

# New occurrences of mollusks from the Santa Marta and Snow Hill Island (Gamma Member) formations, Upper Cretaceous, James Ross Island, Antarctic Peninsula

## Novas ocorrências de moluscos das formações Santa Marta e Snow Hill Island (Membro Gamma), Cretáceo Superior, Ilha James Ross, Península Antártica

## Nuevos registros de moluscos de las formaciones Santa Marta y Snow Hill Island (Miembro Gamma), Cretácico Superior, Isla James Ross, Península Antártica

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**Abstract:** Although the fossil record from Antarctica is increasing continuously, there is still a great lack of knowledge regarding the past biodiversity of this continent. Here we present the first occurrences of the ammonoid *Pseudophyllites? cf. latus* in the Santa Marta Formation (Santonian-early Campanian) and the scaphopod *Laeventallium? sp.* (Laeventallidae) in the Gamma Member (late Campanian) of the Snow Hill Island Formation (late Campanian - early Maastrichtian). The presence of Laeventallidae in the Gamma Member characterizes the oldest occurrence of this family in Antarctica and it is apparently another taxon that originated in this continent and later migrated to lower latitudes.

**Key words:** Ammonoidea, Scaphopoda, Santonian-Campanian, Larsen Basin, Antarctica.

**Resumo:** Embora o registro fóssil da Antártica esteja aumentando continuamente, ainda há uma grande falta de conhecimento sobre a biodiversidade do passado deste continente. Apresenta-se aqui as primeiras ocorrências do amonoide *Pseudophyllites?* cf. *latus* na Formação Santa Marta (Santoniano-Campaniano inicial) e do escafópode *Laevidentallium?* sp. (*Laevidentallidae*) no Membro Gamma (Campaniano tardio) da Formação Snow Hill Island (Campaniano tardio - Maastrichtiano inicial). A presença de *Laevidentalliidae* no Membro Gamma caracteriza a ocorrência mais antiga desta família na Antártida e é aparentemente mais um dos táxons que surgiu neste continente e posteriormente migrou para latitudes mais baixas.

**Palavras-chave:** Ammonoidea, Scaphopoda, Santoniano-Campaniano, Bacia de Larsen, Antártida.

**Resumen:** Los fósiles antárticos, a pesar de ser abundantes, aún son poco conocidos. Se presenta aquí la primera aparición de el ammonoideo *Pseudophyllites?* cf. *latus* en la Formación Santa Marta (Santoniense-Campaniense inicial) y el escafopodo *Laevidentallium?* sp. (*Laevidentallidae*) en el Miembro Gamma (Campaniense tardío) de la Formación Snow Hill Island (Campaniense tardío - Maastrichtiense inicial). La presencia de *Laevidentalliidae* en el Miembro Gamma caracteriza la ocurrencia más antigua de esta familia en la Antártida y aparentemente es uno de los taxones que apareció en este continente y luego migró a latitudes más bajas.

**Palabras clave:** Ammonoidea, Scaphopoda, Santoniense-Campaniense, Cuenca de Larsen, Antártida.

## INTRODUCTION

Where exposed, the Antarctic sedimentary rocks from the Mesozoic and Cenozoic have proven to be quite fossiliferous (*e.g.*, Olivero, 2012a; Zinsmeister, 1982) but there is still lots of work to be done before a more comprehensive picture of the paleobiodiversity of this continent can be established. Abundant occurrences of ammonoids have been documented especially from the James Ross area (Larsen Basin, James Ross Sub-Basin) (*e.g.*, Olivero, 1992; Olivero, 2007; Olivero, 2012a, 2012b; Olivero & Medina, 2000; Spath, 1953). Although these invertebrates have been studied in this region for more than a century (*e.g.*, Kilian & Reboul, 1909; Weller, 1903a, 1903b) further paleontological studies are needed considering that many areas are still relatively unexplored due to adverse climatic conditions and difficult logistics to carry out fieldwork.

Studies involving extinct Antarctic scaphopods are even more incipient than those of ammonoids, with the few available studies focusing on Cenozoic deposits (*e.g.*, Stilwell & Zinsmeister, 1992; Pugaczewska, 1984). Records of Cretaceous genera or species of scaphopods from Antarctica are restricted to the Karlsen Cliffs Member (late Campanian) of the Snow Hill Island Formation and the López de Bertodano Formation (Maastrichtian - Danian; Medina & DelValle 1985; Stilwell, 2008; Stilwell & Zinsmeister, 1987). Although there have been previous reports of scaphopods from the Santa Marta Formation (Santonian - early Campanian) at James Ross Island (*e.g.*, Crame, Pirrie, Riding, & Thomson, 1991; Scasso, Olivero, & Buatois, 1991), no taxonomic descriptions were published so far.

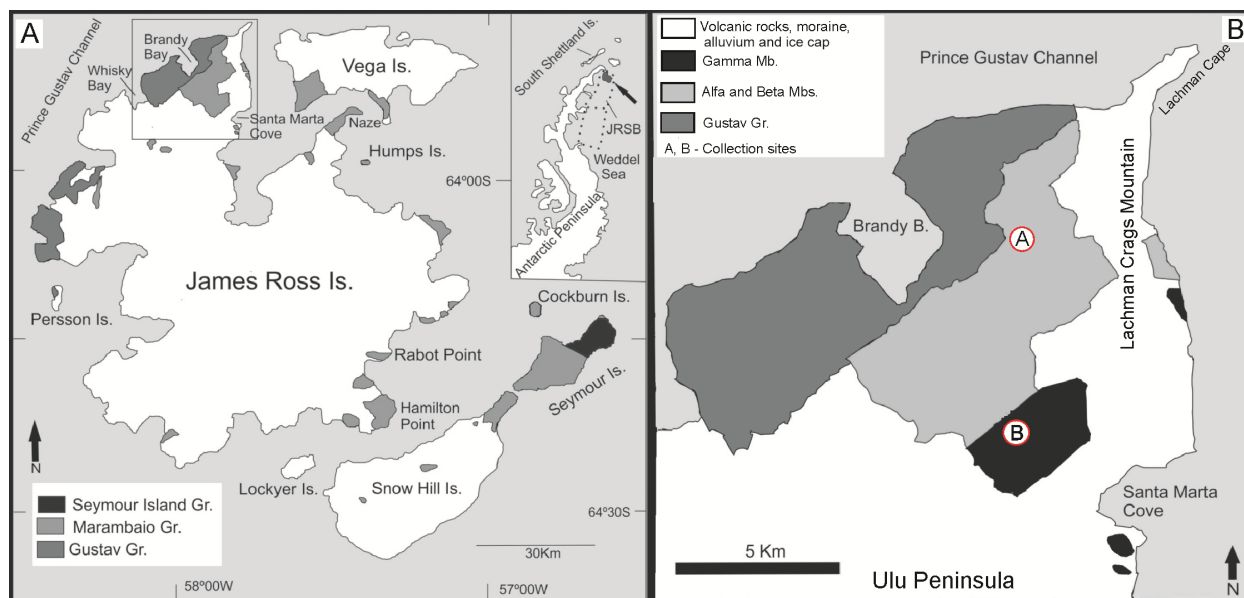
In this paper we record the first occurrence of ammonoid *Pseudophyllites? cf. latus* from the Santa Marta Formation (Santonian - early Campanian) and the scaphopod *Laevidentalium? sp.* from the Gamma Member (late Campanian) of Snow Hill Island Formation (late Campanian - early Maastrichtian) These specimens were collected by the first field expedition of the *PALEOANTAR* project (e.g., Kellner et al. 2011).

## GEOLOGICAL SETTING

The James Ross Sub-Basin, part of the Larsen Basin (DelValle, Elliot, & Macdonald, 1992), is located in the northeast of the Antarctic Peninsula and contains a significant Meso-Cenozoic sedimentary succession (Fig. 1), related to the Gondwanan break-up and subsequent development of a back-arc basin (Hathway, 2000).

Figure 1: A: sedimentary deposits of the Cretaceous/Paleogene outcrops of the James Ross Sub-Basin.

In detail, the region where the *PALEOANTAR* expedition was concentrated; B: simplified geological map of the Ulu Peninsula, showing outcrops of the Santa Marta and Snow Hill Island (Gamma Member) formations, as well as the collection areas of the studied fossils. B.A - represents field number point 02, Abernethy flats (*Pseudophyllites? cf. latus*); B.B. - represents point 96, Paso San José (*Laevidentalium? sp.*).



Source: A - adapted from Reguero, Olivero & Pol (2016); B - adapted from Castro & Carvalho (2015).

Two thick sedimentary sequences are recognized at the James Ross Island (Olivero, 2012a): the Gustav Group (Aptian - Coniacian) and the Marambio Group (Santonian - Danian). The Marambio Group is formed by fossiliferous layers of siltstones, argillites, and fine-grained sandstones, interpreted as being deposited in a shallow inner to outer continental shelf environment with the presence of a prograding delta (Crame et al., 1991; Olivero, 2012a; Pirrie, Crame, Lomas, & Riding, 1997). Although there are several proposed subdivisions for the Marambio Group (e.g., Olivero, 2012a; Olivero & Medina, 2000; Pirrie et al., 1997), here the interpretation of Olivero (2012a) is used (Fig. 2).

Figure 2: Several proposals of subdivisions for the Marambio Group, highlighting the proposal by Olivero (2012a).

Anderson (1906)	Bibby (1966)	Rinaldi <i>et al.</i> (1978)	Olivero <i>et al.</i> (1986); Medina <i>et al.</i> (1989); Lirio <i>et al.</i> (1989)	Pirrie <i>et al.</i> (1997)	Olivero & Medina (2000)	Olivero (2012a)				
Snow Hill Island Series	Snow Hill Island Series	Sobral Fm.	Sobral Fm.	Sobral Fm.		Sobral Fm.	Selandian			
		López de Bertodano Fm.	Marambio Group	López de Bertodano Fm.	Marambio Group	López de Bertodano Fm.	Depositional Sequence MG	Danian		
								Maastrichtian	Haslum Craggs Mb.	
									Snow Hill Island Fm.	Depositional Sequence NG
									Sanctuary Cliffs Mb.	
								Campanian	Karlsen Cliffs Mb.	
									Santa Marta Fm.	Depositional Sequence N
									Herbert Sound Mb.	
								Santonian	Lachman Craggs Mb.	
									Santa Marta Fm.	
						Santa Marta Fm.				
						Rabot Fm.				

Source: adapted from Milanese, Olivero, Kirschvink & Rapalini (2017).

### Santa Marta and Snow Hill Island (Gamma Member) formations

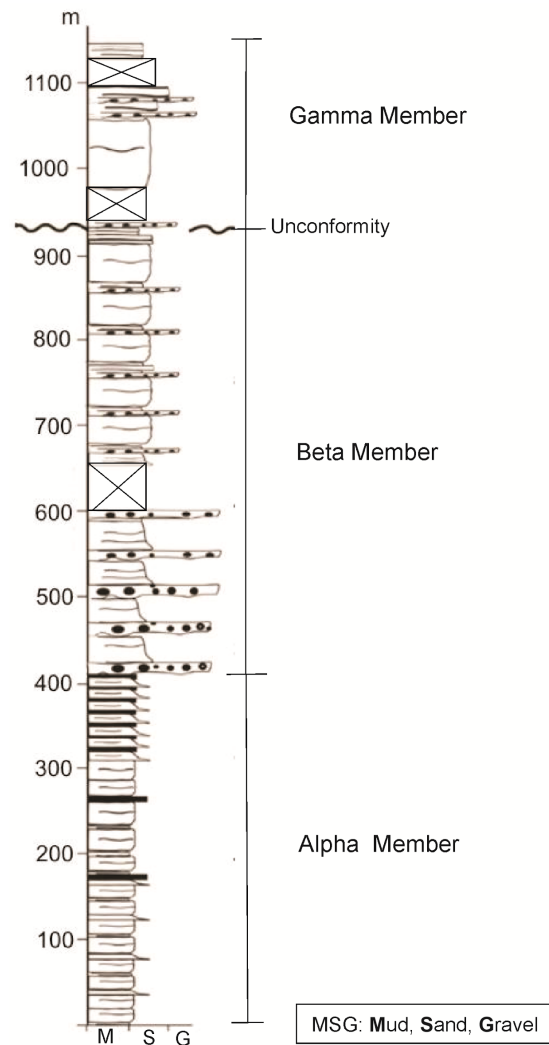
The fossils studied in the present contribution were collected in the Santa Marta (Abernethy flats) and Snow Hill Island (Gamma Member, Paso San José) formations (Fig. 3).

The Santa Marta Formation (Santonian – early Campanian) is composed of intercalation of sandstones, siltstones, and argillites with volcanic tuffs and rare coquinas (Olivero, 2012a). It was originally defined at the northwestern area of the James Ross Island and subdivided into Alpha, Beta, and Gamma members by Olivero, Scasso, and Rinaldi (1986).

Olivero (2012a) pointed out that the Gamma Member is included in the Snow Hill Island Formation instead of the Santa Marta Formation, as originally defined. The Gamma Member crops out at Santa Marta Cove and Dreadnought Point and is dominated by sandstones beds with scarce *Neograhamites primus* ammonites, common gastropods, bivalves, and coquinas (Guerra, Concheyro, Lees, Fauth, Carvalho & Ramos, 2015).

The Campanian fauna from Santa Marta Formation and Gamma Member are not yet completely known (Crame, 2019), but it is often referred to as part of the Weddellian Biogeographic Province. This province included the seas of New Zealand, South America (Patagonia), and Antarctica from the late Cretaceous to late Eocene (*e.g.*, Novas, D’Angelo, O’Gorman, Agnolín, Lirio, & Isasi, 2015; Olivero & Medina, 2000; Zinsmeister 1979, 1982). More recently, Brazilian researchers have made significant progress to the understanding of the invertebrate (*e.g.*, Pinheiro *et al.*, 2020; Videira-Santos *et al.*, 2020) and vertebrate faunas (*e.g.*, Kellner *et al.*, 2011, 2019), nannofossils (Guerra *et al.*, 2015), and dinoflagellate cyst assemblage (*e.g.*, Castro & Carvalho, 2015) of this stratigraphic unit.

Figure 3: Sedimentological profile of the Santa Marta and Snow Hill Island formations (Gamma Member) in the Ulu Peninsula. The ammonoid *Pseudophyllites? cf. latus* was collected from Alpha Member and the scaphopod *Laevidentalium? sp.* was collected from Gamma Member.



Source: adapted from Olivero (2012b).

## MATERIALS AND METHODS

The studied specimens were collected in the austral summer of 2007 during the expedition to James Ross Island (Ulu Peninsula) carried out by the *PALEOANTAR* project, led by researchers from the Departamento de Geologia e Paleontologia of the Museu Nacional/Universidade Federal do Rio de Janeiro.

The analyzed fossils are part of the paleoinvertebrate collection housed at the Departamento de Geologia e Paleontologia of the Museu Nacional/Universidade Federal do Rio de Janeiro (MN-I). The specimens studied here were recovered from inside the building of Museu Nacional hit by a tragic fire on September 2, 2018 (Kellner, 2019). The



Scaphopoda specimen was recovered in relatively good condition, while the material of Ammonoidea was severely damaged.

For taxonomic identification, the *Treatise on Invertebrate Paleontology* (Knight et al., 1960; Wright, Calloman & Howarth, 1996) and papers, in general, dealing with ammonoids and scaphopods from Antarctica and related areas such as New Zealand and Australia (e.g., Lamprell & Healy, 1998) were consulted. For technical terms, dimensions, and morphological descriptions of ammonoids, the procedures outlined by Korn (2010) were used. Specimens were measured with a digital caliper (0.02 mm accuracy). For open nomenclature identification, we followed the recommendations of Bengtson (1988).

## SYSTEMATIC PALEONTOLOGY

Class Cephalopoda Cuvier, 1795  
 Order Ammonitida Hyatt, 1889  
 Suborder Lytoceratina Hyatt, 1889  
 Superfamily Tetragonitaceae Hyatt, 1900  
 Family Tetragonitidae Hyatt, 1900  
 Subfamily Tetragonitinae Hyatt, 1900  
 Genus *Pseudophyllites* Kossmat, 1895  
 Type species: *Ammonites indra* Forbes, 1846

*Pseudophyllites?* cf. *latus* (Marshall, 1926)  
 (Fig. 4)

**Material:** MN 8546-I, one internal mold without shell preservation.

**Provenance:** Alpha Member, Santa Marta Formation, Abernethy flats, field number Point 02 (S 63°50'93,4" W 057° 53' 11,0").

**Description:** subinvolute, weakly depressed, discoidal (whorl width/conch diameter - 0,50), without ribs, the sutures have a strong incision, whorl expansion rate (WER) is extremely high (> 2,50). The total diameter of the specimen is 91 mm (moderate) while that of the umbilical region is 20 mm. The umbilicus/diameter ratio is 22% (narrow).

**Remarks:** The genus *Pseudophyllites* is known in the Santa Marta Formation, but has never been identified at the species level (e.g. Olivero, 1992; Olivero, 2012a). The difference among the species *P. latus* (Marshall, 1926), *P. indra* (Forbes, 1846), and *P. loryi* (Kilian & Reboul, 1909) is very subtle, involving slight differences in the umbilicus/diameter ratio and the shape of the whorl sections. Spath (1953) described *P. peregrinus* for the Campanian of the Antarctic (Snow Hill Island Series). However, Henderson and McNamara (1985) consider *P. peregrinus* as synonymous with *P. latus*, while Macellari (1986) believes that this species is equivalent to *P. loryi*. The specimen of *P. peregrinus* described by Spath (1953) is in fact very similar to *P. latus* and *P. loryi*, but its proportion umbilicus/diameter of 16% makes it more similar to *P. loryi* (on average 18 %) than to *P. latus* (on average 20%) (Henderson & McNamara, 1985; Macellari, 1986). Based on this information, in this paper, *P. peregrinus*

was considered as a junior synonym of *P. loryi* as suggested by Macellari (1986). The specimen MN 8546-I differs from *P. indra* because it has a depressed whorl section and is distinguished from *P. loryi* because it presents a somewhat larger umbilicus/diameter ratio, thus being more evolute. The MN 8546-I specimen does not have very well preserved sutures and neither shows the typical whorl expansion of *Pseudophyllites*. However, we believe that these characteristics have been altered in the studied specimen due to taphonomy. Since the general morphology of the shell is similar to that of *Pseudophyllites* we advocate classifying our specimen in this genus but with open nomenclature. Among the existing species of *Pseudophyllites*, the specimen described here is more similar to *P. latus*.

**Occurrence for the species *Pseudophyllites latus*:** late Santonian - early Maastrichtian of Antarctica, Southern Argentina, New Zealand, South-eastern Africa, Madagascar, Western Australia, and Greenland (Henderson & McNamara, 1985).

Class Scaphopoda Bronn, 1862

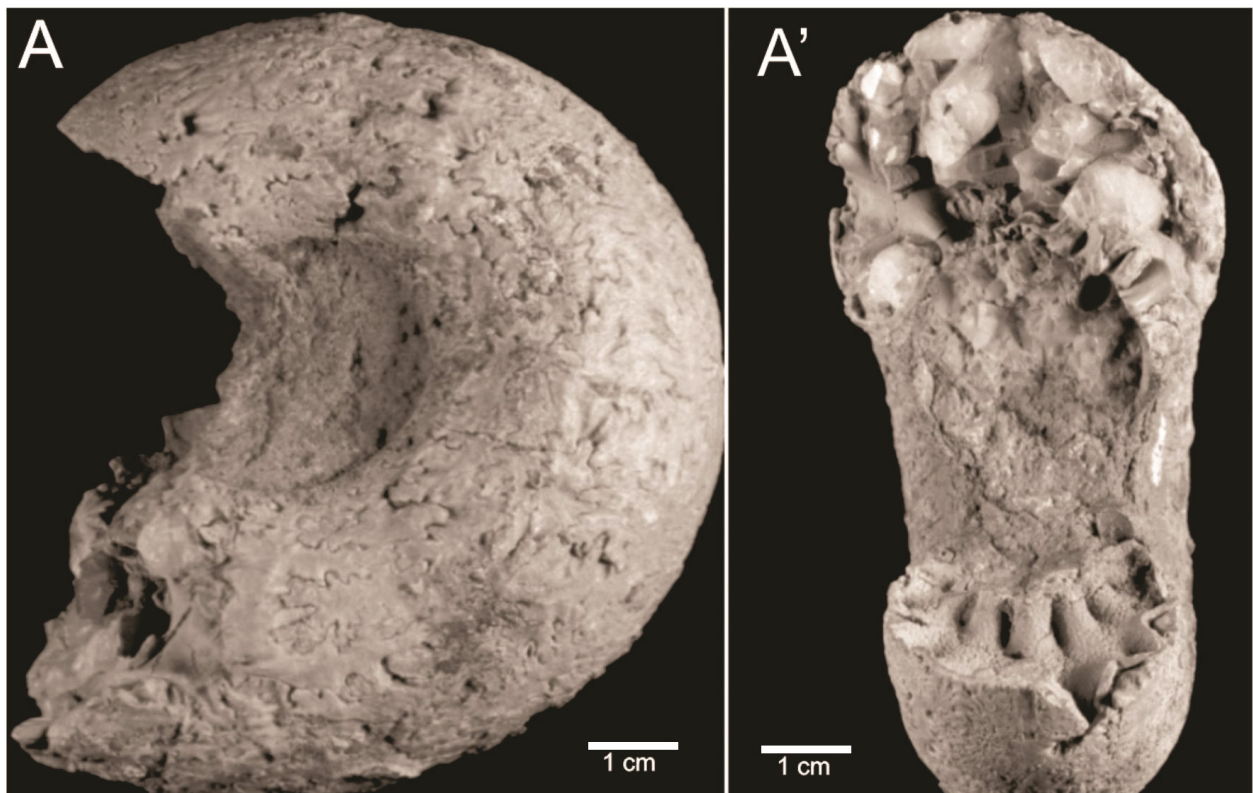
Order Dentaliida Da Costa, 1776

Family Laevidentaliidae Palmer, 1974

Genus *Laevidentalium* Cossmann, 1888

Type species: *Dentalium incertum* Deshayes, 1825

Figure 4: A: *Pseudophyllites?* cf. *latus* (MN 8546-I) (side view), A': *Pseudophyllites?* cf. *latus* (MN 8546-I) (frontal view).



***Laevidentalium?* sp.**

(Fig. 5)

**Material:** MN 8608-I, one internal mold with shell preservation.**Provenance:** Gamma Member, Snow Hill Island Formation, Paso San José, Point 96 (S63°54'16,8"; W057°54'39,5").**Description:** conical, thick, and weakly curved shell, transverse sections of the aperture and apex ovals, shell tapers uniformly from anterior to posterior, absence of ribs or longitudinal ornaments. The shell is 36 mm long, with a 5.0 mm wide aperture and 0.5 mm wide apex.**Remarks:** although the specimen is mainly an internal mold, there is a small fragment of the preserved shell (detail of figure 5). From the analysis of this fragment, it is possible to infer that it was relatively thick and did not have longitudinal sculpture. This is corroborated by the fact that the mold itself does not have ribs, which would be reflected in the internal mold. These features support the classification of MN 8608-I to the family Laevidentalidae (see Lamprell & Healy, 1998). Although the only known genus of this family is *Laevidentalium* (Lamprell & Healy, 1998), since in the studied specimen the shell is not completely preserved, we prefer to classify it with open nomenclature. The only known species of *Laevidentalium* in the Cretaceous of Antarctica reported so far is *Laevidentalium wilckensi* from the Lopez de Bertodano Formation, briefly cited by Medina and DelValle (1985). It should be noted, however, that the latter publication is a technical report, and therefore this species (*L.wilckensi*) should not be considered taxonomically valid.**Occurrence for the genus *Laevidentalium* in the Cretaceous:** Albian, Australia (Stilwell, 2008), Santonian? – Maastrichtian, New Zealand (Stilwell, 2008), Maastrichtian, Chatham Islands (Stilwell, 1998), Maastrichtian, Antarctica (Medina and DelValle, 1985), late Cretaceous, Patagonia (South America) (Stilwell, 2008).**Observation:** *Laevidentalium* is a living genus (e.g., Lamprell and Healy, 1998).



Figure 5: *Laevidentalium* ? sp. (MN 8608-I). In detail, we show part of the preserved thick shell without ribs or longitudinal ornamentation.



## FINAL CONSIDERATIONS

This paper tries to make the first description of a species of *Pseudophyllites* from the Santa Marta Formation, considering that *Pseudophyllites* species of this stratigraphic unit have never been described. However, due to the relatively poor preservation of the specimen, this identification could only be done with open nomenclature. Nonetheless, this specimen shows a higher ammonoid diversity in the Santa Marta Formation.

The taxon *Pseudophyllites*? cf. *latus*, known from Santonian - early Campanian beds is not endemic to the Weddellian Biogeographic Province. This species follows the general trend of occurrence of Santonian – early Campanian Antarctic ammonites: a cosmopolitan or Indo-Pacific fauna (Olivero, 2012a; Olivero & Medina, 2000; Raffi, Olivero, & Milanese, 2019; Raffi & Olivero, 2016).

The occurrence of the first specimen of Laevidentalidae in the Gamma Member of the Snow Hill Island Formation is also reported here. During the Cretaceous, this family was, apparently, restricted to the Southern Hemisphere, in the Weddellian Biogeographic Province. It is represented by the species *Laevidentalium cretaustralium* recorded in the Albian of Australia (Stilwell, 2008), *Laevidentalium* sp. from the Cenomanian of Australia (Stilwell, 2008), *Laevidentalium morganianum* in the ?Santonian to Maastrichtian of New Zealand (Stilwell, 1998; Wilckens, 1922), *Laevidentalium wilckensi* from the Maastrichtian

of the Seymour and Snow Hill islands (Antarctica) (Medina & DelValle, 1985; Stilwell & Zinsmeister, 1987) and *Laevidentaliium limatum* from the ?Cenomanian to ?Maastrichtian of Patagonia (Stanton, 1901; Stilwell, 2008). The presence of Laevidentalliidae in the late Campanian Gamma Member of Snow Hill Island Formation characterizes, therefore, the oldest occurrence of this family in Antarctica.

The scaphopod specimen studied here (MN 8608-I) was collected in the sequence NG *sensu* Olivero (2012a) that was deposited in an inner shelf environment, corroborating that the austral scaphopods during the Cretaceous lived in shallow to the mid-shelf environment (Stilwell, 2008).

The family Laevidentalliidae does not currently occur in Antarctica, being restricted to tropical regions (*e.g.* Almeida & Oliveira, 2000; Díaz, 1988; Tan, Ang, Nguang, & Low, 2015). The migration of organisms that lived during the Cretaceous in Antarctica to regions of lower latitudes has been reported in other taxa such as colonial corals (Videira-Santos et al., 2020). This suggests that the members of the family Laevidentalliidae do not tolerate very cold waters, given that the waters in Antarctica began to cool between the late Campanian and the early Maastrichtian (Crame & Luther, 1997; Dingle & Lavelle, 1998; Francis & Poole, 2002; Olivero, 2012a; Pirrie & Marshall, 1990).

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