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## THE CRETACEOUS AND PALEOCENE PLEUROTOMARIID (GASTROPODA: VETIGASTROPODA) FAUNA OF SEYMOUR ISLAND, ANTARCTICA

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# THE CRETACEOUS AND PALEOCENE PLEUROTOMARIID (GASTROPODA: VETIGASTROPODA) FAUNA OF SEYMOUR ISLAND, ANTARCTICA

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**ABSTRACT**—*Leptomaria antipodensis* and *Leptomaria hickmanae* are described from the Upper Cretaceous [Maastrichtian] Lopez de Bertodano Formation, Seymour Island, and represent the first Mesozoic records of the family Pleurotomariidae from Antarctica. *Leptomaria stillwelli*, *L. seymourensis*, *Conotomaria sobralensis* and *C. bayeri*, from the Paleocene [Danian], Sobral Formation, Seymour Island, are described as new. *Leptomaria larseniana* (Wilckens, 1911) new combination, also from the Sobral Formation, is redescribed based on better-preserved material. The limited diversity of the pleurotomariid fauna of Seymour Island is more similar to that of the Late Cretaceous faunas of Australia and New Zealand in terms of the number of genera and species, than to the older, more diverse faunas of South America, southern India, or northwestern Madagascar, supporting the status of the Weddellian Province as a distinct biogeographic unit. The increase in the species richness of this fauna during the Danian may be due to the final fragmentation of Gondwana during this period.

## INTRODUCTION

THE THICK sequence of loosely consolidated fossiliferous rocks on Seymour Island represents the most nearly complete and well-exposed shallow-marine section of Upper Cretaceous to lower Tertiary rocks known in the Southern Hemisphere (Zinsmeister, 1982a). Cretaceous and Tertiary marine mollusks from Seymour Island were first described a century ago by Sharman and Newton (1894) and Wilckens (1910, 1911). However, extensive field work on Seymour Island from 1970 through the 1990s revealed much greater molluscan species diversity than had previously been encountered. This was particularly true for the Late Cretaceous and early Paleocene molluscan faunas, which are neither as common nor as well preserved as those of the Eocene (Stillwell et al., 2004). Only one species of the family Pleurotomariidae, *Leptomaria larseniana* (Wilckens, 1911), had previously been described from the Paleocene of the Seymour Island. The 1994 to 1995 field season on Seymour Island yielded six additional species of Pleurotomariidae belonging to two genera—*Leptomaria* E. Eudes-Deslongchamps, 1864, and *Conotomaria* Cox, 1959. These species from the Lopez de Bertodano and Sobral formations range in age from Late Maastrichtian to Early Danian. Three Early Paleocene species of *Conotomaria* were figured by Stillwell et al. (2004) but were not formally described. This review of the pleurotomariid assemblage constitutes the first detailed record of Late Cretaceous to Early Paleocene pleurotomariid gastropods from the continent of Antarctica. This newly described pleurotomariid fauna sheds light on the evolution and biogeographic history of the family Pleurotomariidae in the Southern Hemisphere.

## GEOLOGIC SETTING

The upper Cretaceous and lower Paleocene sedimentary sequence of Seymour Island was described by Anderson (1906), Rinaldi et al. (1978), Zinsmeister (1982a), Macellari and Huber (1982), Macellari and Zinsmeister (1983), Huber (1984), Macellari (1984, 1986, 1988), Sadler (1988), and Stillwell and Zinsmeister (1992) and consists of approximately 1600 m of gently eastward-dipping fossiliferous marine

clastics. Two major stratigraphic units are recognized for the upper Cretaceous and lower Paleocene part of the sequence, the Lopez de Bertodano and Sobral formations. These units comprise the upper part of the Marambio Group (Rinaldi, 1982; Macellari, 1984).

The Lopez de Bertodano Formation (Figs. 1, 2) consists of approximately 1,200 m of tan to medium-gray, concretion-bearing sandstone with occasional horizons of silty sandstone and siltstone (Fig. 2). Some horizons are enriched with limonite, which gives them a reddish-brown color. Hard carbonate concretions are scattered throughout the section. Concretions are spherical to irregularly rounded, range in size from 2 cm up to 1 m in diameter, and commonly contain mollusks preserved in the center. Near the top of the Lopez de Bertodano Formation, concretions seem to become less abundant, and the sandstone grades into light tan siltstone. Finer-grained, medium-gray, sandy siltstones without concretions occur at several horizons throughout the formations. Beds with a large number of concretions tend to form higher and steeper hills as compared with layers free of concretions (Zinsmeister, 1982a). The Lopez de Bertodano Formation is characterized by a large number of well-preserved ammonites, most of which occur in concretions (Zinsmeister, 1982a; Macellari, 1986). Bored and abraded wood debris ranging in size up to 1 m in diameter, bivalves, and gastropods are commonly encountered throughout the sequence. The highly bioturbated nature of the sediments and the absence of primary sedimentary structures indicate that deposition was, in all likelihood, mid-shelf below effective wave-base (Macellari and Zinsmeister, 1983; Macellari, 1988). The age of the Lopez de Bertodano Formation ranges from Maastrichtian through Early Paleocene. An Early Paleocene (Danian stage) age determination of the uppermost unit of the Lopez de Bertodano Formation was based on dinoflagellates (Palmarczuk et al., 1984) and siliceous microfossils (Harwood, 1988), as well as planktic and benthic foraminifers (Huber, 1988). The Lopez de Bertodano Formation is overlain by the slightly sandier Lower Paleocene Sobral Formation. Although there is a disconformity between the Lopez de Bertodano and Sobral

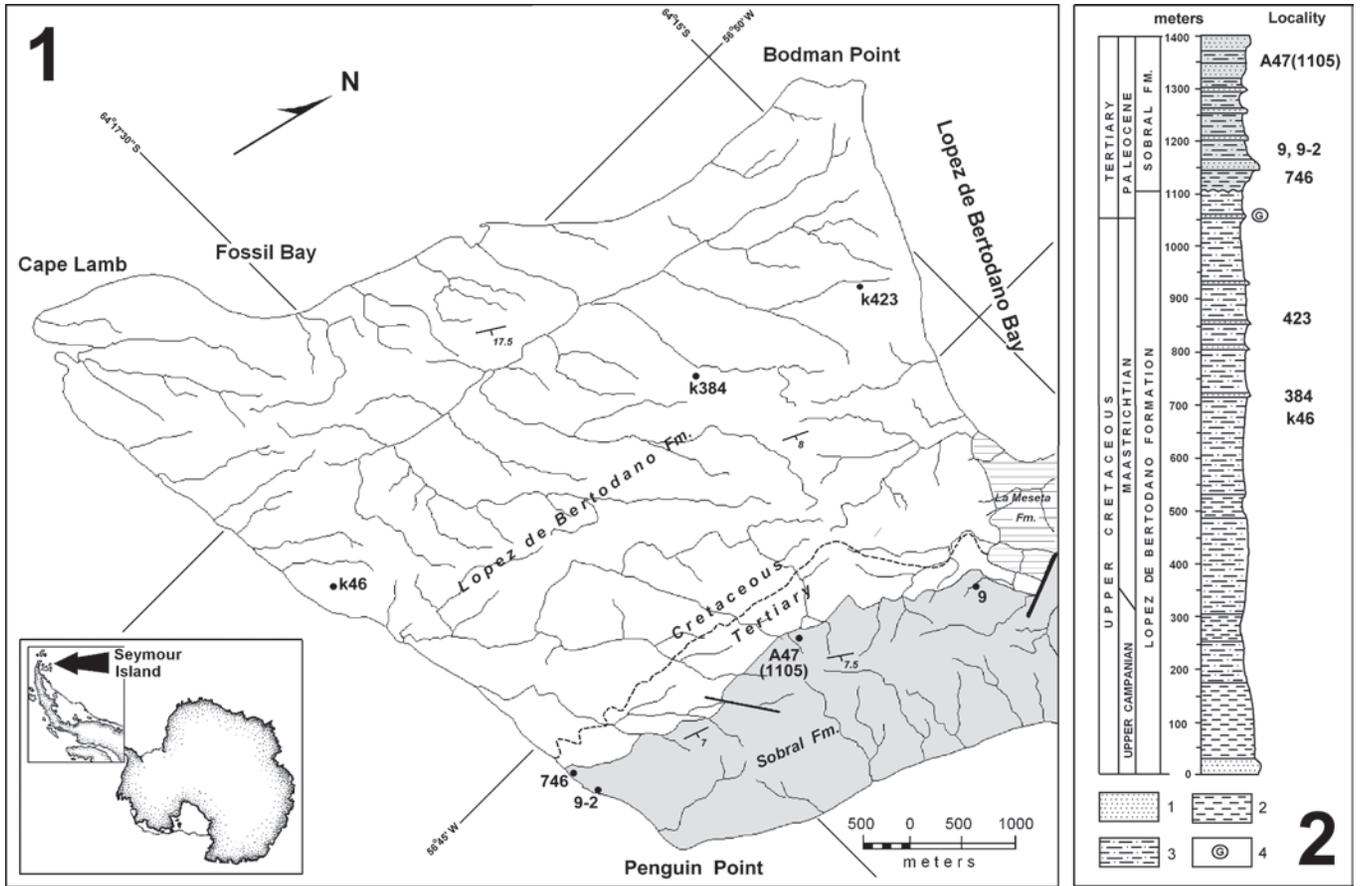
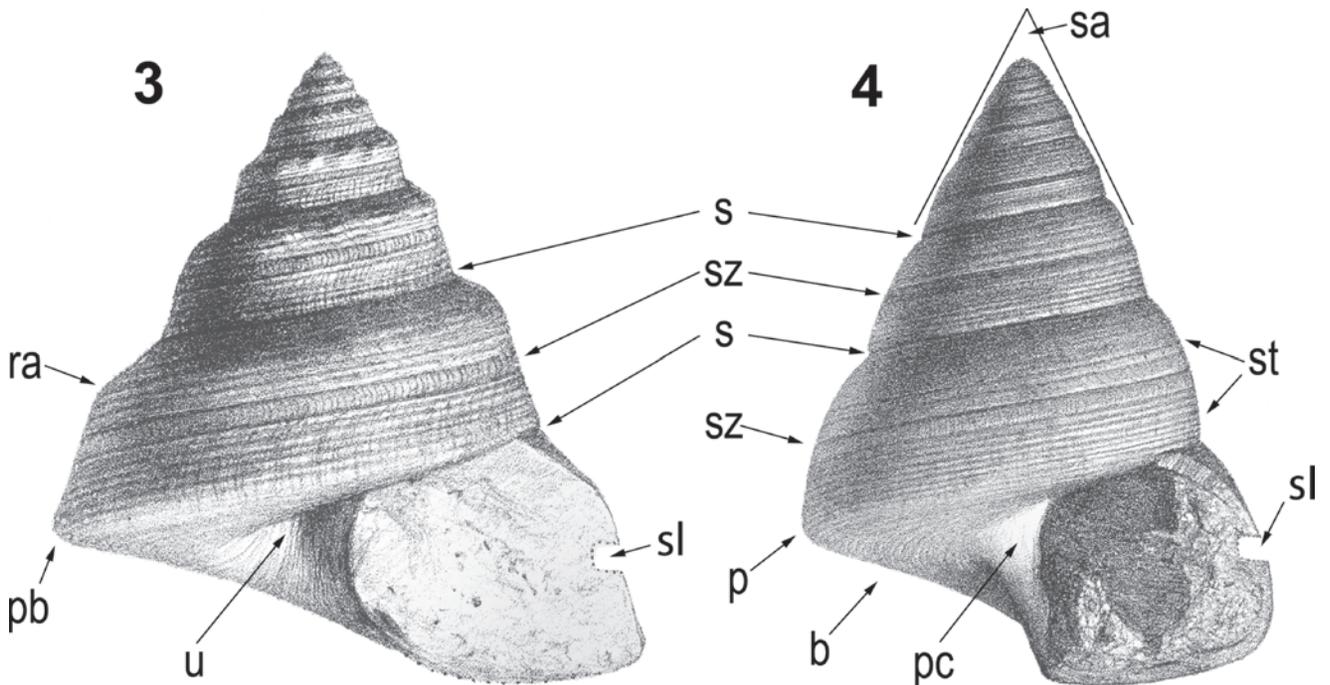


FIGURE 1—Localities on Seymour Island from which Cretaceous and Paleocene pleurotomariids have been collected.  
 FIGURE 2—Stratigraphic distribution of Pleurotomariidae in the Upper Cretaceous and Lower Paleocene sediments of the Seymour Island. 1 = medium to fine-grained sandstone, 2 = mudstone, 3 = siltstone, 4 = glauconite.



FIGURES 3–4—Drawings of 3, umbilicate [phaneromphalous] and 4, non-umbilicate [anomphalous] pleurotomariids, illustrating descriptive terms used in the text. b, base; p, periphery; pb, peripheral bulge; ra, ramp angle; s, suture; sa, spire angle; sl, slit; st, spiral threads, sz, selenizone; u, umbilicus.

formations, faunal similarities between the two units indicate that little time is missing (Elliot and Trautman, 1982; Rinaldi et al., 1978; Macellari and Zinsmeister, 1983; Macellari, 1988).

The Sobral Formation (Figs. 1, 2) consists of approximately 255 m (Macellari, 1988) of silty to medium-grained, well-bedded, dark brown to greenish-grey concretionary sandstone. The lower part of the Sobral Formation consists of 40–90 m of loosely consolidated greenish-grey glauconitic sandstone. The upper 120–170 m of Sobral sandstones is essentially the same in composition but better cemented and more resistant to erosion than the lower part. The combination of numerous concretions in the lower part of the formation and resistant beds overlying the concretionary horizons results in the development of higher and steeper hills as compared to the lower gently rolling topography of the Lopez de Bertodano Formation. Cross-bedding on a scale of 1–3 m becomes well developed and fossil remains become more poorly preserved and less abundant in the uppermost 100 m of the Sobral Formation (Zinsmeister and Macellari, 1988; Stillwell and Zinsmeister, 1992). The upper half of the Lopez de Bertodano Formation and lower part of the Sobral Formation are characterized by diverse and well-preserved marine mega-fossils, dominated by mollusks. Corals, brachiopods, annelid tubes, scaphopods, decapods, echinoderms, marine reptiles and fishes are locally abundant. An early Paleocene (Danian stage) age of the Sobral Formation has been established based on the dinoflagellates (Hall, 1977), planktonic and benthic foraminifers (Huber, 1988; Palmarczuk et al., 1984), and spores and pollen (Askin, 1988), as well as on radiometric dating of glauconite (Macellari, 1984). Specimens used and figured in this paper were collected during the 1994–1995 field seasons on Seymour Island.

Figured types are housed in the United States National Museum of Natural History, Smithsonian Institution, Washington, D.C. (USNM). Additional material is housed in the invertebrate fossil collection of the Department of Earth and Atmospheric Sciences, Purdue University (EASPU).

#### SYSTEMATIC PALEONTOLOGY

##### Class GASTROPODA Cuvier, 1797

##### Subclass ORTHOGASTROPODA Ponder and Lindberg, 1997

##### Superorder VETIGASTROPODA Salvini-Plawen, 1989

##### Superfamily PLEUROTOMARIOIDEA Swainson, 1840

##### Family PLEUROTOMARIIDAE Swainson, 1840

##### Genus LEPTOMARIA E. Eudes-Deslongchamps, 1864

*Type species.*—*Pleurotomaria amoena* J. A. Eudes-Deslongchamps, 1849 (By original designation). Bajocian (Middle Jurassic) of France.

*Diagnosis.*—“Conical or cyrtocoid, anomphalous to broadly phaneromphalous; whorls weakly to strongly convex, not angular, last one rounded at periphery of convex base; selenizone at mid-whorl; ornament spiral threads that may be cancelled by collabral threads. Middle Jurassic (Bajocian) to Upper Cretaceous (Danian). Cosmopolitan.” (Knight et al., 1960, p. I219)

*Range.*—Middle Jurassic (Bajocian) to Paleocene (Thanetian; range extended by Pacaud, 2004:fig. 20). Cosmopolitan.

*Remarks.*—Harasewych and Kiel (2007, p. 77–78) provided an updated synopsis of the supraspecific classification within the family Pleurotomariidae and summarized the currently recognized geological ranges of the genera and subgenera (Harasewych and Kiel (2007, fig. 3, Appendix 1) as well as the characters used to distinguish them (Harasewych and Kiel (2007, table 1). Pacaud (2004, fig. 20) reported *Pleurotomaria* Defrance, 1826 from multiple Danian (Paleocene) records

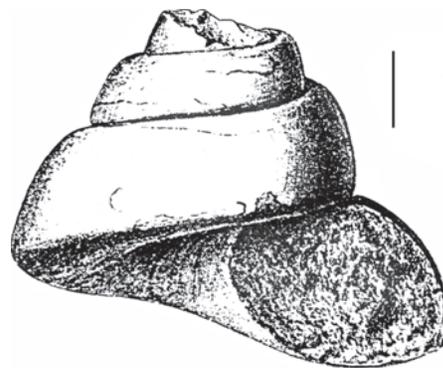


FIGURE 5—*Leptomaria larseniana* (Wilckens, 1911). Reproduction of the original illustration (Wilckens, 1911, pl. 3, fig. 24, as *Pleurotomaria larseniana*). Scale bar = 2 cm.

throughout Europe and extended the ranges of both *Conotomaria* and *Leptomaria* into the Thanetian (Paleocene). These three genera are the only genera that are currently recognized as having survived from the Mesozoic into the Cenozoic.

Whereas the generally applied diagnosis of *Leptomaria* accommodates a broad range of morphologies, the type species, *Leptomaria amoena*, is large, with strongly convex whorls, a well-rounded periphery along the last whorl, a selenizone situated at mid-whorl, and lacking an umbilicus.

#### LEPTOMARIA LARSENIANA (Wilckens, 1910) new combination Figures 5–6, Table 1

*Pleurotomaria larseniana* WILCKENS, 1910, p. 73, pl. 3, fig. 24.

*Original description (translated).*—“Only the internal mold of the shell is present. Apex and aperture are missing. Not quite three whorls are preserved. The shape of the shell is broadly conical, the whorls are laterally flattened and roundly edged below. The selenizone seems to have lain quite close above this edge. The base of the last preserved whorl shows weak curvature. Toward the final whorl, the shell seems to have had strong growth striae.

I name this species after the deserving leader of the ship of the Swedish South Pole expedition, Captain Larsen, who brought the first fossils from the Antarctic.

##### *Dimensions:*

Height (incomplete!) . . . . . 98 mm.

Width . . . . . 114 mm.

*Discovery site:* Seymour Island, Locality 9: 1 specimen (internal mold).

*Similar species:* Comparison with other species is made very difficult by the poor preservation of the single specimen, which makes the description of a new species appear somewhat daring. A *Pleurotomaria* of similarly enormous dimensions, but with a flatter shell shape is *Pl. tardensis* Stanton from the Belgrano layers. The form of the whorls is not very different from that of *Pl. larseni*. Stanton noted that no other Cretaceous species is known to him that could be considered for comparison. There are no similar forms described from the Cretaceous of India, and the Upper Cretaceous and Tertiary of Argentina have not yet produced any *Pleurotomaria*.” (Wilckens, 1910, p. 73).

*Redescription.*—Shell large for genus (maximum diameter 100.4 mm, minimum diameter 85.1 mm, height 108.8 mm), with a tall, broadly conical spire consisting of eight preserved teleoconch whorls. Base weakly but evenly convex, lacking an

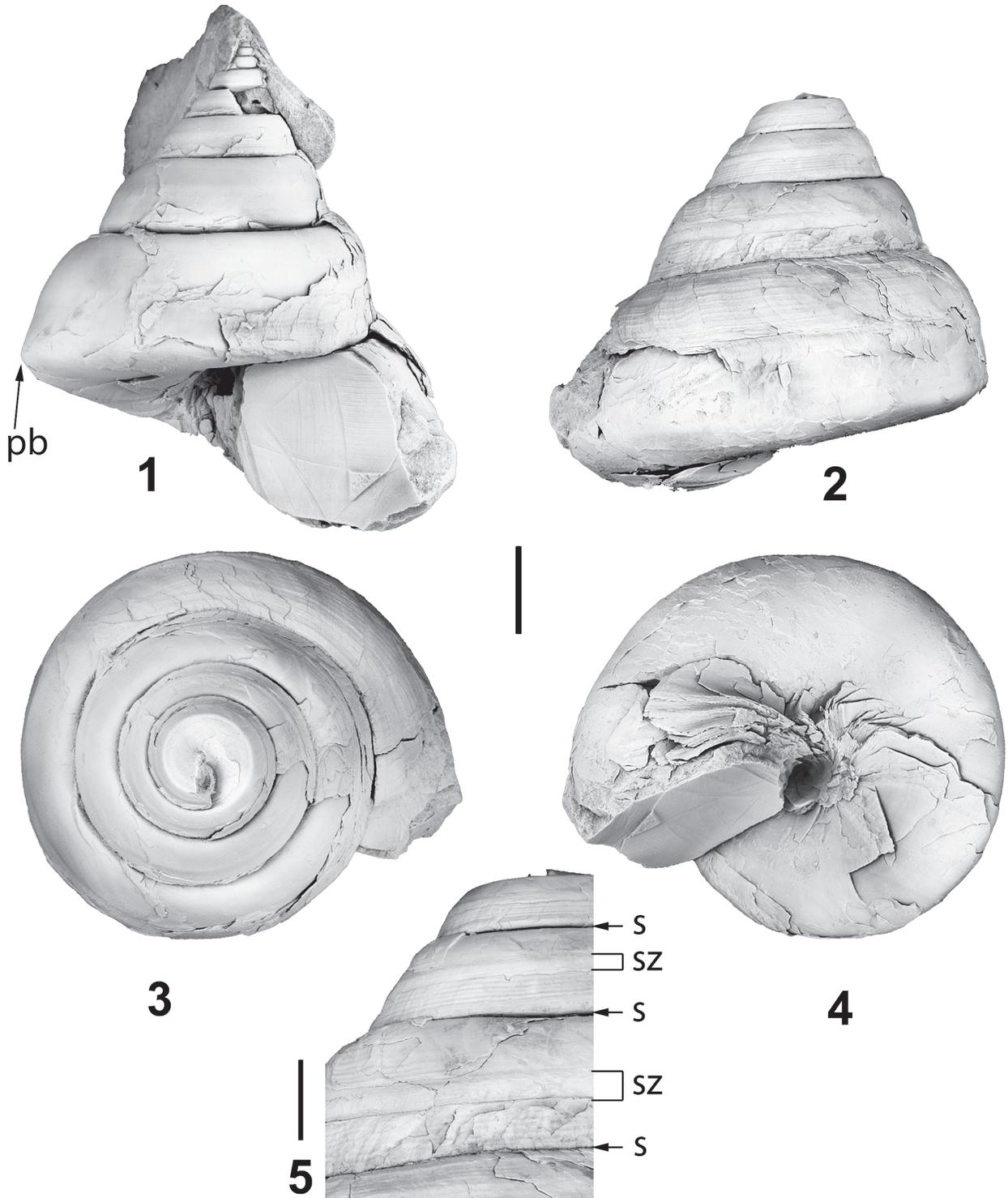


FIGURE 6—*Leptomaria larseniana* (Wilckens, 1911). 1, apertural; 2, dorsal; 3, apical, and 4, basal views of specimen from locality 9, Seymour Island, USNM 467213. 5, Details of sculpture on the dorsal surface of whorls five through seven. Scale bars = 2.0 cm, pb, peripheral bulge; s, suture; sz, selenizone.

umbilicus (Fig. 6.4). Spire angle  $\sim 68^\circ$ . Spire evenly conical in profile. Suture (Fig. 6.5) weakly adpressed, joining previous whorl at or above a weak peripheral bulge (Fig. 6.1). Protoconch and approximately first two teleoconch whorls missing. Subsequent early whorls very weakly gradate, slightly convex, without distinct ramp angle. Spiral sculpture dominant, of six to seven low, narrow cords as broad as intervening

spaces between suture and selenizone, and 12–15 between selenizone and peripheral bulge. Base with similar spiral cords, estimated to be 19–22 on final whorl. Selenizone (Fig. 6.5) broad (selenizone width/suture to suture distance = 0.24), weakly convex, situated at mid-whorl. Surface without spiral cords, sculpture limited to strong lunulae. Axial sculpture limited to fine growth striae that become conspicuously

TABLE 1.—Pleurotomariidae from the Late Cretaceous/Paleocene of Seymour Island, Antarctica, in stratigraphic sequence (youngest to oldest, see Fig. 2), with discriminating characters. s → sz, between suture and selenizone; sz → p, between selenizone and periphery; sz/s → s, selenizone width/suture to suture distance.

Taxon	No. spec.	Strat. posit.	Maximum diameter	Height/diameter	Umbilicus	Spire angle	Spire profile	Periph. bulge	Ramp angle	Cords, s → sz	Cords, sz → p	Cords, base	Sz/s → s	Slit, whorls
<i>Conotomaria sobralensis</i>	1	1240	107.5	1.01	present	68°	conical	strong	absent	10–12	4–5	absent	0.15	1/4
<i>Leptomaria larseniana</i>	1	1167	100.4	1.08	absent, narrow pc	68°	conical	weak	absent	6–7	12–15	19–22	0.24	<1/4
<i>Leptomaria stilwelli</i>	1	1167	95.1	0.72	absent, broad pc	96°	weakly gradate	weak	weak	13–15	3–5	absent?	0.16	<1/4
<i>Conotomaria bayeri</i>	1	1167	48.1	0.61	absent, narrow pc	87°	conical	strong	weak	7–9	5–6	20–25	0.20	<1/3
<i>Leptomaria seymourensis</i>	3	1134	94.4	0.86	absent, narrow pc	84°	conical	moderate	absent	13–15	9–11	31–33	0.13	<1/3
<i>Leptomaria hickmanae</i>	1	855	90.2	0.90	absent, narrow pc	70°	weakly gradate	weak	absent	18–18	9–11	36?	0.17	<1/3
<i>Leptomaria antipodensis</i>	2	703/666	76.5	76.5	absent, narrow pc	62°	conical	moderate	absent	absent	absent	absent	0.19	<1/3

coarser and more irregular on last quarter whorl. Aperture broadly elongate, long axis deflected from the coiling axis by ~104°. Outer lip damaged, slit broad (6.2 mm), extending for less than ¼ whorl. Inner lip thickest along columellar region, where it forms a narrow parietal callus.

*Type locality*.—Seymour Island, Antarctic Peninsula (Fig. 1, Locality 9, 64°16'52.58"S, 56°42'50.64"W).

*Material examined*.—USNM 467213, Paleocene, Danian, Sobral Formation.

*Stratigraphic occurrence*.—1,167 m (Fig. 2).

*Remarks*.—The taxon *Pleurotomaria larseniana* was based on a unique, partial internal mold comprising nearly three whorls, but lacking apex, aperture, or any remnants of shell material (Fig. 5). A redescription of this species, based on a more nearly complete specimen (Fig. 6.1–6.5) from the type locality is provided. This species is transferred to the genus *Leptomaria* on the basis of its high spire, rounded whorl profile, position of selenizone at mid-whorl, absence of shoulder, lack of nodes along periphery or significant axial sculpture and, like the type species, lack of an umbilicus.

Wilckens (1910, p. 73) compared his new species with *Pleurotomaria tardensis* Stanton, 1901 from the Belgrano beds [Barremian, Lower Cretaceous] of Argentina, noting that *P. larseniana* was of similar size but that *P. tardensis* had a much flatter shape. Subsequently, Weaver (1931) reported on four species of pleurotomariids from the Jurassic and early Cretaceous of west-central Argentina. Of the Argentinian pleurotomariids known to date, the Jurassic [Callovian] *Leptomaria leufuensis* (Weaver, 1931), new combination, most closely resembles *L. larseniana* in shape. However, it is much smaller (55 mm diameter), slightly lower spired (spire angle estimated at 70°), with a narrow selenizone, and a moderately developed umbilicus.

*Leptomaria larseniana* does not appear to have close relatives in the Maastrichtian of western Australia (Darragh and Kendrick, 1994). Wilckens (1922, p. 3) compared his *Pleurotomaria maoriensis* [Amuri Group, Late Cretaceous and Paleocene, of New Zealand (Roberts, 1992, fig. 2)] with *L. larseniana*, but the two can be easily distinguished, as *P. maoriensis* has a shoulder. Among the Cretaceous species from India, *L. indica* Stoliczka, 1868 [Ootatoor Group, Cenomanian and Arrialoor Group, Maastrichtian] is comparable in size, but is broadly umbilicate, whereas *P. glabella* Stoliczka, 1868 [Ootatoor Group] is similarly high spired, but smaller, with less inflated whorls, much broader selenizone and more sharply angled periphery.

*Leptomaria larseniana* resembles *L. gyroplata* (Eudes-Deslongchamps, 1849) (see Gründel, 2003, pl. 1, figs. 12–14) from the Bajocian (Middle Jurassic) of southern Germany in terms of size, proportions, absence of umbilicus, shape of whorls, and position and of selenizone.

#### LEPTOMARIA STILWELLI new species

##### Figure 7, Table 1

*Diagnosis*.—Shell large, cyrtocoid, spire angle ~96°, weakly gradate, anomphalous; whorls convex; aperture broadly oval; selenizone narrow, just below mid-whorl; peripheral band weak; spiral sculpture dominant, intersected by weak growth striae.

*Description*.—Shell large (holotype, maximum diameter 95.1 mm, minimum diameter 78.0 mm, height 68.4 mm), with a moderately high, broadly trochiform spire, consisting of three and three quarter preserved teleoconch whorls. Base somewhat inflated, broadly convex, lacking an umbilicus

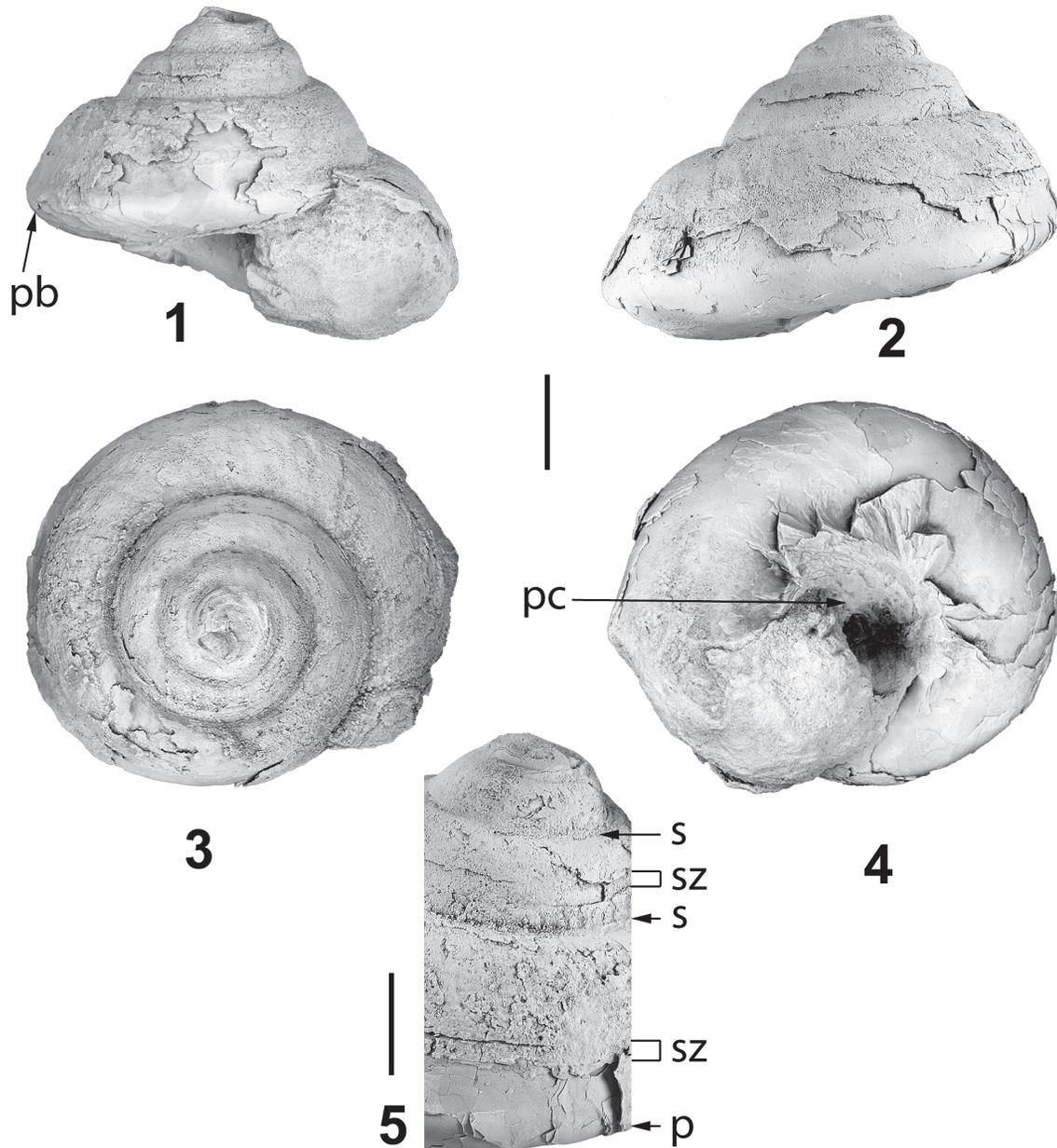


FIGURE 7—*Leptomaria stilwelli* new species. 1, apertural; 2, dorsal; 3, apical, and 4, basal views of the holotype, USNM 467214. Locality 9, Seymour Island. 5, Details of sculpture on dorsal surface. Scale bars = 2.0 cm, p, periphery; pb, peripheral bulge; pc, parietal callus; s, suture; sz, selenizone.

(Figure 7.4). Spire angle  $\sim 96^\circ$ . Spire conical, weakly gradate in profile. Suture (Fig. 7.5) abutting, joining previous whorl long the top of a weak peripheral bulge (Fig. 7.1). Protoconch and first several teleoconch whorls missing. Subsequent whorls weakly gradate, smoothly convex, with a distinct ramp angle. Spiral sculpture dominant, with an estimated 13–15 broad, closely spaced cords between suture and selenizone, and three to five between the selenizone and periphery. Sculpture along base not well preserved, region near columella smooth (Fig. 7.4). Selenizone (Fig. 7.5) narrow (selenizone width/suture to suture distance = 0.16), weakly convex, situated slightly below mid-whorl. Lunulae concave, surface sculpture unknown. Axial sculpture limited to fine growth striae on early whorls, with weak, low rugae (about 40) developing on final whorl. Aperture broadly ovate, long axis deflected from the coiling axis by  $\sim 100^\circ$ . Outer lip damaged, slit narrow,

4.1 mm, extending for less than one quarter whorl. Shell thickest along inner lip and base near columellar region (2.2 mm), adjacent to a broad, nacreous parietal callus (Fig. 7.4).

*Etymology*.—This species is named for Dr. Jeffery D. Stilwell, School of Geosciences, Monash University, Melbourne, Australia, for his contribution to the study of Cretaceous and early Tertiary faunas of the Southern Hemisphere.

*Types*.—Holotype, USNM 467214, Paleocene, Danian, Sobral Formation, Seymour Island, Antarctic Peninsula (Fig. 1, Locality 9;  $64^\circ 16' 52.58''\text{S}$ ,  $56^\circ 42' 50.64''\text{W}$ ).

*Stratigraphic occurrence*.—1,167 m (Fig. 2).

*Remarks*.—*Leptomaria stilwelli* co-occurs with *L. larseniana* but can be readily distinguished from that species by its lower, more gradate spire, more inflated base, and narrower

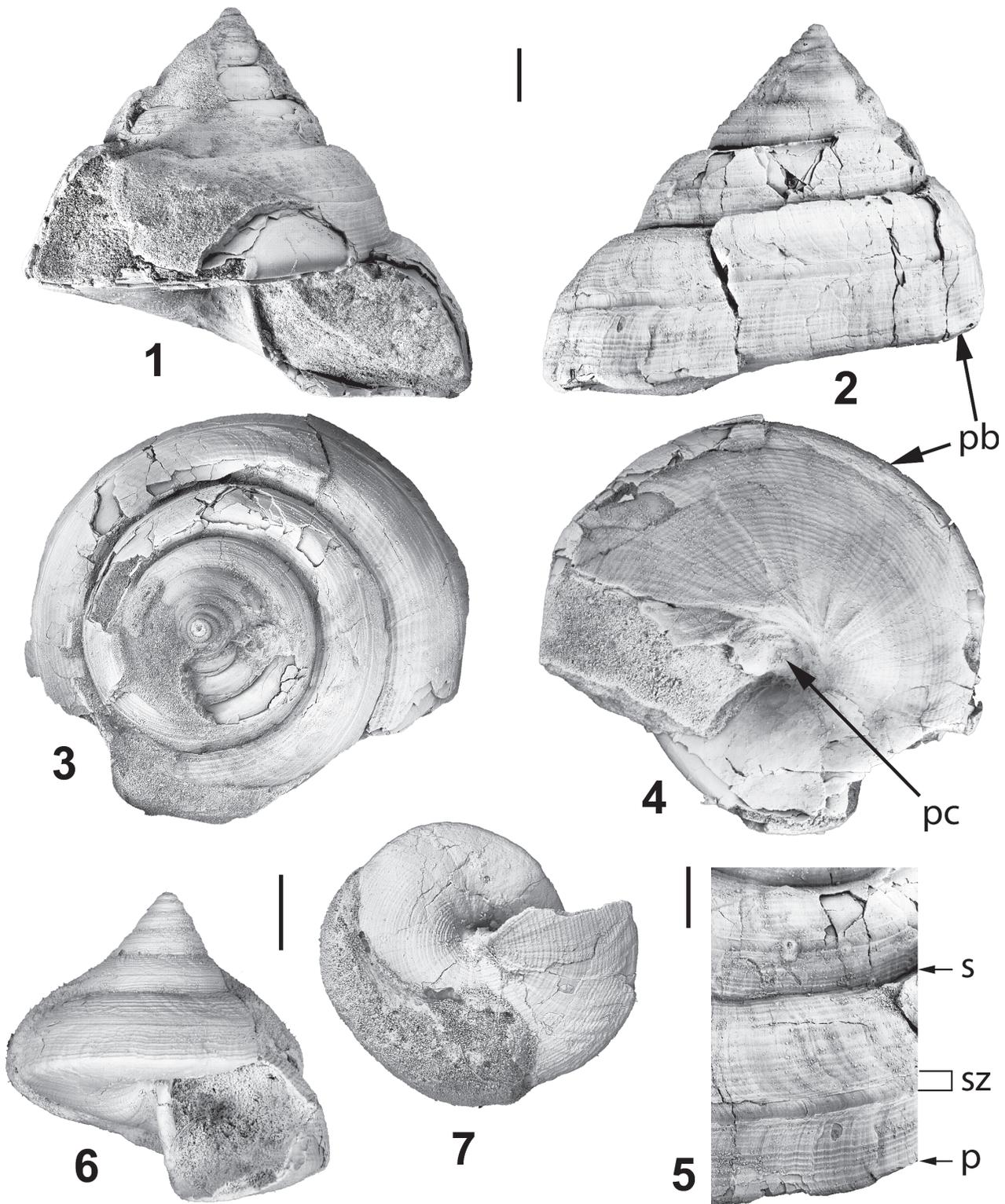


FIGURE 8—*Leptomaria seymourensis* new species. 1, apertural; 2, dorsal; 3, apical, and 4, basal views of the holotype, USNM 467215. Station 746, Seymour Island. 5, Details of sculpture on dorsal surface of holotype; 6, apertural, and 7, basal views of paratype 1. USNM 467216. Locality 746, Seymour Island. Scale bars = 2.0 cm, p, periphery; pb, peripheral bulge; pc, parietal callus; s, suture; sz, selenizone.

selenizone, as well as by the presence of axial rugae on the final whorl.

It does not appear to be similar to fossils reported from the Cretaceous of New Zealand or Australia, but it resembles *Leptomaria leufuensis* [Callovian, Argentina], from which it may

be separated on the basis of its larger size, more inflated whorls, and absence of an umbilicus, and from *L. daityai* Das, Bardhan and Kase, 2005 [Callovian–Oxfordian, NW India], which is similar in size and sculpture, but is umbilicate and has strong spiral sculpture along the base, which is lacking in *L. stillwelli*.

## LEPTOMARIA SEYMOURENSIS new species

Figures 8–9, Table 1

*Conotomaria* species C; STILWELL, ZINSMEISTER AND OLEINIK, 2004, p. 26, pl. 4, fig. 5, 6.

**Diagnosis.**—Shell large, cyrtocooid, weakly gradate, spire angle  $\sim 84^\circ$ , anomphalous; whorls weakly convex; aperture broadly rhomboidal; selenizone narrow, just below mid-whorl; peripheral band weak; spiral sculpture dominant, reticulate sculpture present on early whorls and along shell base.

**Description.**—Shell large for genus (holotype, maximum diameter 94.4 mm, minimum diameter 75.8 mm, height 81.4 mm; paratype 2, maximum diameter 118.4 mm, minimum diameter 102.2 mm, height 87.5 mm), with a broadly conical spire consisting of eight preserved teleoconch whorls. Base weakly sigmoidal, slightly concave near periphery, slightly convex near axis, lacking an umbilicus (Fig. 8.4). Spire angle  $\sim 84^\circ$ . Spire weakly gradate in profile. Suture (Fig. 8.5) abutting previous whorl along top of a peripheral bulge (Figs. 8.2, 8.4) that becomes more pronounced in later whorls. Protoconch and first few teleoconch whorls absent in holotype and paratypes. Subsequent teleoconch whorls become progressively more convex between suture and selenizone without producing an angled shoulder. Region between selenizone and periphery straight to slightly convex. Spiral sculpture dominant, with 13–15 low, narrow cords between the suture and selenizone, 9–11 between the selenizone and periphery. Cords more prominent and closely spaced near the suture and periphery, finer and more widely spaced near the selenizone. Base with 31–33 evenly spaced spiral cords that become slightly more pronounced adaxially. Selenizone (Fig. 8.5) narrow (selenizone width/suture to suture distance = 0.13), flat to weakly convex, situated slightly below mid-whorl. Surface with strong lunulae and zero to one spiral cords in early whorls, thereafter with weaker, less concave lunulae and without spiral sculpture. Axial sculpture of fine growth striae that may produce reticulate sculpture on early whorls and along shell base. Aperture broadly rhomboidal, long axis deflected from the coiling axis by  $112\text{--}114^\circ$ . Outer lip damaged, slit narrow  $\sim 3.5$  mm, extending for less than one third whorl. Inner lip thickest along base and columellar region, where it forms a narrow, nacreous parietal callus.

**Etymology.**—Named after its type locality, Seymour Island, Antarctica.

**Types.**—Holotype, USNM 467215, Paratype 1, USNM 467216, Paratype 2, USNM 467217, all Paleocene, Danian, Lopez de Bertodano Formation, Seymour Island, Antarctic Peninsula (Fig. 1, Locality 746;  $64^\circ 19' 02.4''\text{S}$ ,  $56^\circ 48' 42.4''\text{W}$ ).

**Stratigraphic occurrence.**—1,134 m (Fig. 2).

**Remarks.**—*Leptomaria seymourensis* appears lower in the stratigraphic column than *L. larseniana* and *L. stillwelli*. It is similar to *L. stillwelli* in spire height but can be readily distinguished from this species on the basis of its more gradate spire, angled periphery, more pronounced peripheral band, and flatter base. *Leptomaria seymourensis* more closely resembles *L. larseniana* in whorl profile but has a narrower selenizone and stronger spiral cords, especially along the base. Unlike other species from Seymour Island, *L. seymourensis* has finely reticulate sculpture on the early whorls. *Leptomaria seymourensis* also resembles *L. asurai* Das, Bardhan and Kase, 2005 [Callovian–Oxfordian, NW India] but has a lower, more stepped spire, less inflated whorls, and a more quadrate aperture.

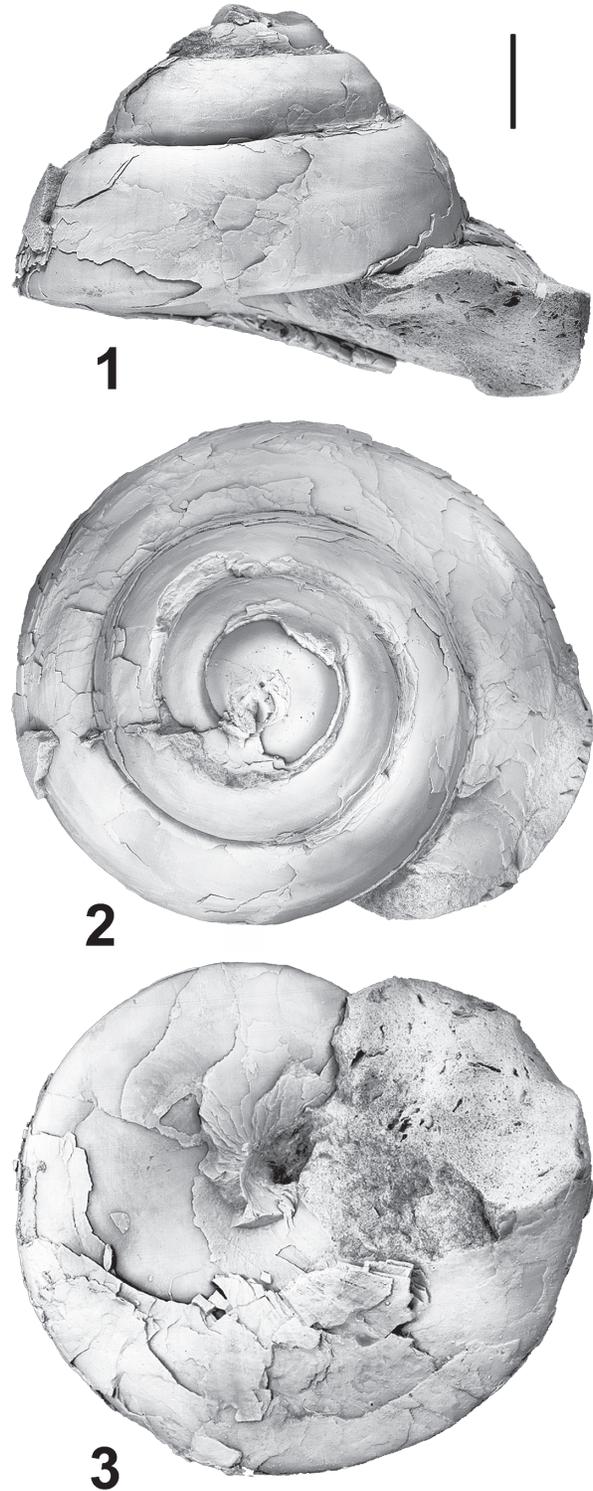


FIGURE 9—*Leptomaria seymourensis* new species. 1, apertural; 2, apical, and 3, basal views of paratype 2, USNM 467217. Locality 746, Seymour Island. Scale bar = 2.0 cm.

## LEPTOMARIA HICKMANAE, new species

Figure 10, Table 1

**Diagnosis.**—Shell large, cyrtocooid, spire angle  $\sim 70^\circ$ , anomphalous; whorls strongly convex; aperture broadly ovate; selenizone broad, just below mid-whorl; peripheral band weak; spiral sculpture dominant.

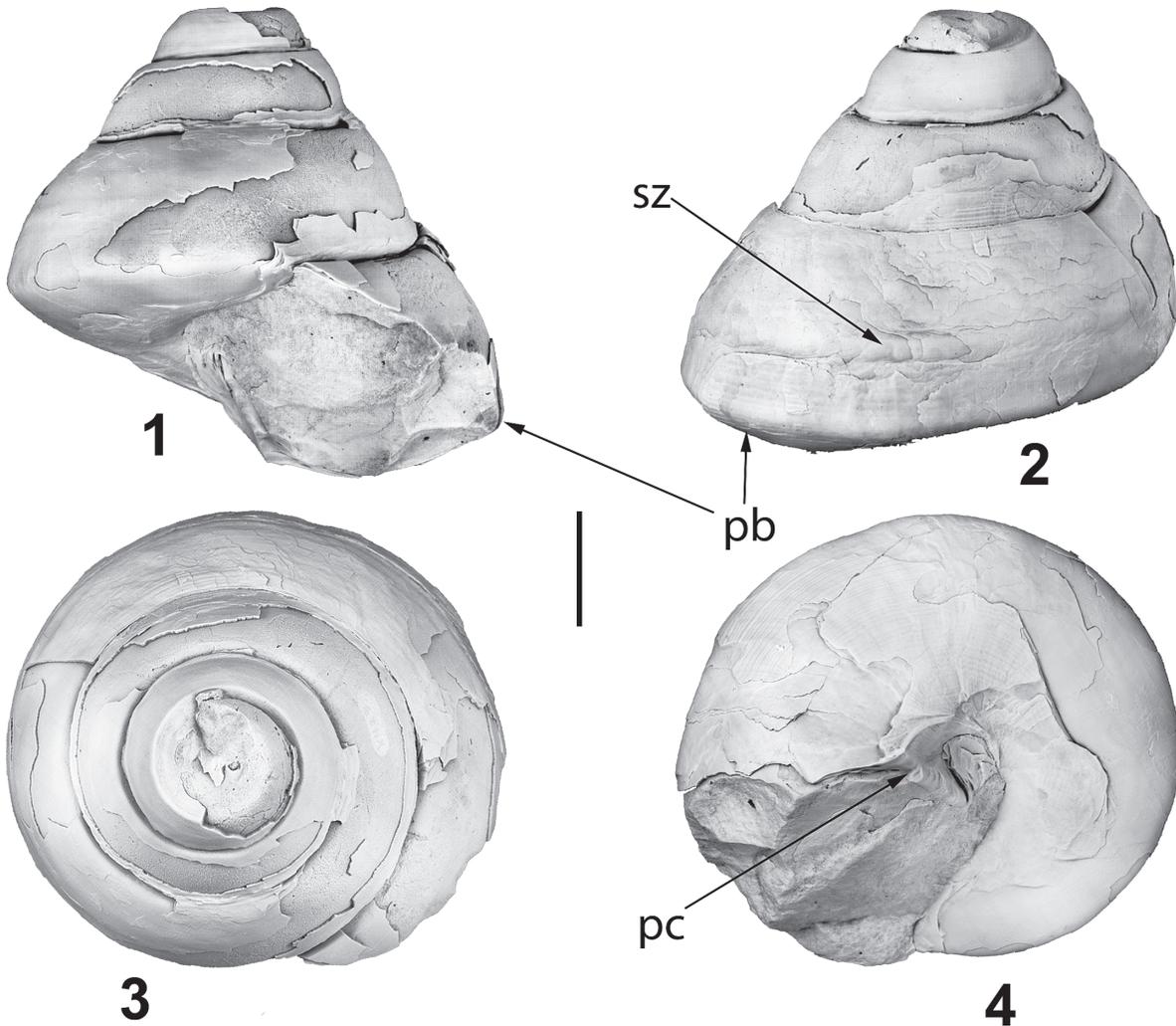


FIGURE 10—*Leptomaria hickmanae* new species. 1, apertural; 2, dorsal; 3, apical, and 4, basal views of the holotype, USNM 467218. Locality K-423, Seymour Island. Scale bar = 2.0 cm, pb, peripheral bulge; pc, parietal callus; sz, selenizone.

**Description.**—Shell large for genus (maximum diameter 90.2 mm, minimum diameter 79.9 mm, height 81.0 mm), with a tall, broadly trochiform spire, consisting of three and a half preserved teleoconch whorls. Base inflated, broadly convex, lacking an umbilicus (Fig. 10.4). Spire angle  $\sim 70^\circ$ . Spire evenly conical in profile. Suture adpressed, joining previous whorl at or above a weak peripheral bulge (Figs. 10.1, 10.2). Protoconch and approximately first four teleoconch whorls missing. Subsequent whorls very weakly gradate, smoothly convex, without distinct ramp angle. Spiral sculpture dominant, with an estimated 15–18 low, narrow cords slightly broader than intervening spaces between suture and selenizone, and 9–11 between selenizone and periphery. Base with similar but weaker spiral cords, estimated to be 36 on final whorl. Selenizone moderately wide (Fig. 10.2; selenizone width/suture to suture distance = 0.17), weakly convex, situated slightly below mid-whorl. Lunulae concave, surface sculpture unknown. Axial sculpture limited to fine growth striae. Aperture broadly ovate, long axis deflected from the coiling axis by  $\sim 102^\circ$ . Outer lip damaged, slit moderately wide 5.5 mm, extending for less than one third whorl. Inner lip thickest along columellar region, where it forms a narrow, nacreous parietal callus (Fig. 10.4).

**Etymology.**—This species is named for Dr. Carole S. Hickman of the University of California at Berkeley, in recognition of her contributions to the study of living and fossil Pleurotomariidae.

**Types.**—Holotype, USNM 467218, Upper Cretaceous, Maastrichtian, Lopez de Bertodano Formation, Seymour Island, Antarctic Peninsula (Fig. 1, Locality K 423;  $64^\circ 15' 18.1''\text{S}$ ,  $56^\circ 46' 02.3''\text{W}$ ).

**Stratigraphic occurrence.**—855 m (Fig. 2).

**Remarks.**—*Leptomaria hickmanae* may easily be distinguished from all other pleurotomariids presently known from Seymour Island on the basis of its cyrtocooid shape, strongly convex whorls, well rounded periphery, very broadly ovate (nearly circular) aperture, and broad selenizone situated just below mid-whorl. It resembles *L. amoena* [Bajocian, France], the type species of the genus in shape and general proportions but is larger in size and appears to lack the reticulate surface sculpture of that species.

*Leptomaria hickmanae* closely resembles *Pleurotomaria vacavillensis* Hickman, 1976 [California, USA], which is here reassigned to the genus *Leptomaria*. *Leptomaria vacavillensis* appears to be higher spired than *L. hickmanae*, and also to have a broader selenizone that is situated above rather than

below mid-whorl. Hickman (1976, p. 1099) noted that the locality data accompanying the holotype of *L. vacavillensis* “are not sufficiently precise to determine its stratigraphic position, which is either lower Eocene or Upper Cretaceous.” Similarities of this species to other *Leptomaria* would suggest that *L. vacavillensis* lived during the Upper Cretaceous rather than the Eocene.

LEPTOMARIA ANTIPODENSIS new species

Figure 11, Table 1

*Diagnosis.*—Shell small, conoidal, spire angle  $\sim 62^\circ$ , anomphalous; whorls very weakly convex; aperture rhomboidal; selenizone broad, well below mid-whorl; peripheral band prominent; spiral sculpture weak to absent, axial sculpture limited to growth striae of varying prominence.

*Description.*—Shell small for genus (maximum diameter 76.5 mm, minimum diameter 68.5 mm, height 75.1 mm), with a tall, conical spire, consisting of four and one half preserved teleoconch whorls. Base weakly convex, nearly flat, lacking an umbilicus (Fig. 11.4). Spire angle  $\sim 62^\circ$ . Spire evenly conical in profile. Suture (Fig. 11.5) abutting previous whorl below periphery of a pronounced peripheral bulge (Figs. 11.2, 11.5). Protoconch and approximately first three teleoconch whorls missing. Subsequent whorls conical, not gradate, very weakly convex. Spiral sculpture weak to absent between suture and selenizone, limited to weak threads and cords most conspicuous near peripheral bulge. Base without discernible spiral sculpture. Selenizone moderately wide (Fig. 11.5; selenizone width/suture to suture distance = 0.19), flat to weakly convex, situated below mid-whorl. Lunulae strongly concave, surface sculpture unknown. Axial sculpture limited to growth striae of varying intensity. Aperture narrowly ovate, long axis deflected from the coiling axis by  $\sim 107^\circ$ . Outer lip damaged, slit moderately wide 4.5 mm, extending for less than one third whorl. Shell relatively thin, thickest along columellar region and base. Columella with a narrow, nacreous parietal callus (Fig. 11.4).

*Etymology.*—*Antipodes* Greek—having the feet opposite, + *ensis*, Latin—place of origin or habitat. = from the opposite end of the world.

*Types.*—Holotype, USNM 467219, Upper Cretaceous, Maastrichtian, Lopez de Bertodano Formation, Seymour Island, Antarctic Peninsula (Fig. 1, Locality K-384;  $64^\circ 16' 27.7''$ S,  $56^\circ 46' 48.3''$ W).

*Other material examined.*—Paratype, USNM 468220, Upper Cretaceous, Maastrichtian, Lopez de Bertodano Formation, Seymour Island, Antarctic Peninsula (Fig. 1, Locality K-46;  $64^\circ 18' 56.7''$ S,  $56^\circ 48' 43.4''$ W).

*Stratigraphic occurrence.*—K-384 = 703 m, K-46 = 666 m (Fig. 2).

*Remarks.*—This new species is placed in the genus *Leptomaria* with some reservation, as it lacks the strongly convex whorls, rounded periphery and medial placement of the selenizone characteristic of the type species. *Leptomaria antipodensis* resembles *L. larseniana* in spire height, but its shell is more conical, with whorls that are nearly straight-sided. Unlike *L. larseniana*, the suture of *L. antipodensis* is situated below a pronounced peripheral bulge, the selenizone is closer to the shell periphery, and the spiral sculpture appears to be much weaker, limited to the peripheral bulge and adjacent areas. It is similar to *Conotomaria sobralensis* (see below) in terms of size and shell profile but can be readily distinguished from that species by the absence of an umbilicus.

Genus CONOTOMARIA Cox, 1959

*Type species.*—*Pleurotomaria mailleana* d'Orbigny, 1843, (by original designation). Cenomanian (Late Cretaceous) of France.

*Diagnosis.*—“Conical, anomphalous to broadly phaneromphalous; whorls flat or slightly sigmoidal in outline, last whorl with sharply angular, often bulging periphery; selenizone at or above mid-whorl, quite close to suture in some species, not coinciding with an angulation; predominant ornament of spiral cords. Jurassic and Cretaceous.” (Cox, 1959, p. 238).

*Range.*—Middle Jurassic (Bajocian) to Paleocene (Thanetian; range extended by Pacaud, 2004, fig. 20). Cosmopolitan.

*Remarks.*—As with *Leptomaria*, *Conotomaria* has been broadly defined to include a wide range of shell forms. The type species of *Conotomaria*, *C. mailleana*, has a shell that is large and broadly conical with whorls that are sigmoidal in profile, and an angular, slightly bulging periphery, a selenizone that is situated at or above mid-whorl, and a broad umbilicus.

CONOTOMARIA SOBRALENSIS new species

Figure 12, Table 1

*Conotomaria* species A; STILWELL, ZINSMEISTER AND OLEINIK, 2004, p. 25, pl. 4, fig. 1, 2.

*Diagnosis.*—Shell large, conical, spire angle  $\sim 68^\circ$ , narrowly phaneromphalous; whorls weakly convex; aperture trapezoidal; selenizone broad, at mid-whorl; peripheral band prominent; spiral sculpture of weak broad cords; base with only axial growth striae.

*Description.*—Shell large for genus (holotype maximum diameter 107.5 mm, minimum diameter 94.0 mm, height 108.1 mm), with a high conical spire consisting of eight preserved teleoconch whorls. Base very weakly convex, with narrow umbilicus (Fig. 12.4). Spire angle  $\sim 68^\circ$ . Early whorls conical, trochiform, final whorl broader. Suture (Fig. 12.2) abutting previous whorl along base of peripheral bulge (Fig. 12.2). Protoconch and first few teleoconch whorls absent in holotype. Subsequent teleoconch whorls convex between suture and selenizone, with maximum curvature just below the suture but without producing an angled shoulder. Region between selenizone and periphery straight. Spiral sculpture of 10–12 weak, broad cords between suture and selenizone, four to five barely discernible cords between the selenizone and periphery, and three to four stronger cords along the peripheral bulge. Base with only axial growth lines and rugae. Selenizone moderately broad (Fig. 12.2; selenizone width/suture to suture distance = 0.15), flat to weakly convex, situated slightly below mid-whorl. Surface with weak lunulae and without discernible spiral cords. Axial sculpture of fine growth striae that become weakly rugose on final whorl, most evident between selenizone and periphery, and along the base. Aperture broadly rhomboidal, long axis deflected from the coiling axis by  $\sim 117^\circ$ . Outer lip worn, slit broad  $\sim 14$  mm, extending for about one quarter whorl. Inner lip thickest along base and columellar region. Umbilicus deep and narrow, forming a narrow, nacreous, parietal callus.

*Etymology.*—Named after the Sobral Formation, described by Rinaldi (1977) as a part of the Marambio Group. Known only from Seymour Island, it was named after Punta Sobral, better known as Penguin Point on the maps of the Seymour Island.

*Types.*—Holotype, USNM 467221, Paleocene, Danian, Sobral Formation, Seymour Island, Antarctic Peninsula (Fig. 1, Locality A47;  $64^\circ 16' 56.0''$ S,  $56^\circ 42' 58.9''$ W).

*Stratigraphic occurrence.*—1,240 m (Fig. 2).

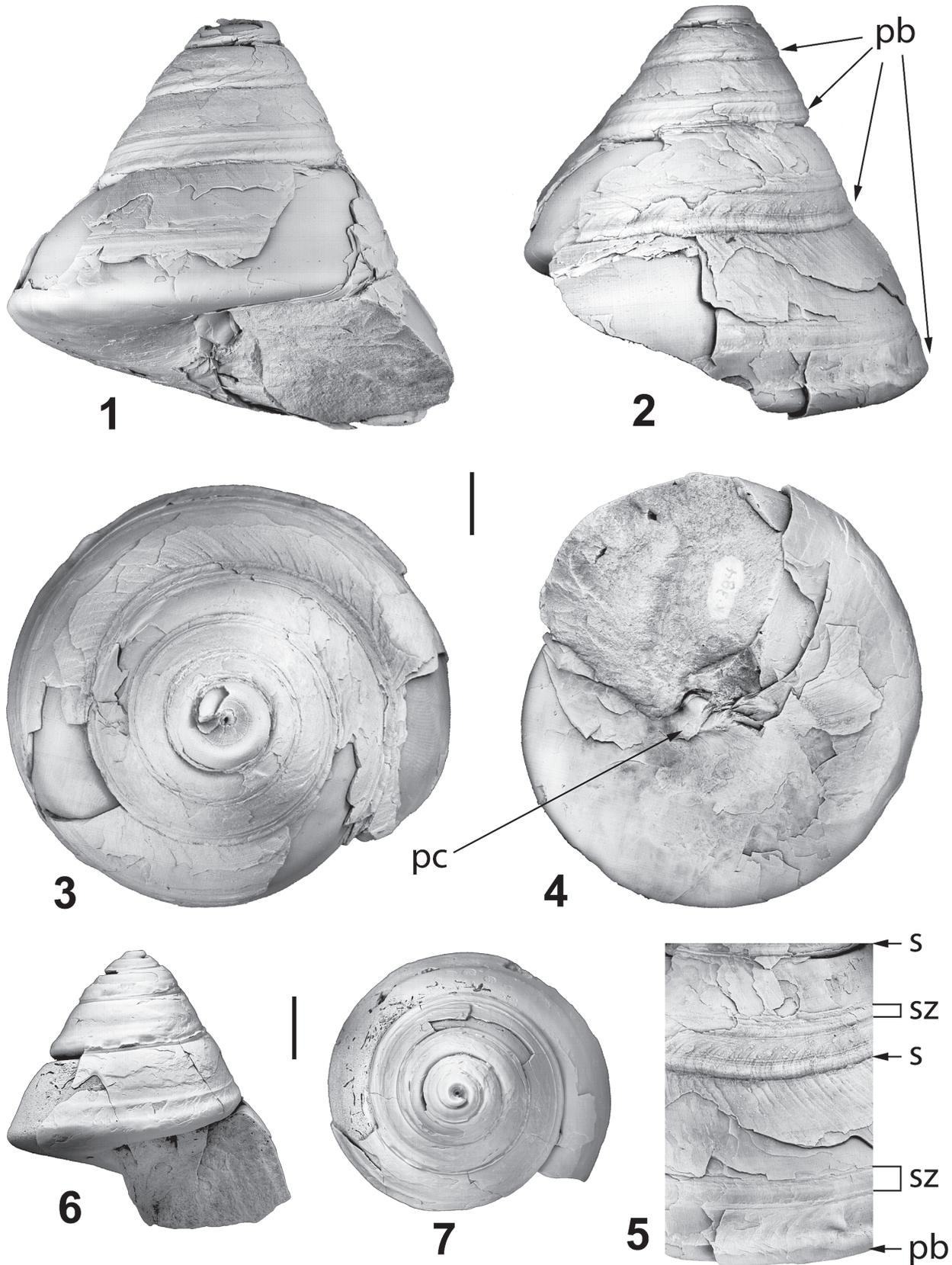


FIGURE 11—*Leptomaria antipodensis* new species. 1, apertural; 2, lateral; 3, apical, and 4, basal views of the holotype, USNM 467219. Locality K-384, Seymour Island. 5, details of sculpture on lateral surface of the holotype; 6, apertural, and 7, apical views of the paratype, USNM 467220. Locality K-46, Seymour Island. Scale bars = 2.0 cm, pb, peripheral bulge; pc, parietal callus; s, suture; sz, selenizone.

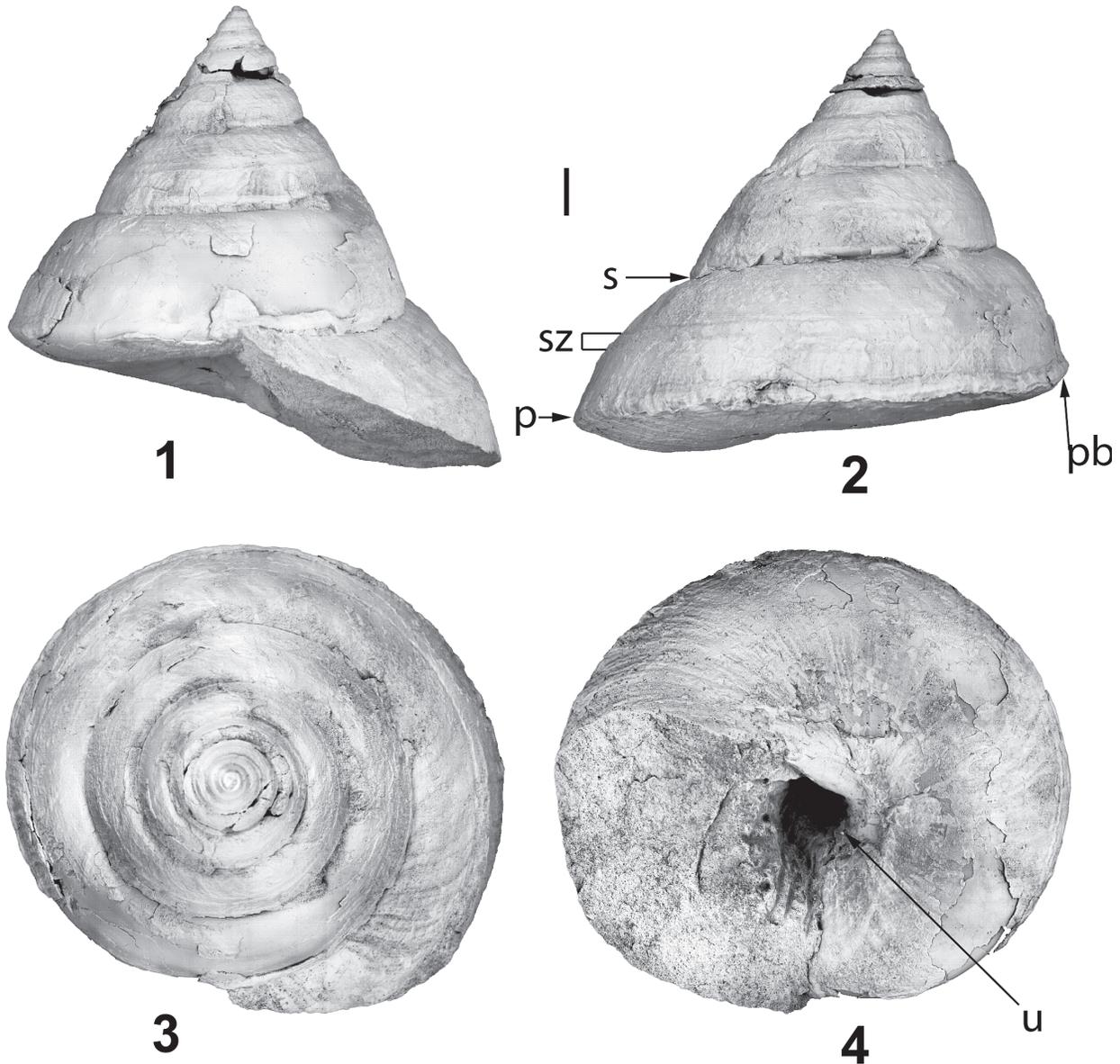


FIGURE 12—*Conotomaria sobralensis* new species. 1, apertural; 2, dorsal; 3, apical, and 4, basal views of the holotype, USNM 467221. Locality A47, Seymour Island. Scale bar = 2.0 cm, p, periphery; pb, peripheral bulge; s, suture; sz, selenizone; u, umbilicus.

*Remarks.*—This species is assigned to the genus *Conotomaria* on the basis of its broadly conical shell, sigmoidal whorl profile, angular periphery with distinct bulge, and broad umbilicus. It is closely allied with the Cretaceous type species, *C. mailleana* from France but has slightly more convex whorls, a broader, lower selenizone, and a slightly less developed peripheral bulge. Of the Seymour Island pleurotomariids, it resembles *Leptomaria antipodensis* (see above) in general form, but may easily be distinguished by its broad umbilicus, and in having the selenizone above rather than below mid-whorl.

CONOTOMARIA BAYERI new species  
Figure 13, Table 1

*Conotomaria* species B; STILWELL, ZINSMEISTER AND OLEINIK, 2004, p. 25–26, pl. 4, fig. 3, 4.

*Diagnosis.*—Shell small, conical, spire angle  $\sim 87^\circ$ , narrowly anomphalous; whorl profile weakly sigmoidal; aperture trapezoidal; selenizone broad, at mid-whorl; peripheral broad

and weak; spiral sculpture of low broad cords also present on base.

*Description.*—Shell small (maximum diameter 48.1 mm, minimum diameter 40.9 mm, height 29.4 mm), thick (1.0 mm on ramp of last whorl), with a broad, low conical spire consisting of three preserved teleoconch whorls. Base evenly convex, lacking an umbilicus (Fig. 13.4). Spire angle  $\sim 87^\circ$ . Spire evenly conical, with pronounced peripheral bulge (Figs. 13.1, 13.5). Suture (Fig. 13.5) abutting previous whorl along base of peripheral bulge. Protoconch and first several whorls absent in holotype. Subsequent teleoconch whorls sigmoidal, slightly convex between suture and selenizone, slightly concave between selenizone and peripheral bulge. Spiral sculpture dominant, with seven to nine low, broad cords between the suture and selenizone, five to six between the selenizone and peripheral bulge. Base poorly preserved, with vestiges of broad, shallow cords (estimated 20–25) and narrow parietal callus (Fig. 13.4). Selenizone moderately broad ((Fig. 13.4; selenizone width/suture to suture distance =

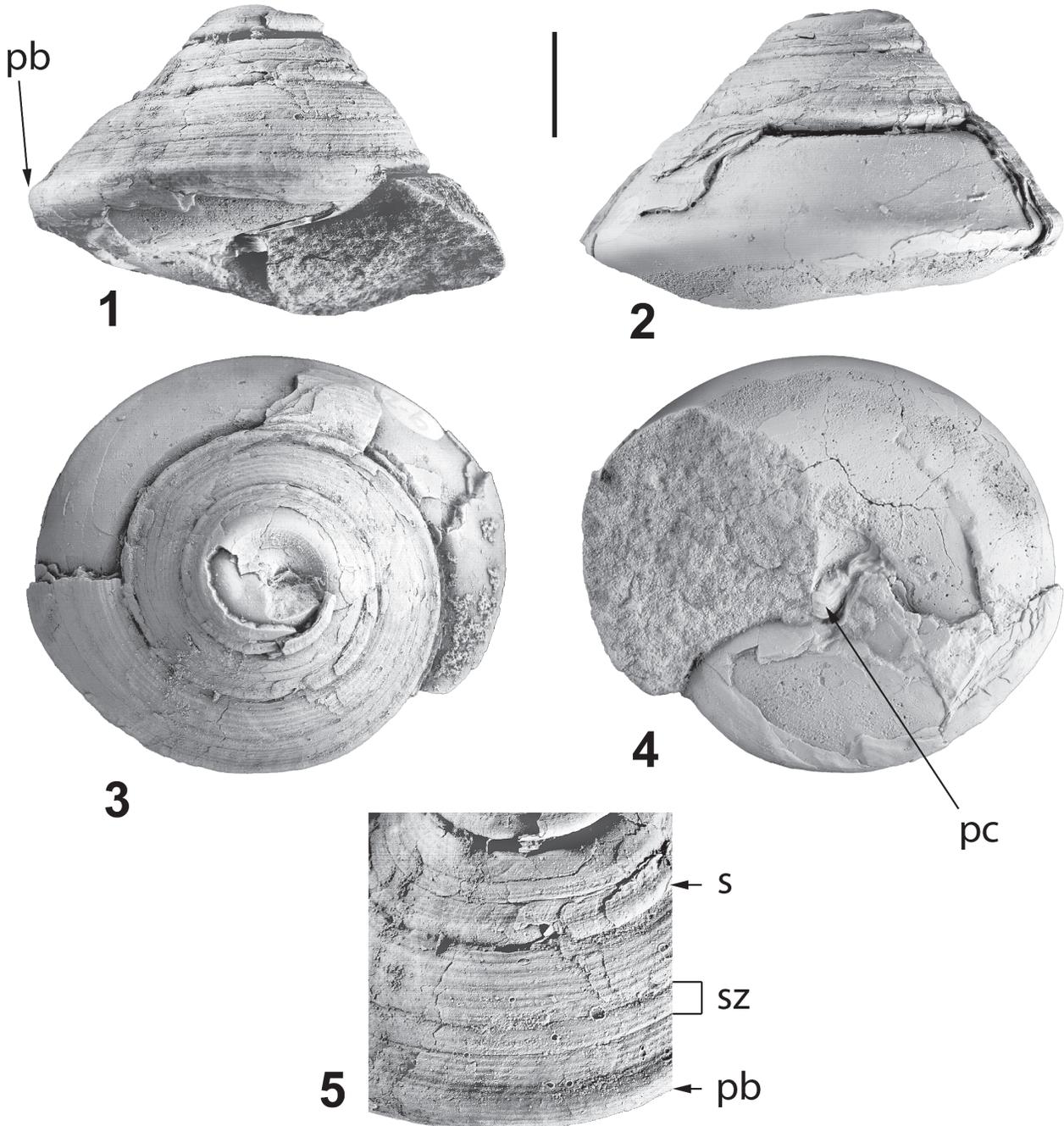


FIGURE 13—*Conotomaria bayeri* new species. 1, apertural; 2, dorsal; 3, apical, and 4, basal views of the holotype, USNM 467222, Locality 9-2, Seymour Island. 5, Details of sculpture on apertural surface of the holotype. Scale bar = 2.0 cm, pb, peripheral bulge; pc, parietal callus; s, suture; sz, selenizone.

0.20), weakly convex, situated at mid-whorl, with weak lunulae and two to three spiral cords. Axial sculpture of fine, oblique growth striae. Aperture narrowly rhomboidal, long axis deflected from coiling axis by  $\sim 100^\circ$ . Outer lip not preserved, slit narrow  $\sim 2.7$  mm, extending for less than one third of a whorl. Parietal callus narrow, nacreous.

*Etymology*.—This species honors the late Dr. Frederick Bayer, in recognition of his contributions to the systematics of living Pleurotomariidae.

*Types*.—Holotype, USNM 467222, Paleocene, Danian, Sobral Formation, Seymour Island, Antarctic Peninsula (Fig. 1, Locality 9-2;  $64^\circ 18' 34.9''$ S,  $56^\circ 43' 56.9''$ W).

*Stratigraphic occurrence*.—1,167 m (Fig. 2).

*Remarks*.—This small species is very easily distinguished from all other Pleurotomariidae on Seymour Island by its comparatively small size, distinctly angulated appearance, and prominent spiral sculpture. It also has a significantly thicker shell, in proportion to the size. In outline and size, *C. bayeri* is comparable to *Pleurotomaria gurgitis* Brongniart in Cuvier and Brongniart, 1822 (p. 96, pl. 9, fig. 7A–B; d'Orbigny, 1843, p. 249–250, pl. 192, fig. 4–6) from the Gault region, France, but the whorls in *C. bayeri* are slightly more flush and less convex, and the ornamentation is a bit weaker, compared with *P. gurgitis*. The specimen figured in Brongniart (1822; see

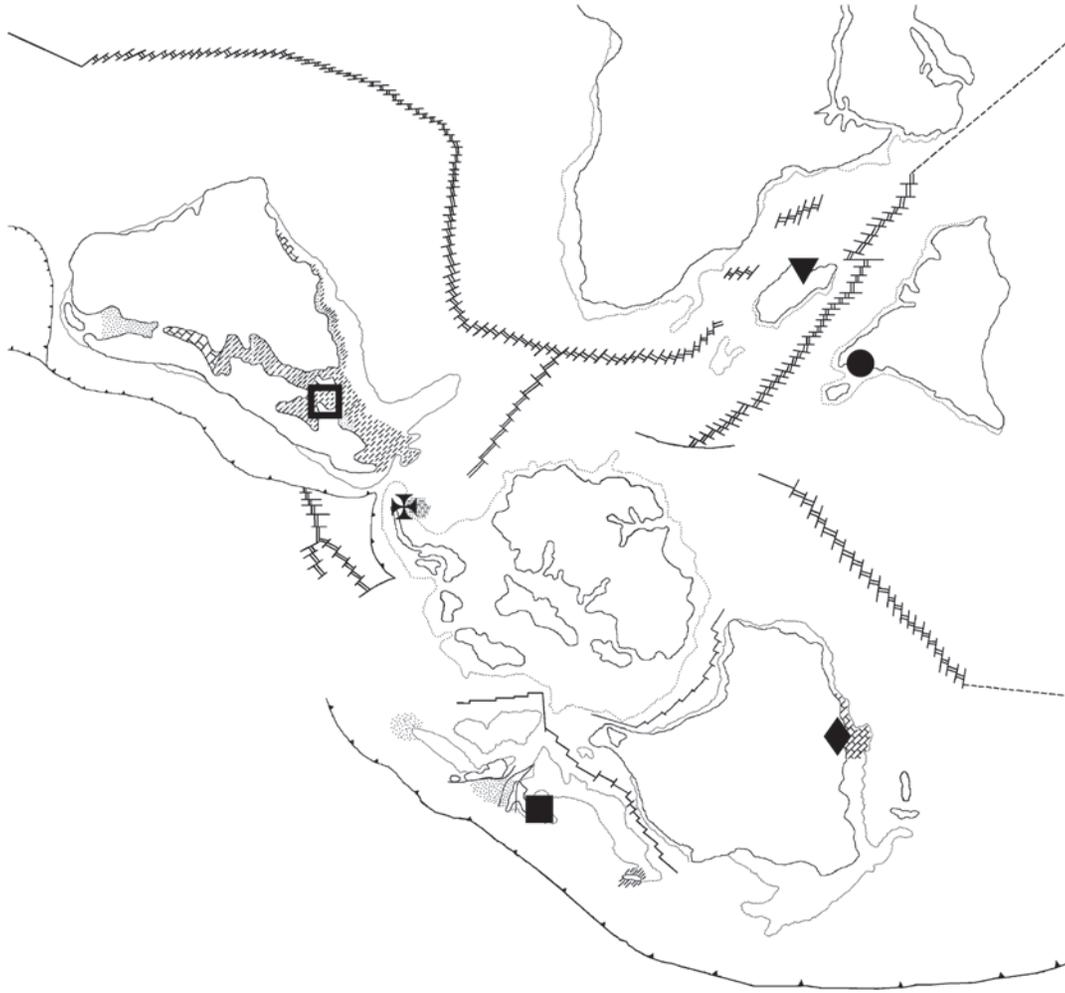


FIGURE 14—Paleogeography of the Antarctic and the Weddellian Province during the Late Maastrichtian–Early Paleocene, showing locations of deposits containing pleurotomariid fossils (See Table 2 for list of pleurotomariid taxa occurring at these localities). ✕—Seymour Island, Antarctica, Late Maastrichtian, Lopez de Bertodano Formation, Danian, Sobral Formation (herein). ◆—Late Maastrichtian, Miria Formation, Northwestern Australia (Darragh and Kendrick, 1994). ■—New Zealand, Senonian, Amuri Group (Wilckens, 1922). ●—Southern India, Campanian–Maastrichtian, Arrialoor Group (Stoliczka, 1868). ▼—Northwestern Madagascar, Lower Albian, Mahajanga Basin, (Collignon, 1959; Kiel, 2006). □—West Central Argentina, Jurassic and Early Cretaceous, (Stanton, 1901; Weaver, 1931; Feruglio, 1936).

especially pl. 9, fig. 7A), is higher spired, with no visible details of a selenizone.

#### DISCUSSION

The Late Cretaceous and early Tertiary fossiliferous deposits of Seymour Island contain the most nearly complete boundary section in the southern hemisphere, and encompass two major events with profound influence on the biota of the region: the K/T extinction event, and the final breakup of Gondwana. The effects of the massive terminal extinction event that marked the end of the Cretaceous appear to have been more gradual and less severe at high southern latitudes (Zinsmeister et al., 1989). Indeed, Feldmann et al. (2005) reported that there is no evidence that the brachyuran fauna of southern Argentina was seriously affected by the K-T extinction event. Many mollusks also survived the K-T extinction event (Stilwell et al., 2004). Sohl (1987, p. 1105) noted that Pleurotomariidae had a cosmopolitan distribution during the Jurassic and Early Cretaceous but experienced a marked reduction in the number of genera surviving into the Tertiary. More recently, Pacaud (2004, fig. 20) documented the survival of three genera into the Danian of northern

Europe. Pleurotomariid diversity at the species level was greatest during the Cenomanian, declined rapidly by the Turonian, and remained relatively stable during the remainder of the Cretaceous (Sohl, 1987, p. 1105, fig. 10).

During the Late Cretaceous, the southern continents were separated by shallow seas extending from the southern tip of South America to eastern Australia. The resulting shallow shelf, cool-temperate seaway, extending along the western margin of Antarctica, was named the Weddellian Province by Zinsmeister (1979) based on a highly endemic (>50% endemism) molluscan fauna. As a result of the final fragmentation of Gondwana, the shelf regions of Antarctica, southern South America, and Australia were increasingly isolated during the early Tertiary. The combination of extinction events at the end of the Cretaceous and the geographic isolation of the continents set the stage for rapid diversification of many components of marine molluscan faunas in this region during the early Paleocene (Oleinik and Zinsmeister, 1996).

Including the species described in this paper, the known species richness of the pleurotomariid fauna of Seymour Island has increased to seven, two species of *Leptomaria* of

TABLE 2—Summary of pleurotomariid occurrences in the Late Cretaceous/Paleocene of the Weddellian Province. See Figure 46 for locations.

✕	Seymour Island, Antarctica. (Sobral Formation Paleocene [Danian] (Wilckens, 1910; herein) <i>Conotomaria sobralensis</i> Harasewych Oleinik and Zinsmeister (herein) <i>Leptomaria larseniana</i> (Wilckens, 1910) <i>Leptomaria stillwelli</i> Harasewych Oleinik and Zinsmeister (herein) <i>Conotomaria bayeri</i> Harasewych Oleinik and Zinsmeister (herein) <i>Leptomaria seymourensis</i> Harasewych Oleinik and Zinsmeister (herein)
(	Lopez de Bertodano Formation—Late Cretaceous [Late Maastrichtian] (herein) <i>Leptomaria hickmanae</i> Harasewych Oleinik and Zinsmeister (herein) <i>Leptomaria antipodensis</i> Harasewych Oleinik and Zinsmeister (herein)
◆	Northwestern Australia—Miria Formation—Late Cretaceous [Late Maastrichtian] (Darragh and Kendrick, 1994) <i>Conotomaria? cypselae</i> Darragh and Kendrick, 1994 <i>Conotomaria minacis</i> Darragh and Kendrick, 1994 <i>Leptomaria perancisa</i> Darragh and Kendrick, 1994
■	New Zealand—Amuri Bluff—Late Cretaceous [Santonian] (Wilckens, 1922) <i>Pleurotomaria maoriensis</i> Wilckens, 1922 <i>Pleurotomaria woodsi</i> Wilckens, 1922
●	Southern India—Ootatoor Group—Late Cretaceous [Cenomanian] (Stoliczka, 1868) <i>Pleurotomaria glabella</i> Stoliczka, 1868 <i>Pleurotomaria loricatea</i> Stoliczka, 1868 <i>Leptomaria indica</i> (Forbes, 1856)
▼	Madagascar—Ambaramanina—Lower Cretaceous [Albian] (Collignon, 1949; Kiel, 2006) <i>Leptomaria magneti</i> Collignon, 1949
□	Argentina (Stanton, 1901; Weaver, 1931; Feruglio, 1936) <i>Pleurotomaria? andina</i> Feruglio, 1936. Late Cretaceous [Senonian], Arroyo Calafate <i>Pleurotomaria cf. provincialis</i> d'Orbigny, 1842. Early Cretaceous [Valanginian] Quintuco Fm <i>Pleurotomaria gerthi</i> Weaver, 1931. Early Cretaceous [Barremian], Agrio Fm <i>Pleurotomaria cf. jaccardi</i> Pictet and Campiche, 1861. Early Cretaceous [Barremian], Agrio Fm <i>Pleurotomaria tardensis</i> Stanton 1901. Early Cretaceous [Barremian], Belgrano Beds

Late Maastrichtian age, and three species of *Leptomaria* and two species of *Conotomaria* of Danian age. Given that molluscan fossils of Late Cretaceous and Early Paleocene age on Seymour Island are well preserved and moderately well collected (Stillwell et al., 2004), it is likely that this represents but a subset of the true species richness.

The Seymour Island Late Cretaceous pleurotomariid fauna is comparable in species richness and generic composition to the coeval faunas of Australia (Darragh and Kendrick, 1994), New Zealand (Wilckens, 1922), and southern India (Stoliczka, 1868), less so to the older, more diverse faunas of southern South America (Weaver, 1931), and Madagascar (Delpey, 1948; Collignon, 1959; Kiel, 2006) (Fig. 14). Comparisons of the Danian pleurotomariid fauna to regional contemporaneous faunas are not possible, since Danian Stage pleurotomariid records are presently known only from northern Europe (Hickman, 1976, p. 1092, text-fig. 2; Pacaud, 2004, p. fig. 20). However, there does appear to be an increase in the species richness of the pleurotomariid fauna of Seymour Island during the Paleocene. The pattern of diversification immediately following the K/T extinction in Antarctic faunas has been previously observed in the gastropod genus *Seymourosphaera* (Oleinik and Zinsmeister, 1996) as well as in palynomorphs (Askin, 1988), diatoms, and silicoflagellates (Harwood, 1988). The pleurotomariid fauna of the Late Maastrichtian Miria

Formation of Northwestern Australia, which was contemporaneous with the Lopez de Bertodano Formation of Seymour Island, consisted of two species of *Conotomaria* and a single species of *Leptomaria* (Darragh and Kendrick, 1994). The ratio of *Conotomaria* to *Leptomaria* sampled in this fauna was 25:1 (n = 390) (Darragh and Kendrick, 1994, table 1). However, given the tentative generic assignments for the most common Seymour Island species—*L. antipodensis* (herein), *C. (?) cypselae* (Darragh and Kendrick, 1994, p. 15) and *L. perancisa* (Darragh and Kendrick, 1994, p. 20), the apparent difference in generic composition between the two faunas may be an artifact of our currently accepted taxonomy. Alternatively, it may indicate that patterns of fine-scale allopatry, possibly on the basis of depth or substrate type, are similar to those evident in Recent pleurotomariid faunas. Although up to four species of living pleurotomariids may be collected on a single sub dive, they are, in fact, allopatric, occurring at different depths and on different substrates. These patterns are both consistent and dramatic (Harasewych, 2002, p. 274, fig. 12) and may also have been present in Late Cretaceous faunas.

The sediment type, lack of an associated hard substrate fauna, and co-occurrence of a number of soft-substrate bivalves and gastropods, indicate that Late Maastrichtian and Danian Pleurotomariidae from the Seymour Island inhabited fine-grained sandy and silty substrates of the outer continental shelf, a habitat more similar to that of Permian (Batten, 1958) than Recent pleurotomariids, which inhabit hard substrates and steeply sloped walls along the outer continental shelf and upper continental slope (Harasewych, 2002). Batten (1958) hypothesized that environments with high levels of fine suspended sediments resulted in dwarfing, based on studies of Paleozoic pleurotomarioideans. However, Seymour Island Pleurotomariidae are of larger size, and more similar to the Recent species than to the smaller Paleozoic forms. The shift in habitat from shallow water to deeper water was evident by the early Eocene (Hickman, 1976, p. 1093). Kanno (1961, p. 115) hypothesized that this shift reflected an ontogenetic pattern, while Hickman (1976, p. 1093) considered it more likely that the shift was due to range constriction and elimination of the shallow-water forms. The elimination of the shallow-water Pleurotomariidae may be related to competition with rapidly diversifying groups of other shelf mollusks following the K/T extinction event. Direct observations from the submersibles and in aquaria, supplemented by gut content analysis, indicate that Recent Pleurotomariidae are primarily spongivorous (Harasewych et al., 1988). However, when kept in aquaria under stressed conditions, pleurotomariids consumed a variety of organisms (Arakawa et al., 1978; Hickman, 1984; Harasewych, 2002), raising the possibility that, in spite of today's restricted diet and highly specialized radula (Hickman, 1981, 1984; Harasewych, 2002), they may have occupied a broader trophic niche in the past. Radley (1992, p. 173) deduced that Jurassic pleurotomariids lived in warm, shallow-water, photic habitats, and fed at least partly on algae.

In terms of size and morphology, many of the Seymour Island species resemble more closely taxa from the Jurassic of Europe and southern South America than more geographically proximal Late Cretaceous species. *Leptomaria hickmanae*, for example, more closely resembles *L. amoena* [Jurassic, France], *Pleurotomaria vacavillensis* Hickman, 1976 [Cretaceous, California, USA] and *L. tardensis* [Lower Cretaceous, Argentina] than contemporaneous southern hemisphere species. Similarly, Early Paleocene *L. stillwelli* new species, closely morphologically resembles *L. leufuensis* [Late Jurassic, Ar-

gentina] and *L. daityai* [Late Jurassic, India]. Those similarities support the conclusion of Stilwell et al. (2004) concerning the breakup of the Weddellian Province by the end of Cretaceous and interrupted connections with the Australia-New Zealand region. It may also indicate that Antarctic Cretaceous and Early Tertiary Pleurotomariidae were remnants of a once cosmopolitan group that was widespread in the Jurassic and had their habitats fragmented as a result of the progress in the breakup of Gondwana.

## ACKNOWLEDGMENTS

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