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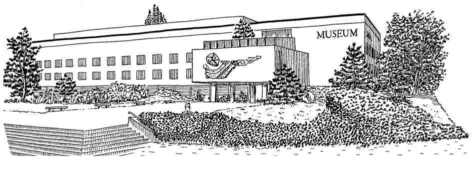

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New Campanian kossmaticeratid ammonites from the James Ross Basin, Antarctica, and their possible relationships with *Jimboiceras*? *antarcticum* RICCARDI

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Abstract

Field work on James Ross Island, Antarctica, has resulted in the finding of a new upper Campanian ammonite fauna, which in SE James Ross Island includes in stratigraphic succession: a) *Neokossmaticeras redondensis* gen. et sp. nov., recorded in the upper part of the Rabot Formation, and b) *Neograhamites primus* sp. nov., Kossmaticeratinae gen. nov., and *Baculites delvallei* RICCARDI, recorded in the basal part of the Hamilton Point Member of the Snow Hill Island Formation. All these species are also recorded in NW James Ross Island as reworked fossils in a single conglomerate bed at the base of the Gamma Member, Snow Hill Island Formation, indicating a marked unconformity between the Santa Marta and Snow Hill Island formations. Kossmaticeratinae gen. nov. is very similar to *Jimboiceras*? *antarcticum* RICCARDI, and thus the association of *J.*? *antarcticum* and *B. delvallei*, previously known only from a Pleistocene glacial boulder, can be interpreted as upper Campanian and derived from the Hamilton Point Member of the Snow Hill Island Formation.

Keywords

Antarctica, James Ross Island, Campanian, Ammonoidea, Kossmaticeratidae, Baculitidae.

INTRODUCTION

The Santonian-Maastrichtian ammonite fauna, particularly the Kossmaticeratidae, from the James Ross Basin, Antarctica (Fig. 1) are relatively well known at the generic level through systematic studies carried out during the last century, mainly by KILIAN & REBOUL (1909), SPATH (1953), HOWARTH (1958, 1966), OLIVERO (1984, 1988, 1992), MACELLARI (1986), MEDINA *et al*. (1988, 1992), and KENNEDY *et al*. (2007). In subsequent stratigraphic studies (*e.g.* CRAME *et al*., 1991, 1996, 2004; PIRRIE *et al*., 1997; OLIVERO & MEDINA, 2000; OLIVERO *et al*., 2008) no new ammonite taxa were discovered or added to the list of fossils described in these systematic papers. The only exception was the finding of a new association consisting of *Jimboiceras*? *antarcticum* RICCARDI and *Baculites delvallei* RICCARDI, recovered from a Cretaceous boulder in the Quaternary glacial deposits of Seymour Island (RICCARDI, 1980). RICCARDI referred tentatively this association to the Santonian-early Campanian but the provenance of these species has remained enigmatic, as they were not subsequently recorded in the Santonian-Campanian deposits of the James Ross Basin.

Field work conducted by the author in NW and SE James Ross Island (Fig. 1) has resulted in the finding of a new Campanian ammonite fauna, which includes *Neograhamites primus* sp. nov., *Neokossmaticeras redondensis* gen. et sp. nov., Kossmaticeratinae gen. nov., which is very similar to *Jimboiceras*? *antarcticum* RICCARDI, and *Baculites delvallei* RICCARDI. The main objectives of this study are thus to document the new ammonite fauna and provide new evidence on the stratigraphic provenance of the ammonites described by RICCARDI (1980). In addition, the Campanian ammonite biostratigraphy of the Rabot Formation, upper Santa Marta Formation, and lower Snow Hill Island Formation, exposed in the NW and SE areas of James Ross Island, is analyzed with the aim to improve the correlation of these geographically distant stratigraphic intervals.

STRATIGRAPHY

Stratigraphic framework

The James Ross Basin is a back arc basin developed to the east of an active magmatic arc located along the Antarctic Peninsula (Fig. 1). Cretaceous strata in the James Ross archipelago include two major stratigraphic units: the deep-water Aptian-Coniacian Gustav Group (INESON, 1989) and the shelfal Santonian-Danian Marambio Group (RINALDI *et al*., 1978). The Marambio Group, about 3 km thick, is dominated by mid-outer to inner-shelf, highly fossiliferous fine-grained sandstone

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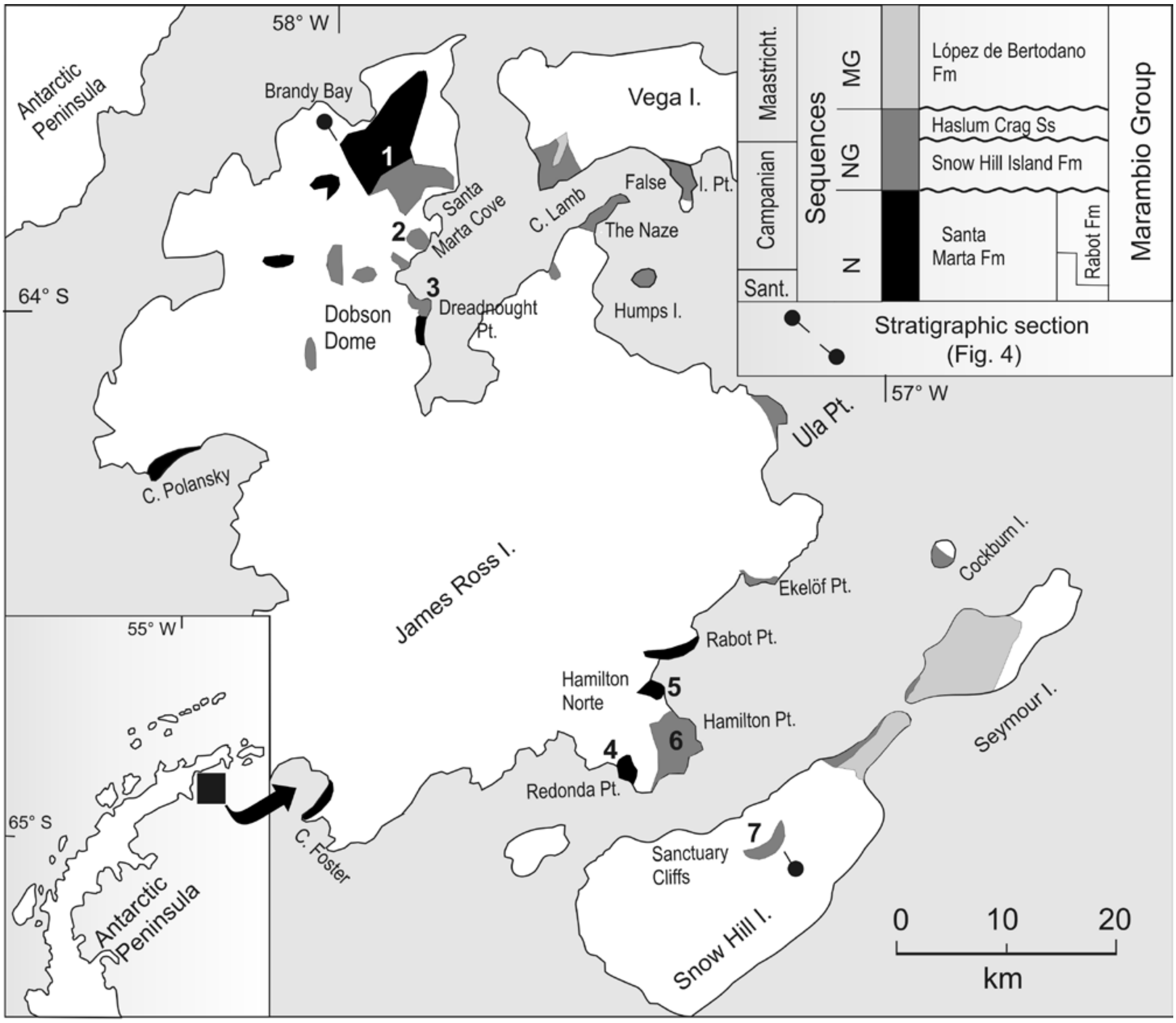

Fig. 1: Location, geological sketch, and stratigraphy of the studied area. Numbers 1-7 indicate the relative positions of the studied stratigraphic sections.

and mudstone, with subordinate conglomerate and coquina (CRAME *et al*., 1996, 2004; PIRRIE *et al*., 1997; OLIVERO & MEDINA, 2000; OLIVERO *et al*., 2008).

The Marambio Group deposits represent a prograding shelf that extended for more than 100 km into the proto-Weddell Sea. The expansion of this shelf area was punctuated by three major sedimentary cycles (OLIVERO & MEDINA, 2000): the N (Santonian-early Campanian); NG (late Campanian-early Maastrichtian); and MG (early Maastrichtian-Danian) sequences (Fig. 1). These sequences include the Santa Marta and Rabot formations (N Sequence); the Snow Hill Island Formation and Haslum Crag Sandstone (NG Sequence) and the López de Bertodano Formation (MG Sequence), which were correlated across the basin by means of 14 Santonian-Maastrichtian ammonite assemblages (see OLIVERO & MEDINA, 2000; OLIVERO *et al*., 2008; and the bibliography therein).

Study area and fossil localities

In the NW area of James Ross Island, the studied sections (see Fig. 1 for location) comprise the upper Beta Member (SCASSO *et al*., 1991) of the Santa Marta Formation exposed in Brandy Bay-Santa Marta Cove (section 1) and Dreadnought Point (section 3), and the Gamma Member (STRELIN *et al*., 1992; OLIVERO & MEDINA, 2000; OLIVERO *et al*., 2008) of the Snow Hill Island Formation exposed in Santa Marta Cove (section 2) and Dreadnought Point (section 3). In SE James Ross Island the studied sections comprise the Rabot Formation (LIRIO *et al*., 1989; MARENSSI *et al*., 1992) at Redonda Point (section 4) and Hamilton Norte (section 5) and the Hamilton Point Member (PIRRIE *et al*., 1997) of the Snow Hill Island Formation (section 6). The latter, is complemented with the section of the Sanctuary Cliffs Member (PIRRIE *et al*., 1997) of the Snow Hill Island Formation at Snow Hill Island (section 7).

Biostratigraphy and correlation of NW and SE Upper Cretaceous sections

In NW James Ross Island six successive ammonite assemblages (Fig. 2) were recognized in the Alpha and Beta members of the Santa Marta Formation. The lowest Ammonite Assemblage 1: *Baculites* cf. *kirki*,

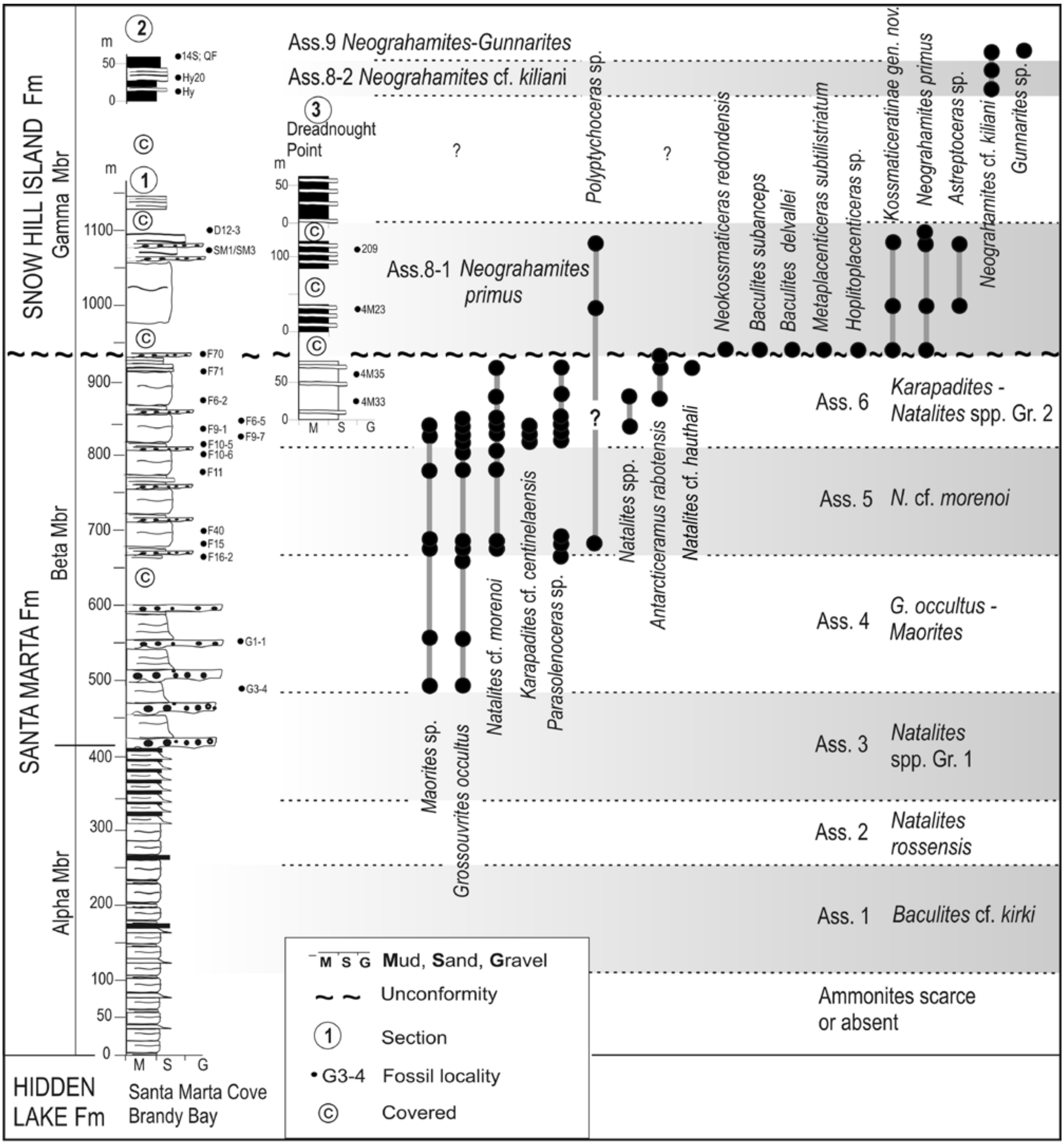

Fig. 2: Biostratigraphic range of selected ammonites for the Beta Member of the Santa Marta Formation and the Gamma Member of the Snow Hill Island Formation in the Santa Marta Cove-Brandy Bay and Dreadnought Point sections exposed in NW James Ross Island. Vertical succession of Ammonite Assemblages 1 to 9 (Ass. 1-Ass. 9) slightly modified from OLIVERO (1992) and OLIVERO & MEDINA (2000). Location of sections 1, 2, and 3 are shown in Fig. 1.

lacks kossmaticeratids and was referred to the Santonian (OLIVERO, 1992). The bases of the following early Campanian ammonite assemblages 2 to 6 were defined at the first occurrence of a particular kossmaticeratid genus and/or species (OLIVERO, 1992). The stratigraphic distribution of these six assemblages in the type section of the Santa Marta Formation is shown in Figure 2 together with the biostratigraphic range of selected ammonite taxa for ammonite assemblages 4 to 6. The top of Ammonite Assemblage 6: *Karapadites-Natalites* spp. Group 2, preserves the last record of Antarctic inoceramids (*Antarcticeramus rabotensis* CRAME & LUTHER) and abundant *Natalites* cf. *hauthali* (PAULKE) (Locality F71, Fig. 2). At about the 940 m level, a poorly exposed conglomerate with abundant reworked fossiliferous concretions (Locality F70, Fig. 2) records diagnostic basal upper Campanian ammonites, including *Baculites subanceps* HAUGHTON, *Metaplacenticeras subtilistriatum* (JIMBO), and *Hoplitoplacenticeras* sp. (OLIVERO, 1992), associated with fragments of inoceramid shells, tentatively interpreted as shell fragments of *A. rabotensis*. From this locality the new material described in this study, including *Baculites delvallei* RICCARDI, *Neograhamites primus* sp. nov., *Neokossmaticeras redondensis* gen. et sp. nov., and Kossmaticeratinae gen. nov. was also recovered. The conglomerate bed of locality F70 is interpreted as resting on a marked unconformity that separates the Santa Marta Formation from the Gamma Member of the Snow Hill Island Formation (Fig. 2, OLIVERO & MEDINA, 2000). Most of the Gamma Member exposures in the Santa Marta Cove area are dominated by sandstone beds that bear rare ammonites, including scarce *Neograhamites primus* sp. nov. and Kossmaticeratinae gen. nov. (localities SM1, D12-3). The stratigraphically equivalent, sandy siltstone beds of the Gamma Member at the Dreadnought Point section (localities 4M23, 209, Fig. 2) record relatively abundant *Astreptoceras* sp., *Polyptychoceras* sp., *Neograhamites primus* sp. nov., and Kossmaticeratinae gen. nov. The last two species were previously mentioned as *Neograhamites* sp. nov. and *Mesopuzosia* sp., respectively by STRELIN *et al*. (1992). The mud-dominated uppermost part (section 2, Fig. 2) bears in succession, abundant *Neograhamites* cf. *kiliani* SPATH (localities Hy and Hy20), corresponding to Ammonite Assemblage 8: *Neograhamites*, of OLIVERO & MEDINA (2000), followed by a distinctive horizon corresponding to Ammonite Assemblage 9: *N.* cf. *kiliani* -*Gunnarites* sp. (localities 14S, QF), referred to the uppermost Campanian-early Maastrichtian (OLIVERO & MEDINA, 2000).

In SE James Ross Island, the Rabot Formation at Redonda Point and Hamilton Norte contains ammonite assemblages 6 and 7 (Fig. 3, OLIVERO & MEDINA, 2000). Ammonite Assemblage 6 is characterized by abundant *Natalites* cf. *hauthali* associated with *Parasolenoceras* sp. and *Antarcticeramus rabotensis*. The succeeding mudstones and intercalated fine-grained sandstones bear abundant specimens of *Neokossmaticeras redondensis* sp. nov., *Polyptychoceras* sp. and *A. rabotensis*, with rare records of *Metaplacenticeras subtilistriatum* and *Hoplitoplacenticeras* sp. This stratigraphic interval includes Ammonite Assemblage 7: Kossmaticeratidae gen. nov. of OLIVERO & MEDINA (2000), which preserves the last record of the Antarctic inoceramid *A. rabotensis*. Following the systematics presented here, this assemblage is renamed as Ammonite Assemblage 7: *Neokossmaticeras redondensis*.

Above a marked change in sedimentary facies, interpreted as an unconformity between the Rabot and Snow Hill Island formations, the Hamilton Point Member (LIRIO *et al*., 1989; MARENSSI *et al*., 1992; PIRRIE *et al*., 1997) of the Snow Hill Island Formation records in its lower part a new ammonite succession, including *Neograhamites primus* sp. nov., Kossmaticeratinae gen. nov. and *Baculites delvallei*. The upper part of the Hamilton Point Member and most of the Sanctuary Cliffs Member of the Snow Hill Island Formation (Fig. 3) contain abundant *Neograhamites* cf. *kiliani* (Ammonite Assemblage 8 of OLIVERO & MEDINA, 2000), and the uppermost part of the Sanctuary Cliffs Member the distinctive association of *N.* cf. *kiliani* and *Gunnarites* sp. (Ammonite Assemblage 9 of OLIVERO & MEDINA, 2000).

Based on the new ammonite findings reported here, the Ammonite Assemblage 8 (*Neograhamites*) of OLIVERO & MEDINA (2000) is split in two assemblages: Ammonite Assemblage 8-1: *Neograhamites primus* and Ammonite Assemblage 8-2: *Neograhamites* cf. *kiliani*. The base of Ammonite Assemblage 8-1 is defined at the first record of *Neograhamites primus*, which is well recorded with abundant specimens at the base of the Hamilton Point Member of the Snow Hill Island Formation at Hamilton Point (Figs. 3, 4). In this stratigraphic interval, *N. primus* is associated with *Baculites delvallei* RICCARDI, *Astreptoceras* sp., Kossmaticeratinae gen. nov. (Fig. 3) and pachydiscids. A similar ammonite association is recorded in the Gamma Member of the Snow Hill Formation at Santa Marta Cove and Dreadnought Point. Above the basal conglomerate (locality F70), which includes a mixture of reworked components of Ammonite Assemblages 7 and 8-1 (Fig. 2), the upper part of the Gamma Member also includes the association of *N. primus* and Kossmaticeratinae gen. nov. (Figs. 2, 4). The base of Ammonite Assemblage 8-2 is characterized by the first record of *Neograhamites* cf. *kiliani*, which is very abundant both in the NW and SE sections of James Ross Island, including the upper parts of the Gamma Member in Santa Marta Cove and the Hamilton Point Member at Hamilton Point, and most of the Sanctuary Cliffs Member on Snow Hill Island (Figs. 2, 3, 4).

The marked unconformity at the top of the Santa Marta and Rabot formations is associated with a notable change in the Antarctic kossmaticeratid fauna. The relatively diverse fauna dominated by species of *Natalites*, the N

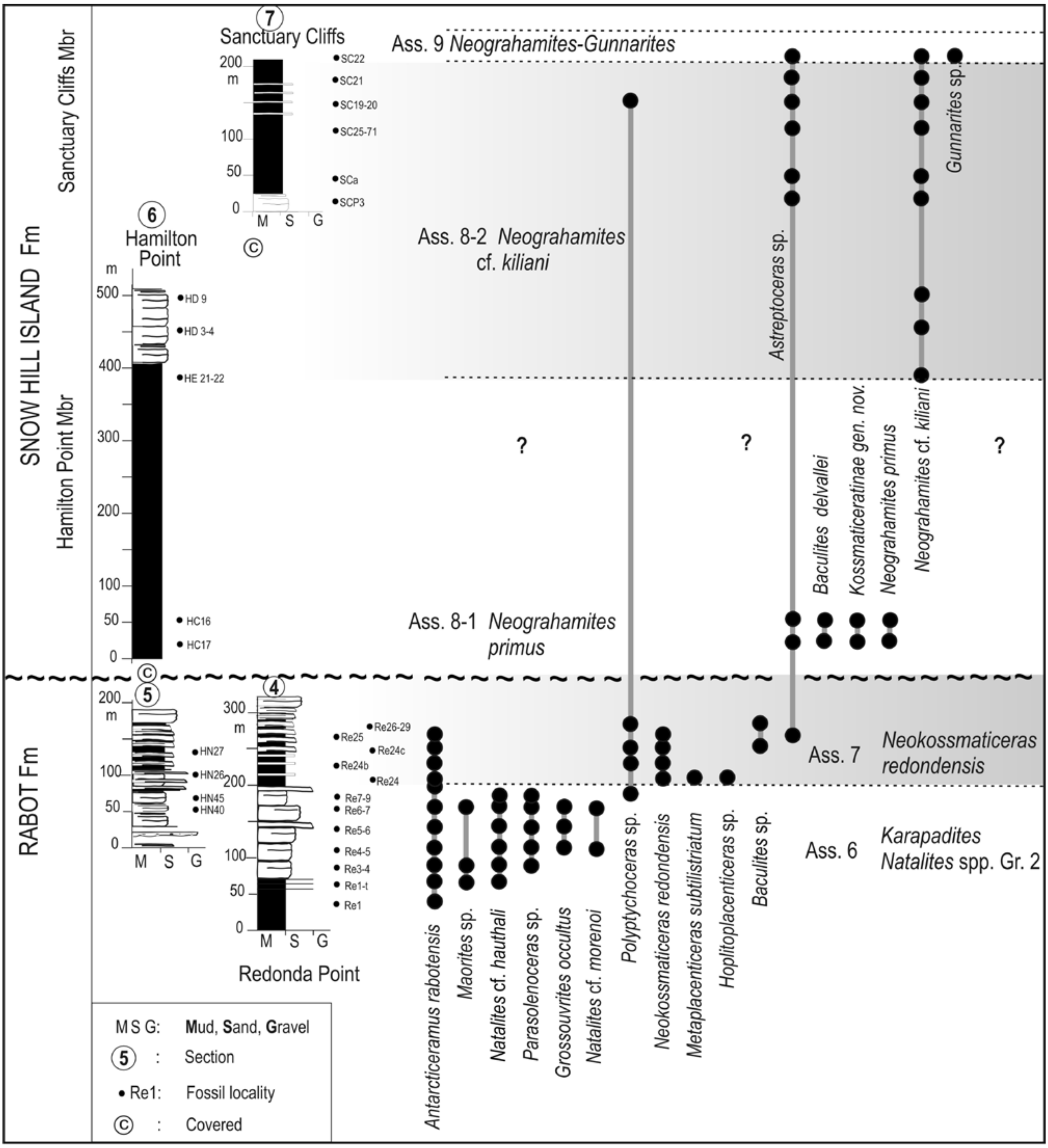

Fig. 3: Biostratigraphic range of selected ammonites for the Rabot Formation and the Hamilton Point and Sanctuary Cliffs members of the Snow Hill Island Formation in the Redonda Point, Hamilton Norte and Sanctuary Cliffs sections exposed in SE James Ross Island. Vertical succession of Ammonite Assemblages 6 to 9 (Ass. 6-Ass. 9) slightly modified after OLIVERO & MEDINA (2000). Location of sections 4, 5, 6, and 7 are shown in Fig. 1.

(for *Natalites*) Sequence of OLIVERO & MEDINA (2000), recorded below the unconformity is replaced above the unconformity by a low-diversity fauna, mostly dominated by abundant specimens of only two kossmaticeratid genera, the NG (for *Neograhamites* and *Gunnarites*) Sequence of OLIVERO & MEDINA (2000) (Figs. 1, 4). Erosion, associated with this unconformity, eliminated most of the stratigraphic interval encompassing Ammonite Assemblage 7: *Neokossmaticeras redondensis* and part of Assemblage 8-1: *Neograhamites primus*, in the basin. Thus, the stratigraphic intervals recording the ammonites *Neokossmaticeras redondesis*, *Neograhamites primus*, Kossmaticeratinae gen. nov., which probably includes *Jimboiceras*? *antarcticum*, and *Baculites delvallei* are restricted to limited areas of the basin, in its deepest depositional areas, explaining the rarity of the record of this ammonite fauna (Fig. 4).

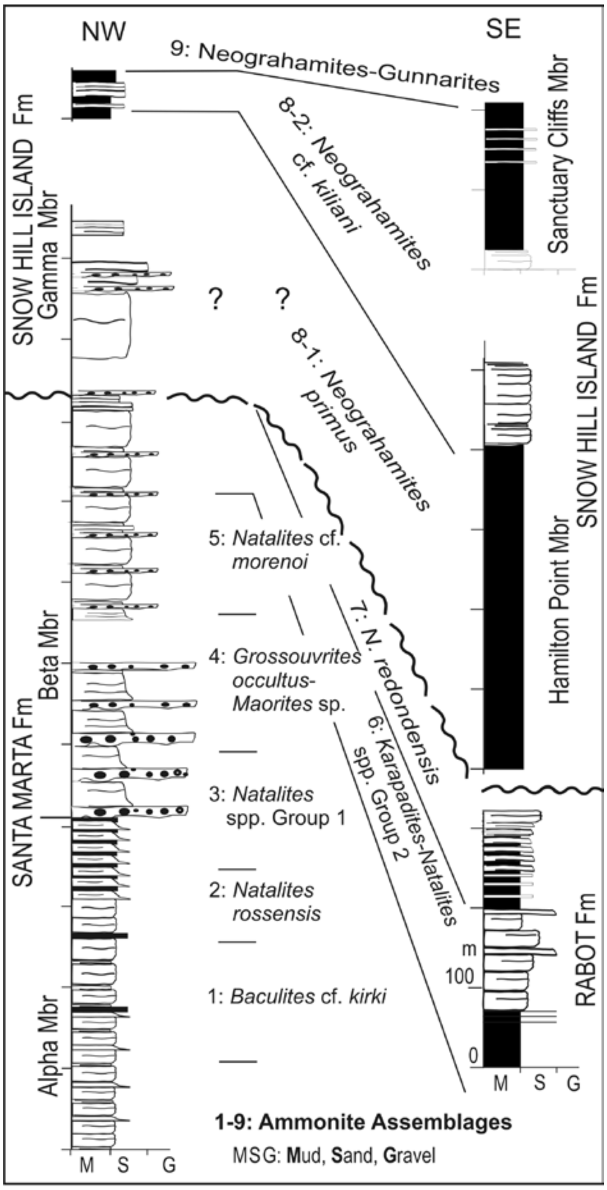

Fig. 4: Correlation of the stratigraphic sections of the Santa Marta, Rabot, and Snow Hill Island formations exposed in the NW and SE areas of James Ross Island. The correlation is based on the stratigraphic distribution of Ammonite Assemblages 1 to 9. Note the marked unconformity at the top of the Beta Member, Santa Marta Formation that eliminates the stratigraphic intervals containing Ammonite Assemblage 7 and part of Ammonite Assemblage 8-1 in NW James Ross Island.

SYSTEMATICS

Abbreviations and measurements: Conventional dimensions are expressed in mm, and include:
D, diameter;
H, whorl height at a given D;
W, whorl width at a given D;
U, umbilical diameter at a given D.
For the heteromorphic *Baculites* shell, the measurements include in addition:
Di, the interval between two successive measurements of H and W, and
Ti, the taper index (after MATSUMOTO & OBATA, 1963).
P½, is the number of primary ribs counted at the lower flank per half whorl of the shell;
P+S½, is the number of primary plus secondary ribs counted per half whorl along the venter, and Const½, is the number of constrictions counted per half whorl.

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Order Ammonitida ZITTEL, 1884
Suborder Ancyloceratina WIEDMANN, 1960
Family Baculitidae GILL, 1871

Genus *Baculites* LAMARCK, 1799

Type species: *Baculites vertebralis* LAMARCK, 1799, by subsequent designation of MEEK (1876).

***Baculites delvallei* RICCARDI, 1980**
Pl. I, figs 1-3; Figs 5-6

1980. *Baculites delvallei*.- RICCARDI, p. 324, pl. 1, figs. 1-2, text-fig. 1.

Holotype: The specimen described by RICCARDI (1980, pl. 1, figs. 1-2, text-fig. 1) recovered from a glacially transported boulder on Seymour Island, Antarctica.
Material: 46 internal molds of the phragmocone and body chambers, preserving only small patches of the shell, from the Upper Campanian basal Snow Hill Island Formation, James Ross Island, Antarctica. Specimens CIRGEO 1415 (1-3) from locality F70, basal Gamma Member, Santa Marta Cove-Brandy Bay area; specimens CADIC PI 153, 153a,b,c from localities HC16-HC17, basal Hamilton Point Member at Hamilton Point, and specimen CADIC PI 152 and about 40 fragmentary specimens CADIC PI 160, from Ekelöf Point, basal Hamilton Point Member.

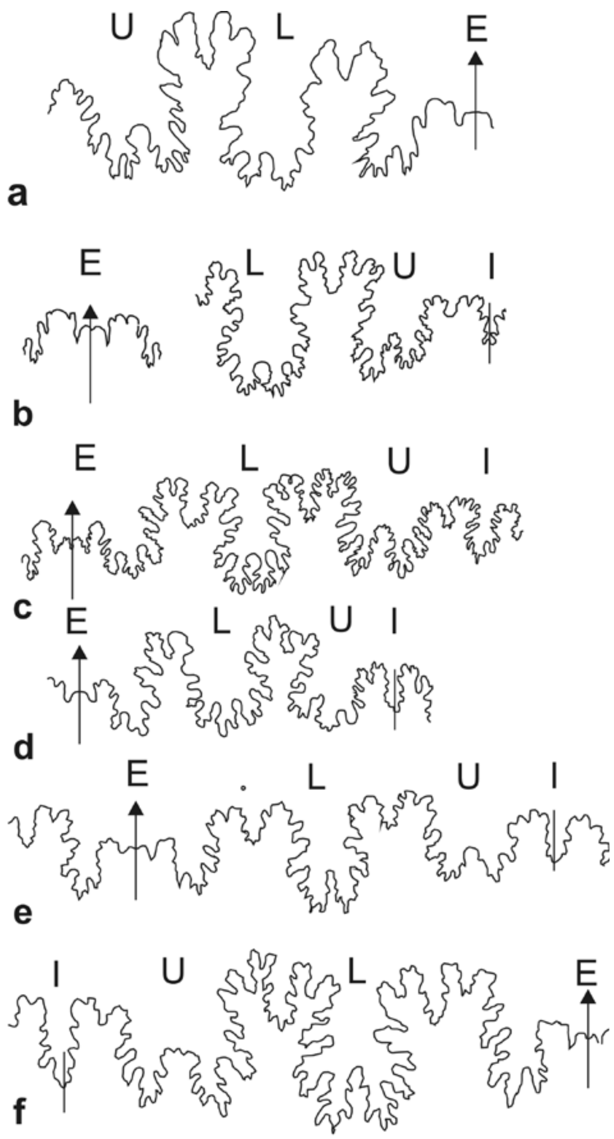


Fig. 5: Sutures of *Baculites delvallei* RICCARDI, 1980: **a-b**, holotype MLP 12248, H= 29.5, a, reproduced from RICCARDI (1980); **c**, CADIC PI 152, H= 24.2; **d**, CIRGEO 1415, H= 11.8. Sutures of *B. duharti* HÜNICKEN, 1975: **e**, holotype, H= 23.2; **f**, paratype, H= 27.6, reproduced from HÜNICKEN *et al*. (1975).

Description: Shell relatively large (largest H= 44), smooth and of low tapering index (average Ti= 5.77, equivalent to an expansion angle of about 3°). Whorl section elliptical, compressed (average W/H ratio= 0.67), with venter slightly narrower than dorsum. The aperture, preserved in one specimen (CADIC PI 153), consists of a short dorsal rostrum, a prominent lateral sinus and a larger ventral rostrum. The suture is incised and relatively simple, with open, rectangular or subquadrate saddles and lobes. Folioles of saddles and lobes have mostly non-phylloid culminations.

Measurements:

Specimen	H	W	W/WH	Di	Ti
CIRGEO1415 -1	11.3	7	0.62		
	13.1	8.4	0.64	26	6.92
CADIC PI 160-1	22.1	14.2	0.64		
	27	18.7	0.69	107	4.58
CADIC PI 152	22.5	14.8	0.66		
	26.2	19	0.72	82	4.51
	28.4	20	0.70		
	32.5	22.6	0.70	64.5	6.36
CADIC PI 160-2	23.4	15.8	0.67		
	26.5	17.7	0.67	48	6.46
CADICPI 153	34.8	21.5	0.62		
	36.2	23.6	0.65	57	2.46

Remarks: The studied material is closely comparable in size, morphology, and whorl section to *B. delvallei* RICCARDI, 1980. The suture line of *B. delvallei* (RICCARDI, 1980, text-fig. 1, reproduced here in Fig. 5a) seems to be less incised than in our material, but this probably reflects the fact that the suture was drawn near the end of the adult phragmocone, where the sutures are generally simpler (KLINGER & KENNEDY, 2001). In addition, the original drawing of the suture line of the holotype (RICCARDI, 1980, text-fig. 1) is incomplete and it finished at one of the incisions of the dorsal saddle, not at the internal lobe (compare Figs. 5a and 5b).

The elliptical whorl section and the large, smooth shell with low taper ratio differentiate *B. delvallei* from other smooth species of Upper Campanian *Baculites*. As already noted by RICCARDI (1980), one of the most similar species is *Baculites duharti* HÜNICKEN, 1975

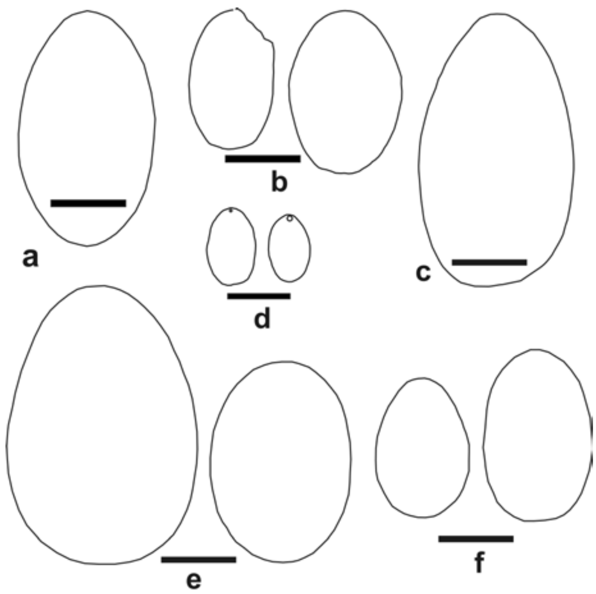


Fig. 6: Whorl section of *Baculites delvallei* RICCARDI, 1980: **a**, holotype MLP 12248, reproduced from RICCARDI (1980); **b**, CADIC PI 152; **c**, CADIC PI 153; **d**, CIRGEO 1415 (1). Whorl section of *B. duharti* HÜNICKEN, 1975: **e-f**, reproduced from HÜNICKEN *et al.* (1975). Scale bars 1 cm.

from the Middle-Upper Campanian of Tierra del Fuego (HÜNICKEN *et al*., 1975) and Campanian III of Zululand (KLINGER & KENNEDY, 1997). *B. duharti* has a similar suture (Fig. 5e-f) although it has a different elliptical to ovoid whorl section, with a notably wider dorsum (Fig. 6e-f). In addition, some specimens of *B. duharti* may bear ribs and undulations on the venter and ventral flanks (HÜNICKEN *et al*., 1975; KLINGER & KENNEDY, 1997), and this type of ornament is never seen in the holotype or in our numerous specimens of *B. delvallei*.

Baculites inornatus MEEK, 1862, from the Campanian of California, Vancouver, and Hokkaido (See MATSUMOTO & OBATA, 1963; WARD, 1978) has a more ovoid cross-section and a different suture line, with marked phylloid folioles, as described by WARD (1978).

Baculites rectus MARSHALL, 1926 from New Zealand is another smooth species that was also recorded in Antarctica (SPATH, 1953; OLIVERO, 1984) but it is readily differentiated from *B. delvallei* by its more complex suture. *B. delvallei* generally differs from other smooth baculitids, such as *B. bailyi* WOODS, 1906, *B. rex* ANDERSON, 1958, *B. occidentalis* MEEK, 1862, and *Baculites* "smooth species" COBBAN, 1962, in details of the suture and its typical, compressed elliptical section (See RICCARDI, 1980 for a complete comparison with these species).

Suborder Ammonitina HYATT, 1889
Family Kossmaticeratidae SPATH, 1922
Subfamily Kossmaticeratinae SPATH, 1922

Genus *Neograhamites* SPATH, 1953

Type species: *Neograhamites kiliani* SPATH (1953, p. 27, pl. 4, fig. 4) from the upper Campanian of Humps Island, Antarctica, by original designation of SPATH (1953, p. 23).

Diagnosis: Shell small to moderate; evolute; inner whorls depressed to subcircular, outer whorl compressed or nearly as high as broad; umbilical shoulder broadly rounded; inner whorls with stephanoceratid-like style of ribbing, consisting of nearly rectiradiate primary ribs, regularly branching in two or more secondary ribs at umbilical or lower flank tubercles, outer whorls with single, rarely branching or intercalated, rectiradiate or prorsiradiate and somewhat flexuous long ribs. Umbilical tubercles subdued or absent on the adult body chamber. Suture complex, with retracted umbilical auxiliaries lobes (modified after SPATH, 1953, p. 27; MATSUMOTO, 1955, p. 144).

Comments: *Neograhamites* is clearly a very distinctive, albeit not well understood, kossmaticeratid genus. It has been frequently compared (e.g. SPATH, 1953; HENDERSON & MCNAMARA, 1985) or even considered as a synonym (MATSUMOTO, 1991) of *Pseudokossmaticeras* SPATH, 1922. Whereas the mature shell of *Neograhamites kiliani* is comparable to species of *Pseudokossmaticeras*, particularly in relation to the common presence of rectiradiate single ribs, their inner whorls are totally different, and the regular stephanoceratid-like branching of ribs from umbilical or mid-flank tubercles is never seen in *Pseudokossmaticeras* (e.g. WRIGHT, 1957; WRIGHT *et al.,* 1996). As interpreted here, *Neograhamites* includes the type species *N. kiliani* SPATH, recorded in Antarctica (KILIAN & REBOUL, 1909; SPATH, 1953; OLIVERO, 1992), Patagonia (MACELLARI, 1988) and possibly New Caledonia (COLLIGNON, 1977) and *N. primus* sp. nov., described here. Other species, previously included in *Neograhamites*, such as *N. taylori* SPATH (SPATH, 1953), *N. morenoi* RICCARDI (RICCARDI, 1983) and *N. transitorius* HENDERSON (HENDERSON, 1970) lack the diagnostic features of *Neograhamites*, e.g. rounded umbilical shoulder, inner whorls with primary ribs regularly branching at umbilical or low flank tubercles, and outer whorls with subdued tubercles and mostly rectiradiate single ribs. These species have distinct umbilical shoulders, strong umbilical tubercles and a different ribbing style, and they should be transferred to *Natalites* (HENDERSON & MCNAMARA, 1985; OLIVERO, 1992). *Neograhamites carnavonensis* HENDERSON & MCNAMARA (HENDERSON & MCNAMARA, 1985) has a whorl section similar to that of *Neograhamites*, but it lacks the diagnostic stephanoceratid-like style of ribbing in its inner whorls. The species was based on a single, somewhat incomplete specimen and it is not included here in *Neograhamites*.

Neograhamites primus sp. nov.
Pl. I, figs 4-9; Fig 7

1992. *Neograhamites* sp. nov.- OLIVERO, p. 58.
1992. *Neograhamites* sp. nov.- OLIVERO in STRELIN *et al.* (1992, p. 207).

Holotype: The specimen CADIC PI 154, figured in Plate I, figs. 4-6.

Material: 18 specimens from the basal Snow Hill Island Formation; Hamilton Point Member, locality HC 16/17 (CIRGEO1604/07, 1609, 1614/15, 1618, 1623, 1626, CADIC PI 154, holotype, and CADIC PI 155, 156, 157, 159); Gamma Member, locality 4M23 CIRGEO 1340, 1340-a; locality F70 CIRGEO 1629, locality D12/3 CIRGEO 1316, and locality SM3 CADIC PI 158.

Origin of name: From *primus*, first in order of time, primitive, indicating the oldest species of *Neograhamites* recorded in Antarctica.

Diagnosis: Small species of *Neograhamites* with primary ribs bifurcating at lower mid-flank on inner whorls and with subdued ornamentation and somewhat flexuous weak ribs on the outer whorl.

Description: Shell small, moderately evolute, with successive whorls overlapping by about one half up to a diameter of 20-25 mm and then by about one third. Whorl

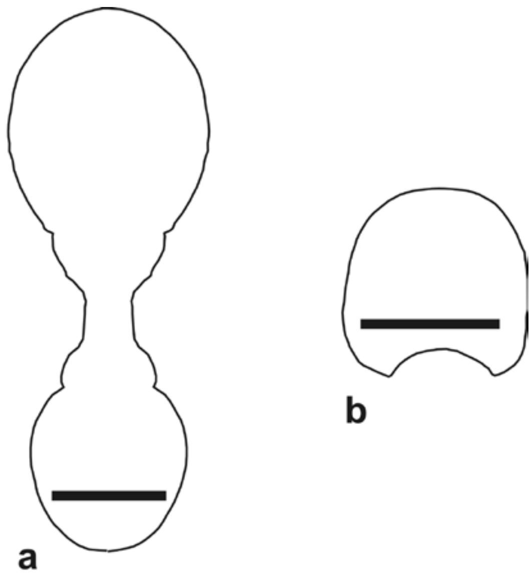


Fig. 7: Whorl section of *Neograhamites primus* sp. nov. **a**, the holotype CADIC PI 154; **b**, CIRGEO 1609. Scale bars, 1 cm.

section at first depressed or circular (D<25 mm), then slightly compressed, suboval, with subparallel flanks; venter broad and rounded, umbilical shoulder rounded and with a low inclined umbilical wall. Up to D = 20-25 mm the ornament consists of strong, distant primary ribs (9 to 12 per half whorl) branching regularly at the lower-mid flank into three, or rarely two, secondary ribs. Every primary ribs is provided at the point of branching with a pointed, radially elongate tubercle. All ribs pass straight across the venter, where the total number of ribs varies between 29 and 31. Deep, prorsiradiate constrictions are somewhat flexuous and projected on the venter, interrupting several ribs. Constrictions are double-collared, of which the adapical collar is strongest. In the succeeding stage (D>25 mm) tubercles are absent and the ornament is more irregular, with long and flexuous primary ribs that occasionally bifurcate or are accompanied by intercalated ribs. At this stage the total number of ribs on the venter is about 20. On the last whorl of the larger specimens (D = 35 to 47 mm) all ribs weakens but the constrictions are still well marked and projected on the venter. Suture similar to that of *N. kiliani* SPATH.

Remarks: *N. primus* can be easily distinguished from *N. kiliani* SPATH by its small size, higher point of rib branching on the flank, and effaced ribs on the last whorl. Despite its small size, the marked change in ornamentation between the inner and outer whorls suggests maturity.

Genus *Neokossmaticeras* gen. nov.

Type species: *Neokossmaticeras redondensis* sp. nov. from the upper Campanian of James Ross Island, Antarctica.

Origin of name: New (Greek Neo) *Kossmaticeras* aluding to its homeomorphic similarities with species of the genus *Kossmaticeras* DE GROSSOUVRE, 1901 distributed mainly in the Upper Turonian-Coniacian (cf. COLLIGNON, 1955; KENNEDY & KLINGER, 1985; MATSUMOTO, 1991). Incidentally, the mention in the latest Cretaceous of Costa Rica (AGUILAR, 2009, p. 87) of ?*Neokossmaticeras* sp. was probably a typographic error trying to indicate the ammonite ?*Neokentroceras* or *Pseudokossmaticeras* (AGUILAR, 2011, written comm. to F.A. MEDINA)

Diagnosis: Shell size fairly small to moderate, moderately evolute, inner whorls at first depressed to subcircular then compressed; phragmocone with mostly rectiradiate primary ribs, branching regularly in the mid to dorsal flank and projected adorally on the venter; body chamber with long, flexuous primary and shorter intercalate ribs.

Comments: The ribbing style of the upper Campanian *Neokossmaticeras* is similar to true upper Turonian-Coniacian species of *Kossmaticeras*, particularly *K. recurrens* (KOSSMAT, 1897), and *K. pavlowskyi* COLLIGNON, 1955 (KENNEDY & KLINGER, 1985). This similarity is attributed to homeomorphism as there are not intermediate forms between the Turonian-Coniacian true *Kossmaticeras* and the upper Campanian *Neokossmaticeras* gen. nov. In addition, *Neokossmaticeras redondensis* sp. nov. has a different suture, with retracted elements in the umbilical auxiliaries (Fig 8), which are not present in the typical sutures of

Measurements: *N. primus*

Specimen	D	H	W	W/H	U	U/D	P½	P+S½	Const½
CIRGEO1623	10	4.9	6	1.22					
		15.2	6.5	7	1.08	4.2	.28	12	2
CIRGEO1615	18.5	7.7	8.4	1.09	5.4	.29	9	30	2/3
	24.3	12	10.3	.87	7.5	.31	10	31	3
CIRGEO1618	21						9	30	3
		28.6	12	10.6	.88	9.2	.32		
CIRGEO1606	32.3	16.4	14	.85	10.4	.32			
CADIC PI 154	22						11	29	3
	47	20.8	18	.87	15	.29	11	20	3

Kossmaticeras s. st. (e.g. KOSSMAT, 1897, pl. VII, fig 5). The ribbing style and whorl section of *Neokossmaticeras* are quite similar to those of *Neograhamites* Spath. Because of their relative stratigraphic position, the latter is interpreted to be derived from the former.

Neokossmaticeras redondensis sp. nov.
Pl. I, fig. 10; Pl. II, fig. 1-12; Figs 8-9

2000. Kossmaticeratidae nov. gen. OLIVERO & MEDINA, p. 272.

Holotype: Specimen CIRGEO 1550, a probable macroconch, illustrated in Plate II, figs. 1-2.

Material: More than 70 specimens from the Upper Campanian of James Ross Island. From the Rabot Formation, Redonda Point, locality Re 24/25: probable macrochonchs CIRGEO 1550, 1555, 1558, 1591, 1595, 1596; probable microconchs CIRGEO 1551, 1552, 1554, 1556, 1598, 160, CADIC PI 163; juvenile specimens CIRGEO 1553, 1557, 1559, 1560, 1562, 1563, 1564, 1565, 1566, 1567, 1568, 1569, 1570, 1571, 1572, 1573, 1574, 1575, 1576, 1578, 1579, 1580, 1581, 1583, 1584, 1585, 1587, 1588, 1589, 1590, 1592, 1593, 1594, 1599, 1600, 1602 and CADIC PI 161. From the Rabot Formation, Hamilton Norte: locality HN10, juvenile specimens CIRGEO 1538, 1539, 1540, 1541, 1542, 1543,1544; locality HN27-B30, juvenile specimens CIRGEO 1603, CADIC PI 162-1, 162-2, 162-3, 162-4; locality HN 26-1, juvenile specimens CADIC PI 162-5. From the Gamma Member of the Snow Hill Island Formation, Santa Marta Cove, locality F70: probable microconch CIRGEO 1548; juvenile specimens CIRGEO 1315, 1549.

Diagnosis: Young shell with dense, prorsiradiate, strong and elevated primary ribs that regularly bifurcate or trifurcate at mid flank. Adult body chamber has long flexuous primary ribs with some intercalated ribs.

Description: Juvenile shells with fairly evolute to moderate coiling; overlapping of successive whorls between one half and one third. Umbilicus of moderate width (average U/D= 0.33).

Juvenile phragmocones have a depressed or circular whorl section (average W/H= 1.08), a broad and rounded venter, convex sides and a low rounded umbilical wall. The juvenile phragmocone is regularly ornamented with strong, elevated and radial primary ribs (9 to 18 per half whorl), arising at the umbilical shoulder and bifurcating at the mid- or dorsal flank. Some primary ribs are trifurcated or less commonly there is a secondary intercalated rib. The total number of ribs on the venter of juvenile specimens varies between 16 and 40 per half whorl. Branched or intercalated ribs are prorsiradiate in most specimens but gently flexuous in some, all are markedly projected on the venter and generally the ribs weaken along the siphonal line. Constrictions, about 2 to 3 per half whorl, are deep, prorsiradiate and strongly projected on the venter, cutting several ribs behind them. Adult shells include two distinct groups: fairly small shells (microconch?) with the last suture at D between 38 to 45 mm, and shells of moderate size (macroconch?) with the last suture at D between 56 and 65 mm. In the smaller adult shells (microconch?), the body chamber has a somewhat compressed whorl section (W/H is .80 to .89), slightly convex to subparallel sides and a short vertical umbilical wall with rounded shoulders. In the

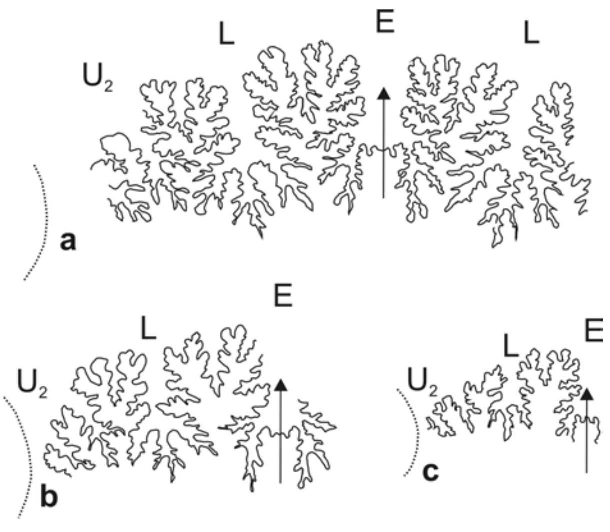


Fig. 8: Sutures of *Neokossmaticeras redondensis* sp. nov. **a**, CIRGEO 1600, H= 13; **b**, CIRGEO PI 1566, H= 10; **c**, CIRGEO PI1589, H= 5.3.

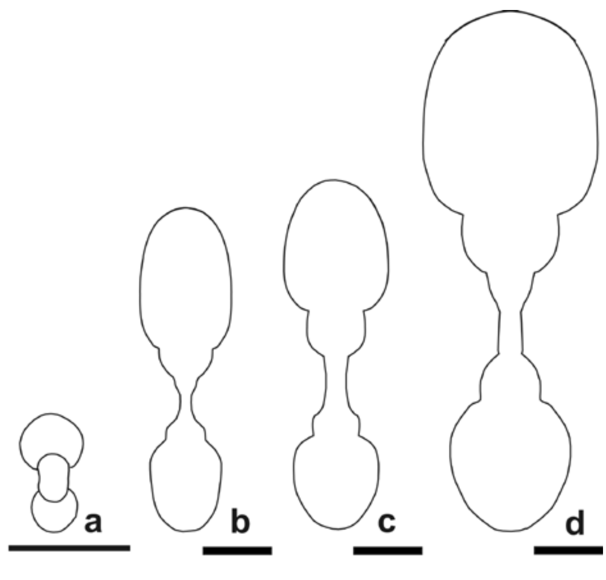


Fig. 9: Whorl sections of *Neokossmaticeras redondensis* sp. nov. **a**, juvenile specimen CIRGEO 1587; **b**, probable mature microconch, CADIC PI 163; **c**, juvenile specimen of a probable macroconch CIRGEO 1555; **d**, mature macroconch CIRGEO 1550. Scale bars, 1 cm.

largest adult shells (macroconch?) the whorl section is less compressed (W/H is .86 to .98), suboval with a broadly rounded venter. Both adult body chambers have a more irregular ornamentation with many flexuous or sigmoidal long and intercalated ribs, which are strongly projected on the venter. Constrictions are slightly flexuous and often provided with strong adapical collars, leaving a broad smooth zone behind them. The adapical collar is stronger than the adoral one.

Suture moderately incised, with deep siphonal lobe (E); tripartite subsymmetrical lateral lobe (L), and retracted auxiliaries of the umbilical lobe (U).

Remarks: The species is characterized by a marked ontogenetic change in ornamentation. Young shells are characterized by the regular branching of primary ribs at the mid-dorsal flank, whilst mature shells have a more irregular ornamentation with many flexuous or sigmoidal long and intercalated ribs. Associated mature specimens differing in size, but with identical juvenile whorls, are suspected to represent sexual dimorphs. Probable microconchs (Pl. I, fig. 10; Pl. II, figs 7, 8, 10) differ from probable macroconchs (Pl. II, figs 1, 2, 9) in size (see measurements) and whorl section (Fig. 9). Diphormism, first recognized in the Kossmaticeratidae in *Grossouvrites* KILIAN & REBOUL, 1909 by OLIVERO & MEDINA (1989) is now recognized as a widespread feature of the family (MATSUMOTO, 1991; MAEDA, 1993; MEDINA & RICCARDI, 2005).

Ribbing in some juvenile specimens consists of denser and more flexuous ribs (e.g. Pl. II, fig. 3) than in typical specimens, which have more widely spaced and rectiradiate ribs (e.g. Pl. II, figs 4, 5). As these features are seen on specimens that are closely associated in a relatively thin stratigraphic horizon (Fig. 3), the differences are interpreted as part of the natural variability of the species.

Measurements: *N. redondensis*

	D	H	W	W/H	U	U/D	P½	P+S ½	Const. ½
Juvenile specimens									
CIRGEO1588	9.1	4.5	5.4	1.2	2	.22			
	12.3	5.7	6.4	1.12	3.2	.26	18	36	3
CIRGEO 1589	14.2	6	7.4	1.23	4.5	.32	18		2/3
CIRGEO 1587	14.2	6	7.3	1.22	3.7	.26	16	34	2
CIRGEO 1573	21.3	7.8	10	1.28	7.5	.35	17	35	3
CIRGEO 1575	22	9	10.2	1.13	7.5	.34	15		2
CIRGEO 1581	23.5	10	10.5	1.05	9.7	.41	9	16	4
CIRGEO 1572	23			.95			11	24	3
CIRGEO 1571	25	11.3	10.3	.91	7.4	.3	18	34	3
CIRGEO 1574	27	11.7	11.2	.96	7.8	.29	15	31	3
CIRGEO 1570	28.1	13	12.4	.95	10	.36	11	17	4
CIRGEO 1568	21.6	9.4	10.6	1.13	7.3	.34	13	34	3
	30	13.3	14.5	1.09	10	.33	13	40	2/3
CADIC161-1	32.6	13.3	15	1.13	11.6	.36	13	30	3
CIRGEO 1566	34.3	14.6	14.5	.99	12.1	.35	14	30	3
CIRGEO 1567	35.2	14	14.2	1.01	12.2	.35	14	31	2/3
CIRGEO 1562	36.5	14	15.3	1.09	13.2	.36	13	26	2
CIRGEO 1565	40	16	16.5	1.03	14	.36	13	27	2
CIRGEO 1557	40	16.6	16.8	1.01	13	.32	17	35	2
Probable microconch									
CADIC PI 163	50.6	21	17	.81	16.3	.32	13	24	3
	39.4	16.5	13.8	.84	12.2	.31	13	31	3
CIRGEO 1556	53.4	22.8	18.8	.82	18.5	.35	14	30	2/3
CIRGEO 1552	52	21.4	19	.89	19	.37			
CIRGEO 1551	68	28.7	23	.80	24.6	.36	15	30	3
Probable macroconch									
CIRGEO 1558	49.8	19.3	19	.98	19.4	.39	14	28	2
CIRGEO 1555	42	17.2	15.5	.90	14.5	.35	14	30	2
	51.5	20	18.4	.92	18	.35	16	34	2
CIRGEO 1550	79.5	32	27.6	.86	27.6	.35	17	24	3
CIRGEO 1591	c.83	34							
CIRGEO 1596	c.90	45.2							

Kossmaticeratinae gen. et sp. nov.
Pl. II, figs 13-15; Fig. 10

1992. *Mesopuzosia* sp.- OLIVERO in STRELIN *et al.* (1992, p. 207)
cf. 1980. *Jimboiceras*? *antarcticum*.- RICCARDI, p. 330, pl. 1, figs. 3-5, text-fig. 2.

Material: 16, mostly juvenile specimens and a few incomplete external molds of mature? shells, from the Upper Campanian Gamma and Hamilton Point members of the Snow Hill Island Formation, James Ross Island. From the Gamma Member, Dreadnought Point, locality 209, CIRGEO 1537; locality 4M23, CIRGEO 1364, 1527, 1528, 1529, 1530, 1531,, 1532, 1533, 1535, 1536. From the Gamma Member, Santa Marta Cove, locality F70, CIRGEO 1546, 1547, CADIC PI 164. From the Hamilton Point Member, locality HC 16-17, CIRGEO 1613, 1621.

Description: Fairly evolute shell; moderate umbilical width; whorl section subcircular or depressed in the initial whorls (D< 5-6 mm) then compressed elliptical, with slightly convergent flat sides and rounded venter, umbilical wall short and vertical and rounded umbilical shoulder. Phragmocone and body chamber ornamented with dense, flexuous and strongly projected primary ribs, about 20-25 per half whorl, starting at the umbilical wall; few ribs are intercalated at the lower third of the flank so that on the venter there are about 22 to 34 ribs per half whorl. Deep, irregularly spaced constrictions with double collared ribs, of which the adapical one is the strongest, about six to seven per whorl and cutting one or two ribs behind them. Constrictions and collars are flexuous and strongly projected on the venter.

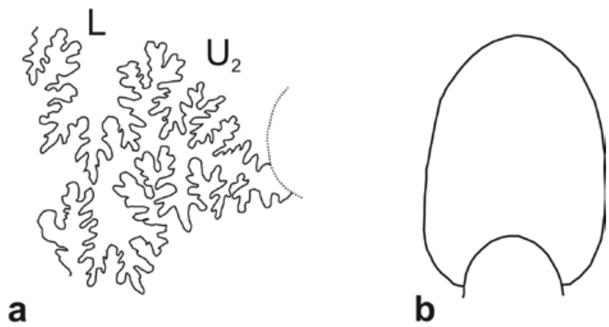


Fig. 10: Kossmaticeratinae gen. nov. **a**, suture of specimen CIRGEO 1535, D= 14, H= 6; **b**, whorl section of specimen CIRGEO 1527, D= 24, H= 10.

Remarks: The material is referred to the subfamily Kossmaticeratinae because of the double collared constrictions that cut at least two ribs on the apical side (see MAEDA, 1993). Previous views, e.g. RICCARDI (1980); MATSUMOTO (1991) on the sutural differences between puzosiine and kossmaticeratids, i.e. the exclusive restriction of retractive auxiliaries of the umbilical lobe to the former is not a definite criterium as this feature is

Measurements: Kossmaticeratinae gen. et sp. nov.

Specimen	D	H	W	W/H	U	U/D	P½	P+S ½	Const. ½
CIRGEO 1535	10	4	4	1					
	11	5	5.2	1.04	3	.27			
	14.5	7	6.2	.89	3.1	.21			3/4
CIRGEO1534	12.1	6	5.8	.97	2.9	.24			3/4
CIRGEO 1531	20	9	7.4	.82	5	.25			3
CIRGEO 1527	22.7	10.6	7.2	.68	6	.26	20	22	3
CIRGEO 1530	32				10	.31	28	34	3
CIRGEO 1536					13.8	.34	26	34	3

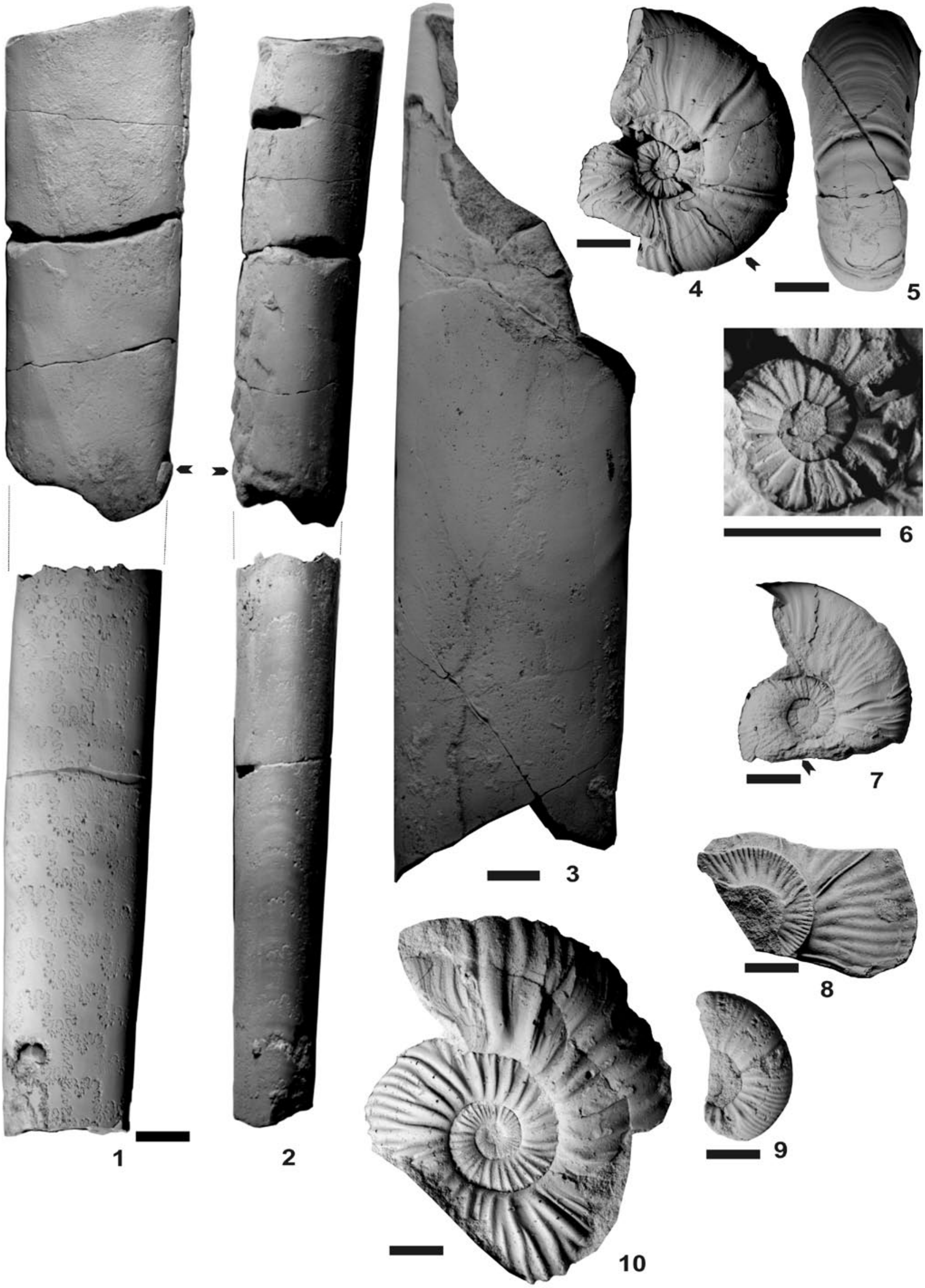
Plate I

Scale bars 1 cm; arrow indicates the last suture.

Figs. 1-3: *Baculites delvallei* RICCARDI, 1980, Upper Campanian, Hamilton Point Member, Snow Hill Island Formation, James Ross Island. 1-2: Lateral and ventral views, CADIC PI 152, Ekelöf Point, James Ross Island. 3: Lateral view, CADIC PI 153, locality HC16/17, Hamilton Point.

Figs. 4-9: *Neograhamites primus* sp. nov., Upper Campanian, Hamilton Point and Gamma members, Snow Hill Island Formation, James Ross Island. 4-6: Holotype, CADIC PI 154, locality HC16/17, Hamilton Point, lateral (4), ventral (5), and enlarged, lateral view of inner whorls (6). 7: Lateral view CADIC PI 155, locality HC16/17, Hamilton Point. 8: External mold, lateral view CIRGEO 1629, locality F70, Santa Marta Cove. 9: Lateral view, incomplete phragmocone CADIC PI 158, locality SM-3, Santa Marta Cove.

Fig. 10: *Neokossmaticeras redondensis* gen. et sp. nov., Upper Campanian, Snow Hill Island Formation, CIRGEO 1548, locality F70, Santa Marta Cove, James Ross Island, lateral view of a silicone cast of external mold.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known in several kossmaticeratids, e.g. *Neograhamites*. Conversely, double collared constrictions cutting several ribs appear to be a diagnostic character of the Kossmaticeratidae, particularly now that *Neopuzosia*, previously interpreted as an exceptional puzosiine having double collared constrictions, has been transferred to the Kossmaticeratinae (MAEDA, 1993).

The coiling and ribbing of the studied material is very similar to *Jimboiceras*? *antarcticum* RICCARDI, but the preservation is not good enough to prove that they correspond to the same species. The major difference seems to be the whorl section, which in the last preserved whorl of *Jimboiceras*? *antarcticum* is almost as broad as high, however it is deformed and its relative dimensions do not correspond to the original section. Both *J*.? *antarcticum* and our Kossmaticeratinae gen. nov. are associated with *Baculites delvallei*, which now we know is of late Campanian age, similar to that suggested by RICCARDI (1980). *Jimboiceras* MATSUMOTO, 1954, represented only by the type species *J. planulatiformis* (JIMBO), is a true puzosiine known to be restricted to the Turonian (MATSUMOTO, 1988). Thus, there are no intermediate forms between Turonian *Jimboiceras* and the doubtful *Jimboiceras* from the Campanian of Antarctica.

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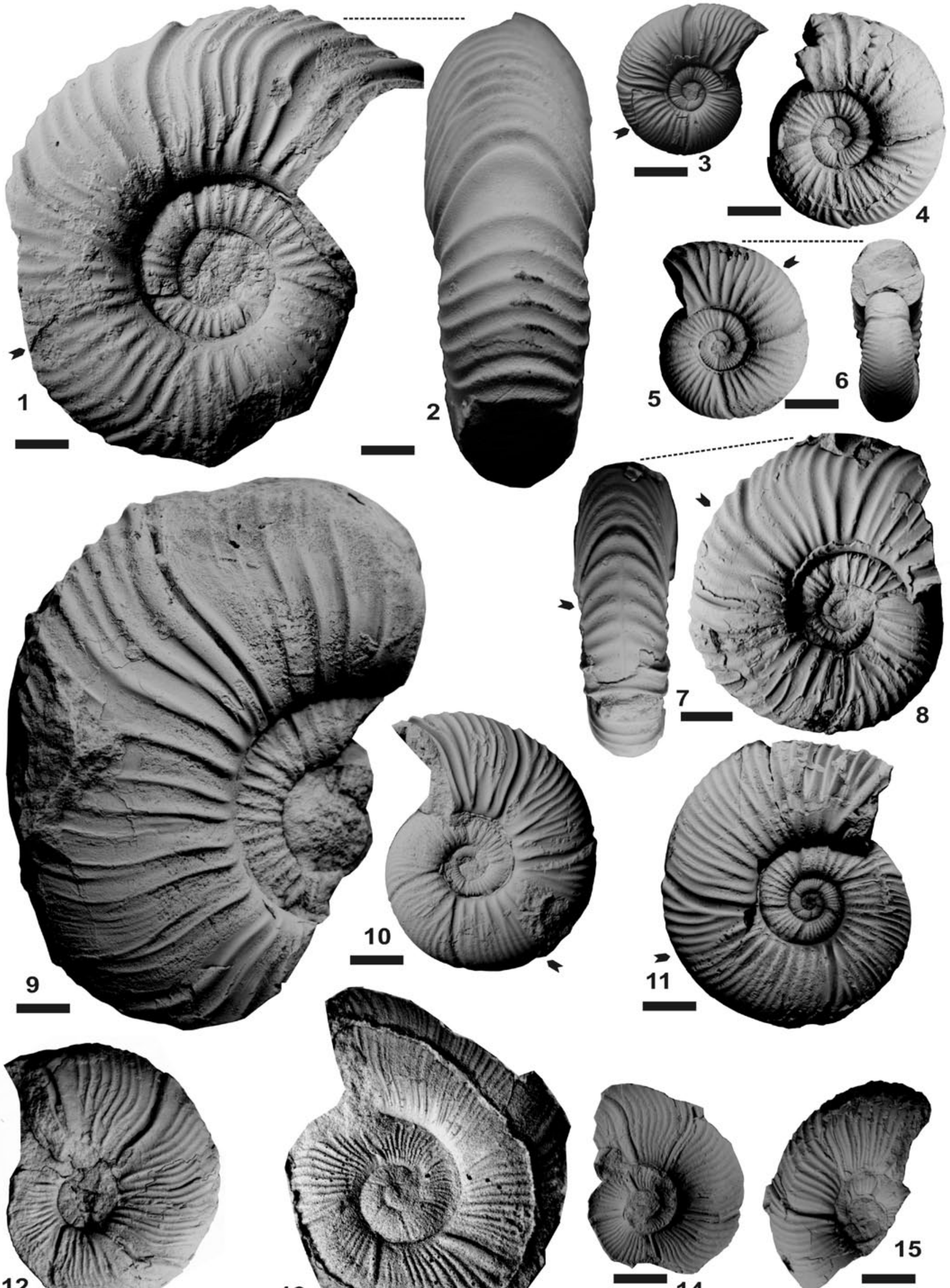
Plate II

Scale bars 1 cm; arrow indicates the last suture.

Figs. 1-12: *Neokossmaticeras redondensis* gen. et sp. nov., Upper Campanian, Rabot Formation, localities Re 24-25, Redonda Point (1-11) and HN 10, Hamilton Norte (12), James Ross Island. 1-2: Holotype, CIRGEO 1550, lateral (1) and ventral (2) views. 3: Lateral view, juvenile specimen CIRGEO 1568. 4: Lateral view, incomplete phragmocone CIRGEO 1562. 5-6: Lateral (5) and apertural (6) views, juvenile specimen CIRGEO 1566. 7-8: Ventral (7) and lateral (8) views, adult specimen with incomplete body chamber CIRGEO 1551. 9: Lateral view, last part of body chamber and inner phragmocone CIRGEO 1596. 10: Lateral view, adult? specimen, phragmocone and part of body chamber CADIC PI 163. 11: Lateral view, juvenile specimen, phragmocone and part of body chamber CIRGEO 1555. 12: Lateral view, deformed, laterally compressed specimen CIRGEO 1539.

Figs. 13-15: Kossmaticeratinae gen. nov., Upper Campanian, Gamma Member, Snow Hill Island Formation, James Ross Island. 13: Silicone cast of external mold of ?adult specimen, locality F70, Santa Marta Cove, CIRGEO 1546. 14: Silicone cast of external mold, juvenile specimen, locality 209, Dreadnought Point, CIRGEO 1537. 15: Incomplete juvenile phragmocone, locality 4M 23, Dreadnought Point, CIRGEO 1536.

Plate II



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