleistocene of the Ross Sea identified as *Patellina antarctica* Williamson by Fillon (1974) are probably better referred to *P. corrugata*.

Suborder Miliolina Delage and Hérouard, 1896
Superfamily Milioloidea Ehrenberg, 1839
Family Hauerinidae Schwager, 1876
Subfamily Hauerininae Schwager, 1876

Genus ***Quinqueloculina*** d'Orbigny, 1826

Type species. *Serpula seminulum* Linné, 1758.

Quinqueloculina sp.

Figure 7.3

Remarks. Resembles *Q. weaveri* Rau illustrated by Majewski (2005, fig. 17.4a–c) with a subtriangular cross-section and circular aperture with a flattened base, but differs by its smaller test.

Subfamily Mililinellinae Vella, 1957

Genus ***Pyrgo*** Defrance, 1824

Type species. *Pyrgo laevis* Defrance, 1824.

Pyrgo depressa (d'Orbigny, 1826)

Figure 7.4

1826. *Biloculina depressa* d'Orbigny, p. 298; Parker, Jones and Brady, 1871, p. 247, pl. 8, fig. 5.

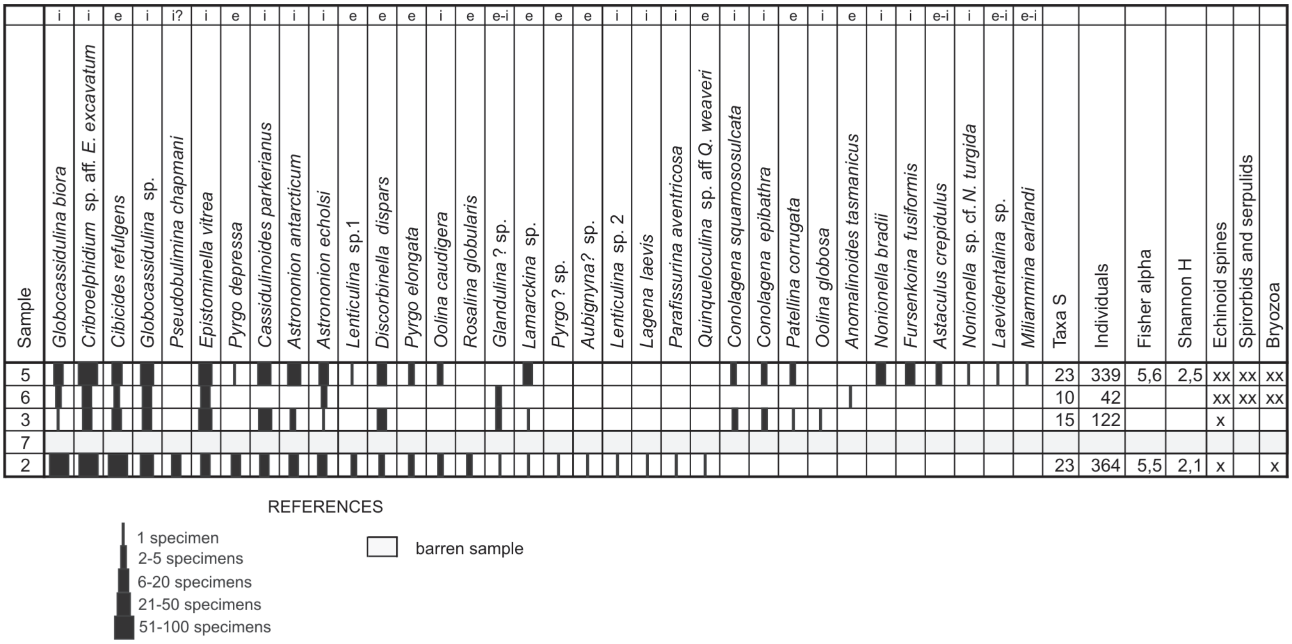


Figure 5. Foraminifera range distribution and species diversity assemblages from the Cape Lamb diamictite deposits/ *Cuadro de distribución de species y diversidad de las asociaciones halladas en los depósitos diamictíticos de Cabo Lamb.*

1975. *Pyrgo depressa* (d'Orbigny); Anderson, p. 92, pl. 4, fig. 6; Igarashi *et al.*, 2001, p. 159, pl. 6, fig. 8a–c; Majewski, 2005, p. 189, figs. 19.4a–c–5.
1996. *Pyrgo fornasinii* (Chapman and Parr); Gaździcki and Webb, p. 159, pl. 34, figs. 1–3.

Remarks. Some specimens with a more rounded aperture resemble the species originally described as *Biloculina murrhina* Schwager and *Biloculina bradyi* Fornasini, but we do not separate them because all of our specimens have more ovate early chambers. *Biloculina ringens* Brady (1884) is synonymous with *Pyrgo fornasinii* Chapman and Parr (1935), but differs by having a more rounded periphery. In our opinion the specimen illustrated as *Pyrgo fornasinii* by Gaździcki and Webb (1996) would belong to *Pyrgo depressa*.

Pyrgo elongata (d'Orbigny, 1826)

Figure 7.5

1826. *Biloculina elongata* d'Orbigny, p. 298, pl. 8, fig. 6.
1839a. *Biloculina patagonica* d'Orbigny, p. 65, pl. 3, figs. 15–17.
1960. *Pyrgo patagonica* (d'Orbigny); Crespin, p. 22, pl. 1, fig. 1.
2001. *Pyrgo elongata* (d'Orbigny); Igarashi *et al.*, p. 159, pl. 6, fig. 7a–c; Gaździcki and Majewski, 2003, fig. 5. 1a–b; Majewski, 2005, p. 189, fig. 19.2a–c.
1974. *Pyrgo williamsoni* (Silvestri); Fillon, p. 140, pl. 3, fig. 11; Anderson, 1975, p. 92, pl. 4, fig. 7.

Remarks. It is very similar to *P. williamsoni*, but compared to the original illustrations of *Biloculina elongata* d'Orbigny and *Biloculina williamsoni* Silvestri, the first species has a pyriform compressed test and the second one, an oval test, more circular in section. Thus, the specimens illustrated and identified as *Pyrgo williamsoni* (Silvestri) by Fillon (1974) from the Pleistocene of the Ross Sea (EA), and from the Recent of the Weddell Sea (WA) by Anderson (1975), in our opinion, belong to *Pyrgo elongata*.

Pyrgo? sp.

Figure 7.6

Remarks. This species is represented by one specimen that probably corresponds to a juvenile form without a biloculine early stage.

Suborder LAGENINA Delage and Hérouard, 1896
Superfamily NODOSARIACEA Ehrenberg, 1838
Family NODOSARIIDAE Ehrenberg, 1838

Genus ***Laevidentalina*** Loeblich and Tappan, 1986

Type species. *Laevidentalina aphelis* Loeblich and Tappan, 1986.

Laevidentalina sp.

Figure 7.7

Remarks. This species is represented by one specimen. The test is large, elongated, arcuate and apiculate, with 10 uniserial chambers separated by depressed and oblique sutures. The aperture is terminal, rounded and radiate.

Family VAGINULIDAE Reuss, 1860
Subfamily LENTICULININAE Chapman, Parr and Collins, 1934

Genus ***Lenticulina*** Lamarck, 1804

Type species. *Lenticulites rotulatus* Lamarck, 1804.

Lenticulina sp. 1

Figure 7.8

2000. *Lenticulina* sp. Strong and Webb, p. 470, pl. 2, fig.1.

Remarks. The species is characterized by its large, smoothly finished test with 6–7 chambers, flush, oblique and slightly curved sutures, and a sharp periphery.

Lenticulina sp. 2

Figure 7.9

Remarks. The species is represented by one specimen. The test is large, compressed, biumbonate and with a sharp periphery. The planispiral test consists of a proloculus followed by 12 chambers separated by flush, curved sutures. The last two chambers tend to uncoil.

Subfamily MARGINULININAE Wedekind, 1937

Genus ***Astacolus*** de Montfort, 1808

Type species. *Astacolus crepidulatus* de Montfort, 1808.

Astacolus crepidulus (Fichtel and Moll, 1798)

Figure 7.10

1798. *Nautilus crepidula* Fichtel and Moll, p. 107, pl. 19, figs. g–i.
1986. *Astacolus crepidulus* (Fichtel and Moll); Leckie and Webb, p. 1111, pl. 19, figs. 6–7.

Remarks. Compressed test consisting of about 9 chambers separated by steep, oblique and flush sutures.This species was originally described from the Recent of Italy.

Family LAGENIDAE Reuss, 1862

Genus ***Lagena*** Walter and Jacob, 1798, in Kanmacher 1798

Type species. *Serpula (Lagena) sulcata* Walker and Jacob, in Kanmacher, 1798.

Figure 6. Foraminifera species distribution in the multiple Antarctic locations/ *Distribución de las especies de foraminíferos en otras regiones antárticas.*

AREA	EAST ANTARCTICA																WEST ANTARCTICA									
AGE	Lower Oligocene	Olig.-Miocene				Late Miocene - Recent	Pliocene					Pleistocene		Quaternary	Recent		Late Miocene		Late Pliocene		Late Plio.- Early Pleist.	Recent				
		Late Oligocene - Early Miocene		Olig. and Mio.	Early Miocene																					
LOCALITY	CRP-3 Drillhole, Cape Roberts	DSDP Site 270, Ross Sea	CRP-2/2A Drillhole, Cape Roberts	CRP-2/2A Drillhole, Cape Roberts	CRP-1 Drillhole, Robert Ridge	ODP Site 1166 Prydz Bay	CRP-2 Drillhole, Cape Roberts	CRP-1 Drillhole Robert Ridge	Ross Sea	Larsemann Hills, Vestfold Hills	Heidemann Valley	DSDP Site 270, Ross Sea	Ross Sea	CRP-1 Drillhole, Robert Ridge	Lützow-Holm Bay	Vestfold Hills	Fiordo Belén, James Ross Is., Belén Formation	Hamilton and Rabbot Points, James Ross Is., Hobbs Glacier F.	Cockburn Island, Cockburn Island Formation	Cape Gage, James Ross Is., Gage Formation	Fiordo Belén, Terrapin Formation	Larsen Ice Shelf, Weddell Sea	Firth of Tay, between Joinville Is. and Dundee Is.	Deception Island	Admiralty Bay, King Geoge Is., South Shetland Is.	Weddell Sea, several locations
REFERENCE	Strong and Webb (2001)	Leckie and Webb (1986)	Webb and Strong (2006)	Strong and Webb (2000)	Strong and Webb (1998)	Quilty (2003)	Webb and Strong (2000)	Webb and Strong (1998b)	Fillon (1974)	Quilty *et al.* (1990)	Quilty (2010)	Leckie and Webb (1986)	Fillon (1974)	Webb and Strong (1998a)	Igarashi *et al*. (2001)	Crespin (1960)	Jonkers *et al.* (2002); Lirio *et al.*(2003); Concheyro *et al.* (2007)	Jonkers *et al.* (2002); Lirio *et al.*(2003); Concheyro *et al.* (2007)	Gaździcki and Webb (1996)	Jonkers *et al.* (2002); Lirio *et al.*(2003); Concheyro *et al.* (2007)	Lirio *et al.*(2003); Concheyro *et al.* (2007)	Murray and Pudsey (2004)	Majewski and Anderson (2009)	Finger and Lipps (1981)	Majewski (2005; 2010); Gaździcki and Majewski (2003)	Anderson (1975)
Globocassidulina biora						×			×		×	×	×		×	×	×	×	×	×	×		×	×	×	
Cribroelphidium sp. aff. *E. excavatum*																					×				×	
Cibicides refulgens	×	×	×			×	×	×		×	×	×		×	×		×	×	×	×	×	×		×	×	×
Globocassidulina sp.	×	×				×	×	×	×	×	×	×	×	×	×	×	×	×		×	×	×	×	×		×
Pseudobulimina chapmani		×						×						×	×									×	×	×
Epistominella vitrea		×								×		×		×			×	×	×	×				×		
Pyrgo depressa							×							×	×				×					×	×	×
Cassidulinoides parkerianus										×	×		×	×	×		×	×	×	×				×	×	×
Astrononion antarcticum						×	×				×		×	×	×	×				×			×	×	×	×
Astrononion echolsi						×			×	×	×	×			×							×	×	×	×	×
Pyrgo elongata												×	×		×	×			×					×	×	×
Oolina caudigera															×										×	
Rosalina globularis		×	×	×			×				×		×	×	×									×	×	
Conolagena squamososulcata							×							×			×								×	
Patellina corrugata							×						×	×	×				×	×					×	×
Oolina globosa	×	×	×		×		×			×				×					×					×		×
Nonionella bradii	×	×	×	×	×	×			×			×		×	×	×		×	×	×		×	×	×	×	×
Fursenkoina fusiformis																		×	×		×		×	×	×	×
Nonionella sp. cf. *N. turgida*																		×	×							×
Miliammina earlandi													×		×							×	×	×	×	×
Lenticulina sp. 1				×																						
Astaculus crepidulus		×												×												
Lagena laevis		×												×												×
Number of common species	4	10				6	14					12		14	14		9		13		5	21				

Lagena laevis Montagu, 1803

Figure 7.11

1803. *Vermiculum laeve* Montagu, p. 524.

1975. *Lagena laevis* Anderson, p. 90, pl. 5, fig.10; Leckie and Webb, 1986, p. 1111, pl. 4, fig. 6.

Remarks. Our specimen agrees with those illustrated by Anderson (1975) and Leckie and Webb (1986), with apiculate base.

Genus ***Conolagena*** Malumián, Náñez and Caramés, 1991

Type species. *Conolagena argentina* Malumián, Náñez and Caramés 1991.

Conolagena squamososulcata (Heron-Allen and Earland, 1922)

Figure 7.12

1922. *Lagena squamoso-sulcata* Heron-Allen and Earland, p. 151, pl. 5, figs. 15, 19.

2005. *Lagena squamososulcata* Heron-Allen and Earland; Majewski, p. 188, fig. 20.11a–b.

Remarks. The species was originally described from the Recent of the Ross Sea (EA). Webb and Strong (1998a) reported this species as *Oolina squamososulcata*.

Conolagena epibathra (Patterson and Richardson, 1988)

Figure 7.13

1988. *Favulina epibathra* Patterson and Richardson, p. 249, figs. 30–31.

Remarks. Test ovate, sculptured by 11–13 longitudinal ribs and 7 transverse alternating bars forming rectangular reticular cells, which become less rectangular and more rounded towards the apertural end. Aboral structure polygonal with a central ring. Apertural end truncated. The conus shaped neck is poorly developed. *Lagena squamosa* Montagu illustrated by Brady (1884, pl. 58, fig. 30) may belong to this species.

Family Ellipsolagenidae A. Silvestri, 1923

Subfamily Oolininae Loeblich and Tappan, 1961

Genus ***Oolina*** d'Orbigny, 1839a

Type species. *Oolina laevigata* d'Orbigny, 1839.

Oolina caudigera (Wiesner, 1931)

Figure 7.14

1931. *Lagena* (*Entosolenia*) *ovata* (Terquem) var. *caudigera* Wiesner, p. 119, pl. 18, fig. 215.

2005. *Oolina globosa caudigera* (Wiesner); Majewski, p. 188, pl. 21, fig. 2a–b; Igarashi *et al.*, 2001, p. 158, pl. 8, fig. 1a–c.

Remarks. Originally described from the Recent of the Bellingshausen Sea (WA).

Oolina globosa (Montagu, 1803)

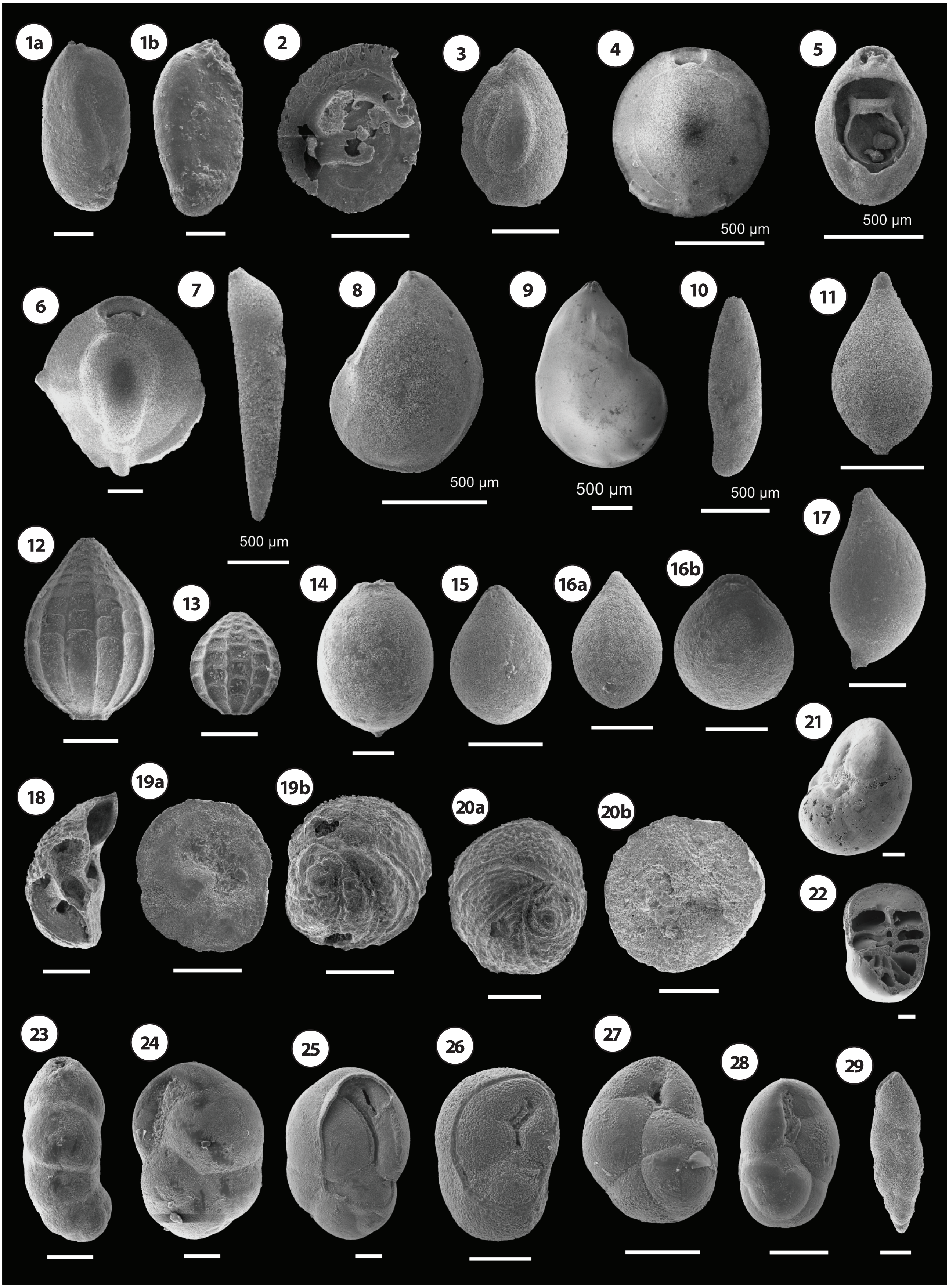
Figure 7.15

1803. *Vermiculum globosum* Montagu, p. 523, pl. 1, fig. 8.

1975. *Oolina globosa* (Montagu); Anderson, p. 90, pl. 7, fig. 14; Leckie and Webb, 1986, p 1112, pl. 4, fig. 10 and pl. 18, fig. 17; Quilty *et al.*, 1990, p. 3, pl. 1, fig. 5; Gaździcki and Webb, 1996, p. 161.

Remarks. The species is represented by one specimen in our sample.

Figure 7. Except indication the scale bar equals 100 μm/ *Excepto indicación la escala gráfica equivale a 100 μm.* **1a–b, *Miliammina earlandi*** Loeblich and Tappan, opposite sides/ *vistas laterales*, Sample 5/ *Muestra 5* (LM-FCEN 3130). **2, *Patellina corrugata*** Williamson, ventral view/ *vista ventral*, Sample 3/ *Muestra 3* (LM-FCEN 3131). **3, *Quinqueloculina*** sp., side view/ *vista lateral*, Sample 2/ *Muestra 2* (LM-FCEN 3132). **4, *Pyrgo depressa*** (d'Orbigny), side view/ *vista lateral*, Sample 2/ *Muestra 2* (LM-FCEN 3133). **5, *Pyrgo elongata*** (d'Orbigny), side view of one broken test/ *vista lateral de un ejemplar roto*, Sample 5/ *Muestra 5* (LM-FCEN 3134). **6, *Pyrgo*?** sp., side view/ *vista lateral*, Sample 2/ *Muestra 2* (LM-FCEN 3135). **7, *Laevidentalina*** sp., side view/ *vista lateral*, Sample 5/ *Muestra 5* (LM-FCEN 3136). **8, *Lenticulina*** sp.1, side view/ *vista lateral*, Sample 2/ *Muestra 2* (LM-FCEN 3137). **9, *Lenticulina*** sp. 2, side view/ *vista lateral*, Sample 2/ *Muestra 2* (LM-FCEN 3138). **10, *Astacolus crepidulus*** (Fichtel and Moll), side view/ *vista lateral*, Sample 5/ *Muestra 5* (LM-FCEN 3139). **11, *Lagena laevis*** Montagu, side view/ *vista lateral*, Sample 2/ *Muestra 2* (LM-FCEN 3140). **12, *Conolagena squamososulcata*** (Heron-Allen and Earland), side view/ *vista lateral*, Sample 3/ *Muestra 3* (LM-FCEN 3141). **13, *Conolagena epibathra*** (Patterson and Richardson), side view/ *vista lateral*, Sample 3/ *Muestra 3* (LM-FCEN 3142). **14, *Oolina caudigera*** (Wiesner), side view/ *vista lateral*, Sample 2/ *Muestra 2* (LM-FCEN 3143). **15, *Oolina globosa*** (Montagu), side view/ *vista lateral*, Sample 3/ *Muestra 3* (LM-FCEN 3144). **16a–b, *Parafissurina aventicosa*** McCulloch, Sample 2/ *Muestra 2* (LM-FCEN 3145); **16a,** peripheral view/ *vista periférica*; **16b,** side view/ *vista lateral*. **17, *Glandulina*?** sp., side view/ *vista lateral*, Sample 3/ *Muestra 3* (LM-FCEN 3146). **18–20, *Lamarckina*** sp.; **18,** peripheral view of broken specimen showing a external umbilical aperture and internal partition or division of the chambers/ *vista periférica de un ejemplar roto mostrando las divisiones internas de las cámaras*, Sample 3/ *Muestra 3* (LM-FCEN 3147); **19a–b,** Sample 2/ *Muestra 2* (LM-FCEN 3148); **19a,** umbilical side/ *lado umbilical*; **19b,** spiral side/ *lado espiral*; **20a–b,** Sample 5/ *Muestra 5* (LM-FCEN 3149); **20a,** spiral side/ *lado espiral*; **20b,** umbilical side/ *lado umbilical*. **21–22, *Pseudobulimina chapmani*** (Heron-Allen and Earland); **21,** umbilical side/ *lado umbilical*, Sample 2/ *Muestra 2* (LM-FCEN 3150); **22,** broken specimen showing internal structure/ *ejemplar roto mostrando la estructura interna*, Sample 2/ *Muestra 2* (LM-FCEN 3151). **23, *Cassidulinoides parkerianus*** (Brady), umbilical side/ *lado umbilical*, Sample 2/ *Muestra 2* (LM-FCEN 3152). **24–25, *Globocassidulina biora*** (Crespin); **24**, umbilical side/ *lado umbilical*, Sample 2/ *Muestra 2* (LM-FCEN 3153); **25,** oblique view/ *vista lateral oblicua*, Sample 2/ *Muestra 2* (LM-FCEN 3154). **26–28, *Globocassidulina*** sp.; **26,** apertural view/ *vista lateral*, Sample 2/ *Muestra 2* (LM-FCEN 3155); **27,** umbilical view/ *lado umbilical*, Sample 2/ *Muestra 2* (LM-FCEN 3156); **28,** apertural view/ *vista apertural*, Sample 2/ *Muestra 2* (LM-FCEN 3157). **29, *Fursenkoina fusiformis*** (Williamson), side view/ *vista lateral*, Sample 5/ *Muestra 5* (LM-FCEN 3158).


1a
1b
2
3
4
500 µm
5
500 µm
6
7
500 µm
8
500 µm
9
500 µm
10
500 µm
11
12
13
14
15
16a
16b
17
18
19a
19b
20a
20b
21
22
23
24
25
26
27
28
29

Subfamily Parafissurininae R.W. Jones, 1984

Genus *Parafissurina* Parr, 1947

Type species. *Lagena ventricosa* A. Silvestri, 1904, p. 10.

Parafissurina aventicosa McCulloch, 1977

Figure 7.16

1977. *Parafissurina aventicosa* McCulloch, p. 138, pl. 70, fig. 19; Boltovskoy and Giussani de Kahn, 1982, p. 443, pl. 13, figs. 11–12.

Remarks. This species was recorded in high latitudes, in the late Oligocene-late Miocene of DSDP Site 360, Cape Basin; Pliocene of DSDP Site 329, Falkland Outer Basin, and Pliocene of South Atlantic Islands and South Atlantic Ocean (Boltovskoy and Giussani de Kahn, 1982).

Family Glandulinidae Reuss, 1860

Subfamily Glandulinianae Reuss, 1860

Genus *Glandulina* d'Orbigny, 1839b

Type species. *Nodosaria* (les Glandulines) *laevigata* d'Orbigny, 1826.

Glandulina? sp.

Figure 7.17

Remarks. Test elongate, ovate, fusiform, tapering at both ends, circular in section, translucent wall with a nearly horizontal white collar over the first-third of test length, likely as a result of a reabsorbed chamber; surface smooth; aperture terminal, rounded with radiating slits at the end of a short neck, with a long and straight entosolenian tube attached to the wall. Some specimens are symmetrical and others are asymmetrical.

Symmetrical specimens resemble *Glandulina laevigata* (d'Orbigny) from the Eocene to Oligocene of CIROS-1 Core, McMurdo Sound, Ross Sea (EA), illustrated by Coccioni and Galeotti (1997). This species differs from *Glandulina antarctica* Parr (1950) in having a more delicate test.

Suborder Robertininina Loeblich and Tappan, 1984

Superfamily Ceratobuliminoidea Cushman, 1927

Family Ceratobuliminidae Cushman, 1927

Subfamily Ceratobuliminae Cushman, 1927

Genus *Lamarckina* Berthelin, 1881

Type species. *Pulvinulina erinacea* Karrer, 1868.

Lamarckina sp.

Figure 7.18–20

Remarks. Previously referred as *Heronallenia?* sp. by Caramés *et al.* (2008) but the recent finding of additional and better preserved specimens allowed us to observe the smooth or rugose umbilical view without radial grooves. Also a broken specimen allowed us to see an internal partition or division of the chambers.

Lamarckina sp. resembles *Heronallenia wilsoni* (Heron-Allen and Earland) illustrated by Earland (1934, pl. 8, figs. 30–32) from Antarctica, with a rugose dorsal surface, and limbate sutures with elevated marginal edges. However it is distinguished from the original illustration of *Discorbina wilsoni* Heron-Allen and Earland (1922), which is the type species of genus *Heronallenia*, and *Heronallenia wilsoni* illustrated by Finger and Lipps (1981), by the absence of umbilical radial grooves that characterize the genus, as well as the shape of dorsal sutures, flush with high edges, instead of them being completely raised as ribs.

Superfamily Robertinoidea Reuss, 1850

Family Robertinidae Reuss, 1850

Subfamily Alliatininae McGowran, 1966

Genus *Pseudobulimina* Earland, 1934

Type species. *Bulimina chapmani* Heron-Allen and Earland, 1922.

Pseudobulimina chapmani
(Heron-Allen and Earland, 1922)

Figure 7.21–22

1922. *Bulimina chapmani* Heron-Allen and Earland, p. 130, pl. 4, figs. 18–20; Anderson, 1975, p. 84, pl. 7, fig. 22a–b.
2001. *Pseudobulimina chapmani* (Heron-Allen and Earland); Igarashi *et al.*, p. 158, pl. 10, fig. 4a–b; Majewski, 2005, p. 189, fig. 22.5a–c.

Remarks. Originally described from the Recent of Antarctica.

Suborder Rotaliina Delage and Hérouard, 1896

Superfamily Cassidulinoidea d'Orbigny, 1839

Family Cassidulinidae d'Orbigny, 1839

Subfamily Cassidulininae d'Orbigny, 1839

Genus *Cassidulinoides* Cushman, 1927

Type species. *Cassidulina parkeriana* Brady, 1881.

Cassidulinoides parkerianus (Brady, 1884)

Figure 7.23

1884. *Cassidulina parkeriana* Brady, p. 432, pl. 54, figs. 11–16.
1990. *Cassidulinoides* cf. *parkerianus* (Brady); Quilty *et al.*, p. 3, pl. 1, fig. 10.

1974. *Cassidulinoides parkerianus* (Brady); Fillon, p. 139, pl. 4, fig. 5; Anderson, 1975, p. 84, pl. 7, fig. 20; Gaździcki and Webb, 1996, p.161, pl. 35, figs. 4–6; Jonkers *et al.*, 2002, p. 590, fig. 11d; Gaździcki and Majewski, 2003, fig. 6.3a–b.; Quilty, 2010, p. 197, fig. 3.13.
2001. *Cassidulinoides parvus* (Earland); Igarashi *et al.*, 2001, p. 156, pl. 10, figs. 12a–b.

Remarks. We follow Quilty (2010) who considers *Ehrenbergina parva* Earland (1934) and *Cassidulinoides parva* (Earland) by Nomura (1984) as a synonym of *C. parkerianus*, but the latter has priority.

Cassidulinoides parkerianus differs from *Cassidulinoides bradyi* (Norman) by possessing more inflated chambers, and from *C. porrectus* (Heron-Allen and Earland) by the more delicate test, smaller diameter and more chambers in the unrolled biserial portion.

Our specimens differ from *Cassidulinoides parkerianus* illustrated by Majewski (2005, fig. 23.1a–b–2) and Majewski and Anderson (2009, fig. 4.11), both located in West Antarctica, by the more robust test with less globose chambers, less marked sutures, smoother surface and less perforated wall.

Genus ***Globocassidulina*** Voloshinova, 1960

Type species. *Cassidulina globosa* Hantken, 1876.

Globocassidulina biora (Crespin, 1960)

Figure 7.24–25

1960. *Cassidulina biora* Crespin, p. 28, pl. 3, figs. 1–10.
1974. *Globocassidulina biora* (Crespin); Fillon, p. 139, pl. 1, figs. 9–12, 14–15; Finger and Lipps, 1981, p. 129, pl. 2, fig. 6a–c; Leckie and Webb, 1986, p. 1115, pl. 12, fig. 10; Igarashi *et al.*, 2001, p. 156, pl. 10, fig. 13a–b; Gaździcki and Majewski, 2003, figs. 6.4a–b, 5a–b; Majewski, 2005, p. 188, figs. 23.4–7; Majewski and Anderson, 2009, fig. 4.10; Quilty, 2010, p. 196, figs. 3.8–10.
1966. *Cassidulina crassa* d'Orbigny; Gaździcki and Webb, p. 161, pl. 35, figs. 2–3.
1966. *Globocassidulina subglobosa* (Brady); Gaździcki and Webb, p. 161, pl. 35, fig. 7.
2002. *Cassidulina crassa* d'Orbigny ; Jonkers *et al.*, p. 590, figs. 11.f–h.
2003. *Globocassidulina crassa biora* (Crespin); Quilty, p. 24. pl. 1, fig. 9.

Remarks. *Globocassidulina biora* is the most abundant species in Sample 2. It is recognized on the basis of its large and compressed test, a broadly rounded periphery, moderately inflated chambers, a protruding last chamber and aperture partly obscured by a broad thin plate surrounded by two elongated openings, one along the lower edge and other along the upper edge. The lower opening is oriented parallel to the basal suture and is more elongated than the upper one.

We had the opportunity of exmining specimens coming from Fiordo Belén belonging to Belén and Terrapin Formations that were identified as *G. crassa* (the same microfossils that were reported in Lirio *et al.*, 2003), but they should have been designated as *G. biora* based on the apertural characters. Taking into account that the Belén Formation is late Miocene in age (Jonkers *et al.*, 2002; Lirio *et al.*, 2003; Concheyro *et al.*, 2007) based on the presence of *Globigerinita glutinata* (Egger), and the ^{87}Sr/^{86}Sr dating that indicates 6.8±1.3 –0.5 Ma obtained on *Zygochlamys anderssoni* (Jonkers, 1998), the oldest record of *G. biora* could span the late Pliocene (Quilty, 2010) to the late Miocene.

Globocassidulina sp.

Figure 7.26–28

1960. *Cassidulina* sp. Crespin, p. 29, pl. 3, fig. 11.
1960. *Cassidulina crassa* d'Orbigny; Crespin, p. 29, pl. 3 , figs. 12–13.
1974. *Globocassidulina biora* (Crespin)?; Fillon, p. 140, pl. 1, figs. 8, 13.
1981. *Globocassidulina* sp. Fingers and Lipps, p. 129, pl. 4, fig. 1a–c; Igarashi *et al.*, 2001, pl. 11, fig. 2a–b.
1986. *Globocassidulina crassa* (d'Orbigny), Leckie and Webb, p. 1115, pl. 12, figs. 7–9; Quilty *et al.*, 1990, p. 3, pl. 1, fig. 9; Strong and Webb, 2001, p. 356, pl. 1, fig. 17.
2001. *Globocassidulina subglobosa* (Brady); Strong and Webb, pl. 1, fig. 18; Murray and Pudsey, 2004, p. 80, pl. 2, figs. 12–13; Concheyro *et al.*, 2007, p. 580, fig. 5.d; Quilty, 2010, p. 197, fig. 3.12.
1975. *Cassidulina subglobosa* (Brady); Anderson, p. 84, pl. 11, fig. 1a–b; Jonkers *et al.*, 2002, p. 590, fig. 11.i.
2003. *Globocassidulina crassa rossensis* Kennett; Quilty, p. 24, pl. 1, fig. 10.
2009. *Globocassidulina* spp. Majewski and Anderson, fig. 4.7–9.

Remarks. This study agrees with Nomura (1983) and Belford (1966) who concluded, based on observations of the holotype, that specimens previously referred to *G. subglobosa* with a tripartite aperture, L-shaped or V-shaped, must be excluded from the that species.

Globocassidulina sp. differs from *Globocassidulina crassa* by the longer areal apertural branch and shorter basal apertural branch, and from *G. rossensis* by the shorter basal apertural branch and the globular and inflated test.

It seems likely that the specimens here included in *Globocassidulina* sp. May correspond to more than one species, but scarcity of well preserved specimens precludes a more certain identification. Some of them resemble those illustrated by Nomura (1983) as *G. oriangulata* Belford and *Globocassidulina parva* (Asano and Nakamura).

Superfamily FURSENKOINOIDEA Loeblich and Tappan, 1961
Family FURSENKOINIDAE Loeblich and Tappan, 1961

Genus ***Fursenkoina*** Loeblich and Tappan, 1961

Type species. *Virgulina squammosa* d'Orbigny, 1826.

Fursenkoina fusiformis (Williamson, 1858)

Figure 7.29

1858. *Bulimina pupoides* d'Orbigny var. *fusiformis* Williamson, p. 63, pl. 5, figs. 129–130.
1981. *Fursenkoina earlandi* (Parr); Finger and Lipps, p. 129, pl. 3, fig. 5.
1996. *Fursenkoina* cf. *earlandi* (Parr); Gaździcki and Webb, p. 162, pl. 35, figs. 8–9; Jonkers *et al.*, 2002, p. 594, fig. 11.a–b.
1975. *Fursenkoina fusiformis* (Williamson); Anderson, p. 88, pl. 10, fig. 11. Gaździcki and Majewski, 2003, fig. 5.5. Majewski, 2005, p. 187, fig. 23.9–12; Majewski and Anderson, 2009, p. 147, fig. 4.5–6.

Remarks. This small and variable species has been mentioned as *Fursenkoina* cf. *earlandi* (Parr) from the late Miocene of Hobbs Glacier Formation, James Ross Island (Jonkers *et al.*, 2002), and from the Pliocene Pecten Conglomerate, Cockburn Island (WA) (Gaździcki and Webb, 1996), but these specimens, like those reported hereein, differ from Parr's species by the twisted plane of biseriality. *Bolivina earlandi* Parr in its original illustration and a good SEM photograph (Igarashi *et al.*, 2001, pl. 10, fig. 5a–b) lacks a twisted biserial arrangement; in consequence, according to Igarashi *et al.* (2001), *Bolivina earlandi* Parr belongs in the genus *Bolivinellina*. In our opinion, the recovered specimens as those included in the synonymy with twisted biserial arrangement, match the original description of *B. pupoides* var. *fusiformis.*

Superfamily Discorboidea Eherenberg, 1838
Family Rosalinidae Reiss, 1963
Genus ***Rosalina*** d'Orbigny, 1826

Type species. *Rosalina globularis* d'Orbigny, 1826 (Galloway and Wissler, 1927, p. 62).

Rosalina globularis d'Orbigny, 1826

Figure 8.1

1826. *Rosalina globularis* d'Orbigny, p. 271, pl. 13, figs. 1–4; Fillon, 1974, p. 140, pl. 4, figs. 11–12; Finger and Lipps, 1981, p. 132, pl. 2, fig. 10a–b; Leckie and Webb, 1986, p. 1113, pl. 6, figs. 6–7; Strong and Webb, 2000, p. 472, pl. 2, fig. 18; Igarashi *et al.*, 2001, p. 159, pl. 11, fig. 13a–c; Gaździcki and Majewski, 2003, fig. 5.3a–b; Majewski, 2005, p. 207, figs. 24.1a–b, 2a–b, 3, 4a–b; Quilty, 2010, p. 199, fig. 3.16a–b.

Remarks. Originally described from the Recent; cosmopolitan distribution.

Superfamily Discorbinelloidea Sigal, 1952
Family Pseudoparrellidae Voloshinova, 1952
Subfamily Pseudoparrellinae Voloshinova, 1952
Genus ***Epistominella*** Husezima and Maruhasi, 1944

Type species. *Epistominella pulchella* Husezima and Maruhasi, 1944.

Epistominella vitrea Parker, 1953

Figure 8.2–4

1953. *Epistominella vitrea* Parker, in Parker *et al.*, p. 9, pl. 4, figs. 34–36, 40–41; Leckie and Webb, 1986, p. 1113, pl. 6, figs. 1–5; Quilty *et al.*, 1990, p. 3, pl. 1, figs. 12–13; Gaździcki and Webb, 1996, p. 162, pl. 35, figs. 10–11; Jonkers *et al.*, 2002, p. 594, fig. 12.a–c.

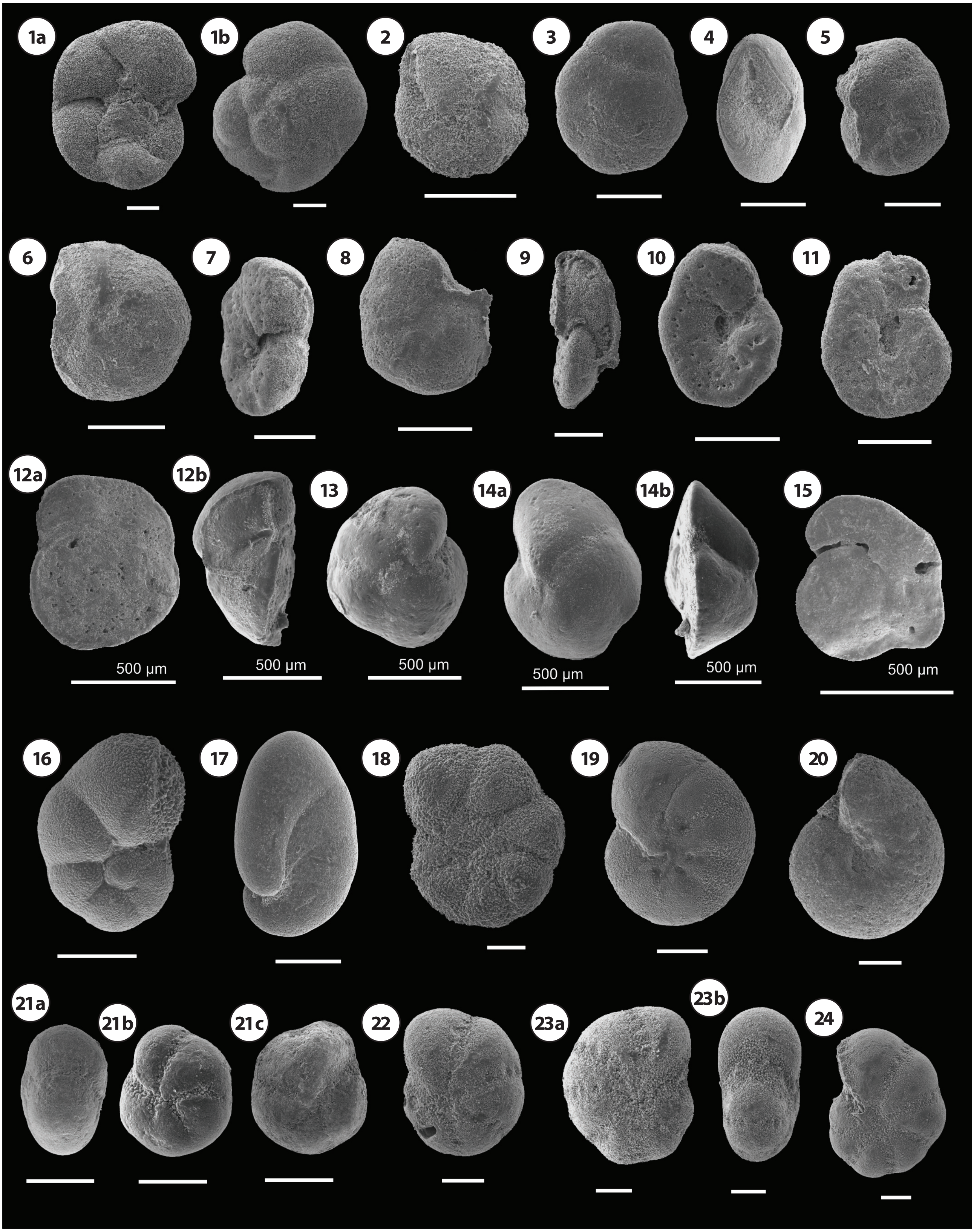
Remarks. *Epistominella vitrea* is similar to *E. exigua*. It differs in having a more inflated test in side view, a rounded periphery, and it usually has more chambers in the final whorl (6–6.5 *vs.* 5). Pawlowski *et al.* (2007) discussed their identification and reported that the two species are fairly distinct whether morphologically or at a molecular level.

Specimens identified as *Pseudoparrella exigua* by Finger and Lipps (1981) and as *Epistominella exigua* by Fillon (1974), Strong and Webb (2000, 2001), Quilty (2003), Webb and Strong (2006) and Majewski (2010) may be referable to *E. vitrea.*

Family Discorbinellidae Sigal, 1952
Subfamily Discorbinellinae Sigal, 1952
Genus ***Discorbinella*** Cushman and Martin, 1935

Type species. *Discorbinella montereyensis* Cushman and Martin, 1935.

Figure 8. Except indication the scale bar equals 100 µm/ *Excepto indicación la escala gráfica equivale a 100 µm.* **1a–b, *Rosalina globularis*** d'Orbigny, Sample 2/ *Muestra 2* (LM-FCEN 3159); **1a**, umbilical side/ *lado umbilical*; **1b**, spiral side/ *lado espiral*. **2–4, *Epistominella vitrea*** Parker; **2,** umbilical side/ *lado umbilical*, Sample 5/ *Muestra 5* (LM-FCEN 3160); **3,** spiral side/ *lado espiral*, Sample 3/ *Muestra 3* (LM-FCEN 3161); **4,** apertural view/ *vista apertural*, Sample 3/ *Muestra 3* (LM-FCEN 3162). **5–11, *Discorbinella dispars*** (d'Orbigny); **5,** dorsal side/ *lado dorsal*, Sample 2/ *Muestra 2* (LM-FCEN 3163); **6,** dorsal side/ *lado dorsal*, Sample 2/ *Muestra 2* (LM-FCEN 3164); **7,** apertural view/ *vista apertural*, Sample 3/ *Muestra 3* (LM-FCEN 3165); **8,** dorsal side/ *lado dorsal*, Sample 3/ *Muestra 3* (LM-FCEN 3166); **9,** apertural view/ *vista apertural*, Sample 3/ *Muestra 3* (LM-FCEN 3167); **10,** ventral side/ *lado ventral*, Sample 3/ *Muestra 3* (LM-FCEN 3168); **11,** ventral side/ *lado ventral*, Sample 2/ *Muestra 2* (LM-FCEN 3169). **12–15, *Cibicides refulgens*** de Montfort; **12a–b,** Sample 2/ *Muestra 2* (LM-FCEN 3170); **12a,** ventral side/ *lado ventral*; **12b,** apertural view/ *vista apertural*; **13,** dorsal side/ *lado dorsal*, Sample 2/ *Muestra 2* (LM-FCEN 3171); **14a–b** Sample 2/ *Muestra 2* (LM-FCEN 3172); **14a,** dorsal side/ *lado dorsal*; **14b,** apertural view/ *vista apertural*; **15,** ventral side/ *lado ventral*, Sample 3/ *Muestra 3* (LM-FCEN 3173). **16, *Nonionella bradii*** (Chapman), dorsal or spiral side/ *lado dorsal espiral*, Sample 5/ *Muestra 5* (LM-FCEN 3174). **17, *Nonionella*** sp., ventral side/ *lado ventral*, Sample 6/ *Muestra 6* (LM-FCEN 3175). **18, *Astrononion antarcticum*** Parr, side view/ *vista lateral*, Sample 2/ *Muestra 2* (LM-FCEN 3176). **19, *Astrononion echolsi*** Kennett, side view/ *vista lateral*, Sample 5/ *Muestra 5* (LM-FCEN 3177). **20, *Anomalinoides tasmanicus*** (Parr), umbilical side/ *lado umbilical*, Sample 6/ *Muestra 6* (LM-FCEN 3178).



21, *Aubignyna*? sp., Sample 2/ *Muestra 2* (LM-FCEN 3179); **21a**, apertural view/ *vista apertural*; **21b**, ventral side/ *lado ventral*; **21c** spiral side/ *lado espiral*. **22–24, *Cribroelphidium*** sp. aff. ***E. excavatum*** Terquem; **22,** lateral view/ *vista lateral*, Sample 2/ *Muestra 2* (LM-FCEN 3180); **23a–b,** Sample 2/ *Muestra 2* (LM-FCEN 3181); **23a,** lateral view/ *vista lateral*; **23b**, apertural view/ *vista apertural*; **24,** lateral view/ *vista lateral*, Sample 2/ *Muestra 2* (LM-FCEN 3182).

Discorbinella dispars (d'Orbigny, 1839)

Figure 8.5–11

1839a. *Truncatulina dispars* d'Orbigny, p. 38, pl. 5, figs. 25–27; Heron-Allen and Earland, 1932, p. 420, pl. 14, figs. 32–34.

Remarks. Test small, trochospiral, compressed, concavo-convex, circular to ovate in outline, with an acute periphery and earlier whorls centrally visible on both sides. Spiral face convex with proloculus and 1.5–2 whorls visible, 6–8 chambers in the final whorl separated by depressed and strongly curved sutures. Concave umbilical side, with deep umbilicus, sutures strongly curved backwards. The aperture is an interiomarginal slit from the umbilicus to the periphery. The ventral surface is coarsely perforated.

Our specimens agree very well with those described and illustrated by Heron-Allen and Earland (1932) as *Truncatulina dispars* d'Orbigny. Some specimens also resemble *Discorbina bertheloti* d'Orbigny illustrated by Brady (1884, pl. 89, figs. 10–12), but differ by the coarsely perforated ventral surface.

Superamily Planorbulinoidea Schwager, 1877

Family Cibicididae Cushman, 1927

Subfamily Cibicidinae Cushman, 1927

Genus ***Cibicides*** de Montfort, 1808

Type species. *Cibicides refulgens* de Montfort, 1808.

Cibicides refulgens de Montfort, 1808

Figure 8.12–15

1808. *Cibicides refulgens* de Montfort, p. 123, pl. 92, figs. 7–9; Anderson, 1975, p. 84, pl. 10, fig. 3a–c; Finger and Lipps, 1981, p. 129, pl. 3, fig. 1a–c; Leckie and Webb, 1986, p. 1115, pl. 11, figs. 13–15; Quilty *et al.*, 1990, p. 3, pl. 1, fig. 17; Gaździcki and Webb, 1996, p. 162, pl. 36, figs. 4, 5a–b, 6; Igarashi *et al.*, 2001, p. 156, pl. 12, fig. 4a–c; Gaździcki and Majewski, 2003, fig. 5.4a–c; Majewski, 2005, p. 187, fig. 25.1a–c; Quilty, 2010, p. 201, figs. 5.9a–b, 10a–b.

1884. *Truncatulina refulgens* (de Montfort); Brady, p. 659, pl. 92, figs. 7–9.

1996. *Cibicides lobatulus* (Walter y Jacob); Gaździcki and Webb, p. 163, pl. 36, figs. 1–3; Strong and Webb, 2001, p. 356, pl. 1, figs. 7–8; Jonkers *et al.*, 2002, p. 590, fig. 12.e–f.

Remarks. Great confusion exists between *C. lobulatus* and *C. refulgens*, probably because of the brief original descriptions and the schematical original drawings. We based our classification on Brady (1884). This author included in *Truncatulina refulgens* a form with a lobulate periphery that tends to spread laterally, with dorsal sutures gently curved and the last suture strongly curved back near the periphery (Brady, 1884, pl. 92, fig. 8a–c), as well as a form with higher and convex umbilical side and periphery less acute and not lobulate (Brady, 1884, pl. 92, fig. 7a–c). He also separated *Truncatulina lobatula* as a form circular in outline, with strongly convex umbilical side, small and deeper umbilicus and more radial dorsal sutures (Brady, 1884, pl. 92, fig. 10, pl. 93, fig. 1a–c).

Our specimens match those figured as *Truncatulina refulgens* Montfort by Brady (1884).

Superfamily Nonionoidea Schultze, 1854

Family Nonionidae Schultze, 1854

Subfamily Nonioninae Schultze, 1854

Genus ***Nonionella*** Cushman, 1926

Type species. *Nonionella miocenica* Cushman, 1926.

Nonionella bradii (Chapman, 1916)

Figure 8.16

1884. *Nonionina*(?) *scapha* (Fitchel andMoll); Brady, p. 730, pl. 109, figs. 14–16.

1916. *Nonionina scapha* (Fichtel and Moll) var. *bradii* Chapman, p. 71, pl. 5, fig. 42.

1932. *Nonionella iridea* Heron-Allen and Earland, p. 438, pl. 16, figs. 14–16; Crespin, 1960, p. 26, pl. 3, fig. 16; Fillon, 1974, p. 140, pl. 5, figs. 11, 14; Anderson, 1975, p. 90, pl. 11, fig. 7a–b; Leckie and Webb, 1986, p. 1115, pl. 13, figs. 3–4, pl. 23, figs. 5–7; Strong and Webb, 2000, p.470, pl. 2, figs. 7–8; Strong and Webb, 2001, p. 357, pl. 1, figs. 23, 25; Igarashi *et al.,* 2001, p. 158, pl. 12,fig. 6a–c; Murray and Pursey, 2004, p. 80, pl. 2, figs. 15–17; Majewski, 2005, p. 189, fig. 25.2a–c–3; Webb and Strong, 2006, p. 99, fig. 3.18; Majewski and Anderson, 2009, p. 146, fig. 4.15a–b.

1974. *Nonionella bradii* Chapman; Fillon, p. 140, pl. 5, figs. 12–13; Finger and Lipps, 1981, p. 130, pl. 3, fig. 4a–d; Anderson, 1975, p. 90, pl. 11, figs. 6a–b; Leckie and Webb, 1986, p. 1115, pl. 13, fig. 6, pl. 23, figs. 1–2; Strong and Webb, 1998, p. 520, pl. 1, fig 12; Gaździcki and Webb, 1996, p. 163, pl. 36, figs. 7–8; Strong and Webb, 2000, p. 520, pl. 2, fig. 6; Strong and Webb, 2001, p. 357, pl. 1, figs. 21–22; Igarashi *et al.,* 2001, p. 520, pl. 12, fig. 5a–c.; Jonkers *et al.*, 2002, p. 594, fig.11.n–p. Majewski, 2005, p. 189, figs. 25.4a–c–5; Webb and Strong, 2006, p. 99, fig. 3.17; Majewski and Anderson, 2009, p. 146, fig. 4.17a–b.

2009. *Nonionella* cf. *iridea* Heron-Allen and Earland, Majewski and Anderson, fig. 4.16.

Remarks. In most of the Antarctic literature consulted, *N.bradii* Chapman and *N. iridea* Heron-Allen and Earland are considered two different species, and there is a tendency to separate as *N. bradii* those forms with a more involute test, without an umbilical boss and with chambers increasing greatly in width as added, and as *N. iridea* those forms which have a more evolute test, an umbilical boss and chambers that rapidly increase their height. Contrarily, we adopt a broad taxonomic definition to account for the range of morphological variability encountered, and we consider that *N. bradii* and *N. iridea* are extreme forms of the same species for the following reasons. On the one hand, all the specimens of *Nonionina*(?) *scapha* (Fitchel and Moll) illustrated by Brady (1884) were included by Chapman (1916) in the list of synonyms for his variety *Nonionina scapha* var.*bradii*, which was later raised to specific rank as *Nonionella bradii.* However, one of the figured specimens in Brady's paper matches the original illustration of *Nonionina iridea* Heron-Allen and Earland. On the other hand, *N. bradii* and *N. iridea* show a similar distribution, and they both were described for the Recent, the former from nearby the Malvinas (Falkland) Islands and the second one from Ross Sea (WA)

Nonionella sp.

Figure 8.17

2002. *Nonionella turgida* (Williamson), Jonkers *et al.*, p. 594, fig. 11.q–s.
1975. *Nonionella bradii* (Chapman), Anderson, p. 90, pl. 11, fig. 6a–b.

Remarks. This species is represented by one small specimen that differs from *N. turgida* (Williamson) by a lesser development of the last chamber over the umbilicus. It differs from *N. bradii* (Chapman) by having a more compressed, elongated and tapering test, the rapid increment in width as the chambers as added, and by the more extended last chamber over the umbilicus.

Subfamily ASTRONONIONINAE Saidova, 1891

Genus ***Astrononion*** Cushman and Edwards, 1937

Type species. *Nonionina stelligera* d'Orbigny, 1839.

Astrononion antarcticum Parr, 1950

Figure 8.18

1950. *Astrononion antarcticus* Parr, p. 371, pl. 15, figs. 13–14; Fillon, 1974, p. 139, pl. 6, figs. 4–6; Anderson, 1975, p. 84, pl. 11, fig. 3a–b; Quilty, 2010, p. 201, fig. 5.11.
1960. *Astrononion antarcticum* Parr; Crespin, p. 26, pl. 2, fig. 9; Igarashi *et al.*, 2001, p. 156, pl. 12, fig. 10a–b; Gaździcki and Majewski, 2003, fig. 5.6a–b; Quilty, 2003, p. 24, pl. 1, fig. 11; Jonkers *et al.*, 2002, p. 590, fig. 11.j–k; Majewski, 2005, p. 187, fig. 25.8; Majewski and Anderson, 2009, p. 146, fig. 4.18.

Remarks. The specimens from Cape Lamb and the others included in the preceding list of synonyms have more regular planispiral coiling, are more compressed and have more oblique sutures than the holotype illustration.

Astrononion echolsi Kennett, 1967

Figure 8.19

1967. *Astrononion echolsi* Kennett, p. 134, fig. 7a–b, 8; Fillon, 1974, p. 139, pl. 6, figs. 1–3; Anderson, 1975, p. 84, pl. 11, fig. 4a–b; Finger and Lipps, 1981, p. 129, pl. 3, fig. 6a–b; Leckie and Webb, 1986, p. 1115, pl. 13, figs. 1–2; Igarashi *et al.*, 2001, p. 156, pl. 12, fig. 11a–b; Quilty, 2003, table T4, pl. 1, fig. 12; Gaździcki and Majewski, 2003, fig. 5.7a–b; Murray and Pudsey, 2004, p. 79, pl. 2, fig. 8; Majewski and Anderson, 2009, p. 146, fig. 4.19; Quilty, 2010, p. 201, fig. 5.12.
1990. *Astrononion* sp. Quilty *et al.*, p. 5, pl. 1, figs. 18–20.

Remarks. The specimens from Cape Lamb have 7–8 chambers in the last whorl. The elongated sutural plates are barely visible over the limbated sutures and their distal part is marked by a pit.

Originally described from the Recent of Ross Sea (Kennett, 1967).

Superfamily CHILOSTOMELLOIDEA Brady, 1881

Family HETEROLEPIDAE Gonzáles-Donoso, 1969

Genus ***Anomalinoides*** Brotzen 1942

Type species. *Anomalinoides plummerae* Brotzen, 1942.

Anomalinoides tasmanicus (Parr, 1950)

Figure 8.20

1950. *Anomalina tasmanica* Parr, p. 363, pl. 15, fig. 4a–c.

Remarks. We only found one specimen that matches the description of *Anomalina tasmanica* Parr, with entire and rounded periphery, evolute spiral side showing a last whorl and a translucent central plug that permits the observation of the proloculus and the first whorl, which is formed by 8 chambers separated by flush curved sutures. The involute umbilical side is deeply umbilicate and shows 12 chambers separated by radial sutures. Wall perforated.

It closely resembles *Anomalinoides alazanensis spissiformis* (Cushman and Stainforth, 1945) reported from the Eocene to Miocene of Trinidad, but it is distinguished by the fewer chambers and more curved dorsal sutures.

Anomalinoides tasmanicus is also related to *Anomalina glabrata* described by Cushman (1924), but the former has more chambers and a smoother periphery than *A. glabrata.*

Anomalina macraglabra Finlay (1940) posseses a finely punctuated wall.

Anomalinoides tasmanicus was originally described from the Recent of Tasmania.

Family TRICHOHYALIDAE Saidova, 1981

Genus ***Aubignyna*** Margerel, 1970

Type species. *Aubignyna mariei* Margerel, 1970.

***Aubignyna*? sp.**

Figure 8.21

Remarks. Tiny test with a low trochospiral coil, biconvex and slightly asymmetrical. Spiral side less convex than the umbilical side; apparently, a small plug covers the beginning of the spire; sutures weakly depressed, straight and radial. Umbilical side involute with six chambers separated by curved sutures, deeply incised from the umbilicus midway, becoming weakly depressed towards to the periphery. Smooth surface except for numerous and prominent pustules that cover the lower part of the apertural face and the sutures near the umbilical area. The interiomarginal aperture is hidden by pustules. Retral processes, bridges and fossettes were not seen.

This species is represented by a single small specimen.

Superfamily ROTALIOIDEA Ehrenberg, 1839
Family ELPHIDIDAE Galloway, 1933
Subfamily ELPHIDIINAE Galloway, 1933
Genus ***Cribroelphidium*** Cushman and Brönnimann, 1948

Type species. *Cribroelphidium vadescens* Cushman and Brönnimann, 1948.

***Cribroelphidium* sp. aff. *E. excavatum* Terquem**

Figure 8.22–24

aff. 1932. *Elphidium* (*Polystomella*) *excavatum* (Terquem); Heron-Allen and Earland, p. 439, pl. 16, figs. 22–23.

Remarks. The specimens assigned to *Cribroelphidium* sp. aff. *E. excavatum* Terquem are strictly planispiral and symmetrical. They are characterized by their relatively large size, lobulate outline, rounded periphery, 6–8 chambers in the final whorl, depressed radial sutures with retral processes, ponticuli and at least 7 fossettes per side and small papillae which usually hide the ponticuli and fossettes. They do not have an umbo. Our specimens differ from *E. excavatum* illustrated by Heron-Allen and Earland (1932) by the lower number of chambers (6–8 *vs.* 9). They resemble *E. magellanicum* also illustrated by Heron-Allen and Earland (1932, pl. 16, figs. 26–28), by the number of chambers and the small papillae that fill the sutural depression, but our specimens differ by the less inflated chambers.

The general morphology of *Cribroelphidium* sp. aff. *E. excavatum* and their straight sutures closely resemble *Elphidium* ex. gr. *excavatum* from the late Oligocene–early Miocene of the CRP-2/2A drillhole at Cape Roberts,Victoria Land Basin (EA), illustrated by Strong and Webb (2000) but ponticuli and fossettes seem to be less prominent.

This species is distinguished from *Elphidium* (*Cribrononion*) sp. 1 (Quilty, 2010, p. 202, fig. 5.14; erroneously mentioned in the text as fig.5, 15, Quilty, pers.comm. 2011), from *Elphidium magellanicum* s.l. Heron–Allen and Earland illustrated by Leckie and Webb (1986) which was included by Quilty (2010) as a synonym of his species, and from *Elphidium magellanicum* illustrated by Strong and Webb (2000, p. 469, pl. 1, figs. 13–14) by its larger and more compressed test, less inflated chambers and straighter sutures.

It also differs from *Elphidium* (*Cribrononion*) sp. 2 (Quilty, 2010, p. 202, figs. 5.16a–c, 17; erroneously mentioned in the text as fig.5, 17a–18, Quilty, pers. comm. 2011) from the late Pliocene of Heidemann Valley, Vestfold Hills (EA), and from *Cribroelphidium* sp. (Strong and Webb, 1998, pl. 1, figs. 5–7) from the early Miocene of CRP-1 drillhole, Victoria Land Basin (EA), by the strictly planispiral and less inflated test.

The Cape Lamb species closely resembles *E. excavatum* from Terrapin Formation (WA) mentioned in Lirio *et al.* (2003).

DISCUSSION

Foraminiferal assemblage and paleoenvironmental inferences

Of the five studied samples, four yielded foraminifers and a moderately diverse accompanying biota that includes echinoid spines, spiroribids, serpulids, and bryozoans (Fig. 5). The recovered biota indicates fully marine conditions.

Foraminiferal test preservation was variable. It was regular in samples 2 and 3 and poorer in samples 5 and 6. Under binocular microscope the microfauna coming from samples 2 and 3 showed a smooth appearance but under the SEM, they exhibited irregular rough surfaces resulting from dissolution processes. All tests recovered from samples 5 and 6 have a dull and rough appearance under the binocular microscope, and SEM photographs reveal strong dissolution and recrystallization processes. The preservation of foraminiferal tests in sample 5, located at the top of the sedimentary section, could be influenced by the chemistry of the fluids leaking down from the overlying basaltic lava.

The mixed size and diversity of foraminifera species indicate that the original environment that they inhabited was moderately oxygenated. According to Kaiho (2013) oxic indicators such as large tested (≥0.35mm) and thick walled *Cibicides* allow to estimate paleodissolved oxygen >1ml/l.

The fauna is highly dominated by species with an infaunal lifestyle that suggests a soupy substrate (Murray, 2006).

Hence, the existence of dissolved oxygen levels that are high enough to allow the development of many infaunal and a few epifaunal forms suggests mesotrophic conditions (Jorissen *et al.*, 1992, 1995).

The fossil-bearing samples contain many damaged tests with a broken last chamber or circular holes attributed to predation. The presence of fragmented tests (more than 30%) testifies to the action of vigorous marine currents and remobilization before final burial. An interesting point is that there is a mixture of sizes for all species of foraminifera, which means that transport did not cause a size selection. Furthermore, all tests found in these samples have a similar colour that allows us to hypothesize that the foraminifera were coeval and that the reworking could be have taken place *in situ* or from a nearby area. Thus, it is possible to consider that the studied foraminifera are the remains of a marine biocenosis contemporaneous with the sediment that incorporated it.

The foraminiferal fauna —with the exception of an agglutinated specimen identified as *Miliammina earlandi* (Fig. 5)— is calcareous; thus the community lived and was deposited above the calcite compensation depth (CCD).

The absence of planktonic foraminifera and other deeper water indicators, such as some dominantly arenaceous microfauna and benthic genera as *Oridorsalis* or some bolivinids and buliminids, suggest a sublittoral zone (Fillon, 1974; Quilty, 2010).

The Cassidulinidae, Elphidiidae, Cibicididae and Pseudoparrellidae families are highly dominant, and the high occurrence of *Globocassidulina, Cribroelphidium, Cibicides, Epistominella* and *Astrononion* probably indicate inner shelf environments below 100 m depth.

In samples 2 and 5 (Figs. 4–5) more than 300 foraminiferal tests from 35–45 g of washed sample were counted according to standard statistical methods. Samples 3 and 6 yielded fewer foraminifera than samples 2 and 5. Sample 7 was barren. Foraminifera tests from samples 3 and 6 were too rare to carry out quantitative analyses, but samples 2 and 5 were quantitatively analysed. The low abundance obtained from samples 3 and 6 may be due to dilution produced by a higher sedimentation rate or stressful conditions and food scarcity from the original environment. The α index values (Alpha diversity index; Fisher *et al.*, 1943) are about 5.5 and H(S) (Shannon-Weiner Diversity index, Shannon, 1948) about 2.1–2.5 for the samples 2 and 5, which are typical values for sea shelves with normal salinity. Observing their specific composition, the main components are present in the two samples, but they exhibit different proportions. Sample 2 is dominated by *Globocassidulina biora* (25%) and *Cribroelphidium* sp. aff. *E. excavatum* (24.7%), accompanied by *Cibicides refulgens* (18.9%), *Globocassidulina* sp. (10.7%) and some accessory species (each of them less than 4%). Sample 5 has a more even distribution; it is dominated by *Cribroelphidium* sp. aff. *E. excavatum* (23%), *Cassidulinoides parkerianus* (12.6%) and *Epistominella vitrea* (11.2%), accompanied by *Globocassidulina* sp. (7.9%), *Astrononion antarcticum* (7.6%), *Cibicides refulgens* (5.6%), *Nonionella bradii* (5.3%), *Astrononion echolsi* (5.0%) and some accessories species (each of them less than 5%). The differences observed between these faunas were possibly due to environmental changes.

Globocassidulina biora, which is dominant in sample 2, has been associated with Quaternary Antarctic shallow water, and has also been found in deeper parts of the eastern Weddell Sea shelf (Milam and Anderson, 1981). Other authors have attributed the occurrence of this taxon to a subice shelf environment and/or a habitat influenced by strong marine currents (Mellis and Salvi, 2009). *Cribroelphidium* sp. aff. *E. excavatum* is another important species showing the same proportions in samples 2 and 5. It is similar to *Cribroelphidium webbi*, a subrecent elphidid foraminifer commonly found in waters shallower than 100 m, associated with the retreating tide water glaciers, and considered as a sensitive glacial proximal indicator (Majewski, 2005; Majewski and Tatur, 2009).

Cassidulinoides parkerianus, which increases its proportion in the younger samples, is a typical taxon found in Recent sediments from proximal coastal areas of main channels in Almiraltly Bay, South Shetland Island (Majewski, 2005).

The accompanying biota, represented by serpulids and bryzoans, has an attached epifaunal lifestyle by anchoring on or encrusting shelly fragmented macrofauna and rocks, and they colonized the diamictite after its deposition, suggesting clear waters, with low turbidity and low sedimentation rates.

Age constraints

The foraminiferal species recorded in the Cape Lamb (Vega Island) section are long-ranging benthic taxa. Most of the more abundant species and some of the accessory ones are typical among Cenozoic microfaunas described from West Antarctica and East Antarctica (Fig. 6).

This microfauna does not contain *Ammoelphidiella* sp., a species considered a late Miocene marker by Jonkers *et al.* (2002), recorded in Fiordo Belén, and Hamilton and Rabot points (Jonkers *et al.,* 2002; Concheyro *et al.*, 2007). *Ammoelphidiella antarctica*, an index species for Pliocene deposits of Cockburn Island, Cape Gage and Prospect Mesa Gravel in Wright Valley, Victoria Land, Larsemann Hills (Conato and Segre, 1974; Webb, 1974; Quilty *et al.*, 1990, Gaździcki and Webb, 1996, Webb and Strong, 1998b, 2000, Jonkers *et al.*, 2002) was not recorded either.

Cape Lamb and Terrapin Hills are two nearby localities that contain *Adamussium colbecki* and in which the genus *Ammoelphidiella* has not been reported to date.

The $^{87}Sr/^{86}Sr$ isotopic age obtained from *Adamussium colbecki* in the nearby locality of Terrapin indicates a Plio-Pleistocene age (1.95±1.12/0.52 Ma; Lirio *et al.*, 2003). It is likely that these deposits are coeval with those at Cape Lamb; at this locality the only isotopic age known to date comes from a basalt layer possibly underlying the studied diamictite, and this yielded an age of 2.09±0.11Ma. This date, together with the age of the Terrapin beds, would indicate a Pleistocene age, but further evidence is needed to state this for certain.

CONCLUSIONS

A new foraminifera assemblage was recovered from Cenozoic debris and palagonitic breccia lithofacies exposed at the southwestern tip of Cape Lamb. This assemblage includes 34 benthic taxa with benthic infaunal species such as *Globocassidulina biora*, *Cribroelphidium* sp. aff. *E. excavatum* and *Cassidulinoides parkerianus,* and the epifaunal *Cibicides refulgens*, which are the most representative ones. These benthic foraminiferal genera suggest an infralittoral zone, probably inner shelf environment below 100 m depth. Specimen preservation and occurrence in the Cape Lamb diamictite deposits indicate that the original fossiliferous levels could have suffered short-range transport and the specimens originated from the nearby area.

Finally, this microfauna represents a new record of the very poorly known high latitude late Cenozoic foraminiferal fauna from the James Island Basin.

ACKNOWLEDGEMENTS

The authors are indebted to J.M. Lirio for providing the studied samples, the Instituto Antartico Argentino for the permanent logistic support during the Argentine Summer Antarctic Expedition 2007, L. Luci for improving the English version of the manuscript, C. del Rio for her valuable suggestions and the manuscript improvement, A. Bayarsky for the mineralogic determinations and analyses, P. Alvarez and S. Adamonis for sample preparation and picking, respectively, and F. Tricarico and the Servicio de Microscopia Electrónica de Barrido of the Museo Argentino de Ciencias Naturales "Bernardino Rivadavia" for taking the SEM foraminifera photographs.

This paper is contribution number R-63 of the Instituto de Estudios Andinos 'Don Pablo Groeber' (IDEAN). This work was supported by grant ANPCYT-PICTO- Antártida 07- 36166 and PICTO DNA 2010-00112

REFERENCES

Andersson, J.G. 1906. On the Geology of Graham Land. *Bulletin of the Geological Institution, University of Uppsala* 7: 19–71.

Anderson, J.B. 1975. Ecology and distribution of foraminifera in the Weddell Sea of Antarctica. *Micropaleontology* 21: 69–96.

Belford, D.J. 1966. Miocene and Pliocene smaller foraminifera from Papua and New Guinea. *Bulletin of the Australian Bureau of Mineral Resources, Geology and Geophysics* 79: 1–306.

Bernhard, J. M. 1986. Characteristic assemblages and morphologies of benthic foraminifera from anoxic, organic-rich deposits: Jurassic through Holocene. *Journal of Foraminiferal Research* 16: 207–215.

Berthelin, G. 1881. Coup d'oeil sur la faune rhizopodique du Calcaire Grossier Inférieur de la Marne. *Compte rendu de l'Association Française pour l'Avancement des Sciences*, 9ème session (Reims, 1880), p. 553–559.

Bertels-Psotka, A., Concheyro, A. and Salani, F.M. 2001. Las Diamictitas de cabo Hamilton, isla James Ross, Antártida. Caracterización estratigráfica, sus microfósiles. *4º Congreso de Geología y Minería de la Sociedad Cubana de Geología* (Havanna). CD-ROM.

Bibby, J.S. 1966.The Stratigraphy of Part of North-East Graham Land and the James Ross Island Group. *British Antarctic Survey Scientific Report* 53: 1–37.

Boltovskoy, E. and Giussani de Kahn, G. 1982. Foraminíferos bentónicos calcáreos uniloculares del Cenozoico superior del Atlántico Sur. *Revista de la Asociación Geológica Argentina* 37: 408–479.

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

Brady, H.B. 1884. Report on the foraminifera dredged by H.M.S. Challenger, during the years 1873–1876. *Report on the Scientific Results of the Voyage of H.M.S. Challenger during the years 1873-76: under the command of Captain George S. Nares, R.N., F.R.S. and Captain Frank Turle Thomson, R.N. Prepared under the superintendence of Sir C. Wyville Thomson. Zoology vol. 9.* Neill and Company, Edinburgh, 814 p.

Brotzen, F. 1942. Die Foraminiferengattung *Gavelinella* nov. gen. und die Systematik der Rotaliformis. *Årsbok Sveriges Geogiska Undersökning* 36: 1–60.

Caramés, A., R. Amenábar, C., Di Pasquo, M., Adamonis, S., Lirio, J.M. and Concheyro, A. 2008. Foraminíferos y palinomorfos de la "Diamictita Cabo Lamb", Plioceno superior, isla Vega, Península Antártica. *17º Congreso Geológico Argentino* (Jujuy), *Actas*, p. 992–993.

Chapman, F. 1916. Report on the foraminífera and ostracoda out of marine muds from soundings in the Ross Sea. *Reports of Scientific Investigations, British Antarctic Expedition 1907–1909, Geology* 2, p. 53–80.

Chapman, F. and Parr, W. 1935.Foraminifera and ostracoda from Soundings made by the trawler "Bonthorpe" in the Great Australian Bight. *Journal of the Royal Society of Western Australia* 21: 1–7.

Coccioni, R. and Galeotti, S. 1997. Foraminiferal biostratigraphy and palaeoecology of the CIROS-1 Core from McMurdo Sound (Ross Sea, Antarctica). *Terra Antarctica* 4: 103–1117.

Conato, V. and Segre, A.G. 1974. Depositi marini Quaternari e nuovi foraminiferi dell Antartide (Terre Victoria, Valle Wright). *Atti della Società Toscana di Scienze Naturali Resuidente in Pisa, serie* A81: 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* 62: 568–585.

Concheyro, A., Amenábar, C., Caramés, A., Adamonis, S, Lirio, J.M., Ballent, S., Di Pasquo, M. and Mackern, A. 2010. Cenozoic microbiotas from the eastern sector of the James Ross Islang Group, Antarctic Peninsula. *Scientific Comité on Antarctic Research, 21st SCAR and Open Science Conference*, Buenos Aires. CD-ROM.

Corliss, B.H. and Chen, C. 1988. Morphotype patterns of Norwegian Sea deep-sea benthic foraminifera and ecological implications. *Geology* 16: 716–719.

Crespin, I. 1960. Some Recent foraminifera from Vestfold Hills, Antarctica. *Science Reports, Tohoku University, 2nd Series (Geology), Special Volume* 4: 19–31.

Cushman, J.A. 1924. Samoan foraminifera. *Publications of the Carnegie Institution of Washington Nº. 342, Department of Marine Biology Papers* 21: 1–75.

Cushman, J.A. 1926. Foraminifera of the typical Monterey of California. *Contributions from the Cushman Laboratory for Foraminiferal Research* 2: 53–69.

Cushman, J.A. 1927. An outline of a re-classification of the foraminifera. *Contributions from the Cushman Laboratory for Foraminiferal Research* 3: 1–105.

Cushman, J.A. and Edwards, P.G. 1937. *Astrononion* a new genus of the foraminifera, and its species. *Contributions from the Cushman Laboratory for Foraminiferal Research* 13: 29–36.

Cushman, J.A. and Brönnimann, P. 1948. Some new genera and species of foraminifera from the brackish water of Trinidad. *Contributions from the Cushman Laboratory for Foraminiferal Research* 24: 15–21.

Cushman, J.A. and Martin, L.T. 1935. A new genus of foraminifera, *Discorbinella*, from Monterey Bay, California. *Contributions from the Cushman Laboratory for Foraminiferal Research* 11: 89–90.

Cushman. J.A. and Stainforth, R.M. 1945. The foraminifera of the Cipero marl Formation of Trinidad, British West Indies. *Cushman Laboratory for Foraminiferal Research, Special Publication* 14: 1–74.

Defrance, J.L.M. 1824. *Dictionnarie des Sciences Naturelles, 32, moll-morf.* F.G. Levrault Publisher, Strasbourg.

del Valle, R.A., Elliot, D.H. and Macdonald, D.I.M. 1992. Sedimentary basins on the east flank of the Antarctic Peninsula: proposed nomenclature. *Antarctic Science* 4: 477–478.

Dingle, R.V., McArthur, J.M. and Vroon, P., 1997. Oligocene and Pliocene interglacial events in the Antarctic Peninsula dated using strontium isotope stratigraphy. *Journal of the Geological Society of London* 154: 257–264.

Earland, A. 1934. Foraminifera. Part III. The Falkland sector of the Antarctic (excluding South Georgia). *Discovery Reports* 10: 1–208.

Elliot, D.H. 1988. Tectonic setting and evolution of the James Ross Island basin, northern Antarctic Peninsula. In: R.M. Feldmann and M.O. Woodburne (Eds.), *Geology and Paleontology of Seymour Island, Antarctic Peninsula. Geological Society of America Memoir* 189, p. 541–555.

Fichtel, L. von. and Moll, J.P.C. 1798. *Testacea microscopica aliaque minuta ex generibus Argonauta et Nautilus ad naturam delineata et descripta.* Vienna, 124 p.

Fillon, R.H. 1974. Late Cenozoic foraminiferal paleoecology of the Ross Sea, Antarctica. *Micropaleontology* 20: 129–151.

Finger, K.L. and Lipps, J.H. 1981. Foraminiferal decimation and repopulation in an active caldera, Deception Island, Antarctica. *Micropaleontology* 27: 111–139.

Finlay, H. 1940. New Zealand foraminifera: key species in stratigraphy N°4. *Transactions of the Royal Society New Zealand* 69: 448–472.

Fisher, R.A., Corbet, A.S. and Williams, C.B. 1943. The relationship between the number of species and the number of individuals in a random sample of an animal population. *Journal of Animal Ecology* 12: 42–58.

Galloway, J.J. 1933. *A Manual of Foraminifera.* Principia Press, Bloomington, p. 1–483.

Galloway, J.J. and Wissler, S.G. 1927. Pleistocene foraminifera from Lomita Quarry, Palos Verdes Hills, California. *Journal of Paleontology* 1: 35–87.

Gaździcka, E. and Gaździcki, A. 1994. Recycled Upper Cretaceous calcareous nannoplankton from the Pecten Conglomerate of Cockburn Island, Antarctica. *Polish Polar Research* 15: 3–13.

Gaździcki, A. and Majewski, W. 2003.Recent foraminifera from Goulden Cove of King George Island, Antarctica. *Polish Polar Research* 24: 3–12.

Gaździcki, A. and Webb, P.N. 1996. Foraminifera from the Pecten Conglomerate (Pliocene) of Cockburn Island, Antarctic Peninsula. *Palaeontologia Polonica* 55: 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* 25: 189–204.

Hambrey, M.J. and Smellie, J.L. 2006. Distribution, lithofacies and environmental context of Neogene glacial sequences on James Ross and Vega Islands, Antarctic Peninsula. In: J.E. Francis, D. Pirrie and A. Crame (Eds.), Cretaceous–Tertiary high-latitude palaeoenvironments, James Ross Basin, Antarctica. *Geological Society of London, Special Publications* 258: 187–200.

Hambrey, M.J., Smellie, J.L., Nelson, A.E. and Johnson, J.S. 2008. Late Cenozoic glacier-volcano interaction on James Ross Island and adjacent areas, Antarctic Peninsula region. *Geological Society of America Bulletin* 120: 709–731.

Hantken, M. Von.1876. A *Clavulina szabóoi* rétegek Faunája. I. *Foraminiferak, Magyar Királyi Földtani Intézet Évkönyve* [*Magyar Állami Foldtani Intézet Évkönyve*] 4: 1–82.

Harwood, D.M., 1986. [*Diatom biostratigraphy and paleoecology and a Cenozoic history of Antarctica.* PhD Thesis, Ohio State University, Columbus, Ohio. 592 p. Unpublished].

Heron-Allen, E. and Earland, A. 1922. Protozoa. Part II-Foraminifera. British Antarctic (Terra Nova) Expedition 1910. *Natural History Report, Zoology* 6, p. 25–268.

Heron-Allen, E. and Earland, A. 1930. Some new foraminifera from the South Atlantic: *Miliammina*, a new siliceous genus. *Journal of the Royal Microscopical Society of London, series 3* 50: 38–45.

Heron-Allen, E. and Earland, A. 1932. Foraminifera. Part I- The ice-free area of the Falkland Island and adjacent seas. *Discovery Reports* 4: 291–460.

Heron-Allen, E. and Earland, A. 1933. Foraminifera. Part II. South Georgia. *Discovery Reports* 7: 27–138.

Holland, R. 1910. The fossil foraminifera. *Wissenschaftliche Ergebnisse der Schwedischen Südpolar-Expedition, 1901–03, Geologie und Paläontologie* 3(9): 1–12.

Hunt, A.S. and Corliss, B.H. 1993. Distribution and microhabitats of living (stained) benthic foraminífera from the Canadiam Artic Archipelago. *Marine Micropaleontology* 20: 231–346.

Husezima, R. and Maruhasi, M. 1944. A new genus and thirteen new species of foraminifera from the core-sample of Kasiwazaki oil field, Niigata-ken. *Journal Sigenkagaku Kenkysusyo* 1: 391–400.

Igarashi, A., Numanami, H., Tsuchiya, Y. and Fukuchi, M. 2001. Bathymetric distribution of fossil foraminifera within marine sediments cores from the eastern part of Lützow-Holm Bay, East Antarctica, and its paleoceanographic implications. *Marine Micropaleontology* 42: 125–162.

Ivany, L., Van Simaeys, S., Domack, E. and Samson, S. 2006. Evidence for an earliest Oligocene ice sheet on the Antarctic Peninsula. *Geology* 34: 377–380.

Jonkers, H.A., Lirio, J.M., del Valle, R.A. and Kelley, S.P. 2002. Age and depositional environment of the Miocene–Pliocene glaciomarine deposits, James Ross Island, Antarctica.*Geological Magazine* 139: 577–594.

Jorissen, F.J., Stigter, H.C. and Widmark, J.G. 1995. A conceptual model explaining benthic foraminiferal microhabits. *Marine Micropaleontology* 26: 3–15.

Jorissen, F.J., Barmawidjaja, D.M., Puskaric, S. and van der Zwann, G.J.

1992. Vertical distribution of benthic foraminifera in the northern Adriatic Sea: the relation with the organic flux. *Marine Micropaleontology* 19: 131–146.

Kanmacher, F. 1798. *Adam's Essays on the Microscope: the Second Edition, with Considerable Additions and Improvements*. Dillon and Keating, London, p. 1–712.

Karrer, F. 1868. Die Miocene Foraminiferenfauna von Kostej im Banat. *Sitzungsberichte der Kaiserlichen Akademie der Wissenschaften Wien, Mathematisch-Naturwissenschaftliche Klasse* 58: 121–193.

Kennett, J.P. 1967. New Foraminifera from the Ross Sea, Antarctica.*Contributions from the Cushman Foundation for Foraminiferal Research* 18: 133–135.

Lamarck, J.B. 1804. Suite des mémoires sur les fossiles des environs de Paris. *Annales Muséum National d'Histoire Naturelle* 5: 179–188.

Leckie, R.M. and Webb, P.N. 1986. Late Paleogene and Early Neogene foraminifers of Deep Sea Drilling Project Site 270, Ross Sea, Antarctica. In: J.P. Kennett, C.C von der Borch *et al.* (Eds.), *Initial Reports of the Deep Sea Drilling Project* 90. U.S. Government Printing Office, Washington, D.C., (24) p. 1093–1142.

Linné, C. 1758. *Systema Naturae,* vol 1, 10th ed., L. Salvii, Stockholm, p. 1–824.

Lirio, J.M., Núñez, H.J., Bertels-Psotka, A. and del Valle, R.A. 2003. Diamictos fosilíferos (Mioceno–Pleistoceno): Formaciones Belén, Gage y Terrapin en la isla James Ross, Antártica. *Revista de la Asociación Geológica Argentina* 58: 298–310.

Lirio, J.M., Concheyro, A., Chaparro, M.A., Nyvit, D. and Mlcoch, F. 2007. Diamictita Cabo Lamb, un nuevo depósito fosilífero marino cenozoico en Isla Vega, Península Antártica. *6º Simposio Argentino y 3er Congreso Latinoamericano sobre investigaciones Antárticas* (Buenos aires), *Actas*. In CD.

Loeblich, A.R., Jr. and Tappan, H. 1955. Revision of some Recent foraminiferal genera. *Smithsonian Miscellaneous Collections* 128: 1–37.

Loeblich, A.R., Jr. and H. Tappan.1961. Remarks on the systematics of the Sarkodina (Protozoa), renamed homonyms and new and validated Genera. *Proceedings of the Biological Society of Washington* 74: 213–234.

Loeblich, A.R., Jr. and Tappan, H. 1986. Some new and revised genera and families of hyaline calcareous Foraminiferida (Protozoa). *Transactions of the American Microscopical Society* 105, 239–265.

Loeblich, A.R., Jr. and Tappan, H. 1987. *Foraminiferal genera and their classification*. Van Nostrand Reinhold Company, New York, 970 p.

Majewski, W. 2005. Benthic foraminiferal communities: distribution and ecology in Admiralty Bay, King George Island, West Antarctica. *Polish Polar Research* 26: 159–214.

Majewski, W. 2010. Benthic foraminifera from West Antarctic fiord environments: An overview. *Polish Polar Research* 31: 61–82.

Majewski, W. and Anderson, J.B. 2009. Holocene foraminiferal assemblages from Firth of Tay, Antarctic Peninsula: Paleoclimate implications. *Marine Micropaleontology* 73: 135–147.

Majewski, W. and Tatur, A. 2009. A new Antarctic foraminiferal species for detecting climate change in sub-Recent glacier-proximal sediments. *Antarctic Science* 21: 439–448.

Malumián, N., Náñez, C. and Caramés, A. 1991. Unilocular foraminifera of reticular surface from Argentina. *Micropaleontology* 37: 393–406.

Marenssi, S.A. and Santillana, S.N. 1998. Revision of the Cretaceous stratigraphy of Cape Lamb, Vega island, Antarctica. *10º Congreso Latinoamericano de Geología y 6º Congreso Nacional de Geología Económica* (Buenos Aires), *Actas*: 91–94.

Marenssi, S., Salani, F.M. and Santillana, S. 2001. Geología de cabo Lamb, isla Vega, Península Antártica. *Contribución Instituto Antártico Argentino* 530: 1–43.

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* 22: 193–198.

Margerel, J.P. 1970. *Aubygnyna* nouveau genre de Foraminifères du Pliocène du Bosq d'Aubigny (Manche). *Revue de Micropaléontologie* 13: 58–64.

McCulloch, I. 1977. Quantitative observations on Recent foraminiferal tests with emphasis on the eastern Pacific. *University of Southern California, Special Publications* 1–3, 1078 p.

Melis, R. and Salvi, G. 2009. Late Quaternary foraminiferal assemblages from the western Ross Sea (Antarctica) in relation to the main glacial and marine lithofacies. *Marine Micropaleontology* 70: 39–53.

Milam, R.W. and Anderson, J.B. 1981. Distribution and ecology of Recent benthic foraminifera of the Adelie-George V continental shelf and slope, Antarctica. *Marine Micropaleontology* 6: 297–325.

Montagu, G. 1803. *Testacea Britannica, or natural history of British shells, Marine, land, and fresh waters, Including the most minute: systematically arranged and embellished with figures.* J.S. Hollis, Romsey, 606 p.

Montfort, P. Dennys de. 1808. *Conchyliologie Systématique et Classification Méthodique des Coquilles, offrant leurs figures, leur arrangement génériqus, leurs descriptions caractéistiques; ainsi que leur synonymie en plusieurs lagues.* F. Schoell Publisher, Paris 1, 410 p.

Murray, J.W. 2006. *Ecology and applications of benthic foraminifera.* Cambridge University Press, Cambridge, 426 p.

Murray, J.W. and Pudsey, C.J. 2004. Living (stained) and dead foraminifera from the newly ice-free Larsen Ice Shelf, Weddell Sea, Antarctica: ecology and taphonomy. *Marine Micropaleontology* 53: 67–81.

Nelson, P.H. 1975. The James Ross Island Volcanic Group of north-east Graham Land. *British Antarctic Survey Scientific Reports* 54: 1–62.

Nelson A.E., Smellie, J.L., Hambrey, M.J., Williams, M., Vautravers, M., Salzmann, U., McArthur, J.M. and Regelous, M. 2009. Neogene glacigenic debris flows on James Ross Island, northern Antarctic Peninsula, and their implications for regional climate history. *Quaternary Science Reviews* 28: 3138–3160.

Nomura, R. 1983. Cassidulinidae (Foraminiferida) from the uppermost Cenozoic of Japan (Part 1). *Science Reports of the Tohoku University, series 2 (Geology)* 53: 1–101.

Nomura, R. 1984. Cassidulinidae (Foraminiferida) from the Eastern part of Lützow-Holm Bay, Antarctica. *Transactions and Proceedings of the Paleontological Society of Japan, new series* 136: 492–501.

Nývlt, D. Košler, J., Mlčoch, B., Mixa, P., Lisá, L., Bubík, M. and Hendriks, B.W.H. 2011. The Mendel Formation: Evidence for Late Miocene climatic cyclicity at the northern tip of the Antarctic Peninsula. *Palaeogeography, Palaeoclimatology, Palaeoecology* 299: 363–384.

Olivero, E. 2012. Sedimentary cycles, ammonite diversity and paleoenvironmental changes in the Upper Cretaceous Marambio Group, Antarctica. *Cretaceous Research* 34: 348–366.

Olivero, E.B., Martinioni, D.R. and Mussel, F.J. 1991. Sedimentología y bioestratigrafía del Cretácico Superior de cabo Lamb (Isla Vega, Antártida). Implicancias sobre ciclos sedimentarios y evolución de la cuenca. In C.A. Rinaldi (Ed.), *Geología de la isla James Ross*. Instituto Antártico Argentino, Buenos Aires, p. 125–145.

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

Orbigny, A. d'. 1839a. *Voyage dans l'Amerique méridionale. Foraminifères,* vol. 5, pt. 5. P. Bertrand Publisher, Paris and Strasbourg, p. 1–86.

Orbigny, A. d'. 1839b. Foraminifères. In: Ramon de la Sagra, *Histoire physique, politique et naturelle de l'Île de Cuba.* Arthus Bertrand Publisher, Paris, 224 p.

Orbigny, A. d'. 1839c. Foraminifères. In: P. Barker-Webb and S. Berthelot (Eds.), *Histoire Naturelle des Iles Canaries, Zoologie 2(2)*. Béthune et Plon, Paris, p. 119–146.

Parker, F.L., Phleger, F.B. and Peirson, J.F. 1953. Ecology of foraminifera from San Antonio Bay and environs, southwest Texas. *Cushman Foundation for Foraminiferal Research, Special Publication* 2: 1–75.

Parker, W.K., Jones, T.R. and Brady, H.B. 1871. XXXI. On the Nomenclature of the Foraminifera *The Annals and Magazine of Natural History* 8, Part XIV. The species enumerated by D'Orbigny in the Annals des Sciences Naturelles, 1826. 7, p. 238–266.

Parr, W.J. 1947. The Lagenid foraminifera and their relationships. *Proceedings of the Royal Society of Victoria, new eries* 58: 116–130.

Parr, W.J. 1950. Foraminifera. *Reports B.A.N.Z. Antarctic Research Expedition. 1929–1931, Ser. B (Zoology, Botany)* 5: 232–392.

Patterson, R.T. and Richardson, R.H. 1988. Eight New Genera of Unilocular Foraminifera. *Transactions American Microscopical Society* 107: 240–258.

Pawlowski, J., Bowser, S.S., and Gooday, A. 2007. A note on the generic similarity between shallow-and deep-water *Epistominella vitrea* (Foraminifera) in the Antarctic.*Deep Sea Research Part II: Tropical Studies in Oceanography* 54: 1720–1726.

Pirrie, D., Crame, J.A. and Riding, J.B. 1991. Late Cretaceous stratigraphy and sedimentology of Cape Lamb, Vega Island, Antarctica. *Cretaceous Research* 12: 227–258.

Pirrie, D., Crame, J.A., Riding, J.B., Butcher, A.R. and Taylor, P.D. 1997. Miocene glaciomarine sedimentation in the northern Antarctic Peninsula region: the stratigraphy and sedimentology of the Hobbs Glacier Formation, James Ross Island. *Geological Magazine* 134: 745–762.

Quilty, P.G. 2003. Neogene foraminifers and accessories, ODP Leg 188, Sites 1165, 1166, and 1167, Prydz Bay, Antarctica. *In*: A.K. Cooper, P.E. O'Brien, P.E. and C. Richter (Eds.). *Proceedings of the Ocean Drilling Program, Scientific Results* 188, p. 1–41.

Quilty, P.G. 2010. Foraminifera from the Late Pliocene sediments of Heidemann Valley, Vestfold Hills, East Antarctica. *Journal of Foraminiferal Research* 40: 193–205.

Quilty, P.G., Gillieson, D., Burgess, J., Gardiner, G., Spate, A. and Pidgeon, R. 1990. *Ammoelphidiella* from the Pliocene of Larsemann Hills, East Antarctica. *Journal of Foraminiferal Research* 20: 1–7.

Rinaldi. C.A. 1982. The Upper Cretaceous in the James Ross Island Group. In: C. Craddock (Ed.). *Antarctic Geoscience.* The University of Wiscousin Press, p 331–337.

Salani, F.M. 1999. El Grupo Volcánico Isla James Ross en Cabo Lamb, Isla Vega, Antártica. *14º Congreso Geológico Argentino* (Salta), *Actas*, p. 109.

Salzmann, U., Riding, J., Nelson, A. and Smellie, J.L. 2011. How likely was a green Antarctic Peninsula during warm Pliocene interglacials? A critical reassessment based on the new playnofloras from James Ross Island. *Paleogeography, Paleoclimatology, Palaeoecology* 309: 73–82.

Shannon, C.E. 1948. A mathematical theory of communication. *Bell System Technical Journal* 27: 379–423.

Silvestri, A. 1904. Forme nuove o poco conosciute di Protozoi Miocenici piemontesi. *Atti della Accademia delle Scienze. Torino* 39: 4–15.

Smellie, J.L. 1999. Lithostratigraphy of Miocene–Recent, alkaline volcanic field in the Antarctic Peninsula and eastern Ellsworth Land. *Antarctic Science* 11: 362–378.

Smellie, J.L., McArthur, J.M., Mcintosh, W.C. and Esser, R. 2006. Late Neogene interglacial events in the James Ross Island region, northern Antarctic Peninsula, dated by Ar/Ar and Sr-isotope stratigraphy.*Palaeogeography, Palaeoclimatology, Palaeoecology* 242: 169–187.

Smellie, J.L., Haywood, A.M., Hillenbrand, C.-D., Lunt, D.J. and Valdes, P.J. 2009. Nature of the Antarctic Peninsula Ice Sheet during the Pliocene: geological evidence and modelling results compared. *Earth-Science Reviews* 94: 79–94.

Smellie, J.L., Johnson, J.S., Mcintosh, W.C., Esser, R., Gudmunsson, M.T., Hambrey, M.J. and Van Wyk De Vries, B. 2008. Six million years of glacial history recorded in volcanic lithofacies of the James Ross Island Volcanic Group, Antarctic Peninsula. *Palaeogeography, Palaeoclimatology, Palaeoecology* 260: 122–148.

Strong, C.P. and Webb, P.N. 1998. Lower Miocene foraminifera from CRP-1 Drillhole. *Terra Antarctica* 5: 515–520.

Strong, C.P. and Webb, P.N. 2000. Oligocene and Miocene foraminifera from CRP-2/2A, Victoria Land Basin, Antarctica. *Terra Antarctica* 7: 461–472.

Strong, C.P. and Webb, P.N. 2001. Lower Oligocene foraminiferal fauna from CRP-3 Drillhole, Victoria Land Basin, Antarctica. *Terra Antarctica* 8: 347–358.

Voloshinova, N.A. 1960. Uspekhi mikropaleontologii v dele izucheniya vnutrennego stroeniva foraminifer [Progress in micropaleontology in the work of studying the inner structure of Foraminifera]. *Trudy Pervogo Seminara po Mikrofaune*. Leningrad: Vsesoyuznyy Netfyanoy Nauchno-issledovatel' skii Geologorazvedochnyy Institut (VNIGRI), p. 48–87. (in Russian).

Webb, P.N. 1974. Micropaleontology, paleoecology and correlation of the Pecten gravels, Wright Valley, Antarctica, and description of *Trochoelphidiella onyxi* n. gen., n. sp. *Journal of Foraminiferal Research* 4: 184–199.

Webb, P.N. and Strong, C.P. 1998a. Occurrence, stratigraphic distribution and palaeoecology of Quaternary foraminifera from CRP-1. *Terra Antarctica* 5: 455–472.Webb, P.N. and Strong, C.P. 1998b. Recycled Pliocene Foraminifera from the CRP-1 Quaternary Succession. *Terra Antarctica* 5: 473–478.

Webb, P.N. and Strong, C.P. 2000. Pliocene Benthic Foraminifera from the CRP-2 (Lithostratigraphic Unit 2.2), Victoria Land Basin, Antarctica. *Terra Antarctica* 7: 453–459.

Webb, P.N. and Strong, C.P. 2006. Foraminiferal biostratigraphy and palaeoecology in Upper Oligocene–Lower Miocene glacial marine sequences 9, 10, and 11, CRP-2/2A drill hole, Victoria Land Basin, Antarctica. *Palaeogeography, Palaeoclimatology, Palaeoecology* 231: 71–100.

Wiesner, H. 1931. Die Foraminiferem der deutschen Südpolar Expedition 1901–1903. *Deutsche Südpolar Expedition*, vol. 20, *Zoologie* 12: 53–165.

Williamson, W.C. 1858. *On the Recent foraminifera of Great Britain.* Ray Society, London, p. 1–107.

doi: 10.5710/AMGH.7.2.2013.588

Recibido: 18 de mayo de 2012

Aceptado: 7 de febrero de 2013