

BRACHIOPODS FROM THE EOCENE LA MESETA FORMATION OF SEYMOUR ISLAND, ANTARCTIC PENINSULA

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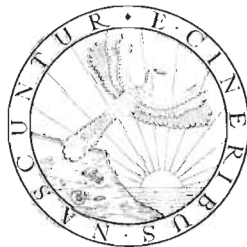
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The remarkably diverse brachiopod assemblage from the Eocene La Meseta Formation of Seymour (Marambio) Island, Antarctic Peninsula, contains nineteen genera and twenty four species. Four genera and eight species are new, i.e. *Basiliola minuta* sp. n., *Tegulorhynchia ampullacea* sp. n., *Paraplicirhynchia gazdzickii* gen. et sp. n., *Seymourella oweni* gen. et sp. n., Gen. et sp. n., *Murravia fosteri* sp. n., *Macandrevia cooperi* sp. n., and *Laquethiris curiosa* gen. et sp. n. A new subfamily Seymourinae is proposed for the species *Seymourella oweni*. Genera *Basiliola*, *Hemithiris*, *Paraplicirhynchia*, *Seymourella*, *Murravia*, *Magella*, *Stethothyris*, *Macandrevia*, and *Laquethiris* are reported for the first time from the La Meseta Formation, although *Hemithiris* and *Magella* have been already noted from the Tertiary strata of adjacent Cockburn Island. Some of the genera (*Basiliola*, *Hemithiris*, *Notosaria*, *Murravia*, *Stethothyris*, *Macandrevia*) described herein represent the oldest occurrences of the genus, thus extending their stratigraphical ranges, which suggests that Seymour Island might play an important role in the evolution of many brachiopod taxa from where they spread northwards before the development of the circum-Antarctic current in the Oligocene time. Thus, the brachiopods from the La Meseta Formation are another example of the heterochrony of high southern latitude faunas. These brachiopods at the generic level show close affinities to those from New Zealand, having nine genera in common. Fewer generic affinities exist between Tertiary brachiopod fauna of Seymour Island and southern South America. The brachiopods indicate warm to warm-temperate conditions of shallow to moderately deep marine environments which supports in general earlier interpretation of the La Meseta Formation depositional conditions. However, the presence in the uppermost part of the formation of such warm-water genera as *Lingula* and *Bouchardia* is in contradiction with a considerable climatic cooling postulated on the basis of oxygen isotopic data.

Key words: Brachiopoda, taxonomy, paleoecology, paleobiogeography, Paleogene, Antarctica.

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INTRODUCTION

The brachiopods from the La Meseta Formation of Seymour Island, Antarctic Peninsula were first described at the beginning of the century by BUCKMAN (1910), however, he mentioned the presence of only two genera: *Lingula* and *Bouchardia*. More recently brachiopods were examined by OWEN (1980) who noted the presence of six genera: *Lingula*, *Notosaria*, *Liothyrella*, *Magellania*, *Bouchardia* and *Terebratella*. WIEDMAN *et al.* (1988) added to this list four other genera, ?*Probolarina*, *Tegulorhynchia*, ?*Plicirhynchia* and *Terebratulina*. BITNER (1991) described a new species of the genus "*Terebratella*". However, none of the previous reports presented so rich and diversified assemblage which comprises nineteen genera and twenty four species. Its importance is in the fact that it contains numerous new taxa and extends both stratigraphical and geographical ranges of several genera known so far from younger deposits. The investigated brachiopods also shed new light on the possible migration routes and origins of some genera.

The brachiopods were collected by Andrzej GAŹDZICKI during the Argentine-Polish field parties in the austral summers of 1987–88, 1991–92 and 1993–94 (DOKTOR *et al.* 1988; GAŹDZICKI 1996 this volume).

Brachiopods described herein are housed in the Institute of Paleobiology of the Polish Academy of Sciences (Warszawa) under the number ZPAL Bp.XXXVII.

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GEOLOGICAL AND STRATIGRAPHICAL SETTING

The La Meseta Formation, extremely fossiliferous marine deposits from where all the brachiopods come, crops out at the northern part of Seymour Island and southwest of Cross Valley (Text-fig. 1). The La Meseta Formation was first divided into three lithological units, I through III, by ELLIOT and TRAUTMAN

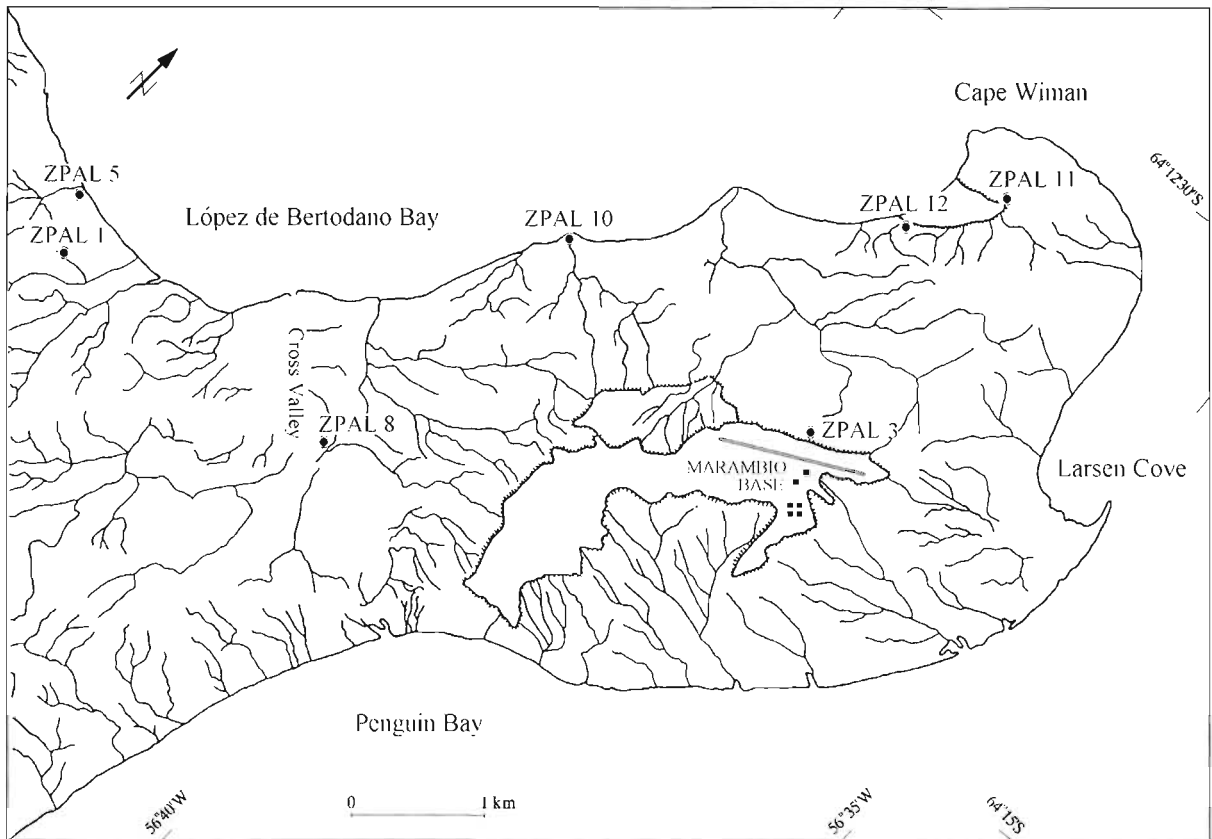


Fig. 1

Map of the northern part of Seymour Island showing the localities where brachiopods were collected.

(1982), but after detailed mapping SADLER (1988) indicated the necessity for further differentiation and divided it into seven lithofacies units (Telm1–Telm7).

The La Meseta Formation deposits lie unconformably on the upper Cretaceous/Paleocene erosional surface (ZINSMEISTER 1982a, b; FELDMANN and ZINSMEISTER 1984; WOODBURNE and ZINSMEISTER 1984; SADLER 1988; STILWELL and ZINSMEISTER 1992; POREBSKI 1995) and are overlain by the Quaternary deposits (Weddell Formation) see *Geologic Map of Seymour Island* in FELDMANN and WOODBURNE (1988).

Characteristics of the Telm units. — The lowermost unit Telm1 crops out at Cape Wiman and west of Cross Valley. Interpreted as transgressive deposits, it is composed of a sandy pebble-conglomerate succeeded by iron-stained quartz sandstones at the westernmost exposure and of a laminated, fissile quartz sandstone with carbonate-cemented concretions associated with a megabreccia facies at the northernmost exposure (SADLER 1988; STILWELL and ZINSMEISTER 1992). The fauna is dominated by bryozoans (GAZDZICKI and HARA 1994; HARA 1995) and brachiopods, with molluscs forming only a minor component. In the studied material, brachiopods from this unit display the greatest taxonomic diversity and are represented by the following 22 species: *Basiliola minuta* sp. n., *Hemithiris antarctica* BUCKMAN, ?*Hemithiris* sp., *Notosaria seymourensis* OWEN, *Notosaria* sp., *Tegulorhynchia imbricata* (BUCKMAN), *T. ampullacea* sp. n., *Tegulorhynchia* sp., ?*Plicirhynchia* sp., *Paraplicirhynchia gazdzickii* gen. et sp. n., *Liothyrella* sp., *L. anderssoni* OWEN, *Seymourella oweni* gen. et sp. n., Gen. et sp. n., *Terebratulina buckmani* OWEN, *Murravia fosteri* sp. n., *Bouchardia antarctica* BUCKMAN, “*Terebratella*” *crofti* OWEN, *Magellania antarctica* (BUCKMAN), *Magella australis* (BUCKMAN), *Macandrevia cooperi* sp. n., *Laquethiris curiosa* gen. et sp. n.

The unit Telm2 exposures in the Cross Valley area and at Cape Wiman, according to SADLER (1988), consists of thick beds of laminated, fine-grained sands and silty sands, deposited in a low-energy environment, below wave base or in a protected embayment (STILWELL and ZINSMEISTER 1992; see also DOKTOR *et al.* 1996 this volume). Locally, in the calcareous siltstones, diverse fossil remains of molluscs, brachiopods, echinoids, leaves, wood fragments, arthropods and fish, are abundant (DOKTOR *et al.* 1988,

Bill Hill (41m a.s.l.)
ZPAL 1



Fig. 2

View of the outcrop ZPAL 1 (as seen from the López de Bertodano Bay) which displays the greatest brachiopod species richness. Photographed by A. GAŹDZICKI, February 1994.

1996 this volume; JERZMAŃSKA 1991; STILWELL and ZINSMEISTER 1992). The brachiopod assemblage from the upper part of this unit is, although poorer and containing 12 species, similar in species composition to that from the unit Telm1, differing in the additional presence of *Stethothyris* sp. and in the absence of *Basiliola minuta*, *Tegulorhynchia* species, ?*Plicirhynchia* sp., *Paraplicirhynchia gazdzickii*, *Liothyrella* species and *Murravia fosteri*. The dominant brachiopod species in this unit is *Macandrevia cooperi*.

The unit Telm3 crops out only at the northern end of the island. It is characterized by buff-weathering cross-bedded sands and silts with abundant shell beds and lenses which could indicate a nearshore, high-energy environment (SADLER 1988; STILWELL and ZINSMEISTER 1992). Venerid bivalves dominate in this unit. Beginning from the unit Telm3 there is a much lower diversity of the brachiopod fauna. In the investigated material brachiopods are represented by three species: *Liothyrella anderssoni*, *Bouchardia antarctica*, and *Magellania antarctica*.

The unit Telm4, which overlies the fine-grained sands of Telm2 in the south and venerid shell beds of Telm3 in the north, is characterized by relatively thick, conglomeratic *Cucullaea* shell beds. Molluscan fauna dominates in this unit. Vertebrate remains also occur (MARENSSI *et al.* 1994). Telm4 is interpreted as to have been deposited in a high-energy environment (SADLER 1988; STILWELL and ZINSMEISTER 1992). In the collected material brachiopods are represented by two species *Bouchardia antarctica* and *Magellania antarctica*.

The unit Telm5 consists of laminated fine-grained sandstones and silty clays with interbedded conglomeratic sandstone (SADLER 1988). The beds and lenses of *Cucullaea* shells are characteristic for this unit. Sedimentary structures and fossil analysis indicate variable nearshore, shallow-marine environments (STILWELL and ZINSMEISTER 1992). Fossil remains, very diversified and abundant, are dominated by molluscs, cirripedes, vertebrates (WOODBURNE and ZINSMEISTER 1984; MARENSSI *et al.* 1994), bryozoans, wood fragments, plant, echinoderms, crustaceans (FELDMANN and ZINSMEISTER 1984) and trace fossils. In my collection there are numerous brachiopods belonging to the species *Bouchardia antarctica*. Earlier from this unit "*Terebratella*" sp. was described (BITNER 1991).

Characterizing the uppermost units, Telm6 and Telm7 are medium- to fine-grained sandstones with intervals of laminated fine-grained sand and silty clay (SADLER 1988). The macrofauna is dominated by molluscs (STILWELL and ZINSMEISTER 1992), however crinoids (RASMUSSEN 1979), echinoids (MCKINNEY

et al. 1988), vertebrate remains (BORSUK-BIALYNICKA 1988; JERZMAŃSKA 1988; MYRCHA *et al.* 1990; TAMBUSSI *et al.* 1994), crustaceans (FELDMANN and WILSON 1988; AGUIRRE-URRETA *et al.* 1995) are also present. The uppermost units are interpreted by STILWELL and ZINSMEISTER (1992) as to have been deposited in a low-energy, shallow-marine environment. The brachiopod assemblage is characterized by the presence of *Lingula antarctica* BUCKMAN, absent in the lower units of the La Meseta Formation. *Liothyrella anderssoni*, abundant *Bouchardia antarctica* and *Magellania antarctica* are also noted in these units.

The most recent description of lithofacies, sedimentary structures and geometries of the La Meseta Formation was presented by PORĘBSKI (1995). Based on these features he interpreted the formation as to have been deposited in an incised-valley estuary dominated by tides.

Age. — The age of the La Meseta Formation was considered as upper Eocene–?lower Oligocene (ZINSMEISTER 1977, 1982a, b, 1984; BLAKE and ZINSMEISTER 1979; ZINSMEISTER and CAMACHO 1982; FELDMANN and ZINSMEISTER 1984; WOODBURNE and ZINSMEISTER 1984), however, recent investigations indicate that the lower units (Telm1 and Telm2?) are early?–middle Eocene in age, while the upper units (Telm6 and Telm7) may indeed be earliest Oligocene in age (WRENN and HART 1988; COCOZZA and CLARKE 1992; STILWELL and ZINSMEISTER 1992; see also age discussion in TAMBUSSI *et al.* 1994).

MATERIAL

Brachiopods are a common element of the fauna and have been noted in the whole section of the La Meseta Formation (see also STILWELL and ZINSMEISTER 1992).

The investigated brachiopods were collected in seven outcrops marked on the map as ZPAL (Text-fig. 1; see also GAŹDZICKI and TATUR 1994) and in several not marked outcrops of the Units II and III. They were found mainly in weakly consolidated sands, sandstones and siltstones (A. GAŹDZICKI, personal communication), in effect many are often crushed and damaged. During washing they easily disarticulate but, unfortunately, internal structures are often damaged and the whole well preserved brachidium is an exception (Pl. 25: 11c). In some cases the poor preservation makes the determination impossible.

The brachiopods coming from the lowermost units (Telm1 and Telm2) represent the most interesting and diverse assemblage in the studied material, containing all the new forms described in this paper. In this part of the formation two outcrops, ZPAL 1 and ZPAL 8 (see Text-figs 1–2) show the greatest brachiopod species richness. In the upper part of the section a considerable decrease in diversity is observed. The total number of the investigated specimens is over 620.

SYSTEMATIC PALEONTOLOGY

Order **Lingulida** WAAGEN, 1885

Superfamily **Linguloidea** MENKE, 1828

Family **Lingulidae** MENKE, 1828

Genus *Lingula* BRUGUIÈRE, 1797

Type species: *Lingula anatina* LAMARCK, 1801.

Lingula antarctica BUCKMAN, 1910

(Pl. 18: 1–2)

1910. *Lingula antarctica* sp. n.; BUCKMAN, p. 9, pl. 1: 7.

1980. *Lingula antarctica* S.S. BUCKMAN; OWEN, p. 126, fig. 10.

1988. *Lingula antarctica* BUCKMAN; WIEDMAN *et al.*, fig. 2.18–20.

Material. — 23 complete specimens, 9 ventral valves, 13 dorsal valves and many variously broken fragments.

Remarks. — The investigated material agrees well with the description and illustrations given by other authors (BUCKMAN 1910; OWEN 1980; WIEDMAN *et al.* 1988). The studied specimens are slightly longer (max. length 33 mm) than those hitherto described, gently biconvex, elongate in outline, with parallel sides, and ornamented by concentric, oblong growth lines. Three of them bear traces of gastropod borings (see Pl. 18: 1–2). The rich and exceptionally well preserved material of this delicate-shelled genus displays clearly visible muscle scars and anterior mantle canals (see Pl. 18: 1b, 2b).

L. waikatoensis PENSELER, known from the New Zealand Tertiary deposits (PENSELER 1930; ALLAN 1936; LEE and CAMPBELL 1987), is slightly smaller than *L. antarctica*, differing also in less elongate outline and less pointed valves.

Occurrence. — The studied material comes from the uppermost units of the La Meseta Formation (Telm6 and Telm7). The presence of this species on Seymour Island was already reported by BUCKMAN (1910), OWEN (1980) and WIEDMAN *et al.* (1988).

Order Rhynchonellida KUHN, 1949
Superfamily Rhynchonelloidea GRAY, 1848
Family Basiliolidae COOPER, 1959
Subfamily Basiliolinae COOPER, 1959
Genus *Basiliola* DALL, 1908

Type species: *Hemithyris beecheri* DALL, 1895.

Basiliola minuta sp. n.
 (Pl. 19: 1–4; Text-fig. 3)

1988. ?*Probolarina* sp.; WIEDMAN *et al.*, fig. 2.16–17.

Holotype: The specimen ZPAL Bp.XXXVII/46 figured on Pl. 19: 2.

Type horizon: Telm1. La Meseta Formation: Eocene.

Type locality: ZPAL 1 (*Bill Hill*), Seymour Island, Antarctic Peninsula.

Derivation of the name: From the Latin *minutus* — small, referring to the small size.

Diagnosis. — *Basiliola* of small size, asymmetrically uniplicate, and with moderately wide outer hinge plates.

Material. — Four complete specimens, 4 pedicle valves and one brachial valve.

Dimensions: Max. length 12.0 mm, width 11.6 mm; length of holotype 11.1 mm, width 11.3 mm, thickness 4.7 mm.

Description. — The shell is small, thin, oval to subcircular in outline and biconvex with the brachial valve more convex than the pedicle one. The anterior commissure is broadly uniplicate, asymmetrically folded (see Pl. 19: 2c). The shell surface is smooth with numerous weakly developed growth lines. The foramen is small, circular to elongate oval, complete, hypothyridid with conjunct, auriculate deltidial plates.

The pedicle valve with an elaborate pedicle collar, forming a wide tube with free anterior edges (Pl. 19: 1c, 4b). The teeth are short but wide, provided with grooves, supported by strong dental plates.

The dental sockets of the brachial valve are deep, with grooves corresponding to those on the teeth, and bordered by short inner socket ridges. The outer hinge plates are moderately wide, while the inner hinge plates are absent, as is also the cardinal process. The crura, partially broken, are attached to the hinge plates. No median septum is present in the brachial valve, but a very low, short median ridge, not reaching the apex, is observed in a young specimen (see Pl. 19: 3); in the larger specimen the median ridge is absent (see Pl. 19: 2e).

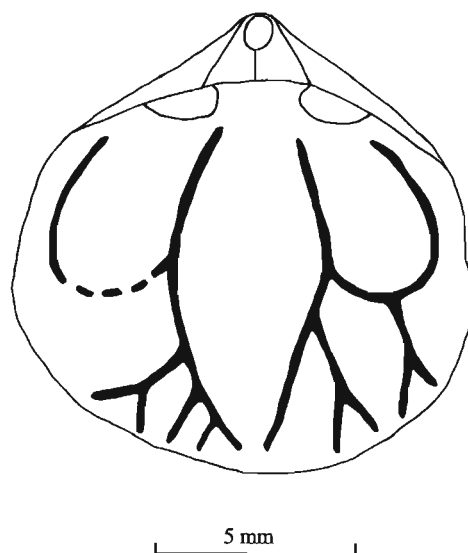


Fig. 3
 Pallial sinuses of the pedicle valve
 of *Basiliola minuta* sp. n.

The pallial markings visible on the pedicle valve are typical of the genus (see Text-fig. 3 and Pl. 19: 1b). The vascula media branch beyond midvalve; the main branch extends anteromedially, the other branch extends laterally and divides, with one branch going posteriorly near the valve margin and the second one — anterolaterally.

Remarks. — The genus *Basiliola* DALL with such its features like smooth shell, auriculate deltidial plates and elaborate pedicle collar is easy to recognize and the described material consists well with those features.

In beak character and cardinalia, *i.e.* auriculate deltidial plates, elaborate pedicle collar, lack of cardinal process, wide outer hinge plates, the genus *Basiliola* resembles *Probolarina* COOPER known from the Eocene of the East Coast of the United States (COOPER 1959, 1988) and from the Upper Paleocene–Lower Eocene of New Zealand (LEE 1980a), differing, however, in having smooth shell surface, while *Probolarina* has the anterior half of the shell strongly costate.

In the present author's opinion the specimens described as *?Probolarina* sp. by WIEDMAN *et al.* (1988) belong to *Basiliola minuta*. The illustrations of this species are poor and show only interior of both valves; however, there is no costation visible on the anterior margins. The shell size and asymmetrical uniplication of *?Probolarina* sp. point also to it being conspecific with *B. minuta* sp. n.

The species *B. minuta* sp. n. differs from the hitherto described species of this genus in gentle asymmetrical uniplication and relatively narrow hinge plates (compare HATAI 1940; COOPER 1957, 1959, 1978, 1981a). It is much smaller than the Recent species *B. beecheri* (DALL), *B. pompholyx* DALL, and the Miocene one, *B. strasfogeli* COOPER from Fiji (COOPER 1959, 1978). It is also smaller than two other Recent species *B. elongata* COOPER and *B. arnaudi* COOPER (COOPER 1959, 1981a). From *B. pompholyx* and *B. arnaudi* it also differs in having narrower hinge plates, and from *B. elongata* in being more circular in outline. In shell size it is comparable to the Pliocene species from Fiji, *B. roddai* COOPER, differing strongly, however, in the degree of anterior uniplication and convexity of the dorsal valve (COOPER 1978). *B. roddai* has an anterior commissure strongly and narrowly uniplicate and a strongly convex dorsal valve. From two Okinawa Pliocene species, *B. nitida* COOPER and *Basiliola* sp., *B. minuta* can be distinguished by less elongate shape and smaller shell convexity (COOPER 1957). *B. minuta* resembles closely *B. lucida* (GOULD) from the Japanese waters in size, shell outline, as well as dimension of hinge plates (HATAI 1940; COOPER 1959).

In its anterior broad asymmetrical folding *B. minuta* is similar to the genus *Streptaria* COOPER, however, the lack of a pedicle collar and the weak development of dental plates in *Streptaria* make these genera strongly different (COOPER 1959).

Occurrence. — Seymour Island, La Meseta Formation: ZPAL 1 (*Bill Hill*), Teln1. It is the first report of this genus from Seymour Island and the oldest occurrence in the record.

Family **Hemithyrididae** RZHONSNITSKAYA, 1956
Genus *Hemithyris* D'ORBIGNY, 1847

Type species: *Anomia psittacea* GMELIN, 1790.

Hemithyris antarctica BUCKMAN, 1910
(Pl. 20: 4–6)

1910. *Hemithyris antarctica* sp. n.: BUCKMAN, p. 13, pl. 1: 8–9.

1980. *Hemithyris antarctica* S.S. BUCKMAN; OWEN, p. 127, fig. 5.

Material. — Six complete specimens and 2 brachial valves.

Dimensions: Max. length 23.8 mm, width 26.5 mm, thickness 6.5 mm. Length 18.0 mm, width 18.4 mm, thickness 6.3 mm.

Remarks. — The investigated specimens show all the characters typical of the species *H. antarctica* as described and illustrated by OWEN (1980). The shell outline is elongate oval to triangular in young and becomes broadly triangular in adult. There are very faint radial striae on the shell surface. The beak is high, nearly straight with a large hypothyriddid foramen and small, triangular disjunct deltidial plates. The anterior commissure is uniplicate with a broad, shallow sulcus on the pedicle valve. The full brachidium can be observed inside one damaged specimen (Pl. 20: 6). It has long, slender crura, curved towards the pedicle valve, typical of this genus. The sockets are deep, cardinal process wide and well developed. The outer hinge plates are very narrow, while inner hinge plates absent. The median ridge is very low and

extending to the apex. On the inner surface of the brachial valve there are clearly visible adductor muscle scars.

The studied specimens are larger than those illustrated by BUCKMAN (1910) and OWEN (1980). They also differ from BUCKMAN's (1910) specimens in much broader outline, which could result, however, from the smaller size of BUCKMAN's specimens, as juveniles have more elongate shape, and in less curved beak. BUCKMAN (1910) did not observe radial striae on the shell surface of his specimens. However, radial striae are visible in the investigated material, as well as in OWEN's (1980) material.

Occurrence. — Seymour Island, La Meseta Formation: ZPAL 1 (*Bill Hill*), Telm1; ZPAL 8, Telm2. That is the first report of this species from the La Meseta Formation of Seymour Island. It was known earlier from nearby Cockburn Island (BUCKMAN 1910; OWEN 1980).

?Hemithiris sp.
(Pl. 18: 7–8)

Material. — Six complete specimens.

Dimensions: Max. length 20.1 mm, width 19.9 mm, thickness 7.5 mm.

Description. — The shell is thin, impunctate, subtriangular in outline, unequally biconvex with brachial valve more convex, and nearly equally biconvex in early growth stages. The anterior commissure is weakly uniplicate. The shell surface is smooth with well marked growth lines which become denser near anterior margin. The beak is suberect with the oval, incomplete, hypothyriddid foramen limited by small, disjunct deltidial plates, pedicle collar present. With the aim to investigate the internal characters one specimen has been opened. Unfortunately, the shell was filled with fairly consolidated sand, which did not allow observation of the details of the cardinalia. The crura are slender, incurved and no hinge plates are seen.

Remarks. — The investigated specimens bear some resemblance to the genus *Hemithiris* in some features such as prominent beak, incomplete foramen, slender crura, but differ in having smooth surface. According to COOPER (1959) *Hemithiris* has the shell surface ornamented by faint striae. However, in THOMSON's (1927) and HATAI's (1940) definition of the genus the surface is smooth to radially striate. The investigated species is also similar in exterior characters to *Neorhynchia* THOMSON that is easily distinguished by its sulcation of the anterior commissure (COOPER 1959).

Occurrence. — Seymour Island, La Meseta Formation: ZPAL 1 (*Bill Hill*), Telm1; ZPAL 8, Telm2.

Genus *Notosaria* COOPER, 1959

Type species: *Terebratulula nigricans* SOWERBY, 1846.

Notosaria seymourensis OWEN, 1980
(Pl. 21: 1–5)

1980. *Notosaria seymourensis* sp. nov.; OWEN, p. 127, fig. 4.

1988. *Notosaria seymourensis* OWEN; WIEDMAN *et al.*, fig. 2.10–11.

Material. — 13 complete specimens and 2 pedicle valves.

Dimensions: Max. length 22.7 mm, width 21.5 mm; length 21.7 mm, width 22.5 mm, thickness ?10.3 mm.

Remarks. — The investigated specimens agree well in outline and ornamentation as well as beak characters with that described by OWEN (1980). They differ in being a little larger but having a smaller number of ribs than OWEN's specimen. The shell outline is transversely oval to subpentagonal, often wider than long in adults, being elongate-triangular in young (see Pl. 21: 1). The surface is covered with distinct ribs, varying in number from 16 to 23, and marked concentric growth lines. The shell is biconvex with more convex brachial valve and uniplicate anterior commissure. The beak is suberect with incomplete, subcircular, hypothyriddid foramen posteriorly limited by horizontally striated apical plate, anteriorly by triangular, disjunct deltidial plates. The large teeth are supported by dental plates (Pl. 21: 4b).

The internal structures of the brachial valve in one open specimen are poorly preserved — crura are broken, but a bilobed cardinal process is visible, short and thick inner socket ridges and deep dental sockets. The median ridge is low and short, not quite reaching the apex.

The species *Notosaria seymourensis* differs from *N. nigricans* (SOWERBY) known from the Tertiary deposits and Recent waters of New Zealand (COOPER 1959; FOSTER 1974; LEE 1978b; LEE and WILSON 1979) in having more marked growth lines and sharper ribs. It can be also distinguished from another

Tertiary species from New Zealand (ALLAN 1937a; LEE and WILSON 1979), *N. antipoda* (THOMSON) that has very characteristic imbricate rib structure. From the second living species in the New Zealand region, *N. reinga* LEE *et* WILSON, 1979 the investigated specimens differ in being much larger.

Occurrence. — Seymour Island, La Meseta Formation: ZPAL 1 (*Bill Hill*), Telm1; ZPAL 8, Telm2. It was also noted by OWEN (1980) and WIEDMAN *et al.* (1988). The present occurrence of *N. seymourensis* is the oldest one of the genus *Notosaria* COOPER.

Notosaria sp.
(Pl. 21: 6)

Material. — One complete specimen.

Dimensions: Length 20.9 mm, width 23.0 mm.

Remarks. — The specimen studied shows all the characters of the genus *Notosaria*, i.e. medium size, subpentagonal shape, costellate ornamentation, large, hypothryidid foramen, disjunct deltidial plates. It differs, however, strongly from *N. seymourensis* in type of ornamentation. The ribs are more numerous (29–30) and much finer, and the growth lines less marked. It resembles slightly in ornamentation the Recent subspecies *N. nigricans pyxidata* (DAVIDSON), having, however, fewer ribs (FOSTER 1974).

Occurrence. — Seymour Island, La Meseta Formation: ZPAL 1 (*Bill Hill*), Telm1.

Genus *Tegulorhynchia* CHAPMAN *et* CRESPIN, 1923

Type species: *Rhynchonella squamosa* HUTTON, 1873.

Remarks. — ZEZINA (1981, 1985) interpreted the crura of *Tegulorhynchia doederleini* (DAVIDSON) as falcifer in type and created a new genus *Acanthobasiliola* for this species. Both COOPER (1959) and LEE (1980b), in the diagnosis of *Tegulorhynchia*, described the crura as short and radulifer in type. In her taxonomical revision LEE (1980b) found the extant *T. doederleini* and Tertiary *T. squamosa* (HUTTON) very similar in every respect, such as size, shape, ornamentation and internal features, and only because of the great discontinuities in geographical distribution and age she retained both specific names. I am rather inclined to be of COOPER's and LEE's opinions in this respect as McNAMARA (1983) was.

Tegulorhynchia imbricata (BUCKMAN, 1910) (Pl. 18: 5–6)

1910. *Hemithyris imbricata* sp. n.; BUCKMAN, p. 11, pl. 1: 12.

1910. *Hemithyris squamosa* (HUTTON); BUCKMAN, p. 10, pl. 1: 13.

1980. *Tegulorhynchia imbricata* (S.S. BUCKMAN); OWEN, p. 128, fig. 11.

1988. *Tegulorhynchia imbricata* (BUCKMAN); WIEDMAN *et al.*, fig. 2.9.

Material. — Nine complete specimens and one pedicle valve.

Dimensions: Length 13.6 mm, width 15.2 mm; length 11.5 mm, width 14.6 mm, thickness 5.6 mm. Max. length of a damaged specimen 16.5 mm.

Remarks. — The investigated specimens show all the characters typical of the species *T. imbricata* as hitherto described (BUCKMAN 1910; OWEN 1980; WIEDMAN *et al.* 1988). The shell is transversely oval, wider than long, ornamented by fine, spinose ribs and numerous growth lines. The shell is biconvex with brachial valve slightly more convex. The anterior commissure is uniplicate. The small, circular foramen is constricted posteriorly by pedicle collar and anteriorly by small, triangular deltidial plates which are disjunct in the investigated material, most probably because of immaturity of the studied specimens.

The specimen described by BUCKMAN (1910) as *Hemithyris squamosa* HUTTON is referred in this paper in accordance with LEE (1980b) into the synonymy of *T. imbricata*. Similar suggestions were given by OWEN (1980), however, because of very poor illustrations he preferred not to place BUCKMAN's specimen in synonymy.

Occurrence. — Seymour Island, La Meseta Formation: ZPAL 1 (*Bill Hill*), Telm1. Earlier this species was already noted from the La Meseta Formation by WIEDMAN *et al.* (1988), as well as from the Tertiary strata of adjacent Cockburn Island by BUCKMAN (1910) and OWEN (1980).

Tegulorhynchia sp.
(Pl. 18: 4; Text-fig. 4)

Material. — One complete strongly crushed specimen and 4 damaged, badly preserved brachial valves.

Remarks. — The valves are transversely oval with maximum width 22.1 mm. The shell surface is covered with numerous, fine ribs interrupted by abundant, denser near anterior margin, growth lines, producing imbricate structure.

The cardinalia of the brachial valve are partially preserved in one specimen. The cardinal process is absent, a short median ridge extends to the apex. On the inner surface there are well visible pallial marks (see Text-fig. 4 and Pl. 18: 4b). A pair of canals, *vascula media*, curves posterolaterally and branches towards the margin.

The very badly preserved material does not allow for any detailed investigation. However, the very characteristic ornamentation clearly indicates its affiliation with the genus *Tegulorhynchia*. The species *Tegulorhynchia* sp. differs from *T. imbricata* in the type of uniplication. The brachial fold of *Tegulorhynchia* sp. is narrower and very distinct, appearing very early in the shell development, while *T. imbricata* has a broad, low, incipient brachial fold visible on the anterior margin. *Tegulorhynchia* sp. is also easily distinguishable from *T. ampullacea* sp. n. by the convexity of the brachial valve.

Occurrence. — Seymour Island, La Meseta Formation: ZPAL 11 (*Cape Wiman*), Telm1.

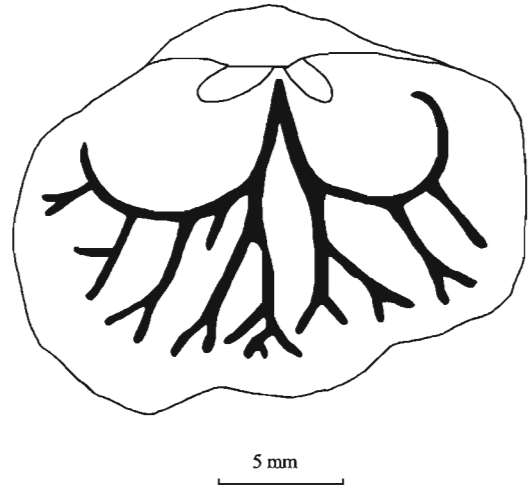


Fig. 4
Pallial sinuses of the brachial valve
of *Tegulorhynchia* sp.

Tegulorhynchia ampullacea sp. n.
(Pl. 18: 3)

Holotype: The specimen ZPAL Bp.XXXVII/95 figured on Pl. 18: 3.

Type horizon: Telm1, La Meseta Formation; Eocene.

Type locality: ZPAL 1 (*Bill Hill*), Seymour Island, Antarctic Peninsula.

Derivation of the name: From the Latin *ampullaceus* — dumpy, referring to the very characteristic shape.

Diagnosis. — *Tegulorhynchia* with the strongly convex dorsal valve, and tongue-like, flattened ventral sulcus and high brachial fold.

Material. — One complete specimen.

Dimensions: Length 14.9 mm, width 17.4 mm, thickness 15.8 mm.

Description. — The shell impunctate, triangular in outline, wider than long with the maximum width near anterior margin. The pedicle valve is nearly flat while the brachial one strongly convex. The anterior commissure is uniplicate with well-developed, high dorsal fold and tongue-like, flattened ventral sulcus. The shell surface is covered with 47 fine, spinose ribs. On the surface there are also numerous growth lines, anteriorly becoming denser. The beak is moderately long, pointed and nearly straight with a small, elongate, hypothrydid foramen, limited anteriorly by discrete, triangular, vertically lengthened, conjunct deltidial plates. The pedicle collar present.

The internal features unknown.

Remarks. — The ornamentation and beak characters of the studied specimen without any doubt allow assignment of this specimen to the genus *Tegulorhynchia*. However, it differs strongly from the hitherto described seven species of this genus (CHAPMAN and CRESPIN 1923; ALLAN 1931, 1937a, 1940; HATAI 1940; COOPER 1957, 1959; LEE 1980b; OWEN 1980; MCNAMARA 1983; WIEDMAN *et al.* 1988) in type of convexity and nature of the anterior commissure. No earlier described species show such a strong difference in convexity between the dorsal and pedicle valves and such a high dorsal fold and deep ventral sulcus as the investigated specimen.

The species *T. ampullacea* sp. n. is smaller than *T. squamosa* (HUTTON), *T. doederleini* (DAVIDSON) and *T. thomsoni* CHAPMAN *et* CRESPIN, being, however, larger than *T. sublaevis* (THOMSON) and *T. imbricata* (BUCKMAN), another species from Seymour Island. The described specimen is comparable in size and rib number to the Australian Tertiary species *T. coelata* (TENISON-WOODS). CHAPMAN and CRESPIN (1923) stressed the strong convexity of the dorsal valve and flattened median fold of *T. coelata*. However, examining the illustrations of *T. coelata* (pl. 1: 3–4 in CHAPMAN and CRESPIN 1923) one can easily exclude the similarity with the studied specimen. In ALLAN's (1940) opinion *T. thomsoni* and *T. coelata* have the same convexity.

T. ampullacea is somewhat similar in the strong convexity of the brachial valve and in the anterior commissure with a strong uniplicate fold to the Early Paleocene–Early Eocene Australian species *T. boongeroodaensis* MCNAMARA, 1983. It differs, however, in being slightly smaller, in having longer, more pointed beak and much less numerous costellae than *T. boongeroodaensis* that bears up to 80 fine ribs. The latter species is also distinguishable from *T. ampullacea* by its subpentagonal outline, while *T. ampullacea* is subtriangular.

Occurrence. — Seymour Island, La Meseta Formation: ZPAL 1 (*Bill Hill*), Telm1.

Genus *Plicirhynchia* ALLAN, 1947

Type species: *Rhynchonella plicigera* IHERING, 1897.

?*Plicirhynchia* sp. (Pl. 21: 7–9)

Material. — Two complete specimens, one pedicle valve, 3 brachial valves.

Dimensions: Length 17.1 mm, width 15.9 mm.

Remarks. — The badly preserved material makes it difficult to give precise determination, however, the specimens show some generic resemblance to the genus *Plicirhynchia* ALLAN. The shell is subtriangular, biconvex, anteriorly costate. The beak is suberect with the elongate oval foramen, narrowed anteriorly by two conjunct deltidial plates. The pedicle collar present. The teeth are supported by distinct dental plates. The deep dental sockets are bounded by short, prominent inner socket ridges. The cardinal process is transverse, prominent, bilobed, with visible concentric lines. The low median ridge on the brachial valve reaches the apex.

The specimens under study differ from the Eocene species of Argentina, *P. plicigera* (IHERING) in the development of the anterior costae which are weaker, broader and limited only to the anterior margin, forming plicae (see ALLAN 1947; COOPER 1959). However, they are close to the specimen described and illustrated by BUCKMAN (1910: pl. 1: 10) under the name of *Hemithyris plicigera* IHERING which also shows plicae on the anterior margin. BUCKMAN's (1910) specimen was attributed by OWEN (1980) to the species *Plicirhynchia* sp., however, he did not illustrate the species, giving only description. WIEDMAN *et al.* (1988) also noted the questionable presence of the genus *Plicirhynchia* in their collection without illustration.

The studied specimens are easily distinguishable from the semicostate genus *Probolarina* COOPER in the beak characters and the presence of a cardinal process (COOPER 1959, 1988). They also differ from the species *Paraplicirhynchia gazdzickii* gen. et sp. n. that has distinct sharp ribs beginning at the middle of the shell, disjunct deltidial plates and lack of dental plates in adult stage. The cardinalia are very similar in both species.

The better preserved material is needed to more precise assignment.

Occurrence. — Seymour Island, La Meseta Formation: ZPAL 1 (*Bill Hill*), Telm1. The genus *Plicirhynchia* was previously recorded from Cockburn (OWEN 1980) and Seymour (WIEDMAN *et al.* 1988) Islands.

Genus *Paraplicirhynchia* gen. n.

Type species: *Paraplicirhynchia gazdzickii* sp. n.

Derivation of the name: Resembling *Plicirhynchia*.

Diagnosis. — Semicostate shell medium-sized with hypothyriddid foramen and disjunct deltidial plates. Dental plates reduced in mature forms. Cardinal process transverse, bilobed.

Paraplicirhynchia gazdzickii gen. et sp. n.
(Pl. 22: 2–3)

Holotype: The specimen ZPAL Bp.XXXVII/107 figured on Pl. 22: 3.

Type horizon: Teln I, La Meseta Formation; Eocene.

Type locality: ZPAL I (*Bill Hill*), Seymour Island, Antarctic Peninsula.

Derivation of the name: In honour of Dr. A. GAŹDZICKI, Warszawa, who collected the material for the present study.

Diagnosis. — As for the genus.

Material. — Five complete specimens and one brachial valve.

Dimensions: Length of holotype 17.8 mm, width 18.7 mm, thickness 6.5 mm.

Description. — The shell outline from subcircular to transversely oval. The shell is biconvex with the brachial valve more convex than the pedicle one. The anterior commissure is weakly uniplicate. The anterior half of the shell surface is ornamented by strong ribs (15–16 in number), while the posterior one is smooth or with radial lines. The growth lines well visible. The hinge line is short and incurved. The beak prominent, erect with a large, longitudinally oval foramen of hypothyriddid type. The foramen is restricted by small, disjunct deltidial plates and posteriorly by a pedicle collar slightly elevated above the valve floor. The teeth are small; in immature forms they are supported by weakly developed dental plates which are reduced in adults and only swellings extending posteroventrally, not meeting the valve floor, are present.

In the brachial valve the deep sockets are bordered by thick, short inner socket ridges. The cardinal process is transverse in outline, bilobed with visible concentric lines. No hinge plates. The crura are broken. On the inner surface of the brachial valve there is a very low median ridge that extends one third of the shell length but does not reach the apex.

Remarks. — Two genera known from Tertiary, *Probolarina* COOPER and *Plicirhynchia* ALLAN, are characterized by the same type of ornamentation, the anterior half strongly costate (ALLAN 1947; COOPER 1959, 1988). However, the investigated specimens differ strongly from both genera in many features. Both genera have conjunct deltidial plates, even those of *Probolarina* are auriculate, while the deltidial plates of specimens from Seymour Island are disjunct. The cardinalia seem to be related to those of *Plicirhynchia*; the cardinal process and median ridge are absent in *Probolarina*. The dental plates differ strongly from those of the studied specimens. So far only the Tertiary New Zealand genus *Aetheia* THOMSON and the Argentinian one *Patagorhynchia* ALLAN have no dental plates (ALLAN 1938; COOPER 1959; LEE 1978a), however, the specimens described herein differ strongly from them in shell ornamentation. They also differ in exterior aspect from ?*Plicirhynchia* sp. in having more distinct, sharper ribs which appear earlier on the shell surface, and disjunct deltidial plates.

Two species with poorly known internal characters, "*Rhynchonella*" *faxensis* POSSELT (ASGAARD 1968) and *Phapsirhynchia sanctapaulensis* PAJAUD, 1976, which are also Tertiary, Danian and Pliocene respectively, have similar ornamentation, but the ribs are less distinct and appear near the anterior margin.

Occurrence. — Seymour Island, La Meseta Formation: ZPAL I (*Bill Hill*), Teln I.

Order **Terebratulida** WAAGEN, 1883
Superfamily **Terebratuloidea** GRAY, 1840
Family **Terebratulidae** GRAY, 1840
Subfamily **Terebratulinae** GRAY, 1840
Genus *Liothyrella* THOMSON, 1916

Type species: *Terebratula uva* BRODERIP, 1833.

Liothyrella anderssoni OWEN, 1980
(Pl. 20: 3)

1980. *Liothyrella anderssoni* sp. nov.: OWEN, p. 143, figs 32–33.

Material. — Nine complete specimens, 3 pedicle valves. Some specimens are damaged.

Dimensions: Length 52.5 mm, width 40.3 mm, thickness 22.4 mm.

Remarks. — The studied specimens correspond well with description and illustrations given by OWEN (1980). The large, elongate oval shell has smooth surface with well-defined concentric growth lines and

is biconvex with slightly deeper pedicle valve. The anterior commissure is rectimarginate. The massive, erect beak is truncated by a large, circular, labiate foramen of mesothyridid type. The deltidial plates are conjunct and form a large symphytium. No pedicle collar is observed. The investigated specimens differ from those described by OWEN (1980) in being slightly larger.

The species *L. anderssoni* differs from another species of this genus in the collected material, namely *Liothyrella* sp., mainly in beak characters: *Liothyrella* sp. has incurved beak, concave symphytium, permesothyridid foramen and well developed pedicle collar. *L. anderssoni* is also much larger and has better marked growth lines.

Occurrence. — Seymour Island, La Meseta Formation: ZPAL 3 (*Metacrinus* site), Telm7; ZPAL 10 (“*Sergio Point*”), Telm3; ZPAL 12 (*Sadler Stacks*), Telm1–Telm2; Telm4–Telm5; Telm6–Telm7. OWEN’s (1980) specimens come from the upper units of the La Meseta Formation. In the investigated material *L. anderssoni* is also noted from the lower units. Also STILWELL and ZINSMEISTER (1992) mentioned its presence in the unit Telm1.

Liothyrella sp.

(Pl. 20: 1–2)

Material. — Nine complete specimens, 4 pedicle valves and 3 brachial valves. Material is badly preserved, 6 other complete specimens may also belong to this species.

Remarks. — Poorly preserved material makes the determination to the specific level impossible, however, on the generic level the studied specimens show typical features of *Liothyrella*. They measure 30–40 mm in length and have smooth shell surface with numerous growth lines. The beak is incurved with a large, circular, permesothyridid foramen limited anteriorly by conjunct deltidial plates that form a small, concave symphytium. The pedicle collar well developed. The teeth are small, not supported by dental plates. The loop is not preserved, but a semi-elliptical, flattened cardinal process, well defined fulcral plates, the presence of outer hinge plates and lack of median septum, all point to the genus *Liothyrella*.

The specimens under study are very close to that of *L. cf. L. lecta* (GUPPY) illustrated by WIEDMAN *et al.* (1988). They are also similar to the Recent species *L. uva* (BRODERIP) living in the Antarctic waters (FOSTER 1974, 1989; COOPER 1983), the fact observed also by WIEDMAN *et al.* (1988).

Occurrence. — Seymour Island, La Meseta Formation: ZPAL 1 (*Bill Hill*), Telm1. OWEN (1980: 141) described *L. lecta* (GUPPY) from the Lower Tertiary of Cockburn Island.

Subfamily **Seymourinae** subfam. n.

Diagnosis. — Smooth shell medium-sized, biconvex with anterior commissure sulcate. Foramen large, submesothyridid to mesothyridid, deltidial plates disjunct. Loop short, squarish in outline with thin transverse band narrowly arched, crural processes long, needle-like, terminal points absent. Outer hinge wide, inner hinge plates absent. Dental plates and brachial medium septum absent.

Remarks. — In external and internal features the investigated specimens form a distinguished group among Terebratulidae (see COOPER 1983). Disjunct deltidial plates and lack of symphytium distinguish them from other terebratulids. The loop with its thin, arched transverse band is not observed in any representative of the Terebratulidae.

Genus *Seymourella* gen. n.

Type species: *Seymourella oweni* sp. n.

Derivation of the name: From the type locality, Seymour Island.

Diagnosis. — Medium-sized, sulcate terebratulid with disjunct deltidial plates and short loop with thin transverse band narrowly arched.

Seymourella oweni gen. et sp. n.

(Pl. 25: 10–12)

Holotype: The specimen ZPAL Bp.XXXVII/135 figured on the Pl. 25: 12.

Type horizon: Telm2, La Meseta Formation; Eocene.

Type locality: ZPAL 8, Seymour Island, Antarctic Peninsula.

Derivation of the name: In honour of Dr. E.F. OWEN, London.

Diagnosis. — As for the genus.

Material. — Four complete specimens and 2 pedicle valves.

Dimensions: Max. length 37.2 mm, width 34.0 mm, thickness 13.7 mm; length of holotype 30.5 mm, width 30.0 mm, thickness 15.8 mm.

Description. — The shell outline is subpentagonal; surface is smooth with numerous distinct growth lines. The anterior commissure is narrowly sulcate. The pedicle fold develops very early in the development of the shell. The shell is biconvex, with a more convex pedicle valve. The massive, suberect beak is truncated by a large, circular, submesothyridid to mesothyridid foramen. The small, triangular deltidial plates are disjunct.

The pedicle collar is very short. The teeth are sharp, not supported by dental plates. There is no median septum in either valves. The cardinal process of the brachial valve is broadly transverse and forms a wide depression along the margin. The fulcral plates are small. The outer hinge plates are triangular and wide, while the inner ones absent. The long, sharply pointed crural processes are directed ventrally. The short, squarish in outline loop (Pl. 25: 11c) occupies one third of the shell length. The thin transverse band forms a narrow, high arch. The terminal points are absent.

Remarks. — The investigated specimens differ strongly from hitherto described terebratulid genera and species both in external and internal morphologies (compare COOPER 1983). Externally this species is characterized by its incomplete foramen with small, disjunct deltidial plates and sulcate anterior commissure. The loop of *Seymourella oweni* gen. et sp. n. is distinguished among terebratulids by its thin, narrowly arched transverse band and needle-like, long crural processes. The cardinal process occurring as a transverse depression along the posterior margin differentiates this species, as cardinal process in Terebratuloidea forms usually a flattened half ellipse.

Occurrence. — Seymour Island, La Meseta Formation: ZPAL 1 (*Bill Hill*) Telm1; ZPAL 8, Telm2.

Subfamily uncertain

Gen. et sp. n.

(Pl. 22: 1)

Material. — One complete specimen.

Dimensions: Length 17.7 mm, width 16.3 mm, thickness 6.6 mm.

Description. — The shell is subtriangular, medium-sized with smooth surface on which only numerous growth lines are visible, four of them are distinct. The shell is unequally convex with a deeper pedicle valve. The anterior commissure is strongly sulcate, with a narrow fold on the pedicle valve appearing very early in the development of the shell. The area is narrow. The beak is erect, truncated by a large, oval, hypothryridid foramen. The small, triangular deltidial plates are disjunct.

In the pedicle valve the well developed pedicle collar is elevated above the valve floor. The teeth are short, but wide, without dental plates.

The interior of the brachial valve was investigated after opening of the specimen. The inner socket ridges are high, projecting beyond the hinge margin. The cardinal process is broadly transverse, occurring as a depression along the posterior margin. The outer hinge plates are very wide, the inner ones being absent. The brachidium is partly broken, but clearly it was a short loop (see Pl. 22: 1d–e). It seems even to have no descending branches, only a transverse band. The crural processes are broad, prominent. There is no median septum.

Remarks. — The scarcity of the material prevents a formal erection of a new genus and species, however, the studied specimen differs strongly from the hitherto described terebratulid genera and species (see COOPER 1983). The incomplete hypothryridid foramen makes this specimen unique among Terebratulidae. In its cardinalia with wide outer hinge plates and a cardinal process as a broad depression along the posterior margin it is similar to *Seymourella oweni* gen. et sp. n., however, it differs in having short, acutely pointed crural processes.

Occurrence. — Seymour Island, La Meseta Formation: ZPAL 1 (*Bill Hill*), Telm1.

Superfamily **Cancellothyridoidea** THOMSON, 1926Family **Cancellothyrididae** THOMSON, 1926Subfamily **Cancellothyridinae** THOMSON, 1926Genus *Terebratulina* D'ORBIGNY, 1847

Type species: *Anomia retusa* LINNAEUS, 1758.

Terebratulina buckmani OWEN, 1980

(Pl. 23: 5–7)

1910. *Terebratulina lenticularis* TATE; BUCKMAN, p. 28. pl. 3: 4.

1980. *Terebratulina buckmani* sp. nov.; OWEN, p. 130, fig. 9.

1988. *Terebratulina buckmani* OWEN; WIEDMAN *et al.*, fig. 2.14–15.

Material. — 20 complete specimens, 2 pedicle valves and 4 brachial valves.

Dimensions: Max. length 19.4 mm, width 12.8 mm; max. length of the brachial valve 23.7 mm, width 17.0 mm; length 16.2 mm, width 9.9 mm and thickness 4.8 mm.

Remarks. — The studied specimens correspond well with those described by other authors (BUCKMAN 1910; OWEN 1980; WIEDMAN *et al.* 1988). The shell is elongate to suboval. Numerous ribs increase in number by bifurcating and intercalating. The anterior commissure in smaller specimens is rectimarginate, while larger specimens have a shallow sulcus on the pedicle valve. The large, circular, submesothyridid foramen is narrowed anteriorly by two small, triangular, disjunct deltidial plates and posteriorly by a well developed pedicle collar. The cardinalia are typical of the genus: narrow hinge line, high inner socket ridges projecting beyond the hinge margin, deep dental sockets, distinct cardinal process (see Pl. 23: 7).

The investigated specimens differ, however, in their more elongate shape, especially when compared with the specimens described by BUCKMAN (1910) and OWEN (1980). In shell outline they are closer to those illustrated by WIEDMAN *et al.* (1988: fig. 2.14–15). In shape they are very close to the species *T. suessi* (HUTTON) from the Oligocene deposits of New Zealand illustrated by MACKINNON *et al.* (1993). However, the specimen of *T. suessi* illustrated by ALLAN (1932b) is pentagonal in outline differing in this respect from the specimens under study.

Occurrence. — Seymour Island, La Meseta Formation: ZPAL 1 (*Bill Hill*), Telm1; ZPAL 8, Telm2. It was already found in the La Meseta Formation of Seymour Island (WIEDMAN *et al.* 1988) as well as on Cockburn Island (BUCKMAN 1910; OWEN 1980).

Genus *Murravia* THOMSON, 1926

Type species: *Terebratulina catinuliformis* TATE, 1896.

Murravia fosteri sp. n.

(Pl. 24: 1–5)

Holotype: The specimen ZPAL Bp.XXXVII/173 figured on Pl. 24: 5.

Type horizon: Telm1, La Meseta Formation; Eocene.

Type locality: ZPAL 1 (*Bill Hill*), Seymour Island, Antarctic Peninsula.

Derivation of name: In honour of Dr. M.W. FOSTER, Peoria, Illinois.

Diagnosis. — Coarsely ribbed *Murravia* with a large, hypothyrnid foramen and sulcate to slightly paraplicate anterior commissure.

Material. — Eight complete specimens and one pedicle valve.

Dimensions: Length of holotype 14.4 mm, width 15.6 mm, thickness 4.6 mm; length of paratype 13.5 mm, width 13.4 mm, thickness 4.4 mm.

Description. — The shell is small-sized and variable in outline, from subtriangular, subquadrate to broadly transverse, usually wider than long, especially in larger specimens. It is slightly biconvex in smaller specimens to plano-convex in adults, with anterior commissure nearly rectimarginate in smaller forms and becoming sulcate to slightly paraplicate in adults (see Pl. 24: 3d). The shell is ornamented by distinct, coarse ribs varying in number from 28 to 52, increasing by bifurcating as well as intercalating. Two to four distinct growth lines are visible. The hinge line is usually wide and straight. The area is narrow. The foramen of hypothyrnid type is large and oval, narrowed by two small, disjunct deltidial plates.

The pedicle collar is wide, elevated from the valve floor. The teeth are wide but short, and there are no dental plates. The deep dental sockets of the brachial valve are bounded by high inner socket ridges, projecting beyond the hinge margin. The cardinal process forms a broadly transverse depression along the margin. The hinge plates narrow. The brachidium only partly preserved as long crura with widening ends (see Pl. 24: 2c). The internal margin of both valves is crenulated.

Remarks. — Four genera belonging to the superfamily Cancellothyridoidea, i.e. *Terebratulina* D'ORBIGNY, *Eucalathis* FISCHER et OEHLERT, *Chlidonophora* DALL and *Murravia* THOMSON, have very similar shell ornamentation and cardinalia, differing mainly in the loop development as well as beak characters. As in the investigated material the loop is not preserved, the attribution of the investigated specimens is based on other features which are characteristic for *Murravia*. The genus *Murravia* can be easily distinguished from *Terebratulina* and *Eucalathis* by the foramen type which is submesothyridid in the two latter genera, being hypothyriddid in *Murravia*. It differs also from them in being plano-convex and having a wide hinge line. The genus *Chlidonophora*, in turn, resembling *Murravia* in hypothyriddid foramen and wide hinge line, differs, however, from it in having biconvex shell with anterior uniplication. Only *Murravia* has sulcate anterior commissure.

COOPER (1977) also included in this superfamily a Recent genus created by himself, *Notozyga*. Showing some resemblance in ornamentation, *Notozyga* differs from the investigated specimens in nearly equally biconvex shell and straight anterior commissure.

The species *Murravia fosteri* sp. n. differs strongly from the Tertiary species from New Zealand and Australia, *M. catinuliformis* (TATE) in shell ornamentation. *M. catinuliformis* has numerous fine ribs (THOMSON 1916; MACKINNON *et al.* 1993), while *M. fosteri* is coarsely ribbed. The extant species from South Australia, *M. exarata* (VERCO) has a more elongate shape and also finer ribs (THOMSON 1927).

Occurrence. — Seymour Island, La Meseta Formation: ZPAL 1 (*Bill Hill*), Telm1. *Murravia fosteri* sp. n. is recorded for the first time in the Tertiary strata of Seymour Island and is the earliest representative of the genus.

Superfamily **Terebratelloidea** KING, 1850

Family **Terebratellidae** KING, 1850

Subfamily **Bouchardiinae** ALLAN, 1940

Genus *Bouchardia* DAVIDSON, 1850

Type species: *Anomia rosea* MAWE, 1823.

Bouchardia antarctica BUCKMAN, 1910

(Pl. 19: 5–6; Text-fig. 5)

1910. *Bouchardia antarctica* sp. n.: BUCKMAN, p. 16, pl. 1: 2–3.

1910. *Bouchardia ovalis* sp. n.: BUCKMAN, p. 16, pl. 1: 1.

1910. *Bouchardia angusta* sp. n.: BUCKMAN, p. 16, pl. 1: 4, pl. 3: 2.

1910. *Bouchardia elliptica* sp. n.: BUCKMAN, p. 17, pl. 1: 5.

1910. *Bouchardia attenuata* sp. n.: BUCKMAN, p. 17, pl. 1: 6.

1980. *Bouchardia antarctica* S.S. BUCKMAN; OWEN, p. 132, figs 19–26.

1988. *Bouchardia antarctica* BUCKMAN; MANCENIDO and GRIFFIN, pl. 1: 11–12.

1988. *Bouchardia antarctica* BUCKMAN; WIEDMAN *et al.*, fig. 2.1–4.

Material. — More than 300, mostly complete, specimens.

Dimensions: Max. length 24.6 mm, width 18.0 mm; length 24.2 mm, width 17.2 mm, thickness 8.7 mm.

Remarks. — This very characteristic, easily distinguishable species is the most abundant one in the deposits of the La Meseta Formation, occurring in the whole section (see also STILWELL and ZINSMEISTER 1992). OWEN (1980) discussed the problems of oversplitting by BUCKMAN (1910). The investigated specimens here appear identical in their external and internal morphologies to the conspecific specimens illustrated by BUCKMAN (1910), OWEN (1980) and WIEDMAN *et al.* (1988). The shell is elongate oval to subtrapezoidal in outline and ornamented only by distinct growth lines. The umbo is massive with a circular, epithyriddid foramen and slightly concave, well exposed symphytium. The posterior regions of both valves are greatly thickened. The pedicle valve interior (Text-fig. 5a) with strong teeth having swollen bases. Beneath the teeth deep grooves occur for the accommodation of the inner socket ridges. The brachial valve interior (Text-figs 5b–c) with massive cardinalia with high inner socket ridges and

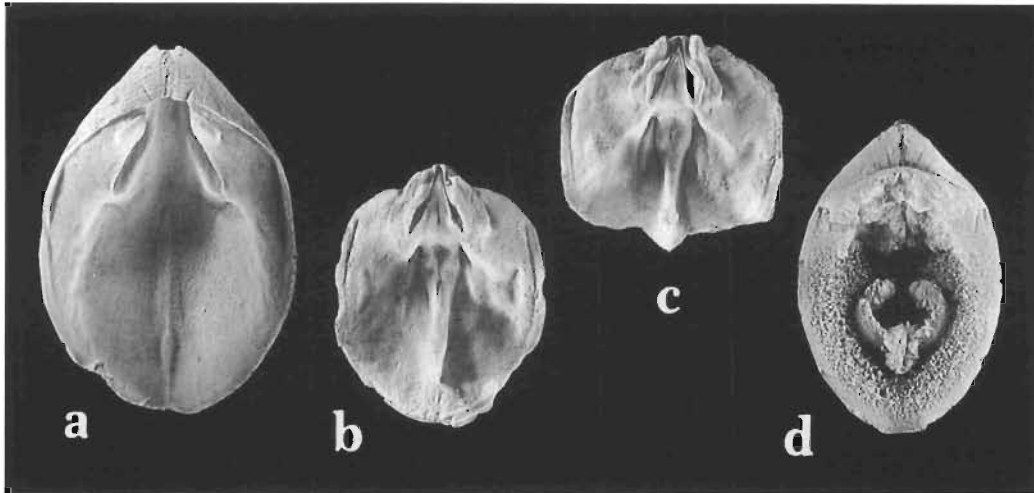


Fig. 5

Bouchardia antarctica BUCKMAN, Telm6–Telm7, $\times 2$: a inner view of the pedicle valve showing strong teeth with swollen bases and deep grooves for reception of socket ridges, ZPAL Bp.XXXVII/258; b–c inner views of the brachial valves showing massive cardinalia with a characteristic cardinal process, and a high median septum. ZPAL Bp.XXXVII/432–433; d inner view of the pedicle valve showing recrystallized lophophore. ZPAL Bp.XXXVII/260.

an inverted V-shaped, big cardinal process. The median septum is high, not associated with the cardinalia. The adductor muscle scars well visible. The loop is in axial phase (Text-fig. 5d); the ascending branches are represented by two curved lamellae which do not unite, while the descending branches are absent.

WIEDMAN *et al.* (1988) determined also in their collection *B. zitteli* VON IHERING. In the investigated material, as well as OWEN's material, there are also specimens with the long hinge line resembling *B. zitteli*, however, they are treated as variants of *B. antarctica*.

Occurrence. — Seymour Island, La Meseta Formation: ZPAL 1 (*Bill Hill*), Telm1; ZPAL 3 (*Metacrinus* site), Telm7; ZPAL 5, Telm1; ZPAL 8, Telm2; ZPAL 10 ("*Sergio Point*"), Telm3; Telm4–Telm5; Telm6–Telm7. It was already reported from Seymour Island (BUCKMAN 1910; OWEN 1980; WIEDMAN *et al.* 1988).

Subfamily *Terebratellinae* KING, 1850

Genus *Terebratella* D'ORBIGNY, 1847

Type species: *Terebraula chilensis* BRODERIP, 1833.

"*Terebratella*" *crofti* OWEN, 1980

(Pl. 19: 7)

1980. *Terebratella crofti* sp. nov.; OWEN, p. 135, figs 27a–c.

1988. "*Terebratella*" *crofti* OWEN; WIEDMAN *et al.*, fig. 2.12.

Material. — Nine complete poorly preserved specimens.

Remarks. — The material is very poorly preserved with most specimens strongly crushed and damaged. However, the observed features allow to attribute the investigated specimens to the species described by OWEN (1980) as *Terebratella crofti*. The shell surface is smooth. The large, circular mesothyridid foramen has small, disjunct deltidial plates and sessile pedicle collar. In two open specimens one can notice a distinct, flattened cardinal process and well developed hinge plates meeting a long median septum.

In their recent paper COOPER and LEE (1993) erected a new genus, *Calloria*, for smooth forms including *Waltonia* and/or *Terebratella*, limiting the last name only to ribbed species. The material under study here does not allow for a conclusive decision, therefore the genus name "*Terebratella*" is given in quotation marks.

Occurrence. — Seymour Island, La Meseta Formation: ZPAL 1 (*Bill Hill*), Telm1; ZPAL 8, Telm2. It was already recorded from Seymour Island by OWEN (1980) and WIEDMAN *et al.* (1988).

Genus *Magellania* BAYLE, 1880

Type species: *Terebratula australis* QUOY *et* GAIMARD, 1834.

Magellania antarctica (BUCKMAN, 1910)
(Pl. 26: 5–7)

1910. *Pachymagas antarcticus* sp. n.; BUCKMAN, p. 21, pl. 2: 5–7.

1980. *Magellania antarctica* (S.S. BUCKMAN); OWEN, p. 136, figs 30–31.

1988. *Magellania antarctica* (BUCKMAN); WIEDMAN *et al.*, fig. 2.5–8.

Material. — 13 complete specimens (some are badly damaged), 4 pedicle valves, 3 brachial valves. Some other poorly preserved specimens may also belong to this species.

Dimensions: Max. length 60.5 mm, width 43.0 mm.

Remarks. — The investigated specimens do not differ from those hitherto described (BUCKMAN 1910; OWEN 1980; WIEDMAN *et al.* 1988), however, they are slightly larger. Their shell surface is smooth with visible concentric growth lines. The shell is biconvex with the pedicle valve more convex and the brachial one somewhat flattened. The umbo is massive, suberect with a large, circular mesothyridid foramen limited by conjunct deltidial plates forming a symphytium. The loop is not preserved, but cardinalia are clearly visible in a few specimens (see Pl. 26: 5), showing typical features of this species as large, flattened cardinal process and inner hinge plates united to a short median septum.

Occurrence. — Seymour Island, La Meseta Formation: ZPAL 1 (*Bill Hill*), Telm1; ZPAL 8, Telm2; ZPAL 10 (*Sergio Point*), Telm3; Telm4–Telm5; Telm6–Telm7. It is already noted from Seymour Island by OWEN (1980) and WIEDMAN *et al.* (1988) as well as from Cockburn Island by BUCKMAN (1910) and OWEN (1980).

Genus *Magella* THOMSON, 1915

Type species: *Magella carinata* THOMSON, 1915.

Magella australis (BUCKMAN, 1910)
(Pl. 23: 1–4)

1910. *Magella australis* sp. n.; BUCKMAN, p. 19, pl. 1: 14–16, pl. 3: 3.

1980. *Magella australis* (S.S. BUCKMAN); OWEN, p. 138, fig. 12.

Material. — Four complete specimens and one brachial valve.

Dimensions: Length 23.8 mm, width 19.0 mm, thickness 8.9 mm.

Remarks. — The investigated specimens agree well in external and internal features with those hitherto described, being, however, considerably larger (compare BUCKMAN 1910; OWEN 1980). The thin shell is oval in outline and has a smooth surface with numerous concentric growth lines. It is biconvex with deeper pedicle valve. The anterior commissure is rectimarginate to slightly sulcate. The massive, suberect pedicle umbo is truncated by a large, incomplete, submesothyridid to mesothyridid foramen with discrete deltidial plates. The pedicle collar and dental plates are absent. The brachial valve is dominated by a long, high median septum with distinct trace of the loop attachment (see Pl. 23: 4). The semi-elliptical, flattened cardinal process is prominent. The hinge plates descend steeply to meet the median septum slightly above the valve floor.

Magella carinata THOMSON, Tertiary species of New Zealand, can be distinguished from *M. australis* by its strongly sulcate anterior commissure (THOMSON 1915, 1927). Another species of this genus from New Zealand, *M. pittensis* ALLAN differs in shell outline, being subcircular (ALLAN 1932b). Both species are much smaller than the investigated specimens.

M. australis with its smooth surface and large, incomplete foramen, and discrete deltidial plates, resembles externally *Laquethiris curiosa* gen. et sp. n., differing, however, strongly in internal features, having a prominent cardinal process and lacking dental plates.

Occurrence. — Seymour Island, La Meseta Formation: ZPAL 1 (*Bill Hill*), Telm1; ZPAL 8, Telm2. The species *Magella australis* is noted for the first time from Seymour Island. It was hitherto described from the Tertiary strata of Cockburn Island (BUCKMAN 1910; OWEN 1980).

Subfamily **Stethothyridinae** MACKINNON, BEUS *et* LEE, 1993Genus *Stethothyris* THOMSON, 1918

Type species: *Stethothyris uttleyi* THOMSON, 1918.

Stethothyris sp.

(Text-fig. 6)

Material. — One complete, slightly crushed specimen.

Dimensions: Length 23.8 mm, width 19.2 mm, thickness ?6 mm.

Description. — The medium-sized shell is elongately oval, with smooth surface where only numerous growth lines are visible. The shell is gently biconvex and has rectimarginate anterior commissure. The beak is suberect, with small, mesothyridid foramen, bordered anteriorly by conjunct deltidial plates which form a concave symphytium; a median ridge is developed on the symphytium.

The internal features unknown.

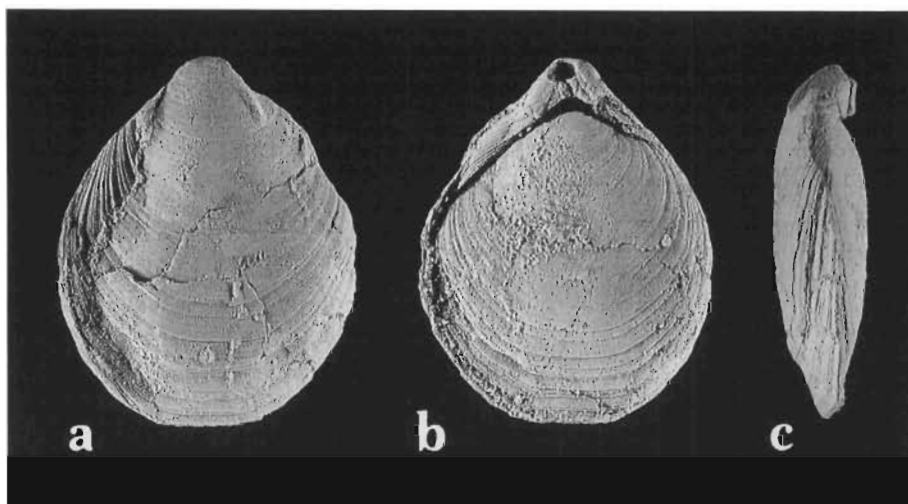


Fig. 6

Stethothyris sp., ZPAL Bp.XXXVII/572, ZPAL 8, Telm2, $\times 2$; a ventral view; b dorsal view; c lateral view.

Remarks. — Despite very limited material in external morphology the investigated specimen agrees well with the diagnosis of the genus (compare THOMSON 1927; MUIR-WOOD *et al.* 1965; MACKINNON *et al.* 1993). Also some genera and species belonging to the subfamily Anakineticinae, being externally similar to *Stethothyris*, possess a symphytium with a median ridge, however, all anakineticinid genera have a permesothyridid foramen (RICHARDSON 1991), while *Stethothyris* has a mesothyridid one.

Stethothyris sp. resembles closely in shell outline, beak characters and foramen size the type species from the Tertiary of New Zealand, *S. uttleyi* THOMSON, differing in being smaller and having somewhat less incurved beak (THOMSON 1927; ALLAN 1940; MUIR-WOOD *et al.* 1965). From *S. tapirina* (HUTTON), another New Zealand Tertiary species, it differs, in turn, in more elongate shape, smaller beak incurvature and larger foramen (MACKINNON *et al.* 1993).

Occurrence. — Seymour Island, La Meseta Formation: ZPAL 8, Telm2. The genus *Stethothyris* has not been hitherto recorded from Seymour Island. It is the oldest occurrence of this genus.

Family **Macandreviidae** COOPER, 1973Genus *Macandrevia* KING, 1859

Type species: *Terebratula cranium* MÜLLER, 1776.

Macandrevia cooperi sp. n.

(Pl. 25: 1–9; Text-figs 7–8)

Holotype: The specimen ZPAL Bp.XXXVII/480 figured on Pl. 25: 2.

Type horizon: Telm2, La Meseta Formation; Eocene.

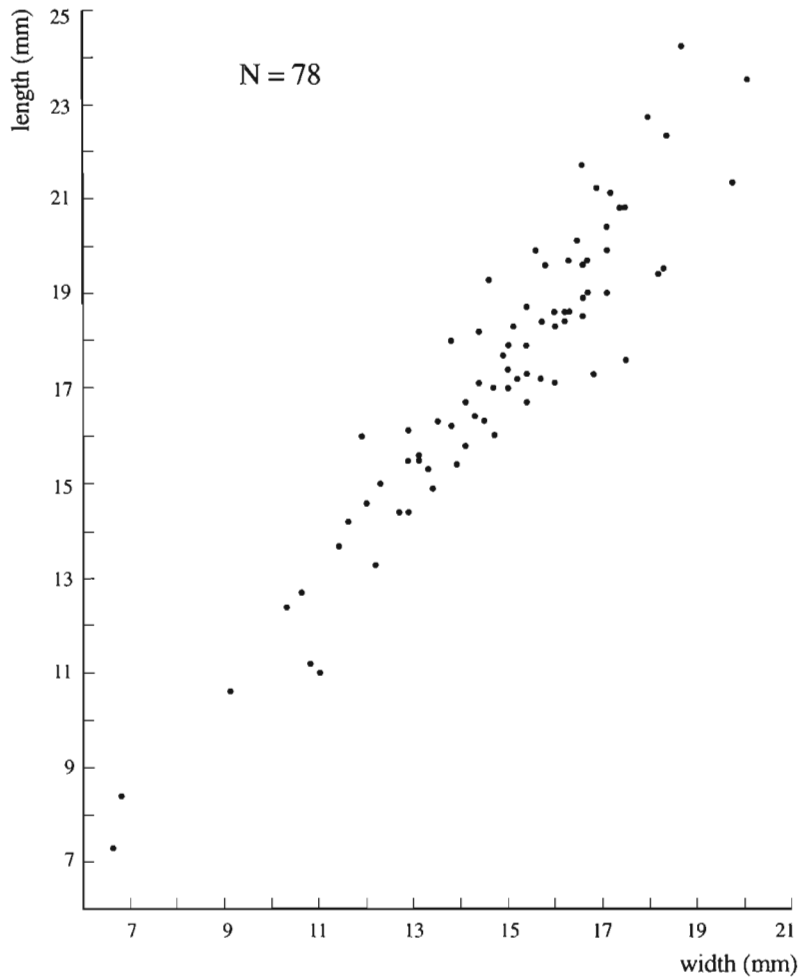


Fig. 7

Scattergram of length-width relationships for specimens of *Macandrevia cooperi* sp. n.

Type locality: ZPAL 8, Seymour Island, Antarctic Peninsula.

Derivation of the name: In honour of Dr. G.A. COOPER, renowned brachiopod specialist.

Diagnosis. — Medium-sized *Macandrevia* with rectimarginate anterior commissure. Foramen permesothyridid, with rudimentary deltidial plates. Loop and cardinalia typical of the genus.

Material. — 85 complete specimens, one pedicle valve and one brachial valve.

Dimensions: Max. length 24.2 mm, width 18.7 mm: length of holotype 20.9 mm, width 17.2 mm, thickness 8.4 mm.

Description. — The shell of medium-size is thin, very variable in outline: from subcircular, oval, elongate-oval to subpentagonal (see Text-figs 7–8 and Pl. 25: 3–6). It is longer than wide with the maximum width generally midway but sometimes somewhat posterior. The shell surface is smooth with weakly developed growth lines. The shell is biconvex with the pedicle valve deeper than the brachial and with rectimarginate anterior commissure. The beak is suberect with medium-sized foramen which is oval to elongate oval, often widening posteriorly, of permesothyridid type. The disjunct deltidial plates are very feebly developed. The hinge line short, curved.

No pedicle collar present. The hinge teeth are small, supported by short dental plates which are united by a callus closely applied to the valve floor (see Pl. 25: 9).

Several specimens have been opened but no fully preserved brachidium was observed. The transverse cardinal process is small, the inner socket ridges high. The two inner hinge plates extend directly to the valve floor (Pl. 25: 7). There is no median septum, but two short, low ridges are visible on interior of the brachial valve. In a specimen with partly damaged loop one can see long, narrow descending branches

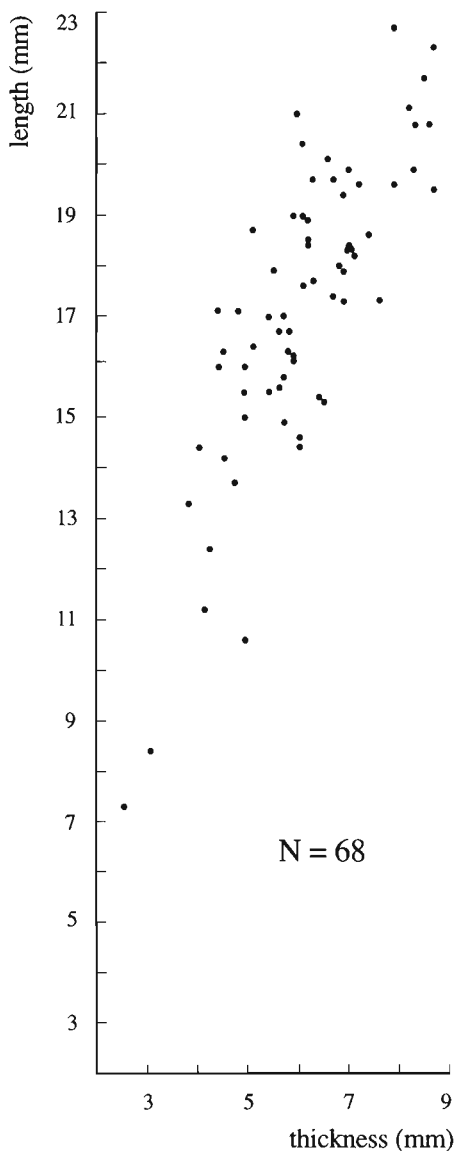


Fig. 8

Scattergram of length-thickness relationships for specimens of *Macandrevia cooperi* sp. n.

and a fragment of ascending branches (Pl. 25: 8). The transverse band is fairly broad. The crural processes are small.

Remarks. — The genus *Macandrevia* KING with its very characteristic external and internal features, can be easily distinguished from other genera. COOPER (1973b) stressing the great difference in its cardinalia proposed a new family for this genus.

The studied specimens, showing all the typical characters, belong without any doubt to the genus *Macandrevia*. They show a great variability in the shell outline and convexity as well as in the size and shape of foramen, the fact which was also observed by FOSTER (1974) among Recent species.

M. cooperi sp. n. differs from the common North Atlantic species, *M. cranium* (MÜLLER), which occurs also in the Pliocene of the Mediterranean region (PHILLIPPI 1844; GAETANI and SACCÀ 1984), in less elongate shape and less convex shell (COOPER 1973b, 1981b). It also differs from another North Atlantic species, *M. tenera* (JEFFREYS) which is much smaller and has narrower loop with shorter ascending branches (COOPER 1973b). *M. novangliae* DALL is also smaller than *M. cooperi* sp. n., and differs in having no deltidial plates (COOPER 1977, 1981b). Two species from West African waters, very similar to each other, *M. bayeri* COOPER and *M. africana* COOPER differ from *M. cooperi* in being larger and having shell narrowed anteriorly (COOPER 1975). *M. bayeri* possesses a cardinal process with expanded myophore, absent in *M. cooperi*. The species *M. cooperi* is easily distinguished from *M. diamantina* DALL by the type of anterior margin which is strongly sulcate in the latter species (FOSTER 1974). The investigated specimens are similar to *M. americana* DALL, occurring around Antarctica as well as Eastern Pacific and southernmost South Atlantic, in shell outline and loop development (COOPER 1973b, 1982; FOSTER 1974, 1989). They are, however, much smaller than the usually shallow-water subspecies *M. americana vanhoffeni* BLOCHMANN which extends to 38 mm long (FOSTER 1974).

The Miocene species from Japan, *M. delicata* HATAI and *M. nipponica* NOMURA *et* HATAI are slightly smaller than the investigated specimens (HATAI 1940). *M. nipponica* can be also distinguished by the convexity of ventral valve, which is twice as deep as the dorsal one, and the absence of cardinal process.

Occurrence. — Seymour Island, La Meseta Formation: ZPAL 1 (*Bill Hill*), Telm1; ZPAL 8, Telm2. The genus *Macandrevia* is reported for the first time from the Tertiary deposits of the Southern Hemisphere and it is the oldest occurrence of this genus.

Family ?**Laqueidae** THOMSON, 1927
Subfamily ?**Laqueinae** THOMSON, 1927
Genus *Laquethiris* gen. n.

Type species: *Laquethiris curiosa* sp. n.

Derivation of the name: After showing affinities to the family Laqueidae and *Laqueus* DALL.

Diagnosis. — Medium-sized shell of smooth surface, having large, incomplete foramen. Deltidial plates discrete. Dental plates present, no cardinal process, hinge plates united to the median septum.

Laquethiris curiosa gen. et sp. n.
(Pl. 26: 1–4)

Holotype: The specimen ZPAL Bp.XXXVII/565 figured on Pl. 26: 1.

Type horizon: Telm2, La Meseta Formation; Eocene.

Type locality: ZPAL 8, Seymour Island, Antarctic Peninsula.

Derivation of the name: After the Latin *curiosus* — curious referring to its uncertain taxonomical position.

Diagnosis. — As for the genus.

Material. — Three complete specimens and 3 pedicle valves.

Dimensions: Length of holotype 19.7 mm, width 17.6 mm, thickness 7.0 mm.

Description. — The shell is smooth, ornamented only by numerous concentric growth lines, and oval to subpentagonal in outline. The anterior commissure is rectimarginate to slightly sulcate. The shell is biconvex with the pedicle valve more convex than the brachial one. The suberect beak is truncated by a large, oval to subcircular, submesothyridid to mesothyridid foramen guarded by very small, disjunct deltidial plates.

The pedicle collar is sessile, closely attached to the floor. The small teeth are supported by distinct dental plates. On the inner surface of the pedicle valve a low, short, fairly wide median ridge is visible.

The median septum in the brachial valve reaches from one third to half of the shell length, becoming very high anteriorly (see Pl. 26: 4d). There are visible traces of attachment of the loop. The outer and inner hinge plates are well developed, separated by crural bases. The inner hinge plates extend nearly horizontally and join the median septum some distance from the valve floor (see Pl. 26: 2). The loop is not preserved.

Remarks. — Lack of preservation of the brachial loop makes the precise assignment to a higher systematic level impossible. In several respects, such as distinct dental plates, absence of cardinal process, outer and inner hinge plates separated by crural bases, the studied specimens are similar to the genus *Laqueus* DALL, differing, however, in having large, incomplete foramen and discrete, disjunct deltidial plates, while *Laqueus* has conjunct deltidial plates forming a symphytium and a small foramen. They also show some resemblance to the genus *Dallina* BEECHER, however, *Dallina* has teeth supported only in young specimens by dental plates, which disappear in adult.

The investigated specimens have some features, such as discrete deltidial plates, dental plates associated with a sessile pedicle collar, lack of separate cardinal process, in common with the Upper Eocene–Lower Miocene Australian genus *Paraldingia* RICHARDSON, 1973a. The genera differ, however, in cardinalia. Crural bases in *Paraldingia* are fused with the socket ridges, the hinge plates slope fairly steeply to fuse with the median septum. The *Paraldingia* species have much more prominent growth lines (RICHARDSON 1973a).

Laquethiris curiosa gen. et sp. n. is externally similar to *Magella australis* (BUCKMAN), differing, however, strongly in internal characters. *M. australis* has a large, flattened cardinal process, teeth not supported by dental plates, longer median septum, and the inner hinge plates are united with the septum near the valve floor.

OWEN (1980) described the species "*Laqueus*" *cockburnensis* from the Lower Tertiary of Cockburn Island. It is larger than *L. curiosa* and has shorter median septum.

Occurrence. — Seymour Island, La Meseta Formation: ZPAL 1 (*Bill Hill*), Telm1; ZPAL 8, Telm2.

PALEOECOLOGY

The La Meseta Formation of Seymour Island has yielded one of the most diverse brachiopod assemblages (BUCKMAN 1910; OWEN 1980; WIEDMAN *et al.* 1988; BITNER 1991, 1995a, b) in the early Tertiary, containing nineteen genera and twenty four species. Although none of the species is extant, many have closely related living congeneric descendants, that provide an opportunity for some comparative ecological analysis (see also WIEDMAN *et al.* 1988). Based on sedimentological observations as well as paleoecological interpretations of other fauna and flora, the La Meseta Formation is considered to be deposited in warm-temperate conditions of nearshore, shallow-marine environments of low-energy in the case of lowermost (Telm1–Telm2) and uppermost (Telm6–Telm7) units and in high-energy in the case of units

Telm3–Telm5 (STILWELL and ZINSMEISTER 1992). In some cases the investigated brachiopod material supports this interpretation, however, brachiopods are not good depth indicators. Their bathymetric ranges are very often remarkably wide which makes these data useless in paleoecology (see also COOPER 1977: 10). According to EMIG (1988) the main factors controlling the bathymetric distribution are environmental hydrodynamics, type of substrate, temperature, sedimentation rate, turbidity, nutrients and water exchange. There are also known cases of changes in ecological requirement of some species during their short Miocene–Recent evolutionary history (REVERT 1985).

COMPARATIVE ECOLOGICAL ANALYSIS

The species *Lingula antarctica* BUCKMAN is the third most common species in the investigated material. It is found in sandstones and sands of the uppermost part of the La Meseta Formation. The burrowing genus *Lingula* BRUGUIÈRE was always used as an indicator of a very shallow-water and warm environment. As it is indeed mostly found in tropical and subtropical waters, its depth range is fairly wide, being the most common at the depth of 5 to 50 m, but is known up to 160 m (EMIG *et al.* 1978; LEE and CAMPBELL 1987). In Recent lingulids the observed relationship between depth and sediment is such that in the intertidal zone they inhabit sandy sediments, while in deeper waters they are associated with finer sediments (PAINE 1970), which may indicate a shallow-water environment for the upper part of the La Meseta Formation, which is sandy.

The species *Basiliola minuta* sp. n. is a rare species in the studied material. It occurs only in the lowermost unit of the La Meseta Formation, Telm1. The Recent species of this genus are found in tropical and subtropical waters of the Pacific and Indian Oceans (HATAI 1940; COOPER 1959, 1981a; ZEJINA 1987; DAWSON 1991; LAURIN 1995). Their bathymetric range is very wide varying from 44 m to 1770 m. The closest extant species, *B. lucida* (GOULD) from off Japan is known from the depths of 86 m to 254 m, living in the temperatures ranging from 11 to 18°C (HATAI 1940). On the other hand, *Basiliola* living today in the New Zealand region (subtropical Kermadec Islands), occurs at the depths from 550 m to 1770 m (DAWSON 1991), *i.e.* a depth which is difficult to accept for the La Meseta Formation.

The species *Hemithiris antarctica* BUCKMAN is a rare species in the collected material, reported only from the lowermost units (Telm1–Telm2) of the formation. Recently the genus *Hemithiris* D'ORBIGNY extends from cold waters of the North Atlantic and the East Pacific around Alaska to warm waters off Japan (THOMSON 1927; HATAI 1940; COOPER 1959, 1973b; BRUNTON and CURRY 1979). The widely distributed extant species *H. psittacea* (GMELIN) more commonly occurs in fairly shallow water from 6 m up to 200 m, but the deepest record is from 2078 m (COOPER 1973b). In effect it seems that *H. antarctica* could also prefer a shallow-water environment. Having a relatively small foramen *H. psittacea* belongs to one of the most strongly attached species (THAYER 1975; RICHARDSON 1981b) with a medium length massive pedicle with short hold-fast papillae (BROMLEY and SURLYK 1973). As THAYER (1975) observed, the relationship between attachment strength and foramen size, although exists, is far from precise. *H. antarctica* might also be a strongly attached species as the type and size of foramen is very similar to that of *H. psittacea*.

The genus *Notosaria* COOPER is relatively common in the investigated material and comes from the lowermost units (Telm1–Telm2). The living species of *Notosaria*, *N. nigricans* (SOWERBY) occurs on rocky and shelly substrates, having a large, irregular attachment area, without rootlets, closely applied to the substrate by numerous holdfasts (LEE 1978b; RICHARDSON 1979, 1981b). It ranges from shallow intertidal waters of rockpools (RUDWICK 1962) up to 800 m, being, however, the most abundant in water less than 200 m (LEE 1978b). It tolerates temperatures from 13–21°C in summer to 9.5–16°C in winter (LEE 1978b). Another living species, *N. reinga* LEE *et* WILSON, 1979 inhabits warmer but deeper waters than *N. nigricans*. Thus, *Notosaria* from Seymour Island, a similarly attached form, might have lived in the same conditions, *i.e.* warm to warm-temperate and fairly shallow waters.

The genus *Tegulorhynchia* CHAPMAN *et* CRESPIN is represented by three species in the discussed material. All of them come from the lowermost unit of the La Meseta Formation. This is a rare genus in modern waters, occurring off Japan to Borneo (HATAI 1940; LEE 1980b), and off St. Paul Island, in the Indian Ocean (COOPER 1981a). The living species *T. doederleini* (DAVIDSON) inhabits moderately deep (120 m to 635 m), warm waters (HATAI 1940; LEE 1980b). LEE (1980b) suggested that the fossil species of New Zealand might inhabit similarly warm but shallower waters. Clearly *Tegulorhynchia* species of Seymour Island lived under the same conditions as those of New Zealand rather than the extant species, as the sedimentary structures of the La Meseta Formation indicate a shallow-water environment.

The specimens assigned with some doubt to the genus *Plicirhynchia* ALLAN occur only in the lowermost unit, Telm1, of the La Meseta Formation. This genus is also reported from the Eocene strata of Patagonia (ALLAN 1947; ZINSMEISTER 1981), nevertheless very little is known of its paleoecology. Judging from sedimentological data and faunal evidence *Plicirhynchia* from Seymour Island inhabited a warm-temperate, shallow-water environment of low energy.

The genus *Liothyrella* THOMSON is quite common in the investigated material, having been found in the lower as well as upper units of the formation. This genus widely distributed in modern seas of the Southern Hemisphere, has a wide bathymetric range. It can occur in very shallow water from 0 up to 2342 m (FOSTER 1974). The species *Liothyrella neozelanica* THOMSON from waters off New Zealand is recorded from the depth of 805 m (FOSTER 1974, 1989). The species of *Liothyrella* are always attached forms and often form large clusters of specimens attached to one another and to a central substrate by long thick pedicles (FOSTER 1974; CURRY 1981; LEE 1991). One may just suppose that *Liothyrella* species from the La Meseta Formation, which have the same type of a functional foramen, exhibited a similar mode of life.

The species *Terebratulina buckmani* OWEN is represented by a relatively great number of specimens in the collected material and occurs only in the lower part of the La Meseta Formation. Recently *Terebratulina* D'ORBIGNY has been found rarely in the Antarctic region and neighbouring waters. FOSTER (1989) noted the presence of *T. kiiensis* DALL *et* PILSBRY off southernmost South America. Its depth range varies from 18 to 1258 m. Although *Terebratulina* is known from the waters up to 1500 m deep, the maximum density of *T. retusa* (LINNAEUS) off Scotland is between 100 and 200 m (CURRY 1982), and that of *T. septentrionalis* (COUTHOUY) off the east coast of Canada between 0 and 30 m (NOBLE *et al.* 1976). Both those species live attached to a rocky or shelly substrate (NOBLE *et al.* 1976; CURRY 1982), commonly by a root-like pedicle (SCHUMANN 1969; BROMLEY and SURLYK 1973; CURRY 1981), and the presence of a suitable substrate seems to be the most important factor controlling the distribution (NOBLE *et al.* 1976). The character of sediments of the La Meseta Formation suggest that *T. buckmani* was attached by a rootlet pedicle. Recent species of *Terebratulina* in fine-grained sediment with rare suitable hard substrate develop a mode of life that ensures shell anchorage (CURRY 1981; see also SURLYK 1972: 21–23).

The species *Murravia fosteri* sp. n. is a rare species in the material from Seymour Island, having been found in the lowermost part (Telm1) of the La Meseta Formation. Today the genus *Murravia* THOMSON occurs off South Australia in relatively shallow water from 73 m to 274 m (THOMSON 1927; FOSTER 1969; ZEJINA 1976).

The species *Bouchardia antarctica* BUCKMAN is most abundant in the investigated material, being known from the entire formation. The only extant species of the genus *Bouchardia*, *B. rosea* (MAWE), is living off the coasts of Brazil at depths of 10–35 m (MANCENIDO and GRIFFIN 1988; see also ZEJINA 1976 who gives the depth range up to 108 m). This warm-water (19–26°C) species inhabits medium- to coarse-grained sandy bottom, *i.e.* similar sedimentary conditions as existed during deposition of the La Meseta Formation. RICHARDSON (1981b) observed strong correlations between pedicle structure and beak type, the conformation of the cardinalia and valve muscle patterns. According to her the shell characters of *B. rosea* indicate a free and mobile life-style with a presumably functional pedicle. If we treat the genus *Bouchardia* as living under similar conditions, the sea during the Paleogene along the Antarctic Peninsula reached significantly warmer temperatures than at the present-day at this region. However, other data, indicating lower temperatures than those characteristic for *B. rosea*, may suggest that *Bouchardia* species have adapted to warmer water conditions since the Eocene.

The species *Magellania antarctica* (BUCKMAN) is relatively common in the discussed material and occurs in the entire section of the La Meseta Formation. The Recent *Magellania* species live in cold water and have a wide depth range, from 2 m to 1894 m (FOSTER 1974, 1989). Also MCCAMMON (1973) studying ecology of *M. venosa* (SOLANDER), a species occurring off southern South America, noticed that the major factors limiting distribution are the nature of the substrate and the current velocity, not the depth. The largest populations are in areas with a clean shelly or rocky bottom and constant, strong but not turbulent currents. The depth of *M. venosa* ranges from the subtidal to 1900 m, however, it is most common on the shelf. The water temperature acceptable to this species is from 3 to 12°C.

The species *Magella australis* (BUCKMAN) is a rare species in the collection from Seymour Island. It has been found only in the lowermost units of the La Meseta Formation. The New Zealand Tertiary strata in which *Magella* species have been found are considered as deposited in warm-water, shallow-shelf (up to 50–70 m) environment (LEE 1986).

The genus *Stethothyris* THOMSON is extremely rare in the investigated material. The closely related species, *S. uttlei* (THOMSON) is considered to belong to a group of brachiopods exhibiting free-living, unattached mode of life (LEE 1986).

The species *Macandrevia cooperi* sp. n. is the second most abundant species in the material under study, associated with the lowermost units (Telm1–Telm2) of the formation. The bathymetric range of the genus *Macandrevia* KING is very wide, from water as shallow as 2 m to more than 4000 m, but usually it occurs in deep water (COOPER 1975, 1977). It could suggest that *Macandrevia* was able, like other groups of invertebrates known from shallow-water deposits of the La Meseta Formation (see BLAKE and ZINSMEISTER 1979, 1988; FELDMANN and ZINSMEISTER 1984; ZINSMEISTER and FELDMANN 1984; FELDMANN and WILSON 1988; BAUMILLER and GAŹDZICKI 1994, 1996 this volume), to adapt to deeper water conditions during the Cenozoic. *Macandrevia* is described by SCHUMANN (1969) as having an undivided pedicle, and BROMLEY and SURLYK (1973) wrote of a long, massive, unbranched pedicle with long hold-fast papillae.

New genera described from the La Meseta Formation have medium- to large-sized forams and were clearly the attached forms. Interesting is the absence of craniid and thecideid brachiopods which are known from the Paleogene of New Zealand (ALLAN 1937b; LEE 1986; 1987) and Australia (ALLAN 1940; ARCHBOLD 1991), which may be easily explained by the lack of suitable substrate and too high sedimentation rate.

PALEOENVIRONMENTAL IMPLICATIONS

The conditions during the deposition of the La Meseta Formation, based on faunal evidence, are defined as warm-temperate, shallow-marine (ZINSMEISTER 1982b; FELDMANN and ZINSMEISTER 1984; WOODBURN and ZINSMEISTER 1984; SADLER 1988; WIEDMAN and FELDMANN 1988; ZULLO *et al.* 1988; STILWELL and ZINSMEISTER 1992; GAŹDZICKI and HARA 1994). Similar conditions have been suggested by WIEDMAN *et al.* (1988: fig. 4) who plotted temperature, depth, and latitude ranges of six extant genera: *Notosaria*, *Liothyrella*, *Terebratulina*, *Bouchardia*, *Terebratella*, and *Magellania*. Excluding *Bouchardia* that lives in much warmer temperatures, closer to the equator, they observed that distributions of other genera overlap near 35 to 40°S latitudes, temperature ranges overlap at 10 to 14°C (although for some there is an extreme cool tolerance level), and all can live in shallow waters (10 to 100 m). In effect, they concluded that conditions in the Eocene time on Seymour Island were analogous to those occurring in shallow-water environments in temperate lower latitudes with temperatures much higher than are recorded at the present-day in the Antarctic Peninsula region.

The newly collected material, containing few genera new to Seymour Island, allows for more detailed analysis. Although the brachiopod fauna is highly endemic at the specific level, due to comparison to congeneric descendants today living one may say that brachiopods in general could be a confirmation of conditions proposed above. Some genera as *Lingula*, *Basiliola*, *Notosaria*, *Tegulorhynchia*, *Murravia*, *Bouchardia* are known today from tropical to warm waters, others, as *Hemithiris* and *Terebratulina* are known both from cold as well as warm waters. The genera *Magella* and *Stethothyris* occur in the early Tertiary warm-temperate facies of New Zealand (LEE 1986). Even if the living congeneric descendants have usually a very wide bathymetric distribution, they are most common at the depth up to 200 m. Those genera which occur today in subtropical or tropical regions, live usually at the greater depth than proposed for the La Meseta Formation. So it may suggest that brachiopods could live in shallower water but cooler climate, and moving to lower latitudes, *i.e.* warmer conditions, they changed the ecological requirements and adapted to deeper, *i.e.* cooler, water environment. The temperature tolerance is much smaller than the depth as was observed for *Magellania venosa* (SOLANDER) by MCCAMMON (1973). Such a significant change in depth with latitude is also known among other groups (see FELDMANN and ZINSMEISTER 1984: 1059).

Because of a significant number of deep-water species in the La Meseta shark assemblage LONG (1992) suggested the presence of local deep-water habitats, *e.g.* a series of deep and lengthy trenches. In such a case the co-occurrence of shallow- and deep-water brachiopod species may be easily explained by the heterogeneity of the environment.

All brachiopods, except *Lingula* which can also be found in brackish water conditions which is, however, a particular case (PLAZIAT *et al.* 1978), indicate normal saline conditions. Also other faunas, such as corals, molluscs, echinoids, crinoids, asteroids, bryozoans, indicate marine conditions with normal salinities (ZINSMEISTER 1977, 1982b, 1984; BLAKE and ZINSMEISTER 1979, 1988; ZINSMEISTER and

CAMACHO 1980, 1982; MCKINNEY *et al.* 1988; STILWELL and ZINSMEISTER 1992; BAUMILLER and GAŻDZICKI 1994, 1996 this volume; GAŻDZICKI and HARA 1994; HARA 1995; RADWAŃSKA 1996 this volume; STOLARSKI 1996 this volume). In effect, the interpretation of the La Meseta Formation as originated within an incised-valley estuary (POREBSKI 1995), which from the definition contains measurable quantities of fresh water, is difficult to accept.

There is also some controversy concerning the climatic conditions during the deposition of the La Meseta Formation. Based on diversity and composition of marine fauna, comparable to that of New Zealand, sea surface temperatures during the deposition of the lower part of the La Meseta Formation ranged from about 10 to 14°C (ZINSMEISTER 1982b, 1991; WOODBURNE and ZINSMEISTER 1984; STILWELL and ZINSMEISTER 1992). Similar or even higher temperature ranges may be estimated also from the brachiopod fauna which contains warm-water indicators (see discussion above). In the upper units a sharp decrease in diversity among calcareous microfossils as well as molluscan fauna is observed which may indicate a climatic change, *i.e.* a cooling event (KENNETT 1980; ZINSMEISTER and CAMACHO 1980, 1982; ZINSMEISTER 1982b, 1991; STILWELL and ZINSMEISTER 1992; JENKINS 1993). Based on oxygen isotope data from Seymour Island GAŻDZICKI *et al.* (1992) postulated a considerable cooling at the boundary of T_{elm}5 and T_{elm}6 (but see also BIRKENMAJER 1992: 254), that can agree with a general cooling at the Eocene/Oligocene boundary in the Southern Ocean (SHACKLETON and KENNETT 1975; MARSHALL *et al.* 1993) when sea-surface temperatures fell to 7°C after gradual cooling during the Paleocene and Eocene. Although a dramatic decrease in diversity among brachiopods is also observed, from 18 genera to 4 genera, the presence of such warm-water genera as *Lingula* and *Bouchardia*, abundant in the uppermost units, is in contradiction to a sharp drop of temperatures.

The conflict between sea-surface temperatures at low latitudes during the Tertiary, obtained from paleontological and isotopic sources was investigated by ADAMS *et al.* (1990). Based on a varied group of shallow-marine organisms, among others larger foraminifera and zooxanthellate corals, they suggest subtropical to tropical temperatures at low latitudes during the Tertiary, while SHACKLETON (1984), based on oxygen isotope studies, postulated a lower temperature, around 18°C. According to ADAMS *et al.* (1990) isotopic data from all marine organisms should be interpreted with caution as the oxygen isotope curves yield temperatures lower by 20–40% than those from paleontological sources. Already LEE (1986) has drawn the attention to the fact that in the New Zealand Tertiary the sea temperatures obtained from paleontological and oxygen isotopic data differ considerably, giving lower temperatures in the case of isotopes. This agrees also with a postulate of MARSHALL *et al.* (1993), who analysed the oxygen isotopic data from the Cretaceous to Eocene sequence of the James Ross Island area, that temperatures calculated from isotopes must be treated with caution.

Based on stable isotopic analyses of benthic and planktonic foraminiferal species from the lower Eocene to Oligocene section at ODP sites 738 and 744 in the Indian Ocean BARRERA and HUBER (1993) concluded that the thermal structure of the water column changed little from the late Eocene to early Oligocene time and that the shift of the $\delta^{18}\text{O}$ values in the early Oligocene resulted from an increase in the volume of continental ice rather than cooling. It should be mentioned that the isotopic temperatures were calculated by SHACKLETON and KENNETT (1975) assuming the absence of continental ice.

PALEOBIOGEOGRAPHICAL REMARKS

The investigated brachiopod assemblage of the La Meseta Formation contains both taxa of a wide stratigraphical and geographical range as well as those restricted to the Southern Hemisphere or endemic to the James Ross Basin.

The genus *Lingula* BRUGUIÈRE is well known from the most of the Tertiary of New Zealand (PENSELER 1930; ALLAN 1936, 1960; LEE and CAMPBELL 1987), being, however, absent in Recent waters in this region. Recently it occurs mostly in the Western Pacific and around the margins of the Indian Ocean (EMIG *et al.* 1978). Its southern limit is the eastern coast of Australia. It is clear that the temperature is the limiting factor for *Lingula*. It indicates that the Tertiary climate in Antarctica and New Zealand would have been much warmer than today, the fact supported also by other data.

Several species of the genus *Basiliola* DALL are known from the Pacific waters around Hawaiian, Japanese, Philippine, Borneo, Fiji, New Caledonia and New Zealand Islands, as well as from the Indian

Ocean (HATAI 1940; COOPER 1957, 1959, 1981a; ZEJINA 1987; DAWSON 1991; LAURIN 1995). The oldest hitherto known occurrence of *Basiliola* was that from the Miocene of Fiji Islands, Southwest Pacific (COOPER 1978), being also known as a fossil from the Pliocene of Okinawa, Japan and Fiji Islands (COOPER 1957, 1978). Its presence in the deposits of the La Meseta Formation extends the stratigraphical range of this genus to the Eocene. It is worth noting that *Basiliola* has not been reported earlier from Seymour Island and that it is not known from the Tertiary of New Zealand and Australia.

The species of *Hemithiris* D'ORBIGNY, both fossil and Recent, are mainly confined to the Northern Hemisphere. In Recent waters *Hemithiris* is widely distributed in the North Atlantic and Pacific (THOMSON 1927; HATAI 1940; COOPER 1959, 1973b). JACKSON (1912) noted the presence of *Hemithiris* off Antarctica, however, his assignment is highly questionable because of fragmentary material which was even pointed out by him (JACKSON 1918). As fossil it is known from Tertiary deposits of Europe, Alaska and Japan (HATAI 1940; COOPER 1959) in the Northern Hemisphere, and of Cockburn (OWEN 1980) and Seymour Islands in the Southern Hemisphere. Its absence in the Tertiary of New Zealand and Australia is of great interest and difficult to explain. The Eocene *H. antarctica* is the oldest representative of the genus.

The genus *Notosaria* COOPER is well known both from Tertiary deposits as well as Recent waters of New Zealand (ALLAN 1932b, 1960; JACKSON 1918; FOSTER 1969, 1974; LEE 1978b; LEE and WILSON 1979; RICHARDSON 1981a; DAWSON 1991), and from Recent waters of the Indian Ocean around Kerguelen (FOSTER 1974) and Heard Islands (COOPER 1973a, 1981a). The stratigraphical range of the New Zealand species is from the Oligocene to Recent, so *N. seymourensis* is the oldest occurrence of the genus.

Although rare in modern seas, *Tegulorhynchia* CHAPMAN *et* CRESPIN is widely distributed in the Tertiary strata of New Zealand and Australia, represented by five species (THOMSON 1927; ALLAN 1931, 1937a, 1940, 1960; LEE 1980b; MCNAMARA 1983). The closely related species, *T. squamosa* (HUTTON) is known from the Early Eocene to Early Miocene. In Australia *Tegulorhynchia* appears earlier, in Early Paleocene, and it is the oldest record of the genus (MCNAMARA 1983). As a fossil *T. doederleini* (DAVIDSON) is known from the Pliocene in Okinawa (COOPER 1957), but its Recent distribution is from off Japan to Borneo (HATAI 1940; LEE 1980b). A single specimen of *Tegulorhynchia* was taken off St. Paul Island, Indian Ocean (COOPER 1981a).

The genus *Plicirhynchia* ALLAN is known only from the Eocene sediments of South America (ORTMANN 1902; ALLAN 1947; ZINSMEISTER 1981) and West Antarctica (OWEN 1980; WIEDMAN *et al.* 1988).

The genus *Liothyrella* THOMSON confined first of all to the Southern Hemisphere is very common in Recent Antarctic and Subantarctic waters, represented by numerous species (EICHLER 1911; BLOCHMANN 1912; JACKSON 1912, 1918; FOSTER 1969, 1974, 1989; COOPER 1973a, b, 1981a, 1982, 1983). Although around New Zealand only a single species, *L. neozelanica* THOMSON, is noted today (ALLAN 1932a; FOSTER 1974, 1989; COOPER 1983; DAWSON 1991), several species of *Liothyrella* are recorded from the New Zealand Tertiary strata (ALLAN 1932a, 1937a, 1960; MACKINNON *et al.* 1993). COOPER (1983) assigned some Recent and fossil Australian and New Zealand species of *Liothyrella* to three new genera.

The genus *Terebratulina* D'ORBIGNY is a cosmopolitan genus, having a wide stratigraphical and geographical distribution. It is noteworthy that being fairly common in the Tertiary of Antarctica (OWEN 1980; WIEDMAN *et al.* 1988) as well as of New Zealand (ALLAN 1932b, 1960; MACKINNON *et al.* 1993), *Terebratulina* is very rare, however, in these regions today (FOSTER 1974, 1989; RICHARDSON 1981a; DAWSON 1991).

The genus *Murravia* THOMSON is limited to New Zealand and Australia, having been known from the Tertiary strata of both these regions (THOMSON 1916, 1927; ALLAN 1960; MACKINNON *et al.* 1993), and from Recent waters of South Australia (THOMSON 1927; FOSTER 1969). The occurrence in the Eocene deposits of the La Meseta Formation extends its stratigraphical range, *M. fosteri* sp. n. being stratigraphically the oldest record of this genus.

As a fossil the genus *Bouchardia* DAVIDSON has a long and continuous stratigraphical range from the Maastrichtian–Paleocene boundary to the Miocene–Pliocene, in the southernmost South America (MANCENIDO and GRIFFIN 1988). It is not known from the Tertiary strata of New Zealand and Australia. However, a related genus, *Neobouchardia* THOMSON, occurs in the Tertiary of these regions (ALLAN 1960; RICHARDSON 1973b; MACKINNON *et al.* 1993). The only living species of *Bouchardia* is known from warm, shallow waters off the coast of Brazil, suggesting migration to the north as the climate gradually cooled (MANCENIDO and GRIFFIN 1988).

The geographical distribution of the genus *Magellania* BAYLE is still questionable. In the Antarctic and Subantarctic waters as well as Tertiary strata of these regions there are numerous species of terebratellids

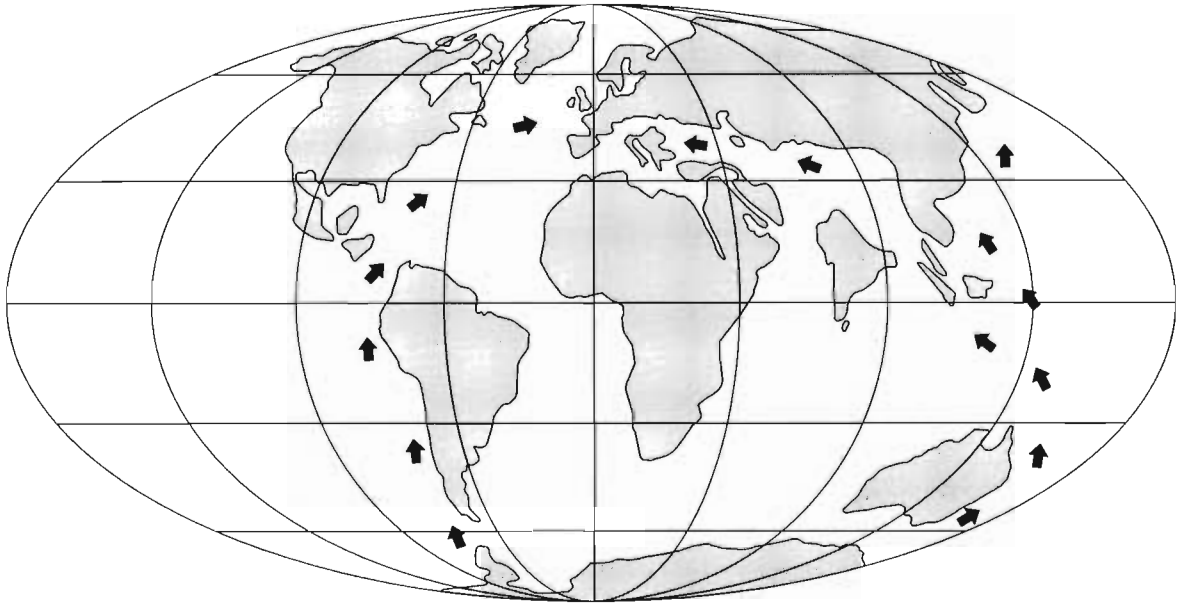


Fig. 9

Possible dispersal routes of the Eocene Antarctic brachiopod fauna from the Southern to Northern Hemisphere, shown on the Eocene paleogeographical map (paleogeography after FELDMANN 1986; modified).

with the *Magellania* stage of loop development, however, their proper generic name is still under discussion. ALLAN (1939, 1949) separated generically all species having in his opinion a separate Cenozoic evolution, and suggested that the genus *Magellania* was solely an Australian form. The Recent species previously assigned to *Magellania* have been assigned by ALLAN (1939) to a new genus *Aerothyris*. The Australian Tertiary species previously attributed to *Magellania* are separated now into two genera *Victorithyris* and *Diedrothyris* (ALLAN 1940; RICHARDSON 1980). FOSTER (1974, 1989), on the other hand, believes that characters used by ALLAN (1939, 1949) are rather of specific value and not sufficient to distinguish particular genera, so he preferred to leave certain species in the genus *Magellania*. In turn, COOPER (1981a), admitting difficulties with applying the proper generic name to many species with magellanian loop, accepted the name *Aerothyris* for the forms from off Macquarie and Kerguelen Islands. Also DAWSON (1991) pointed out the necessity of re-determining the status of this genus. Although the problem still remains unresolved, it is clear that *Magellania* and its closely related genera are exclusively confined to the Southern Hemisphere. They are known from the Tertiary of Patagonia (ORTMANN 1902; LEVY 1961; ZINSMEISTER 1981), of King George Island (BIERNAT *et al.* 1985), Australia (ALLAN 1940; RICHARDSON 1980), New Zealand (LEE 1986), as well as from Recent Antarctic and Subantarctic waters (EICHLER 1911; BLOCHMANN 1912; JACKSON 1912, 1918; ALLAN 1939, 1940, 1960; FOSTER 1969, 1974, 1989; MCCAMMON 1973; COOPER 1981a; DAWSON 1991; LEE 1991).

The genus *Magella* THOMSON, being noted for the first time from Seymour Island, is already known from the Lower Tertiary of nearby Cockburn Island (OWEN 1980), as well as from the Paleogene of New Zealand (THOMSON 1915; ALLAN 1932b; LEE 1986) where it is common. *Magella?* sp. is also reported by BIERNAT *et al.* (1985) from the Lower Miocene Destruction Bay Formation of King George Island, South Shetland Islands, but its state of preservation makes this determination dubious.

The genus *Stethothyris* THOMSON, extremely rare in the investigated material, is recorded for the first time in the Antarctic. So far it was known from the New Zealand Tertiary strata (ALLAN 1940; MACKINNON *et al.* 1993). It is considered to be restricted to New Zealand (ALLAN 1949; LEE 1986), however, RICHARDSON (1980) after the examination of growth stages of cardinalia of the Australian species previously placed by ALLAN (1940) in the genus *Victorithyris* (erected by him) believes that they should be returned to the genus *Stethothyris*.

The presence of the genus *Macandrevia* KING in the La Meseta Formation of Seymour Island is of great interest. Being fairly common in Recent waters and having a wide geographical distribution from the North Atlantic, along the Pacific coast of both Americas to around the Antarctic Continent (EICHLER 1911; JACKSON 1912; FOSTER 1969, 1974, 1989; COOPER 1973b, 1977, 1981b, 1982; D'HONDT 1976;

BRUNTON and CURRY 1979; THOMSEN 1990; LOGAN 1993), as well as off the west coast of Africa (COOPER 1975), *Macandrevia* is a very rare genus in fossil record. Moreover, it was not known so far from the Tertiary of the Southern Hemisphere, and noted until now only from the Northern Hemisphere, from the Pliocene of the Mediterranean region (GAETANI and SACCÀ 1984) and the Miocene of Japan (HATAI 1940). Questionable is the occurrence of *Macandrevia* in the Mediterranean Sea. FISCHER and OEHLERT (1891) mentioned only about finding empty valves, and the presence of *Macandrevia* signaled by COOPER (1973b, 1975, 1981b), ZEZINA (1976, 1985), BRUNTON and CURRY (1979) is difficult to establish because of lack of references, especially as its absence in the Mediterranean was noted by LOGAN (1979, 1983, 1993). Finding *Macandrevia* in the early?–middle Eocene strata of Seymour Island not only extends its stratigraphical range but also changes the picture of the migration routes dramatically. In fact we must accept that it originated in the Southern Hemisphere and spread northwards, which is opposite to so far proposed schema (THOMSON 1927; HATAI 1940; ELLIOTT 1951). Its absence as a fossil in New Zealand and Australia may be caused by the absence of the facies which it preferred. It is also a confirmation of its long geological history which was already suggested based on the loop development and the geographical distribution by THOMSON (1927) and on immunological data by ENDO *et al.* (1994).

Summarizing, one dispersal pattern may be suggested for such genera as *Basiliola*, *Hemithiris*, *Tegulorhynchia*, *Notosaria*, *Murravia*, *Magella*, *Stethothyris*, and *Macandrevia*. They may have migrated from the Antarctic Peninsula region northward to New Zealand and Australia, and farther to Japanese Islands (Text-fig. 9). The possible dispersal routes of three genera, *Hemithiris*, *Notosaria*, and *Macandrevia*, found also in the Late Tertiary of Europe could be either through the Tethys, before its Miocene closing, or along the western coast of South America and then through the region of Central America (Text-fig. 9), as suggested for crabs by FELDMANN (1986), but neither of the suggested directions of dispersal has the fossil evidence of brachiopods to support the contention.

The stratigraphically oldest occurrence of such genera as *Basiliola*, *Hemithiris*, *Notosaria*, *Murravia*, *Stethothyris* and *Macandrevia*, clearly suggests that Seymour Island might be a place of origin of those taxa from which they migrated northwards. Thus, the high-latitude heterochroneity observed earlier among other phyla (ZINSMEISTER and FELDMANN 1984) is present also among Brachiopoda. Consequently, the Antarctic region might have functioned as an evolutionary centre from which new taxa migrated (CRAME 1986; THOMSON 1991; STILWELL and ZINSMEISTER 1992). This view agrees with the Model 2 for the evolutionary history of polar regions proposed by CRAME (1992). This model assumes that most major groups of organisms originate in the highest latitudes and then move equatorward.

The Eocene brachiopod fauna of the La Meseta Formation at the specific level indicates a great individuality, having species known only from Seymour Island and from adjacent Cockburn Island. At the generic level, however, it shows the close affinities to that of New Zealand, having nine genera in common. There is much less similarity with the brachiopods from southern South America. The same observations were made in the use of other faunal groups, as molluscs (ZINSMEISTER 1977, 1982b; ZINSMEISTER and CAMACHO 1982; STILWELL and ZINSMEISTER 1992) or crabs (FELDMANN and ZINSMEISTER 1984; FELDMANN and WILSON 1988; AGUIRRE-URRETA *et al.* 1995), suggesting that although the close geographical location some kind of barrier, physical or oceanographical, or thermal differences due to latitude, existed between Antarctica and South America (STILWELL and ZINSMEISTER 1992; see also ALLAN 1949). While after the separation of New Zealand from Gondwanaland the marine shallow-water connections existed between Antarctica and New Zealand (STEVENS 1989). Although progressively weakening they persisted until the late Eocene (LEE 1986) when they eventually disappeared after the opening of Drake Passage in the Oligocene and the development of the circum-Antarctic current.

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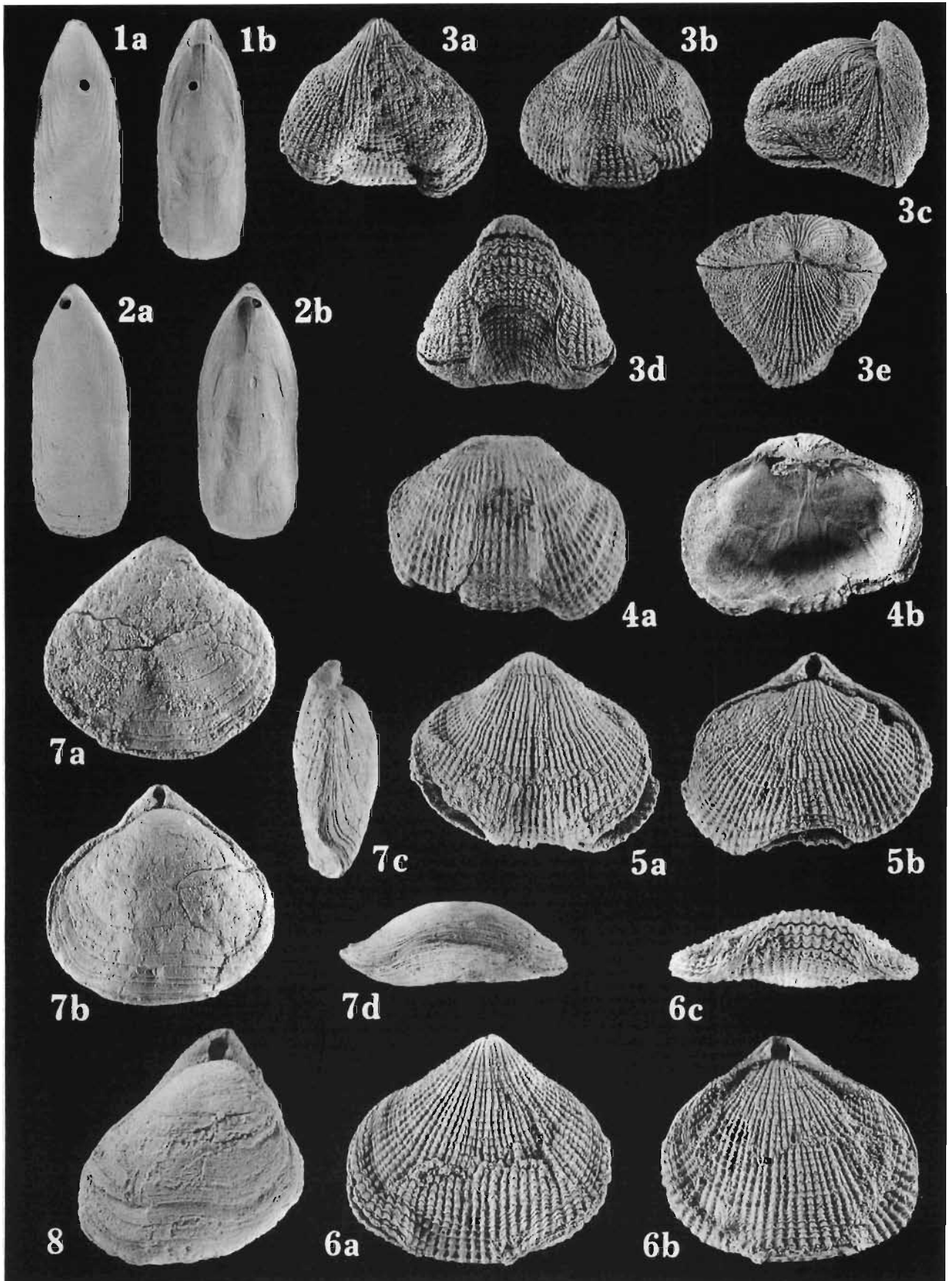
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PLATE 18

- Lingula antarctica* BUCKMAN, 1910 70
- Fig. 1. Ventral valve, ZPAL Bp.XXXVII/1, Telm7, $\times 1.5$, a – outer view; b – inner view showing well visible muscle scars.
- Fig. 2. Dorsal valve, ZPAL Bp.XXXVII/2, Telm7, $\times 1.5$, a – outer view; b – inner view showing well visible muscle scars.
- Tegulorhynchia ampullacea* sp. n. 75
- Fig. 3. Complete specimen, holotype ZPAL Bp.XXXVII/95, ZPAL 1, Telm1, $\times 2$, a – ventral view; b – dorsal view; c – lateral view; d – anterior view showing high anterior fold; e – posterior view.
- Tegulorhynchia* sp. 75
- Fig. 4. Brachial valve, ZPAL Bp.XXXVII/97, ZPAL 11, Telm1, $\times 2$, a – outer view; b – inner view showing pallial sinuses.
- Tegulorhynchia imbricata* (BUCKMAN, 1910) 74
- Fig. 5. Complete specimen, ZPAL Bp.XXXVII/85, ZPAL 1, Telm1, $\times 3$, a – ventral view; b – dorsal view.
- Fig. 6. Complete specimen, ZPAL Bp.XXXVII/86, ZPAL 1, Telm1, $\times 3$, a – ventral view; b – dorsal view; c – anterior view showing anterior fold.
- ?*Hemithiris* sp. 73
- Fig. 7. Complete specimen, ZPAL Bp.XXXVII/63, ZPAL 8, Telm2, $\times 2$, a – ventral view; b – dorsal view; c – lateral view; d – anterior view.
- Fig. 8. Dorsal view of complete specimen, ZPAL Bp.XXXVII/64, ZPAL 8, Telm2, $\times 3$.

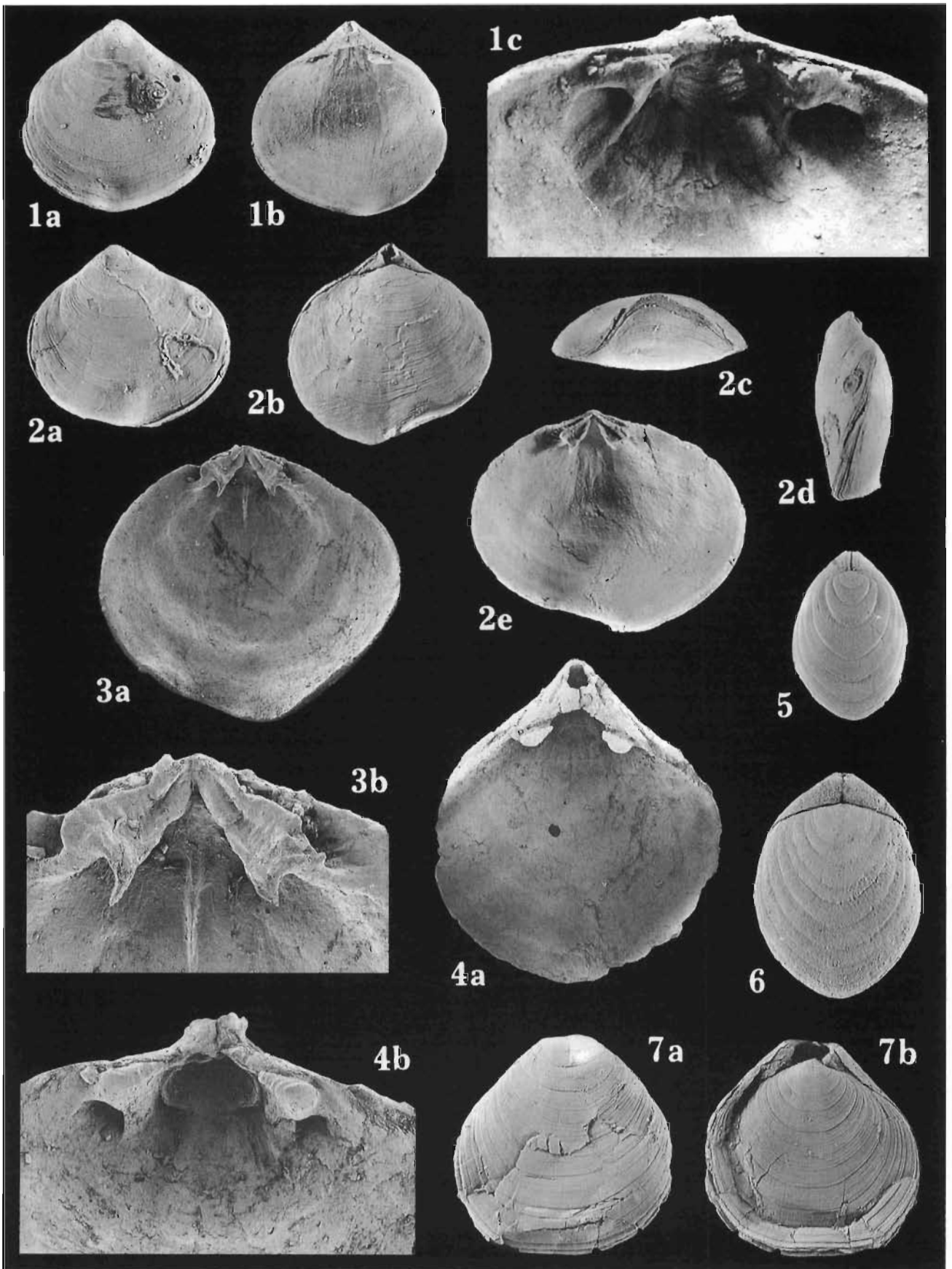


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PLATE 19

- Basiliola minuta* sp. n. 71
- Fig. 1. Pedicle valve, paratype ZPAL Bp.XXXVII/47, ZPAL 1, Telm1, a – outer view, × 3; b – inner view showing pallial sinuses, × 3; c – tilted view of the apex to show elaborate pedicle collar and dental plates, × 10.
- Fig. 2. Complete specimen, holotype ZPAL Bp.XXXVII/46, ZPAL 1, Telm1, a – ventral view, × 3; b – dorsal view, × 3; c – anterior view, × 3; d – lateral view, × 3; e – inner view of brachial valve showing cardinalia, × 4.
- Fig. 3. Inner view of brachial valve, paratype ZPAL Bp.XXXVII/49, ZPAL 1, Telm1, a – full view, × 6.5; b – detail of 3a to show cardinalia, × 20.
- Fig. 4. Inner view of pedicle valve, paratype ZPAL Bp.XXXVII/48, ZPAL 1, Telm1, a – full view, × 6.5; b – tilted view of the apex to show pedicle collar and dental plates, × 13.
- Bouchardia antarctica* BUCKMAN, 1910 81
- Fig. 5. Dorsal view of complete specimen, ZPAL Bp.XXXVII/186, ZPAL 8, Telm2, × 2.
- Fig. 6. Dorsal view of complete specimen, ZPAL Bp.XXXVII/215, Telm7, × 2.
- “*Terebratella*” *crofti* OWEN, 1980 82
- Fig. 7. Complete specimen, ZPAL Bp.XXXVII/446, ZPAL 1, Telm1, × 2, a – ventral view; b – dorsal view.



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PLATE 20

Liothyrella sp. 78

Fig. 1. Pedicle valve, ZPAL Bp.XXXVII/124, ZPAL 1, Telm1, $\times 1.5$, a – outer view; b – inner view; c – lateral view.

Fig. 2. Inner view of pedicle valve, specimen slightly crushed, ZPAL Bp.XXXVII/125, ZPAL 1, Telm1, $\times 1.5$.

Liothyrella anderssoni OWEN, 1980 77

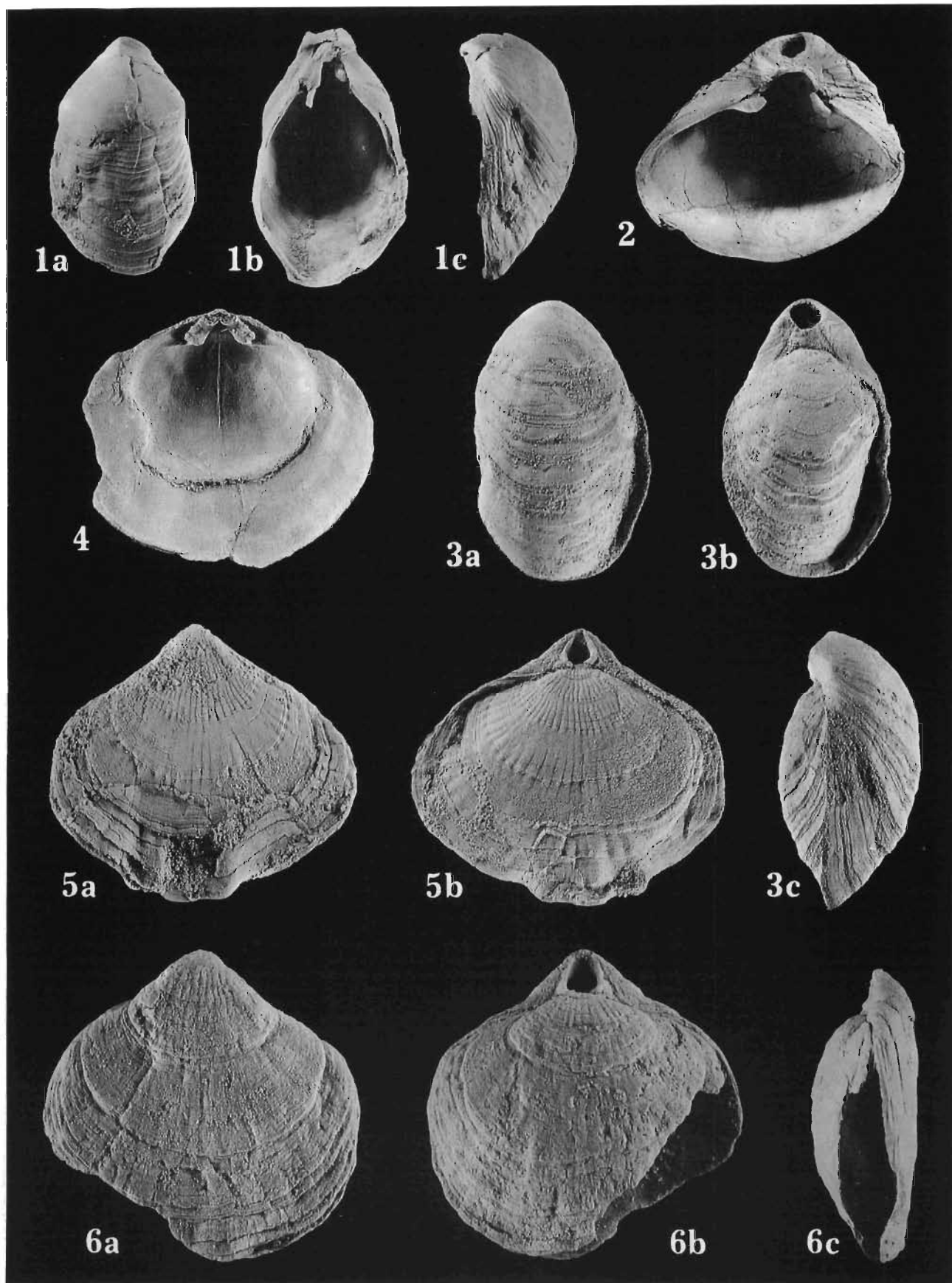
Fig. 3. Complete specimen, ZPAL Bp.XXXVII/112, Telm7, $\times 1$, a – ventral view; b – dorsal view; c – lateral view.

Hemithiris antarctica (BUCKMAN, 1910) 72

Fig. 4. Inner view of brachial valve, visible bilobed cardinal process and a low median ridge, ZPAL Bp.XXXVII/57, ZPAL 8, Telm2, $\times 3$.

Fig. 5. Complete specimen, ZPAL Bp.XXXVII/55, ZPAL 8, Telm2, $\times 2$, a – ventral view; b – dorsal view.

Fig. 6. Complete specimen, slightly damaged, ZPAL Bp.XXXVII/56, ZPAL 8, Telm2, $\times 3$, a – ventral view; b – dorsal view; c – lateral view.

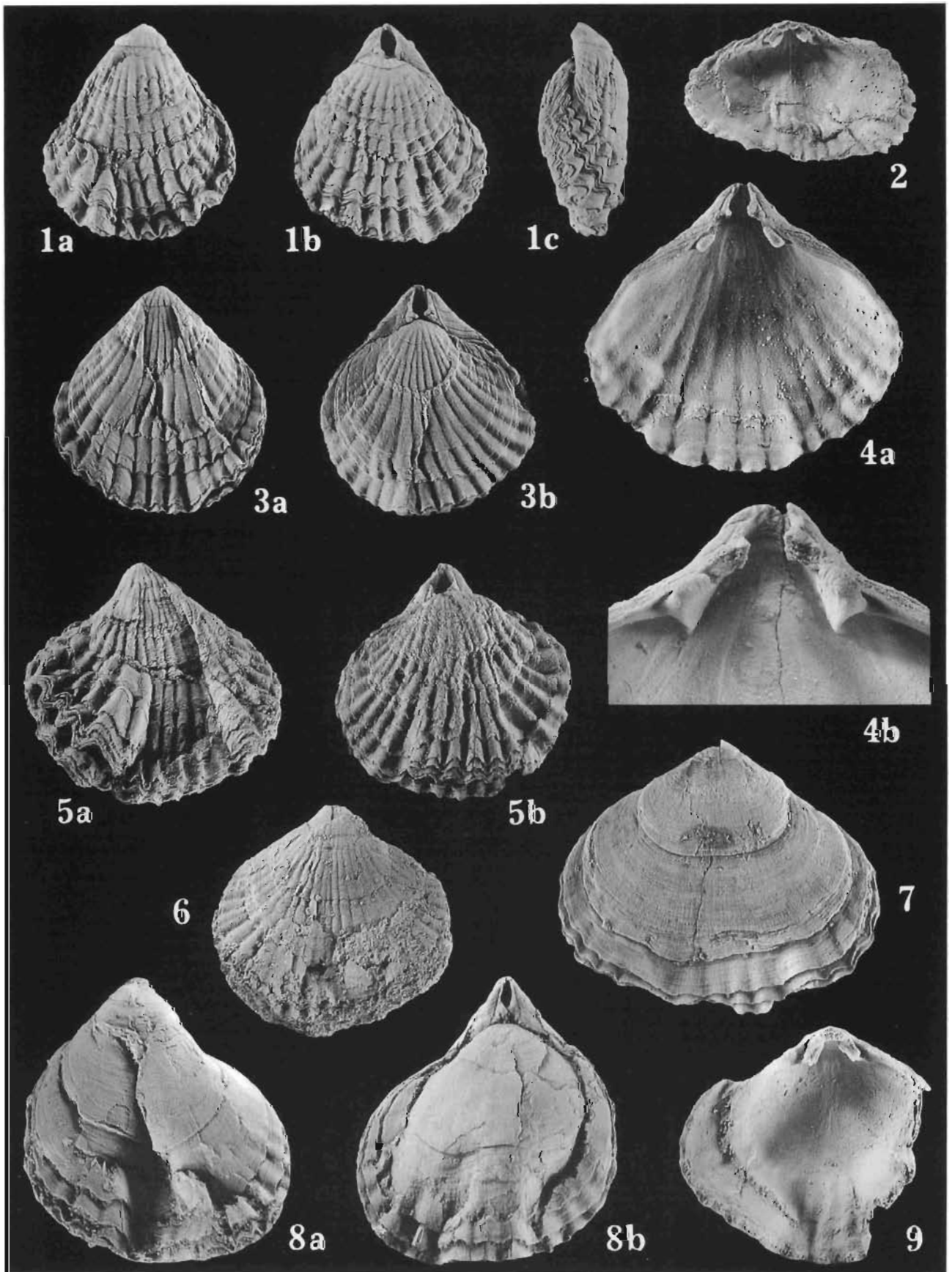


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PLATE 21

- Notosaria seymourensis* OWEN, 1980 73
- Fig. 1. Complete young specimen, ZPAL Bp.XXXVII/71, ZPAL 1, Telm1, × 3, a – ventral view; b – dorsal view; c – lateral view.
- Fig. 2. Inner view of brachial valve, visible bilobed cardinal process and median ridge, ZPAL Bp.XXXVII/73, ZPAL 1, Telm1, × 2.
- Fig. 3. Complete specimen, ZPAL Bp.XXXVII/69, ZPAL 1, Telm1, × 2, a – ventral view; b – dorsal view.
- Fig. 4. Inner view of pedicle valve, ZPAL Bp.XXXVII/72, ZPAL 1, Telm1, a – full view, × 3; b – tilted view of the apex to show dental plates, × 5.
- Fig. 5. Complete specimen, ZPAL Bp.XXXVII/70, ZPAL 1, Telm1, × 2, a – ventral view; b – dorsal view.
- Notosaria* sp. 74
- Fig. 6. Ventral view of complete specimen, ZPAL Bp.XXXVII/84, ZPAL 1, Telm1, × 2.
- ?Plicirhynchia* sp. 76
- Fig. 7. Outer view of pedicle valve, ZPAL Bp.XXXVII/102, ZPAL 1, Telm1, × 3.
- Fig. 8. Complete specimen, ZPAL Bp.XXXVII/101, ZPAL 1, Telm1, × 3, a – ventral view; b – dorsal view.
- Fig. 9. Inner view of brachial valve, visible transverse cardinal process and low median ridge, ZPAL Bp.XXXVII/103, ZPAL 1, Telm1, × 3.



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PLATE 22

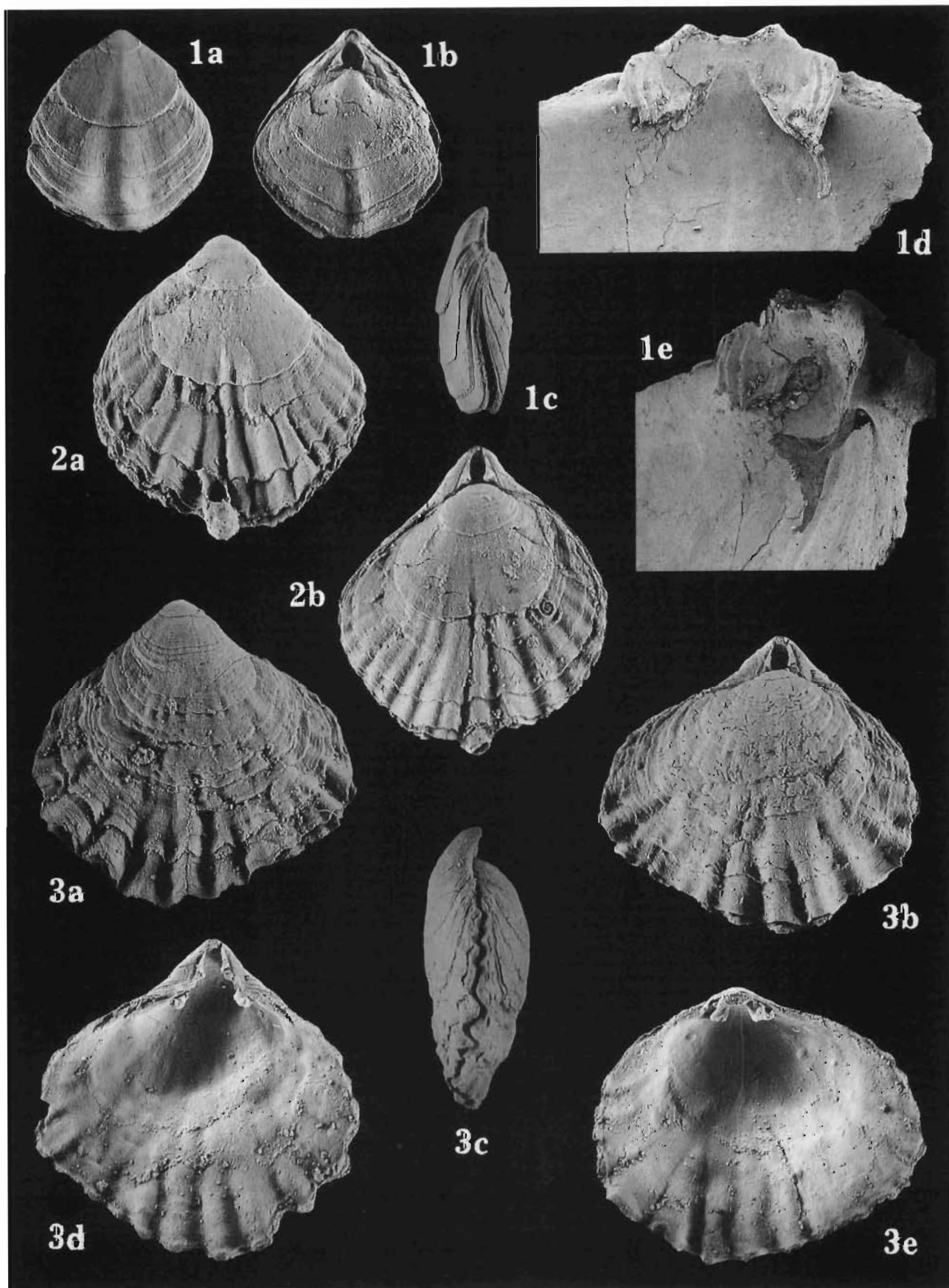
Gen. et sp. n. 79

Fig. 1. Complete specimen, ZPAL Bp.XXXVII/146, ZPAL 1, Telm1, a – ventral view, × 2; b – dorsal view, × 2; c – lateral view, × 2; d – inner view of brachial valve showing cardinalia, × 8; e – lateral view of 1d to show a fragment of the loop, × 10.

Paraplicirhynchia gazdzickii sp. n. 77

Fig. 2. Complete specimen, paratype ZPAL Bp.XXXVII/108, ZPAL 1, Telm1, × 3, a – ventral view; b – dorsal view.

Fig. 3. Complete specimen, holotype ZPAL Bp.XXXVII/107, ZPAL 1, Telm1, × 3, a – ventral view; b – dorsal view; c – lateral view; d – inner view of pedicle valve; e – inner view of brachial valve.



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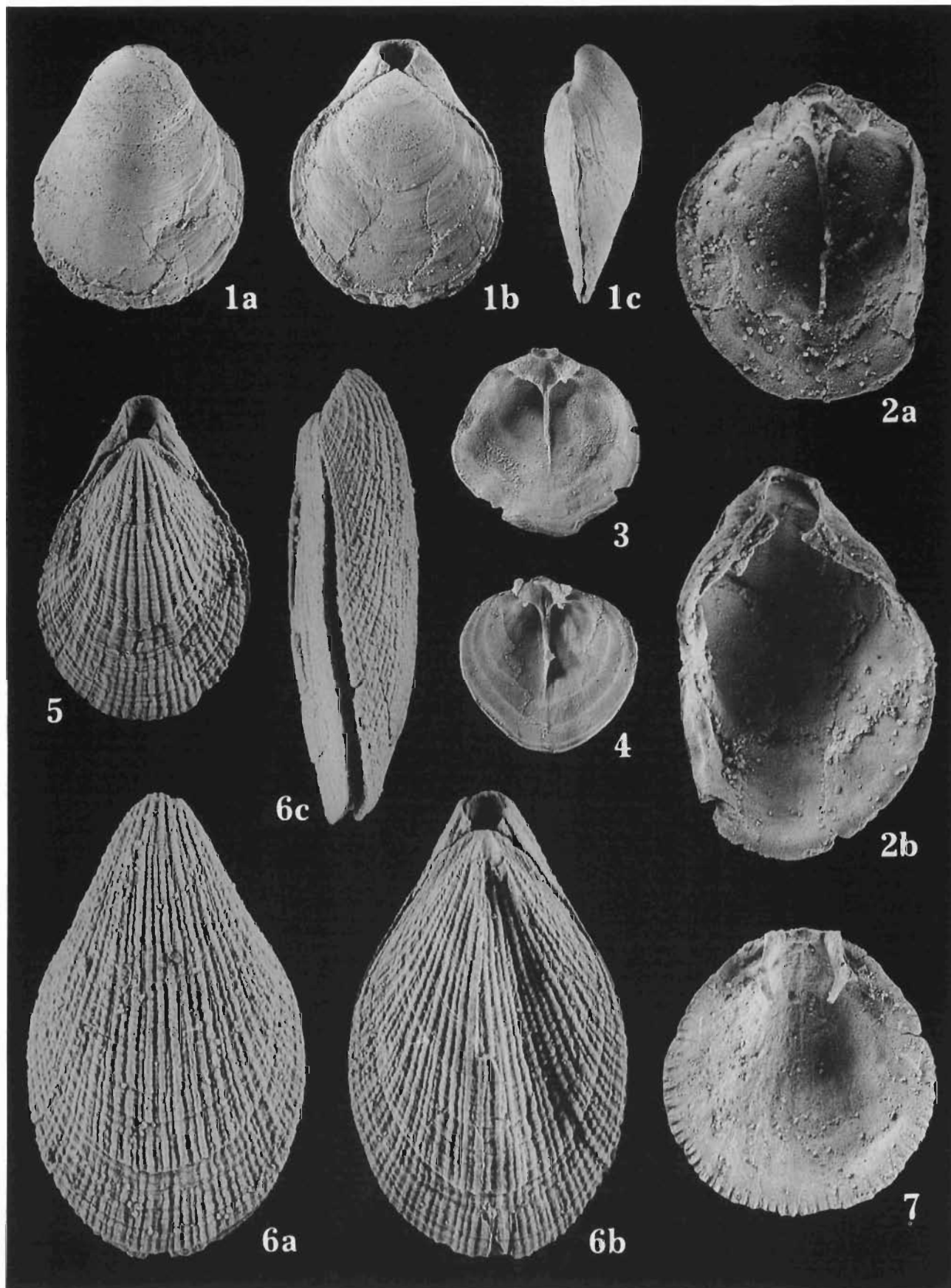
PLATE 23

Magella australis (BUCKMAN, 1910) 83

- Fig. 1. Complete specimen, ZPAL Bp.XXXVII/477, ZPAL 8, Telm2, × 2, a – ventral view; b – dorsal view; c – lateral view.
- Fig. 2. Inner views of young complete specimen, ZPAL Bp.XXXVII/476, ZPAL 1, Telm1, × 5, a – brachial valve; b – pedicle valve.
- Figs 3–4. Inner views of brachial valves showing long median septum, prominent cardinal process and hinge plates which descend steeply to meet median septum, × 2, 3 – ZPAL Bp.XXXVII/478, ZPAL 8, Telm2; 4 – ZPAL Bp.XXXVII/475, ZPAL 1, Telm1.

Terebratulina buckmani OWEN, 1980 80

- Fig. 5. Dorsal view of young complete specimen, ZPAL Bp.XXXVII/148, ZPAL 1, Telm1, × 5.
- Fig. 6. Complete specimen, ZPAL Bp.XXXVII/147, ZPAL 1, Telm1, × 5, a – ventral view; b – dorsal view; c – lateral view.
- Fig. 7. Inner view of brachial valve, showing high inner socket ridges, distinct cardinal process and long crura, ZPAL Bp.XXXVII/171, ZPAL 8, Telm2, × 4.



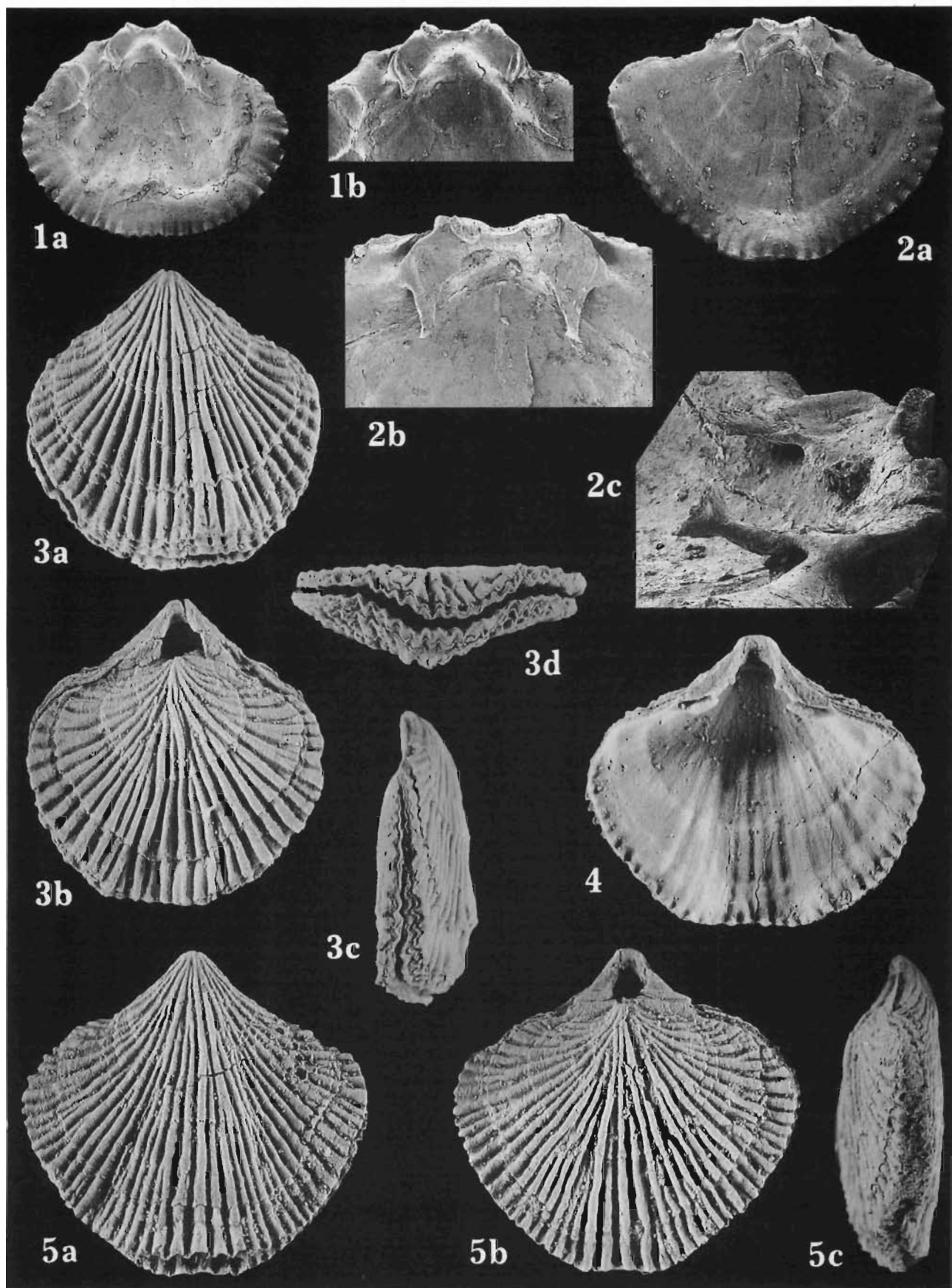
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PLATE 24

Murravia fosteri sp. n. 80

- Fig. 1. Inner view of brachial valve of young specimen, ZPAL Bp.XXXVII/176, ZPAL 1, Telm1, a – full view, × 5; b – detail of 1a to show cardinalia, × 7.5.
- Fig. 2. Inner view of brachial valve, paratype ZPAL Bp.XXXVII/175, ZPAL 1, Telm1, a – full view, × 5; b – detail of 2a to show cardinalia, × 10; c – lateral view to show long crura and a fragment of loop, × 15.
- Fig. 3. Complete specimen, paratype ZPAL Bp.XXXVII/174, ZPAL 1, Telm1, × 4, a – ventral view; b – dorsal view; c – lateral view; d – anterior view showing sulcation.
- Fig. 4. Inner view of pedicle valve, paratype ZPAL Bp.XXXVII/181, ZPAL 1, Telm1, × 4.
- Fig. 5. Complete specimen, holotype ZPAL Bp.XXXVII/173, ZPAL 1, Telm1, × 4, a – ventral view; b – dorsal view; c – lateral view, slightly oblique.



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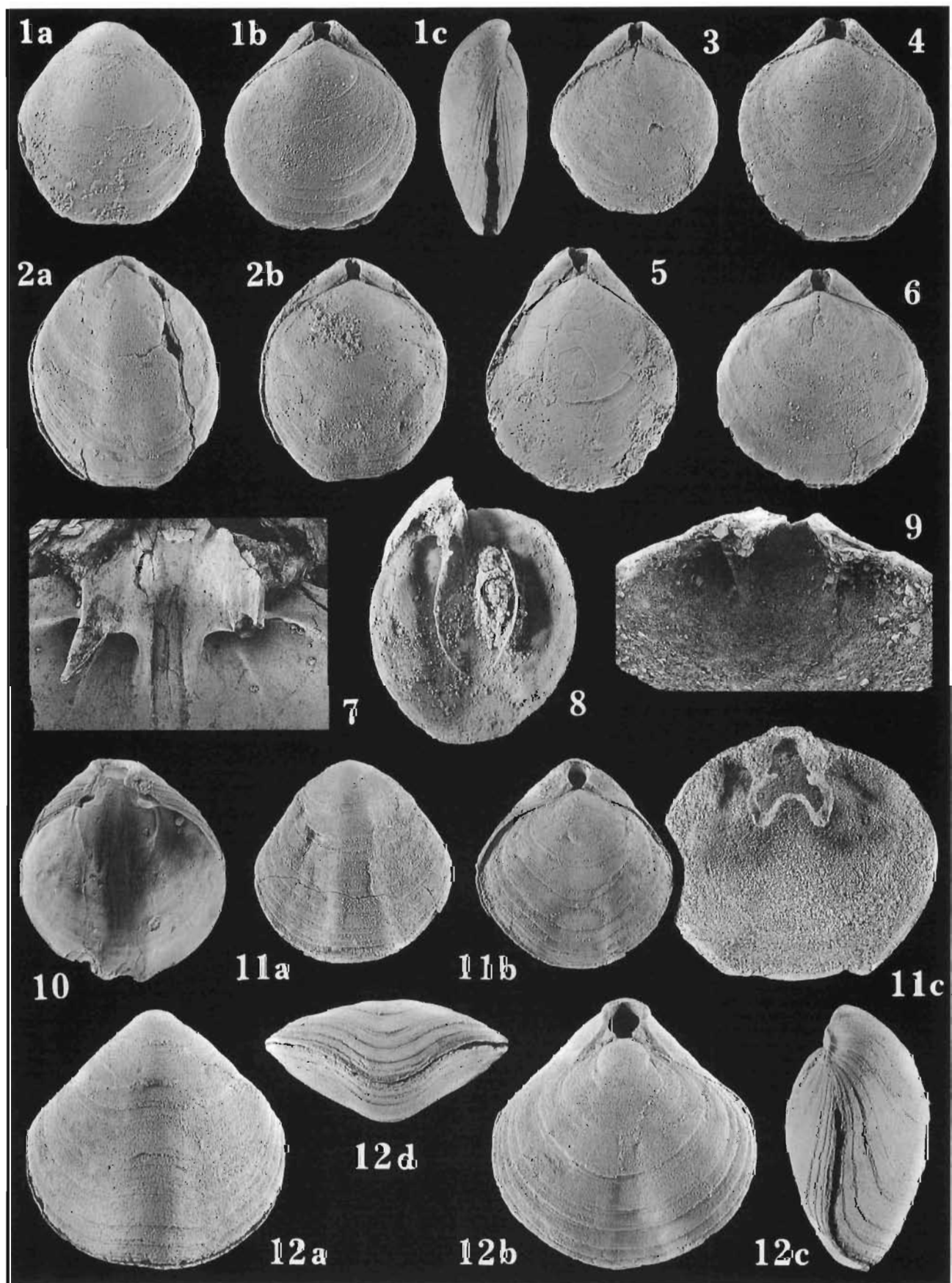
PLATE 25

Macandrevia cooperi sp. n. 84

- Fig. 1. Complete specimen, paratype ZPAL Bp.XXXVII/481, ZPAL 8, Telm2, $\times 2.2$, a – ventral view; b – dorsal view; c – lateral view.
Fig. 2. Complete specimen, holotype ZPAL Bp.XXXVII/480, ZPAL 8, Telm2, $\times 1.9$, a – ventral view; b – dorsal view.
Figs 3–6. Dorsal views of complete specimens, ZPAL 8, Telm2, 3 – ZPAL Bp.XXXVII/482, $\times 2$; 4 – ZPAL Bp.XXXVII/483, $\times 2.5$; 5 – ZPAL Bp.XXXVII/484, $\times 2$; 6 – ZPAL Bp.XXXVII/485, $\times 2$.
Fig. 7. Inner view of brachial valve showing small cardinal process and inner hinge plates extending directly to the valve floor, ZPAL Bp.XXXVII/555, ZPAL 1, Telm1, $\times 5$.
Fig. 8. Inner view of brachial valve showing long lamellae of descending branches and a fragment of ascending branches with broad transverse band, paratype ZPAL Bp.XXXVII/488, ZPAL 8, Telm2, $\times 2$.
Fig. 9. Tilted view of the interior of pedicle valve to show dental plates, ZPAL Bp.XXXVII/487, ZPAL 8, Telm2, $\times 5.5$.

Seymourella oweni gen. et sp. n. 78

- Fig. 10. Inner view of pedicle valve, ZPAL Bp.XXXVII/142, ZPAL 1, Telm1, $\times 2$.
Fig. 11. Complete specimen, paratype ZPAL Bp.XXXVII/141, ZPAL 8, Telm2, a – ventral view, $\times 1$; b – dorsal view, $\times 1$; c – inner view of brachial valve showing a loop, $\times 1.5$.
Fig. 12. Complete specimen, holotype ZPAL Bp.XXXVII/140, ZPAL 8, Telm2, $\times 1.5$, a – ventral view; b – dorsal view; c – lateral view; d – anterior view.



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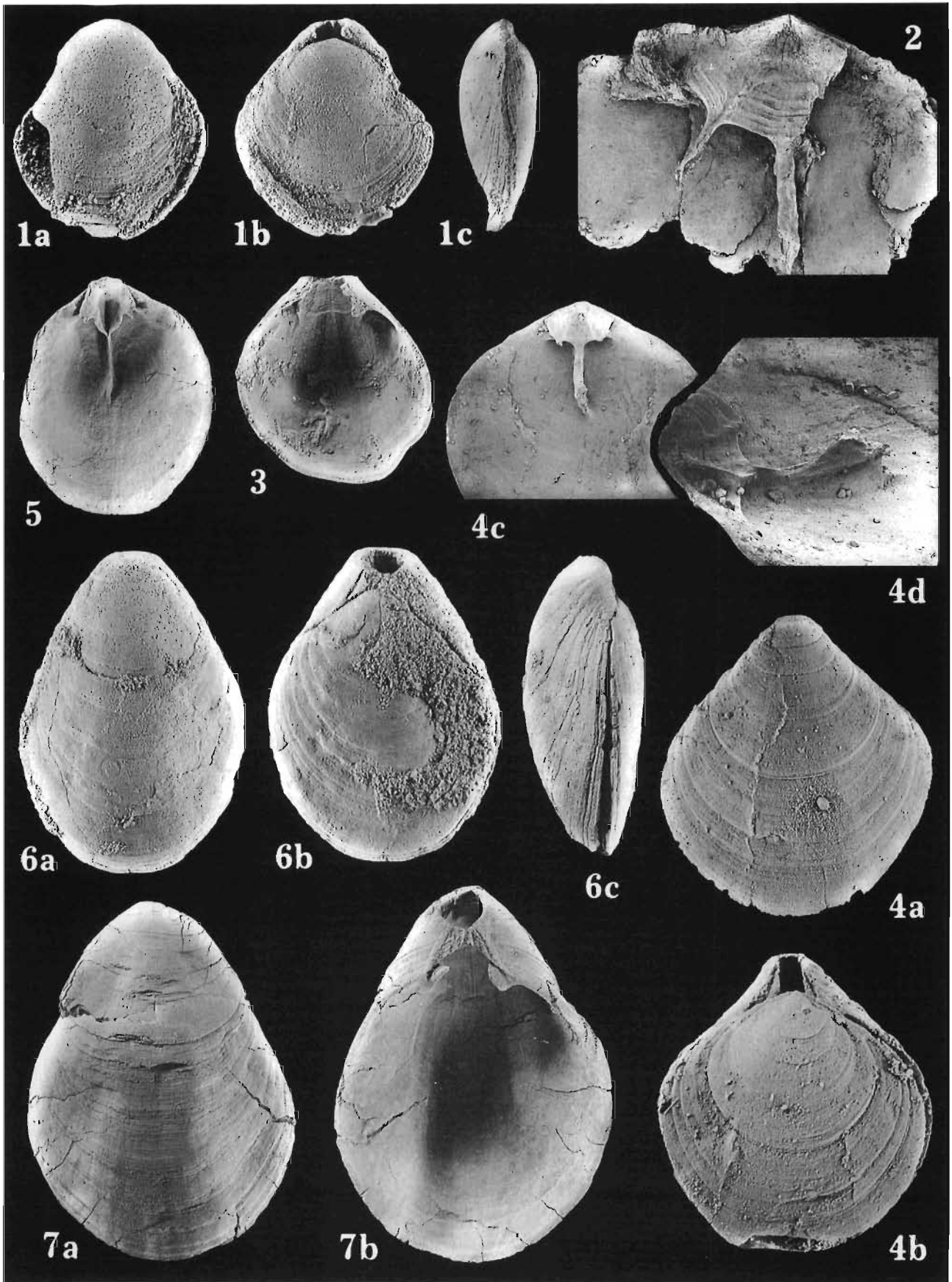
PLATE 26

Laquethiris curiosa gen. et sp. n. 87

- Fig. 1. Complete specimen, holotype ZPAL Bp.XXXVII/565, ZPAL 8, Telm2, $\times 2$, a – ventral view; b – dorsal view; c – lateral view.
Fig. 2. Inner view of brachial valve showing nearly horizontal hinge plates which meet median septum, ZPAL Bp.XXXVII/568, ZPAL 1, Telm1, $\times 7.5$.
Fig. 3. Inner view of pedicle valve showing wide, sessile pedicle collar and dental plates, ZPAL Bp.XXXVII/567, ZPAL 1, Telm1, $\times 2$.
Fig. 4. Young complete specimen, ZPAL Bp.XXXVII/566, ZPAL 1, Telm1, a – ventral view, $\times 5$; b – dorsal view, $\times 5$; c – inner view of brachial valve, $\times 5$; d – lateral view of 4c to show high median septum, $\times 10$.

Magellania antarctica (BUCKMAN, 1910) 83

- Fig. 5. Inner view of brachial valve showing cardinalia and short median septum. ZPAL Bp.XXXVII/464, ZPAL 10, Telm3, $\times 1$.
Fig. 6. Complete specimen, ZPAL Bp.XXXVII/460, ZPAL 8, Telm2, $\times 1.5$, a – ventral view; b – dorsal view; c – lateral view.
Fig. 7. Pedicle valve, ZPAL Bp.XXXVII/455, ZPAL 1, Telm1, $\times 1$, a – outer view; b – inner view.



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